

**Proceedings  
Of  
INTERNATIONAL SYMPOSIUM  
On  
DESERTIFICATION**



13-17 June 2000  
Konya / Turkey



Soil Science  
Society of Turkey



Selçuk  
University



General Directorate  
of Rural Services

Supported by



TÜBİTAK



Ridvan KIZILKAYA

SAMSUN

**Proceedings  
Of  
International Symposium  
On  
Desertification**

**Ridvan Kizilkaya**

ISD

13-17 June 2000  
Konya / Turkey



### **ORGANIZING COMMITTEE**

Dr. Nuri MUNSUZ	Dr. Saim KARAKAPLAN
Dr. Fikret EYÜBOĞLU	Dr. D.Murat ÖZDEN
Dr. Mehmet NİZAMLIOĞLU	Dr. Bülent SÖNMEZ
Dr. Kemal GÜR	İskender UÇAR
A.Naci SEVİNÇ	Dr. İlhami BAYRAMİN
Dr. Sait GEZGİN	Dr. Oğuz BAŞKAN
Dr. Mehmet ZENGİN	Dr. Cevdet ŞEKER
Dr. Orhan DOĞAN	Dr. Nesime CEBEL

### **INTERNATIONAL COMMITTEE**

M.Güner SAYGILI, Turkey  
Dr. Abdurrahman KUTLU, Turkey  
Dr. Mehmet KARA, Turkey  
Dr. W.E.H. BLUM, Austria  
Dr. Darrell L. NORTON, USA  
Dr. Donal GABRIELS, Belgium  
Dr. Peter BULLOCK, UK  
Dr. Hari ESWARAN, USA

### **SCIENTIFIC COMMITTEE**

Dr. Nuri MUNSUZ	Dr. Hüseyin ÖZBEK
Dr. Ural DİNÇ	Dr. Cemil CANGİR
Dr. Hasan H. TOK	Dr. Suat ŞENOL
Dr. Alaattin TAYSUN	Dr. Koray HAKTANIR
Dr. Nevin ERYÜCE	Dr. Selim KAPUR







## PREFACE

Chapter 12 of Agenda 21, as approved by the United Nations Conference on Environment and Development (UNCED), defines desertification as "land degradation in arid, semi-arid and dry subhumid areas resulting from various factors, including climatic variations and human activities". This definition is simplistic, as it does not express clearly the constant interaction between climatic factors and human activities - the latter often being decisive in triggering desertification processes.

Nevertheless, it seems important to state that, in certain parts of the world, desertification processes (land degradation) operate in the absence of human activities, where such activities are negligible because of low population density.

The natural recurring drought processes, which may be caused by global climatic changes that are difficult to evaluate, may lead to land degradation, thus endangering the peoples in and around those areas, or preventing future land use. Although it might appear vain to combat such "geological" desertification, it is nonetheless essential to help local communities confront the situation and adapt to it without making it worse.

The link between desertification and human activities is thus a generally accepted concept and this link be clearly defined as:

"The sum of the geological, climatic, biological and human factors which lead to the degradation of the physical, chemical and biological potential of lands in arid and semi-arid zones, and endanger biodiversity and the survival of human communities."

Desertification as previously defined can only occur on land prone to desertification processes. The vulnerability to desertification of land is determined by current climate, relief, and the state of the soil and natural vegetation. Climate has a major influence through three factors rainfall, solar radiation and wind- which all affect physical and mechanical erosion phenomena and chemical and biological degradation. Relief acts mainly to exacerbate water erosion. The state of the soil, in terms of its texture, structure and chemical and biological status, is a predominant factor in dry subhumid zones, where climate has less impact; it plays a crucial role in vulnerability to desertification through human activities. The same applies to the state of the natural vegetation: the result of past and recent influences; of climatic, pedological and often, human factors. Because of their longevity and powerful root systems, trees are a primary source of protection from soil degradation and their absence, too often caused by human action, is a serious handicap.

Human activities are the main factors triggering desertification processes on vulnerable land. These activities are many and vary by country, society, landuse strategies and the technologies applied. The impact of human society does not depend solely on its density. The concepts of "carrying capacity" and "critical threshold" need to be considered with care, as many examples demonstrate that these criteria can evolve according to the strategies and technologies applied by local people.

Desertification should be viewed as a breakdown of the fragile balance that allowed plant, human and animal life to develop in arid, semi-arid and dry subhumid zones. This breakdown of the equilibrium and of the physical, chemical and biological processes that sustain it, represents the start of a process of self-destruction for all elements of the life system. Thus soil vulnerability to wind and water erosion, the lowering of the water-table, the impairment of the natural regeneration of vegetation, the chemical degeneration of soils - themselves all immediate results of desertification - worsen the situation. Desertification feeds on itself.



Consequently, the effects of desertification are extremely serious and often dramatic for the poor populations of developing countries. By limiting natural potential desertification reduces production and makes it increasingly precarious. Forced to attend to the most urgent things first, populations resort to survival strategies that unfortunately make desertification worse and prevent any development.

Human beings are at the heart of the desertification problem, either as actors or victims. The fight against desertification is a fight for survival. It is an integral part of the socio-economic development programmes of land resources and the inhabitants of concerned areas. The main goal is to enlist the people, government technical services and non-governmental organizations to promote the complete participation of the population.

Soil Science Society of Turkey (SSST) was founded in 1964 by the unforgettable pioneer of Turkish soil science Prof.Dr. Kerim Ömer ÇAĞLAR. Since then the Society has been struggling with nationwide problems faced by the producers and researchers through 14 scientific meeting organised in every two years together with 3 workshops. SSST with its 600 members has been making valuable contributions to the country's agricultural development, especially for the sustainable use of soil and water resources.

We would like to thank the General Directorate of Rural Services and Selçuk University, for their kind support to materialise this symposium.

We are sure that the contribution of all participants will make this symposium a turning point and a success with the appropriate actions.

Last but not the least, our colleagues in the scientific, international and organising committees deserve our special appreciation.

We wish everyone a productive and pleasant symposium.

**Organising Committee**

## CONTENTS

No		Page
1	<b>The Facts of Desertification and United Nations Convention to Combat Desertification</b> <i>D.Murat Özden</i>	1
2	<b>Soil and Water National Information Center – A Resource for Turkey's Future Sustainable Development</b> <i>D.Murat Özden, A.İhsan Koral, Sebahattin Keskin, G.Özlem Kara, Sema Yazıcı, Güler Deveci, Gülşen Öztürk, Pınar Bostan, Sibel Özcan, E.Cüneyt Ural, Çiğdem Eren, Aysun Ünal, Pınar Atalay, Murat Bayat</i>	14
3	<b>The Land Resources of Turkey and Activities of General Directorate of Rural Services</b> <i>D.Murat Özden, Hasan Dursun, A.Naci Sevinç</i>	22
4	<b>Using Geographic Information System and Remote Sensing Techniques in Making Pre-Soil Surveys</b> <i>İlhami Bayramin</i>	27
5	<b>Neural Network Approach for Small Scale Soil Mapping</b> <i>İlhami Bayramin</i>	33
6	<b>The Validation of PI Model for Soil Orders in Ankara</b> <i>Şenay Özden, Kezban Şahin, Sebahattin Keskin</i>	39
7	<b>Quantitative Determination of Erosion by Using Remote Sensing and Geographic Information Systems in The Vicinity of Ankara Çubuk Dam Lake</b> <i>Şenay Özden, Nuri Munsuz</i>	46
8	<b>The Determination of Relationships Between Physical Properties on Some Great Soil Groups in The Antalya Region and Water Erosion Under Simulated Rainfall</b> <i>Kezban Şahin, Zeki Alagöz</i>	52
9	<b>Changes in Vegetation and Soil Properties Along A Slope</b> <i>Taşkın Özteş, Ali Koç, Binali Çomaklı</i>	57
10	<b>International Conventions on Desertification &amp; Sustainable Development : Problems of Inadequate Information Circulation &amp; Urban-Rural Differences As Constraints on Local Involvement in Agendas to Combat Desertification</b> <i>John Muhammed Jamil Brownson</i>	62
11	<b>Status of The Saline And Sodic Soils of The Lower Meriç Valley in Ipsala Flood Plain</b> <i>Cemil Cangir, Duygu Boyraz</i>	67
12	<b>Ecological Changes in Manyas Lake Related to Boron Pollution and Water Regime</b> <i>Sevinç Arcak, Koray Haktanır, Mümtaz Kibar, Orhan Dengiz</i>	73
13	<b>Water Quality and Ecological Properties of Burdur Lake</b> <i>Sevinç Arcak, Ahmet Altındağ</i>	81
14	<b>The Effect of Watertable on Soil Pollution</b> <i>Fariz.D Mikaliyov, Fatih Er</i>	91



15	<b>Performance Assessment of Gediz Basin Using Secondary Data</b>	96
	<i>Göksel Geçgel, Atila Girgin, Müslüm Beyazgül, Charlotte De Frature, Hammond Murray-Rust</i>	
16	<b>The Efficiency of Irrigation Organizations in Tokat Province and Socio-Economic Factors Affecting The Participation of Producer to These Organizations</b>	103
	<i>H.Bahadır Arslankurt, Halil Kızılaslan, Nuray Kızılaslan, Kemal Esengün</i>	
17	<b>Investigation of Boron Concentration of Some Irrigation Waters Used in Aydın Region for Plant Nutrient and Soil Pollution</b>	109
	<i>Gönül (Bilgehan) Aydın, Saime Seferoğlu</i>	
18	<b>Desertification: Development Factors and Conservation in Mountain Areas of The South Central Asia</b>	115
	<i>Kasirov Kokul Khasanovic, Akhmadov Khukmatullo Mahmudovic</i>	
19	<b>The Spread of Different Types of Desertification İn The Mountain Zone of The Pamirs Alai</b>	120
	<i>Akhmadov Khukmatullo Mahmudovic, Kasirov Kokul Khasanovic</i>	
20	<b>Erosion Risk Mapping of Dalaman Basin Located in West Mediterranean Region Using Corine Method</b>	125
	<i>Orhan Doğan, M.E. Özel, H.Yıldırım, N. Küçükçakar</i>	
21	<b>Soil Properties and Soil Erodibility Changes Along A Slope</b>	129
	<i>İrfan Oğuz, Faruk Noyan</i>	
22	<b>Comparison Effect of Conventional Tillage and No Tillage Practices on Some Chemical, Biochemical and Microbiological Properties of Erosion Plots Soils</b>	135
	<i>Nesime Cebel, Michael Mullen, Michael Kircner</i>	
23	<b>Determining of P Factor For Contour Tillage Using Rainfall Simulator Under Field Condition in Aegean Region</b>	139
	<i>Cevdet Köse, Alaattin Taysun</i>	
24	<b>Slope and Phospogypsum's Effects on Seal and Crust Formation and İnfiltration Rate</b>	143
	<i>Mücahit Karaoğlu, Mustafa R. Çanga</i>	
25	<b>Land Degradation of The Mountainous Areas in Turkey</b>	149
	<i>İbrahim Atalay</i>	
26	<b>Assessment of Potentially Available Soil Nitrogen by Incubation Methods As Related to Status of Some Soil-N Forms</b>	158
	<i>A.H. Awad Elkarim, Sadık Usta</i>	
27	<b>N Balance of N<sup>15</sup> Applied As Ammonium Sulphate to Irrigated Potatoes in Sandy-Textured Soils</b>	164
	<i>Mahmut Basri Halitligil, Ali Akin, Adem İlbeyi</i>	
28	<b>Effect of Farmyard and Green Manuring on Organic Cheery Growing : II Kemalpaşa Region (TURKEY)</b>	170
	<i>B.Okur, N.Eryüce, B.Çokuysal, H.Çakıcı, D.Anaç, S.Tezcan, M.A.Ul, A.Ünal</i>	
29	<b>The Effect of Green Manuring on Nitrate Leaching Under Field Conditions</b>	174
	<i>Emine Erman Kara</i>	
30	<b>Dynamics of Nitrogen Combination and Their Balance in The Rotation Systems</b>	179
	<i>Z.R.Movsumov</i>	

31	<b>For Sowing Treatment Celeras Seed With Ozone</b>	182
	<i>N.A.Mamadov</i>	
32	<b>Optical Properties of Soils and Their Agricultural Application</b>	183
	<i>A.P.Geraizade</i>	
33	<b>An Investigation on Determination of Zinc Fractions of Soils in Bafra Plain and Their Availability for Plants</b>	187
	<i>Songül Rakıcioğlu, Ahmet Korkmaz</i>	
34	<b>Degradation of The Harran Plain Soils Due To Irrigation</b>	193
	<i>Mehmet Ali Çullu, İsmail Çelik, Ahmet Almaca</i>	
35	<b>Karapınar : A Case Study of Rehabilitation of A Wind Eroded Area in Turkey</b>	198
	<i>Erhan Akça, Selim Kapur, Memduh Serin, Bahri Çevik, Hari Eswaran</i>	
36	<b>Land Degradation and Desertification in Desert Margins</b>	202
	<i>Paul Reich, Hari Eswaran, Selim Kapur, Erhan Akça</i>	
37	<b>The Effects of Different Stalk Tillage and Seedbed Preparation Methods in Cotton Farming Upon Some Physical Characteristics and Aggregate Stability of The Soil</b>	211
	<i>Tuna Doğan, Gönül Aydın (Bilgehan), İbrahim Yalçın</i>	
38	<b>The Impact of Land Use Changes on Natural Vegetation Along The Coastal Zone Between Edremit and Küçükkuyu (NW Turkey)</b>	217
	<i>Recep Efe</i>	
39	<b>Land Use Planning in Earthquake-Prone Areas</b>	222
	<i>Nicholas Novakowski, Recep Efe</i>	
40	<b>Effects of Landscape Position and Parent Material on The Soil Properties in Kahramanmaraş Province, Turkey</b>	228
	<i>Recep Gündoğan, Kadir Yılmaz</i>	
41	<b>Assesment of Land Suitability for Olive Trees, Growing in Central Portion of The Negev Desert</b>	234
	<i>Micheal Shapiro, Vladimir Kurepin</i>	
42	<b>Deltometric Methods and His Application in Soil Hydrophysical Investigations</b>	239
	<i>Gulaliev Chingiz Gulali Oglu</i>	
43	<b>The Effects of Inoculation of Soil With Different Numbers of Bacteria on Aggregation</b>	242
	<i>Tayfun Aşkın, Coşkun Gülser, Rıdvan Kızılkaya, Nutullah Özdemir</i>	
44	<b>Effects of Vegetation Water of Oil Mills on Some Physical and Chemical Characteristic Of Soils</b>	247
	<i>Saim Seferoğlu, Gönül (Bilgehan) Aydın, Mehmet Aydın</i>	
45	<b>Adverse Effects of Uncontrolled Urbanisation on The Sustainable Agriculture in Konya, Turkey</b>	252
	<i>Kemal Gür, Serpil Önder, Tuğrul Polat</i>	
46	<b>A Study on The Soil Tare of Sugar Beet in Eskişehir – Turkey</b>	258
	<i>Nazmi Oruç , Halil Güngör</i>	
47	<b>A Study on The Increase of Soil Pollution by Using Inaccuracy Fertilizer in Samsun Soils</b>	262
	<i>Osman Özdemir, İbrahim Kaya Ersöz, Sevinç Alpay</i>	

48	<b>Assessment of Infiltration Rate Parameters for Site-Specific Water Management</b>	267
	<i>Sabit Erşahin, M.Rüştü Karaman</i>	
49	<b>The Effects of Drip And Surface Irrigation Methods on The Yields And Quality of Tomato Crop in Different Sized Perlit Culture</b>	273
	<i>Tuncay Demirel, Sabri Şener, Şükrü Kaleli</i>	
50	<b>Rain Splash Detachment and Transport Under Wind Driven Rain</b>	277
	<i>G. Erpul, D.L. Norton, D. Gabriels</i>	
51	<b>Visualizing Spatio-Temporal Mesquite Variation on Desert Grasslands Under Different Grazing Management Applications</b>	283
	<i>Hakan Mete Doğan</i>	
52	<b>Determination of Relations Between Some Soil Properties and Some Soil Moisture Constants Using Path Analysis</b>	289
	<i>Nutullah Özdemir, Çoşkun Gülser, Tayfun Aşkın</i>	
53	<b>Rangeland-Livestock Interaction in Our Near History Problems and Recommendations</b>	293
	<i>Ali Koç, Taşkın Öztaş, Lütfü Tahtacıoğlu</i>	
54	<b>Hydraulic Properties And Erosion of Soils Irrigated With Effluent Water: Effect of Soil Texture and Wetting Rate</b>	299
	<i>Mamedov Amirakh, Mikhailov Fariz</i>	
55	<b>Physical Changes of The Harran Soils by Surge And Continious Furrow Methods</b>	305
	<i>S.Şahan, Erhan Akça, Selim Kapur, Rıza Kanber</i>	
56	<b>A Research on Reclamation of Physical Properties of Bolu Yeniçağa Peat as Plant Growing Medium</b>	308
	<i>Gökhan Çaycı, Abdullah Baran, Cihat Kütük, Yener Ataman, Hüseyin Öztekin, Orhan Dengiz</i>	
57	<b>Effect of Beer Factory Sludge on Yield Components of Wheat and Some Soil Properties</b>	313
	<i>Cihat Kütük, Gökhan Çaycı</i>	
58	<b>Some Chemical Characteristics of Humic Acids, Extracted From Different Organic Wastes</b>	319
	<i>T. Ünsal, Sonay (Sözüdoğru) Ok</i>	
59	<b>Effect of Humic Acid on Some Soil Properties</b>	324
	<i>C.Kütük, G.Çaycı, A. Baran, O.Başkan</i>	
60	<b>Use of Composted Municipal Solid Wastes To Improve Soil Properties and To Increase Crop Yield</b>	329
	<i>M.Aydın, O.Sener, T. Sermenli, A.Özkan, S.Aslan, N.Ağca, K.Doğan, M. Tiryakioğlu, K.Mavi, S.Kılıç</i>	
61	<b>Determination of The Effect of The Sludge From Waste Water Treatment Station Near Sofia-City Fertilizer</b>	333
	<i>Svetla Marinova Garvanska</i>	
62	<b>Investigations on Sewage Sludges: Chemical Composition And Effects on Some Chemical Properties of Soil</b>	339
	<i>S.Arcak, A.Karaca, K.Haktanır</i>	



63	A Study on Potential Agricultural Use of Sewage Sludge of Ankara Wastewater Treatment Plant	345
	<i>Sevinç Arcaç, C.Türkmen, A.Karaca, E. Erdoğan</i>	
64	Effects of The Sewage Sludge of Ankara Waste Water Treatment Plant on Some Soil Biological Activities	350
	<i>Ş.Ataman, S.Arcaç</i>	
65	The Heavy Metal Contents of The Golia Wheat in The Center and Towns in Kahramanmaraş	356
	<i>F.Elinç, E.Güvercin, A.R.Demirkıran</i>	
66	Worldwide Distribution and Sustainable Management of Soils With Gypsum	362
	<i>A.A.Jafarzadeh, J.A.Zinck</i>	
67	Penetration Resistance of Gypsum Crust From Laboratory Experiments	369
	<i>A.A.Jafarzadeh, J.A.Zinck</i>	
68	Laboratory Studies of Evaporation Rate in Gypseous Soils in Relation To: Time, Water Table, Texture and Treatments	375
	<i>A.A.Jafarzadeh</i>	
69	Reflection Values of Saline Soils of Great Meander Basin in Landsat TM Images and Their Statistical Relationships	381
	<i>Yusuf Kurucu, Ünal Altınbaş, Mustafa Bolca, Burçin Çokuysal, Sezai Delibacak</i>	
70	The Relationships Between The Exchangeable Sodium Ratio (ESR) and Sodium Adsorption Ratio (SAR) in Some Soils of The Amik Plain	386
	<i>Necat Ağca, Kemal Doğan</i>	
71	Soil Salinity Monitoring of a Selected Area in The Yüreğir Plain, Adana-Turkey	391
	<i>Hasan Özcan, Erhan Akça, Selim Kapur, Oğuz Dinç</i>	
72	Effects of Leaching With Irrigation Waters in Different Salinity Levels on Change of Profile Salinity	397
	<i>Engin Yurtseven, Ahmet Öztürk, Gökhan Çaycı, Mehmet Parlak</i>	
73	Monitoring and Evaluation of In Situ Hydraulic Conductivity and Groundwater Quality of The Pilot Area in The Lower Seyhan Plain, Adana-Turkey	403
	<i>Mahmut Çetin, Hasan Özcan, Fatih Topaloğlu</i>	
74	The Technological and Mineralogical Characteristics of Raw Materials Used For Brick-Tile Industry in Kahramanmaraş Region	409
	<i>Kadir Yılmaz, Mehmet Nuri Bodur</i>	
75	Effects of Different Lead and Cadmium Compounds on Soil Catalase Enzyme Activity	416
	<i>A.Karaca, R.Kızılkaya, K.Haktanır</i>	
76	Effect of Edta on The Extractability of Zinc, Cadmium and Nickel in Soils	422
	<i>A.Karaca, O.C.Turgay, S.Arcaç</i>	
77	Seasonal Changes in Soil Microbial Biomass and Enzyme Activity in Arable and Grassland Soils	429
	<i>H.S.Uçkan, N.Okur</i>	
78	Situation of Desertification in Turkey and Struggle Carried Out Against Desertification in Karapınar Wind Erosion Control Area	435
	<i>Mevlüt Demiryürek</i>	



79	<b>Effect of Industrial Sewage Sludge Applied To Soil</b>	440
	<i>B.Tasatar, K.Haktanır</i>	
80	<b>Different Indices in Soil Biological Activities; Measurement of Soil Microbial Biomass Carbon, Nitrogen and NRN</b>	447
	<i>Oğuz Can Turgay, Akira Haraguchi</i>	
81	<b>Bitter Gourd (Momordica Charantia L.) Growing in Gödöllő Region Hungary</b>	452
	<i>B.Berényi, C.S.Kleinheincz</i>	
82	<b>A Model Concerning To The Yield Loss of Maize From Weed Density or Dry Biomass</b>	455
	<i>Stefka Alexieva, Ivanka Stoimenova</i>	
83	<b>A Research on Using Different Growing Mediums For Seedlings</b>	460
	<i>Tuncay Demirer, Canan Öztokat Kuzucu</i>	
84	<b>Determination of Nutrient Status in Hazelnut Leaves Sampled From Terme and Ünye Regions</b>	465
	<i>Ayhan Horoz, Ahmet Korkmaz</i>	
85	<b>Determination of Malnutrition of Acacia Yüzüncü Yıl Campus Area</b>	471
	<i>Fusun Gülser, Nalan Türkoğlu, R.İlknur Gazioğlu</i>	
86	<b>Effects of Different Growing Media and Application of Various Nitrogen and Phosphorus Doses on The Nutrient Uptake of Pepper Seedling</b>	477
	<i>Fusun Gülser, Önder Türkmen, Fikret Yaşar, Turgay Kabay</i>	
87	<b>Effects of Nitrogen and Phosphorus Doses on Nutrient Uptake of Tomato Seedling</b>	481
	<i>Önder Türkmen, Fusun Gülser, Turgay Kabay</i>	
88	<b>Effect of N, P, and K Application on Zn Uptake of Tomato</b>	484
	<i>Nizamettin Ağaoğlu, Yıldırım Sezen</i>	
89	<b>Considering Spatial Variability in Organic Matter Values For Site Specific N-Fertilizer Recommendation in Wheat</b>	489
	<i>M.Rüştü Karaman, Sabit Erşahin</i>	
90	<b>An Investigation on Some Nutrient Elements of The Soils Containing High Level of Phosphorus and in Which Sunflower and Wheat Are Grown in Thrace Region</b>	495
	<i>Aydın Adiloğlu, Korkmaz Bellitürk</i>	
91	<b>The Nutrition Status of <i>Vitis Vinifera</i> L. Grown Around Şanlıurfa in Turkey</b>	503
	<i>İlhan Kızılgöz, Rıdvan Kızılkaya, Saadettin Gürsöz</i>	
92	<b>Determination of Iron, Zinc, Manganese, Copper and Boron Levels of The Vineyards in Hadım-Aladağ Region</b>	507
	<i>Fatih Er, Fethi Bayraklı, Mevlüt Mülâyim</i>	
93	<b>Estimation of Soil Compaction Using Some Soil Properties Caused by Wheel Traffic</b>	512
	<i>Cevdet Şeker, A.Ali İşildar, Saim Karakaplan</i>	
94	<b>Pedogenesis and Classification of Soils in Kahramanmaraş Province, Turkey</b>	517
	<i>Kadir Yılmaz, Recep Gündoğan, Ali Rıza Demirkıran</i>	
95	<b>Effect of Sodium Salts on Growth And Nutrient Uptake of Spinach (<i>Spinacia Oleracea</i>) and Beans (<i>Phaseolus Vulgaris</i>)</b>	525
	<i>Adil Aydın, Metin Turan, Yıldırım Sezen</i>	

96	<b>The Effect of Tobacco Waste on The Soil Characteristics and Plant Nutrient Contents of Alkaline Soils</b>	531
	<i>Kadir Saltalı, A.Reşit Brohi, A.Volkan Bilgili</i>	
97	<b>A Research on Salinity and Alkalinity Problems in Soils of Great Menderes Delta</b>	535
	<i>Hüseyin Ekinci, Orhan Yüksel</i>	
98	<b>Research of Utilization in Irrigation and Pollution Criterions of Bafra Badut Canal That Soiled Due To Various Effects</b>	537
	<i>Saadet Sarıcaoğlu, İbrahim Kaya Ersöz, Kenan Avcı, Solmaz Gençoğlu</i>	
99	<b>The Effects of Herbicides 2,4-D on Total Bacteria and <i>Bacillus Cereus</i> Var. <i>Mycoides</i> Growth İn Soil</b>	541
	<i>Rıdvan Kızılkaya</i>	
100	<b>The Distribution Of Available Micronutrients (Fe, Cu, Zn, Mn) İn Great Groups Of Edirne Province And Their Relationship With Some Soil Characteristics</b>	547
	<i>Hüseyin Ekinci, Feridun Çarpık, Orhan Yüksel</i>	
101	<b>Effect of Straw-Stubble Burning on Soil Temperature Transport and Water Content</b>	550
	<i>Havva Kopan, Nuri Munsuz</i>	



# THE FACTS OF DESERTIFICATION AND UNITED NATIONS CONVENTION TO COMBAT DESERTIFICATION

**Assoc.Prof. D.Murat Özden**

*Research Section Director, Head of GDRS CCD Committee  
General Directorate of Rural Services, Ankara, Turkey*

## **I. Introduction**

Desertification is a serious problem that threatens the livelihoods and the lives of nearly a billion people in more than 100 countries. The total area affected covers one-third of the Earth's land surface. The people living in these areas are at risk of having to abandon their homes and migrate because the land can no longer sustain them. Though significant efforts have been initiated to combat desertification, the problem is worsening: each year, according to the Worldwatch Institute, the continents lose 24 billion tons of topsoil, creating a condition that often results in severe desertification.

Desertification does not, as many think, mean the expansion of deserts. It is a process of land degradation in the drylands where previously stable environments are degraded by humans through erosion, overgrazing, overcropping, poor irrigation practices and deforestation, combined with variations in climate. Desertification is an environmental problem that is both the reason behind and the consequence of numerous other ecological concerns, including the loss of biological diversity and the depletion of water resources. As such, it contributes to an environmental spiral that could get progressively worse unless drastic and immediate efforts are taken to correct it. Similarly, it stems from and leads to extreme poverty.

Rapid growth in population causes agricultural expansion into marginal lands, leading to subdivision of land, deforestation and, again, desertification. Excessive use of pesticides and other chemical substances can lead to depletion of soil fertility and soil degradation which, again, contributes to desertification.

The deterioration of life-support systems as a result of desertification causes significant social and economic disruptions. Desertification has a debilitating impact on the capacity of populations and communities to sustain the means needed for livelihood. In extreme cases, as during periods of drought, the land is no longer capable of supporting the people who live there. Often they have no other alternative but to leave the countryside for urban areas. Where rural human settlements gradually disappear, what is left is often a socio-ecological situation in which no development is possible.

Though most of the countries that are affected by desertification are in developing countries, desertification is a problem that must be viewed in an international context because it cuts across political boundaries and is found in all continents. Desertification is the result of a complex interaction of numerous factors, including external aspects such as the state of the world economy, commodity prices, interest rates, energy imports, cultural behaviour and conditional aid packages. These external factors, together with internal ones such as inappropriate political and policy instruments, low environmental investment levels and high population growth, combine to work against good land management and to worsen desertification.

The current global economic system also is part of the problem. The rapid incorporation of indigenous economic systems based on subsistence production into a world economy of mass commodity production often causes indigenous peoples to over-cultivate their land. Trade and structural adjustment programmes and the transfer of inappropriate technology exacerbates the problem. The economies of many developing countries are heavily dependent on the export of raw materials, such as agricultural cash crops, into markets over which they have no control. This leads to an over-exploitation of often fragile dryland resources.

Because desertification brings about the loss of vegetation, it can result in the extinction of plant and animal species, and therefore contribute to the loss of biodiversity. Drylands are the source of many of the world's varieties of food and medicines. The loss of these plants through desertification represents the loss of valuable and irreplaceable genetic material.



## **2. The Causes of Desertification**

Desertification is the degradation of drylands. It involves the loss of biological or economic productivity and complexity in croplands, pastures, and woodlands. It is due mainly to climate variability and unsustainable human activities. The most commonly cited forms of unsustainable land use are overcultivation, overgrazing, deforestation, and poor irrigation practices. Seventy percent of the world's drylands (excluding hyper-arid deserts), or some 3,600 million hectares, are degraded. While drought is often associated with land degradation, it is a natural phenomenon that occurs when rainfall is significantly below normal recorded levels for a long time.

Drylands respond quickly to climatic fluctuations. By definition, drylands have limited freshwater supplies. Precipitation can vary greatly during the year. In addition to this seasonal variability, wide fluctuations occur over years and decades, frequently leading to drought. Over the ages, dryland ecology has become attuned to this variability in moisture; plants and animals can respond to it rapidly.

People must also adjust to these natural fluctuations. The biological and economic resources of drylands, notably soil quality, freshwater supplies, vegetation, and crops, are easily damaged. People have learned to protect these resources with age-old strategies such as shifting agriculture and nomadic herding. However, in recent decades these strategies have become less practical due to changing economic and political circumstances, population growth, and a trend towards more settled communities. When land managers cannot or do not respond flexibly to climate variations, desertification is the result.

The relatively low priority given to environmental protection often leads to poor land management decisions. The overuse of land may result from specific economic conditions or from inappropriate land laws or customs. In many cases, unregulated access to land resources may lead some individuals to maximize their own gains by overexploiting the land at the expense of the community as a whole. Poor people, particularly poor women, often lack access to the best land, depending instead on the most fragile areas and resources. Their poverty may give them little alternative but to extract what they can from the scarce resources available to them, even though this degrades the land.

International economic forces can encourage people to overexploit their land. International trade patterns can lead to the short-term exploitation of local resources for export, leaving little profit at the community level for managing or restoring the land. Similarly, the development of an economy based on cash crops, or the imposition of taxes, can distort local markets and promote overexploitation of the land.

Ignorance, errors, and natural and man-made disasters can also contribute to land degradation. Ignorance of the natural environment played an important role in the US during the infamous Dust Bowl of the 1930s; among other errors, during a time of drought Midwestern farmers used ploughs better suited for the more temperate latitudes of Western Europe. In recent decades, similar mistakes in the choice of policies or technologies have led to land degradation in many countries, both developed and developing. Disasters such as wars and national emergencies also destroy productive land by displacing its managers or causing heavy concentrations of migrants to overburden an area. Natural disasters such as floods and droughts can have a similar effect.

What role do increasing populations and population densities play? It is tempting to conclude that an expanding human population is the ultimate driving force behind desertification. More people in an area inevitably exert a greater pressure on that area's resources; sometimes this pressure is indirect, as when growing urban populations place demands on food production in uncrowded rural areas. But the causes of desertification are complex, and the relationship between two variables such as population and desertification is not clear-cut. For example, a decline in population can result in desertification since there may no longer be enough people to manage the land adequately.

## **3. The Consequences of Desertification**

Desertification reduces the land's resilience to natural climate variability. Soil, vegetation, freshwater supplies, and other dryland resources tend to be resilient. They can eventually recover from climatic disturbances, such as drought, and even from human-induced impacts, such as overgrazing.

When land is degraded, however, this resilience is greatly weakened. This has both physical and socio-economic consequences.

Soil becomes less productive. Exposed and eroded topsoil can be blown away by the wind or washed away by rainstorms. The soil's physical structure and bio-chemical composition can change for the worse. Gullies and cracks may appear and vital nutrients can be removed by wind or water. If the water table rises due to inadequate drainage and poor irrigation practices, the soil can become waterlogged, and salts may build up. When soil is trampled and compacted by cattle, it can lose its ability to support plant growth and to hold moisture, resulting in increased evaporation and surface run-off.

Vegetation becomes damaged. The loss of vegetation cover is both a consequence and a cause of land degradation. Loose soil can sandblast plants, bury them, or leave their roots dangerously exposed. When pastures are overgrazed by too many animals, or by inappropriate types, edible plant species may be lost, allowing inedible species to invade.

Some of the consequences are borne by people living outside the immediately affected area. Degraded land may cause downstream flooding, reduced water quality, sedimentation in rivers and lakes, and siltation of reservoirs and navigation channels. It can also cause dust storms and air pollution, resulting in damaged machinery, reduced visibility, unwanted sediment deposits, and mental stress. Wind-blown dust can also worsen health problems, including eye infections, respiratory illnesses, and allergies.

Food production is undermined. Desertification is considered a major global environmental issue largely because of the link between dryland degradation and food production. A nutritionally adequate diet for the world's growing population implies tripling food production over the next 50 years. This will be difficult to achieve even under favourable circumstances. If desertification is not stopped and reversed, food yields in many affected areas will decline. Malnutrition, starvation, and ultimately famine may result. The relationship between soil degradation and crop yields, however, is seldom straightforward. Productivity is affected by many different factors, such as the weather, disease and pests, farming methods, and external markets and other economic forces.

Desertification contributes to famine. Famine typically occurs in areas that also suffer from poverty, civil unrest, or war. Drought and land degradation often help to trigger a crisis, which is then made worse by poor food distribution and the inability to buy what is available.

Desertification has enormous social costs. There is now increased awareness of the relationship between desertification, movements of people, and conflicts. In Africa, many people have become internally displaced or forced to migrate to other countries due to war, drought, and dryland degradation. The environmental resources in and around the cities and camps where these people settle come under severe pressure. Difficult living conditions and the loss of cultural identity further undermine social stability.

Desertification is a huge drain on economic resources. There is little detailed data on the economic losses resulting from desertification, although an unpublished World Bank study suggested that the depletion of natural resources in one Sahelian country was equivalent to 20% of its annual Gross Domestic Product (GDP). At the global level, it is estimated that the annual income foregone in the areas immediately affected by desertification amounts to approximately US\$ 42 billion each year. The indirect economic and social costs suffered outside the affected areas, including the influx of "environmental refugees" and losses to national food production, may be much greater.

#### **4. An Introduction to the United Nations Convention to Combat Desertification**

The Convention offers new hope in the struggle against desertification. Over the past two decades, the problem of land degradation in dryland regions has continued to worsen. The Convention promotes a fresh new approach to managing dryland ecosystems and -- just as important -- to managing development aid flows.

Desertification is caused by climate variability and human activities. In the past, drylands recovered easily following long droughts and dry periods. Under modern conditions, however, they tend to lose their biological and economic productivity quickly unless they are sustainably managed. Today drylands on every continent are being degraded by overcultivation, overgrazing, deforestation,



and poor irrigation practices. Such overexploitation is generally caused by economic and social pressure, ignorance, war, and drought.

Desertification undermines the land's productivity and contributes to poverty. Prime resources -- fertile topsoil, vegetation cover, and healthy crops -- are the first victims of desertification. The people themselves begin to suffer when food and water supplies become threatened. In the worst cases, they endure famine, mass migration, and colossal economic losses. Over 250 million people are directly affected by desertification, and some one thousand million (or one billion) are at risk.

The Convention to Combat Desertification will be implemented through action programmes. These programmes are the core of the Convention. At the national level, they will address the underlying causes of desertification and drought and identify measures to prevent and reverse it. National programmes will be complemented by subregional and regional programmes, particularly when transboundary resources such as lakes and rivers are involved. Action programmes are detailed in the four regional implementation annexes to the Convention -- Africa, Asia, Latin America and the Caribbean, and the Northern Mediterranean.

The Convention promises to dramatically reshape the international aid process. It seeks to engage donor nations and agencies and recipient countries in a new partnership. In the case of Africa, the respective roles of donors and recipients will be worked out in partnership agreements developed through a consultative process. The aim is to ensure that funding programmes are better coordinated, that funding is based on the needs of the affected countries, that donors can be sure their funds are well-spent, and that recipients obtain the maximum benefit from the sums available.

Another radical departure is the strong emphasis on a "bottom-up" approach with strong local participation in decision-making. Traditionally, local communities have been relatively passive participants in development projects. Now the Convention puts them on an equal footing with other actors in the development process. Communities and their leaders, as well as non-governmental organizations, experts, and government officials, will work closely together to formulate action programmes. For this innovative and complicated process to work, awareness campaigns may be needed to inform people about the new opportunities presented by this Convention.

Science and technology are vital tools in the fight against desertification. Much remains to be learned about the causes and impacts of desertification, so international cooperation in scientific research and observation must be strengthened. Land degradation can be minimized with both new and traditional technologies, ranging from satellite monitoring to the terracing of steep hill slopes. Science and technology must respond to people's real needs, and the Convention encourages researchers around the world to combine their talents for this purpose.

Financial resources need to be channeled and invested more efficiently. Most funding is raised domestically by the affected countries, but bilateral assistance programmes and international agencies also provide large sums. The Convention establishes a Global Mechanism to promote the mobilization of financial resources. Innovative funding sources, including debt swaps and private-sector financing, will also be encouraged.

The Convention establishes a number of institutions and procedures for guiding international action. The supreme body of the Convention is the Conference of the Parties (COP), which include all ratifying governments. There will also be subordinate bodies for science and technology and for the promotion of funding. The Convention, which has been signed by over 160 countries, entered into force on 26 December 1996, three months after the 50<sup>th</sup> country ratified it. The COP held its first session in Rome in October 1997.

Desertification is primarily a problem of sustainable development. It is a matter of addressing poverty and human well-being, as well as preserving the environment. Social and economic issues, including food security, migration, and political stability, are closely linked to land degradation. So are such environmental issues as climate change, biological diversity, and freshwater supplies. The Convention emphasizes the need to coordinate research efforts and action programmes for combating desertification with these related concerns.

## **5. Action Programmes for Combating Desertification**

The Convention to Combat Desertification will be implemented through national action programmes. Donors and affected countries will consult together on their respective roles in



supporting these programmes, which will be developed with the full participation of local communities. Once the (significant) effort has been made to design an overall programme, it should be possible to initiate specific projects and activities within its framework with minimal paperwork and bureaucracy. Because programmes need to be adapted to particular regional circumstances, most of the specific requirements are described in the four regional implementation annexes for Africa, Asia, Latin America, and the Northern Mediterranean.

Programmes will start with long-term strategies and priorities. This is essential for providing continuity for long-term programming and for enabling governments to coordinate and administer their resources more effectively. Programmes will address the underlying causes of desertification and pay particular attention to preventive measures. They will consider all aspects of the problem -- loss of agricultural productivity, reduced vegetation cover, soil erosion, socio-economic costs, and so on.

Local communities will play a key role in formulating programmes. They will also be active in designing and carrying out the resulting projects. Ongoing discussions and effective communication between the local and national levels will be vital. In this spirit, programmes must be sufficiently flexible to accommodate new initiatives and local adaptations as circumstances change. The end result should be an evolving programme that is "owned" by the very people who most depend on and understand the land.

National governments will commit themselves to providing an "enabling environment". Communities can only play a leading part in carrying out a programme if the national government removes obstacles and provides support. This will mean strengthening existing legislation and, when necessary, enacting new laws. For example, the government may adopt long-term policies encouraging greater decentralization of political power. Or it may introduce reforms granting people greater security of land tenure. Other important steps might be effective institutions for resolving conflicts over land and other resources, energy policies that encourage sustainable woodland management or the replacement of fuelwood by other energy sources, and economic reforms that promote investment and reduce poverty.

Action programmes will also specify the practical steps and measures to be taken. Specific measures to improve the economic environment could include creating financial instruments suited to local needs or introducing drought-resistant crops. Measures to conserve natural resources could involve diversifying energy sources away from the uncontrolled gathering of fuelwood. Other measures could include promoting research activities, drought contingency plans, and improved early warning systems.

Efforts to combat desertification will be fully integrated with other development programmes. Reversing land degradation and alleviating poverty go hand in hand. Both involve improving food security, educating and training people, strengthening the capacity of local communities, and mobilizing non-governmental organizations. Similarly, because desertification affects and is affected by environmental concerns such as biological diversity and climate change, national action programmes need to be integrated with the programmes dealing with these issues.

Programmes will specify the resources available and those still needed. Part of the national budget must be clearly ear-marked for efforts to combat desertification and drought. The amount will vary according to national conditions and capabilities. At the same time, action programmes will seek to mobilize substantial financial resources from external sources. The requirements for technical cooperation will also be identified and prioritized.

Subregional and regional action programmes can help to harmonize and strengthen national programmes. They will be designed through consultations among the affected countries of each region (e.g. Africa) and sub-region (e.g. West Africa). In addition to boosting the efficiency of national programmes, they could promote joint programmes for the sustainable management of shared rivers and other cross-boundary ecosystems. They could also promote better cooperation among scientific and technical institutions.

## **6. Partnership Arrangements Between Donors and Affected States**

The Convention to Combat Desertification aims to improve the channeling and investment of official development aid. It recognizes that, in this era of tightening foreign aid budgets, development

aid must be used as effectively as possible. Donors need to be confident that their contributions are well-spent. Recipients need to get the maximum benefit from the limited sums available.

The Convention expresses a consensus on the lessons of the past. Over the years, a great deal of insight has been gained on how to improve the process of development aid. For example, it is generally agreed that many past aid efforts suffered because they were "supply driven" by the financing agency, handled top-down by planners, or delivered without adequate coordination at all levels. These insights are recognized in the Convention.

Partnership arrangements will improve communication and coordination between donors and recipients. A vital part of the Regional Implementation annexes, these agreements will spell out explicitly the role of each partner, including donor agencies and governments, recipient governments, and non-governmental organizations (NGOs). This should help to harmonize efforts and maximize the impact of assistance. Partnership arrangements would be part of, or associated with, national action programmes. They could be used for many different purposes, such as mobilizing financial resources, reorienting assistance mechanisms to fit the Convention's approach, making inventories of funding sources, or developing new models of technological cooperation.

These agreements will be negotiated through a consultative process. Traditionally, consultations have been initiated and led by a donor agency. Under the Convention, however, consultations would be initiated and managed by the recipient country itself. They will be a continuous process. The resulting aid package should better serve the communities affected by desertification.

The consultative process will start within the affected country. The government could set up a coordinating body to act as a forum for consultations. To prepare the way it might want to promote the Convention through public awareness and training activities. It would then need to gain the participation of policymakers, community leaders, members of non-governmental organizations, and others responsible for the resulting activities. They would work together to evaluate past efforts, identify the country's needs, and set priorities. This participatory approach should result in a national action programme and a national consensus on how to work with international partners.

The recipient country must link up with international partners. These partners could include donor governments, regional development banks, and other international agencies. At the same time, donor partners, particularly developed country governments, could also develop a consultation process among themselves to structure their dialogue with recipient governments. This would help them to coordinate their policies, minimize overlaps and gaps, and evaluate and respond to requests for assistance.

Non-governmental organizations are granted an unprecedented role in this process. NGOs tend to be well-organized, close to the community level, and able to draw on a pool of skilled and experienced people. The Convention recognizes these strengths and makes specific provisions for NGOs to become active partners in these partnership arrangements.

## **7. Participatory Development: A bottom-up approach to combating desertification**

What role do local communities have under the Convention to Combat Desertification? Traditional development planning has too often been "top-down". Outside experts start the process by defining objectives, activities, and expected outputs. Sometimes they visit the area to consult local authorities, inform them of the plan, and invite the community to help execute projects. The Convention turns this approach upside-down. The spirit and letter of the Convention reflect the philosophy of participatory development. Action programmes to combat desertification are now to originate at the local level and be based on genuine local participation.

Why is local participation in project planning so important? Over the past two decades, programmes designed with little reference to the perceptions and capacities of local people have often failed. Outsiders cannot necessarily identify local needs and priorities or figure out how best to meet them. Local communities have valuable experience and a special understanding of their own environment. When the responsibility for natural resource management is taken away from them, their use of land and other natural resources can become highly inefficient. The result is often land degradation. Participatory development recognizes the rights of local communities over their resources. They have a greater stake than anyone else in improving agricultural productivity while



ensuring the long-term ecological balance of their fragile lands. In addition, local participation in planning and decision-making is essential for building local capacity.

Who should participate? Those most directly involved in the management, use, and benefits of a particular resource must be active participants. In the case of desertification, small farmers (both men and women), pastoralists, nomads, and other local land users are clearly vital to the process, as they have the most intimate contact with the land. Local leaders -- village elders, traditional chiefs, representatives of community groups -- and regional and national officials are also essential for mobilizing action. Technical experts, researchers, non-governmental organizations (NGOs), and voluntary associations are needed for the invaluable skills and expertise they can bring.

When should local participation start? At the very inception of a development initiative. To begin with, the objectives and planned activities should be identified through a participatory process. Once a programme has started, the participants will need to make regular reviews of the progress made and obstacles encountered. When each phase is completed, they should all be involved in evaluating its outcome and deciding on the next steps.

How should the process be initiated? The unique culture of each society shapes its patterns of decision-making and communication. Activities *must* originate at the local level, but sometimes additional encouragement may be needed to make people feel that they truly own the process of participatory development. NGOs may have a key role to play here. It may also be necessary for the government to delegate more decision-making authority to the local grassroots level.

How can participation be strengthened? The participatory process is time-consuming and labour-intensive. There are no short-cuts. Awareness campaigns may be needed to educate the public about the Convention and about national action programmes. Agricultural extension services and NGOs can help to build up the community's capacity for "participatory programming". Local decision-making procedures may have to be adapted and strengthened. The community may have to go through a long learning and confidence-building process in order to take full advantage of the new resources it will now receive and manage directly. Due attention should also be paid to involving the more marginalized social groups.

How should local inputs be used at the regional and national levels? At the local level, discussions are likely to take place in informal groups as well as in organized meetings. The results need to be brought forward to the provincial level to ensure inter-village cooperation and the coordinated management of the regional environment. At the national level, all of this input will need to be translated into a national action programme. In addition, the national government will need to respond to local aspirations by providing an "enabling environment", including public infrastructure and technical assistance. It will also serve as the central contact point with foreign aid providers. Ideally, information and ideas will flow back and forth continuously between the various levels.

## **8. The Role of Science and Technology**

The Convention to Combat Desertification establishes a Committee on Science and Technology. Composed of government representatives, the Committee will advise the Conference of the Parties to the Convention (COP) on scientific and technological matters relevant to desertification and drought. In addition, ad hoc panels of government-nominated experts will provide information and advice on specific issues. These experts will be appointed by the COP on the recommendation of the Committee. They must have field experience and will represent a wide range of disciplines.

Success in combating desertification will require an improved understanding of its causes and impacts. There is still much to learn about the linkages between desertification and climate, soils, water, plants, animals, and, in particular, people. Key research areas include climatology and meteorology, soil sciences, hydrology, botany, zoology, ecology, and the social sciences. Action programmes for combating desertification will outline the research priorities for particular regions and subregions, reflecting local conditions. The Committee on Science and Technology will also advise on research priorities.

The Convention promotes international cooperation in scientific research and observation. The Parties to the Convention agree to integrate and coordinate the collection, analysis, and exchange of scientific data and information. They will also ensure the systematic observation of land degradation in an effort to better understand and assess the processes and effects of drought and desertification.



The Convention stresses the need to coordinate such efforts with other related Conventions, in particular those dealing with climate change and biological diversity.

New technologies and know-how should be developed, transferred to affected countries, and adapted to local circumstances. Modern communications, satellite imagery, and genetic engineering are only some examples of modern tools that can help to combat desertification. Better weather forecasts and alerts can help to maintain or increase the land's productivity while improving food security and local living conditions. So too can new plant and animal varieties that are resistant to pests, diseases, and other dryland stresses. Photovoltaic cells and wind energy may reduce the consumption of scarce fuelwood and thus deforestation. For all these reasons, the Convention commits Parties to promoting technological cooperation. It calls for promoting and financing the transfer, acquisition, adaptation, and development of technologies that help to combat desertification or cope with its effects. These technologies should also be environmentally sound, economically viable, and socially acceptable.

Local and traditional technologies and know-how should be protected. People have been coping with the degradation of land and other natural resources at least since the advent of agriculture thousands of years ago. Many local populations have developed techniques for managing soil and water, domesticating plants and animals, and even forecasting the weather. Examples include the terracing of steep slopes in the Andes and Himalayas and the use of irrigation systems around the world since prehistoric times. Many of these traditional technologies are still in use and have proved their effectiveness over centuries. Too often, however, changes in economic, ecological, or cultural conditions have led people to abandon techniques that could still be valuable today. The Convention therefore states that traditional and local technologies and know-how should be protected. Inventories should be made of such technologies and information about them widely disseminated. Local populations should benefit directly from any commercial use of their techniques.

The Conference of the Parties will draw scientific and technology researchers into a global network to support the Convention. Under the leadership of the COP, the Committee on Science and Technology will survey and evaluate existing networks, institutions, agencies, and other bodies working on issues relevant to desertification. It will then promote a global research network committed to supporting the Convention. Scientists world-wide will be encouraged to contribute their know-how and research results to this international effort.

Affected developing countries need more scientific and technological capacity. They often suffer from a scarcity of domestic skills, expertise, libraries, and research centres. Many also need improved hydrological and meteorological services. The Convention encourages developed countries to support capacity-building efforts that will enable developing countries to combat desertification more effectively through science and technology.

## **9. Institutions and Procedures of the Convention**

The Convention to Combat Desertification was negotiated under the auspices of the United Nations. In June 1992, the United Nations Conference on Environment and Development (UNCED -- also known as the Rio Earth Summit) recommended that the United Nations General Assembly establish an Intergovernmental Negotiating Committee (INCED) to prepare a convention to combat desertification in those countries experiencing serious drought and/or desertification, particularly in Africa. The Committee was established in early 1993. It held five preparatory sessions before adopting the Convention on 17 June 1994 in Paris. The Convention was opened for signature in Paris on 14-15 October 1994.

The Convention entered into force on 26 December 1996, 90 days after it had been ratified by 50 countries. Over 160 countries have signed it. After a government's representatives have signed the Convention, the national parliament or other designated authority must ratify it. The government then sends its instrument of ratification to the United Nations in New York, which acts as the Depository. Only after the 50th such ratification was received did the 90-day countdown begin for the Convention to enter into force. The first 50 ratifiers became Parties and legally responsible for carrying out their treaty commitments, while other governments will become Parties 90 days after they ratify. In the meantime, many of the Convention's provisions are being carried out voluntarily on the basis of a Committee resolution on urgent action in Africa.

The Conference of the Parties (COP) will oversee the implementation of the Convention. It is established by the Convention as the supreme decision-making body, and it will comprise all ratifying governments (and regional economic integration organizations, such as the European Union). The COP held its first session in October 1997 in Rome, second session in November in Dakar, third session in October in Recife and will hold the fourth session in October in Adelaide. One of its main functions will be to review reports submitted by the Parties detailing how they are carrying out their commitments. The COP will make recommendations on the basis of these reports. It also has the power to make amendments to the Convention or to launch negotiations for new annexes, such as additional regional implementation annexes. In this way, the COP can guide the Convention as global circumstances and national needs change. To assist the COP, the Convention provides for several other supporting bodies and allows the COP to establish additional ones if necessary.

The COP will be supported by a secretariat. Like other Convention secretariats, this one will service the COP by arranging its meetings, preparing documents, coordinating with other relevant bodies, compiling and transmitting information, and facilitating consultations and other actions. Affected developing countries should also be able to rely on the secretariat for information or advice on, for example, organizing their national consultation process.

The Committee on Science and Technology will advise the COP on scientific and technological matters. It will identify priorities for research and recommend ways of strengthening cooperation amongst researchers. It could also advise on such issues as joint research programmes for new technologies. The COP may set up ad hoc panels to assist with specialized issues. The panels would draw their members from a roster of government-nominated experts.

A Global Mechanism will help the COP to promote funding for Convention-related activities and programmes. This Mechanism will not raise or administer funds. Instead, it will encourage and assist donors, recipients, development banks, non-governmental organizations (NGOs), and others to mobilize funds and to channel them to where they are most needed. It will seek to promote greater coordination among existing sources of funding, and greater efficiency and effectiveness in the use of funds. The Global Mechanism will be under the authority of the COP, but the COP will identify another organization to house and operate it.

While only national governments that ratify the Convention can be members of the COP, other bodies and organizations can also participate. International conventions are, of course, legal agreements among sovereign countries. However, this Convention makes special provision for national and international agencies and qualified NGOs to attend the COP's meetings and to contribute to its work. NGOs have not only played a prominent role in the Convention process, but they continue to raise public awareness of the Convention and to lobby parliamentarians for its speedy ratification. For their part, international and regional organizations provide crucial information, expertise, contacts, and research and managerial capabilities.

## **10. Desertification, Global Change, and Sustainable Development**

The Convention to Combat Desertification cannot be viewed in isolation from other efforts to promote sustainable development. The Convention text refers frequently to sustainable development, climate change, biological diversity, water resources, energy sources, food security, and socio-economic factors. The interactions between these issues and desertification are often not fully understood, but they are clearly important. The Convention therefore emphasizes the need to coordinate desertification-related activities with the research efforts and response strategies inspired by these other concerns.

Efforts to combat desertification complement efforts to protect biological diversity. While many people tend to identify the issue of biodiversity with tropical rain forests, dryland ecosystems also contain a rich biota, including plant and animal species not found elsewhere. Many of humanity's most important food crops, such as barley and sorghum, originated in drylands. Though disappearing fast, indigenous varieties remain a vital resource for plant breeders because of their resistance to stresses such as disease. Dryland species also provide drugs, resins, waxes, oils, and other commercial products. Finally, drylands provide critical habitats for wildlife, including large mammals and migratory birds. These habitats are particularly vulnerable to land degradation.



Land degradation affects the quantity and quality of freshwater supplies. Drought and desertification are associated with lower water levels in rivers, lakes, and aquifers. For example, unsustainable irrigation practices can dry the rivers that feed large lakes; the Aral Sea and Lake Chad have both seen their shorelines shrink dramatically in this way. Water crises are raising political tensions in many parts of the world, particularly where rivers and lakes are shared across borders. Land degradation is also a leading source of land-based pollution for the oceans, as polluted sediment and water washes down major rivers.

Natural climate variations can strongly affect drought patterns. Currently the best understood link between global climate variability and drought involves sea-surface temperature patterns. For example, the El Niño-Southern Oscillation, or ENSO, events, are associated with a warming of the eastern equatorial Pacific; they were especially frequent in the 1980s and early 1990s and occurred in tandem with widespread droughts in southern Africa and elsewhere. Research into such climate patterns is starting to improve seasonal rainfall predictions. Efforts to strengthen predictions are an important part of national action programmes to combat desertification and will help dryland farmers and herders to prepare better for droughts.

Climate change could worsen the effects of desertification. According to the United Nations Framework Convention on Climate Change, "countries with arid and semi-arid areas or areas liable to floods, drought and desertification ... are particularly vulnerable to the adverse effects of climate change." Scientists cannot yet predict how rising atmospheric levels of greenhouse gases will affect the global rate of desertification. What they can predict is that changes in temperature, evaporation, and rainfall will vary from region to region. As a result, desertification is likely to be aggravated in some critical areas but eased in other places.

Desertification may temporarily affect climate change. Land degradation tends to reduce surface moisture. Because less water is available for the sun's energy to evaporate, more energy is left over for warming the ground and, as a result, the lower atmosphere. Meanwhile, wind erosion in drylands releases dust and other particulates into the atmosphere. By absorbing the sun's rays or reflecting them back out into space, they may help to cool the Earth's surface. However, the energy they absorb can heat the lower atmosphere and in this way reduce temperature differences between the atmosphere's vertical layers; this can lead to fewer rainshowers and thus drier land. Finally, the periodic burning of arid and semi-arid grasslands, often associated with unsustainable slash-and-burn agriculture, emits greenhouse gases. So does the unsustainable use of fuel-wood and charcoal, a major cause of land degradation. On the other hand, reforestation is likely to have a cooling effect and is also, of course, an important way to combat land degradation.

Desertification exacerbates poverty and political instability. It contributes significantly to water scarcity, famine, the internal displacement of people, migration, and social breakdown. This is a recipe for political instability, for tensions between neighboring countries, and even for armed conflict. Evidence is mounting that there is often a strong correlation between civil strife and conflict on the one hand and environmental factors such as desertification on the other.

## **11. Combating Desertification in the Northern Mediterranean**

The Northern Mediterranean region is a complex mosaic of diversified landscapes. It has been settled and cultivated for millennia by various cultures and civilizations. Much of the region is semi-arid and subject to seasonal droughts, high rainfall variability, or sudden intense downpours. It is also marked by high population densities, heavy concentrations of industry, and intensive agriculture. Although people here often use the term "desert", they do so in the sense of wilderness, lack of population, or isolation.

Mediterranean land degradation is often linked to poor agricultural practices. Soils become salinized, dry, sterile, and unproductive in response to a combination of natural hazards - droughts, floods, forest fires - and human-controlled activities - notably over-tilling and overgrazing. The situation has been aggravated by the social and economic crisis in traditional agriculture in recent years and the resulting migration of people from rural to urban areas. The result is abandoned land, particularly on marginal and easily eroded hillsides, and weakened agricultural planning and land management.



The modern economy is also contributing to the problem. Fertilizers, pesticides, irrigation, contamination by heavy metals, and the introduction of exotic (invasive) plant species is undermining the long-term health of the region's soils. Physical changes imposed on watercourses by the construction of reservoirs, the canalization of rivers, and the drainage of wetlands are affecting land quality. Meanwhile, groundwater levels are declining widely, resulting among other things in salt-water intrusion into coastal aquifers. Some 80% of the region's available freshwater is used for irrigation. The dramatic and continuing growth of industry, tourism, intensive agriculture, and other modern economic activities along the coastlines is placing particular stress on coastal areas.

Four members of the Convention's Regional Annex for the Northern Mediterranean belong to the European Union. The Convention to Combat Desertification offers these countries - Greece, Italy, Portugal, and Spain - a framework for mutual cooperation and more effective national action. In addition to intra-regional cooperation, the Annex calls on its members to cooperate with other regions and subregions, particularly with the developing countries of Northern Africa. The Annex's fifth member is Turkey. Other countries in the region are expected to join soon.

The Annex-4 calls for harmonizing action programmes and reviewing progress in combating desertification. This could be done through a coordination committee. The committee could advise on the preparation and implementation of a national, sub-regional or regional programmes and act as a focal point for promoting and coordinating technical cooperation.

Desertification research is receiving a renewed emphasis. Dryland degradation has been studied for years in Africa and other regions, but less so in Europe. Fortunately, a number of research programmes are now assessing the impact of climate and weather on land and soil degradation in the region. EU members are also investing more in the systematic monitoring of land degradation, although there is still a need for better coordination of the collection, analysis, and exchange of data, including with countries outside the EU. There is a need too for more technical and scientific cooperation on research into the causes of land degradation and on other desertification issues.

A number of other strategies also have great potential. It is widely recognized that one priority for the region should be protecting land that has not yet been significantly degraded. An effective and "integrated" approach to water management at the local, national, and regional levels needs to simultaneously address traditional and intensive agriculture, industry, employment, biodiversity, freshwater resources, water pollution, and the special problems of coastal areas. Synergies with other treaties should be exploited. Traditional knowledge and know-how need to be conserved and used. The development, adaptation, and transfer of anti-desertification technologies that are environmentally sound, economically viable, and socially acceptable can be more actively promoted. Finally, local communities and non-governmental organizations can be further engaged.

## **12. Conclusion and Recommendations**

Combating desertification effectively will require both top-down solutions from governments and bottom-up approaches from communities. Managing the drylands of the world in a manner that can increase overall food security while maintaining the sustainable livelihoods of the people is important. During the past few decades, numerous approaches to this problem have been made. These efforts include reforestation, establishment of shelter or green belts, sand dune stabilization, protection of existing forest reserves, the introduction of agro-forestry practices, establishment of communal woodlots and soil and water conservation measures. Many of the national and regional action programmes, however, have been hampered by lack of political will, poor financial resources and huge external debts.

The 1977 UN Conference on Desertification (UNCOD) acknowledged desertification as a global problem that will require concerted efforts from all nations if practical solutions are to be found. Seventeen years later, an international legal agreement to curb the degradation of drylands worldwide was agreed upon by more than 100 governments. This UN Convention to Combat Desertification, which was called for at the 1992 Earth Summit in Rio de Janeiro, established a framework for national, regional and local programmes to counter the degradation of drylands. It also calls for international action, including the mobilization of "substantial financial resources," transfer of anti-desertification technologies, information exchange and research and training programmes.

The agreement commits countries to a bottom-up approach that integrates local people, national authorities and the international community. The negotiating process to produce the agreement involved an unprecedented number of community and international organizations. The Convention's approach reflects a growing recognition of the importance of grassroots groups and NGOs in fighting desertification, because they reach the people who work the land. The Convention assigns NGOs a role in designing and implementing national programmes and in overseeing national desertification funds.

To combat the problems associated with desertification, it is essential to address a number of environmental issues such as mass migration, loss of plant and animal species and climate change. Often, these issues are best resolved by addressing certain areas of social development such as awareness-raising, education and the empowerment of the marginalized members of society-especially women, who often work the land.

Desertification reflects fundamental ills, such as poverty, underdevelopment and lack of food security. At its root is the fact that, in order simply to survive, many people are forced to engage in environmentally-unsustainable activities. Solving the problem of desertification will not be possible without simultaneously attacking the causes of poverty and addressing the basic needs of rural people.

Stopping desertification would necessitate reversing the processes of land degradation and protecting soil, water and biological resources. At the level of government policy, this would require the promotion of sustainable socio-economic development in order to eradicate poverty and ensure food and energy security, as well as the improvement of living conditions and habitat.

There is a need for international, regional, national and local-level government action to stop the process of desertification. There is also much that must be done at both the community and individual level. Following are some specific suggestions related to desertification that can be carried out at both the individual and community level.

- **Get your community involved.** Community organizations and international NGOs have a vital role to play in combating desertification. This is because community organizations are well placed to help governments put appropriate projects into place. To help communities cope with the effects of drought and the impacts of desertification, there is a need for both short and long-term solutions. If the entire community is motivated and mobilized to deal with desertification, true sustainable solutions will be found.
- **Promote sustainable agriculture.** The development and dissemination of sustainable agricultural methods is essential to reducing causes of desertification, including soil erosion, over-exploitation of fragile lands, overgrazing on rangelands, and in some areas, overuse of chemical inputs that can reduce long-term productivity. Overall, it is important to reduce pressure on marginal lands, to counter land degradation and to rehabilitate degraded lands through the use of appropriate land management techniques, to reforest deforested areas and to develop the use of alternative energy sources.
- **Support education.** More research is needed on how and why land users degrade their land. This research should also focus on land tenure systems, which constitute a major impediment to communities living in fragile ecosystems. Public environmental education is necessary to ensure long-term sustainability of all measures that combat desertification.
- **Promote public information.** Programmes to educate citizens about the value of preserving woodland and about alternatives to current practices are necessary, along with citizen participation in developing the best methods of implementing the goals. Your community can do much to spread awareness of the reality of desertification through media campaigns and public speaking.
- **Pursue partnership with your government.** A supportive political environment together with the necessary infrastructure plays an important role in the success of projects aimed at combating. Community organizations can persuade their governments through letter-writing campaigns, the use of media and other methods to get them to take notice of the problem of desertification. Governments seeking to protect the fundamental, long-term interests of their people in dryland areas should seek to arrest desertification and reverse its effects whenever possible. This involves not only the direct responsibility of each government to sustain lands

under its legal authority, but also a responsibility for all governments to cooperate and to assist in this task as part of a global effort.

- ***Get involved in the Conventions.*** Find out if your government has ratified the Conventions on desertification and biodiversity. If it has, find out what your organization can do to support their implementation. Community organizations also could analyse these Conventions to determine how they can best ensure their implementation in a local context.
- ***Promote popular participation and use of local knowledge.*** Many indigenous people have lived for thousands of years on their land without desertifying it. The inherent survival skills and knowledge of the Earth's processes of traditional peoples living in drylands could offer many solutions to these problems. Any policy taken to combat desertification should take into account the ways of life of indigenous peoples in the areas affected, and try to incorporate their knowledge into an overall action plan.

*Reference: Most of this document is taken and compiled from UNCCD web pages and printed materials.*



## **SOIL AND WATER NATIONAL INFORMATION CENTER A RESOURCE FOR TURKEY'S FUTURE SUSTAINABLE DEVELOPMENT**

D.Murat Özden, Sebahattin Keskin, A.İhsan Koral, G.Özlem Kara, Sema Yazıcı, Güler Deveci,  
Gülşen Öztürk, Pınar Bostan, Sibel Özcan, E.Cüneyt Ural, Çiğdem Eren, Aysun Ünal, Pınar  
Atalay and Murat Bayat

*General Directorate of Rural Services, Soil and Water National Information Centre, Ankara,  
Turkey*

### **ABSTRACT**

This paper describes the establishment of a land information system for Turkey, and the progress made in this work to date by the General Directorate of Rural Services (GDRS). Initially for soil and water it will be termed the National Soil and Water Information System. This ambitious project is of great significance for the modern state of Turkey as, until this system was initiated, there was no definitive, managed national information resource underpinning land and water resource management. The project was commenced in 1999 with a pilot study for the Ankara province. A team of professional scientists and technologists has been assembled in the GDRS Headquarters in Ankara, within the Department of Research Planning and Co-ordination. The complex process of compiling the first national soil map in digital format will be one of the first tasks for this group, as well as the establishment of a national infrastructure for distributing the information amongst the GDRS managers and scientists.

With the likely forthcoming accession of the Turkish Republic to the European Union, alignment of the National Soil and Water Information System with European standards and protocols will prove to be an important facet of the ongoing development.

### **1. INTRODUCTION**

This paper aims to summarise the importance of the significant tasks currently being undertaken by the Turkish General Directorate of Rural Services (GDRS) to establish the Turkish Soil and Water Resources National Information Centre (NIC). The NIC aims to provide a comprehensive data framework for natural resource management for the Directorate as a whole and will serve to underpin the requirements of the European Soils Bureau on the likely forthcoming accession of Turkey to the European Union (King *et al.*, 1998).

Prior to the creation of the NIC, there was no single point of contact for key geographical and related information for use in the operational and research activities of GDRS. In general, existing information was captured and stored in non-digital form. Each Regional and Provincial Directorate collected and managed the information required for its day-to-day activities, with little co-ordination between offices. The result historically has been poor data management and much duplication of resources. The NIC will provide a central repository for the core information resource of GDRS, as well as the ability to integrate and analyse digital data from a variety of different sources both within and outside GDRS, to satisfy a range of operational, research and business applications. The system is intended to extend information and applications to all national offices of GDRS and to provide easy access to managed centralised resource for managers.

In the decades to come, GDRS faces a growing challenge to balance the demands of rural socio-economic development with the constraints of a fragile environmental resource. The NIC has arisen from the need for good-quality, up-to-date information to assist in the decision-making process, thereby enhancing both the environmental management and operational effectiveness of GDRS. In fulfilling this need, the NIC will bring together the expertise and tools required to establish best management practice, which is of vital importance to the future viability of GDRS.

In drawing together the data resources required, the NIC has embarked upon the construction of the first Turkish national soil map in digital form. This essential data resource will constitute the initial focus for the activities of the Centre.

## **2. GENERAL DIRECTORATE OF RURAL SERVICES**

The GDRS (General Directorate of Rural Services) deliver rural and agricultural services and social infrastructure to some 76,457 villages and settlements in Turkey. This infrastructure includes the provision of drinking water, rural road construction, settlement of rural communities and agricultural extension activities.

Traditionally, the Turkish national economy has been heavily dependent upon agriculture. Almost half the population of Turkey live in rural areas and work in the agricultural sector. From a total land area of 77.8 million hectares, Turkey has some 27.7 million hectares under arable farming. Irrigated production has been developed on 4 million hectares. Out of the total of 8.5 million hectares considered to be capable of such economic development, Turkey plans to increase the irrigated land area by 1.62 million hectares by the year 2001, supported by the necessary investments in infrastructure (KHGM, 1995).

As the Turkish economy has developed, so the ongoing importance of the role played by the rural agricultural sector has become more apparent. Turkey's social and economic prosperity still depends upon the interplay of population, agricultural production and rural environment. Consequently, rural areas are in need of significant investment relating to sustainable agricultural production and to social infrastructure and education.

The services provided by GDRS to the rural areas and communities aim to raise the general standard of living, and the Directorate has the responsibility for establishing the infrastructure for economic, social and physical development in these areas. In Turkey, quality agricultural land is a valuable yet limited resource. Great importance is therefore attached to increasing and sustaining agricultural production. To achieve the greatest benefit from the agricultural market, GDRS continually reviews and expands the use of contemporary technological and scientific advances. The role offered by information technology is recognised as being of profound importance in the sustainable management of natural resources, and this tenet has underpinned the establishment of the NIC.

## **3. THE SOIL AND WATER NATIONAL INFORMATION CENTRE**

The GDRS Soil and Water National Information Centre was formed in 1999 with initial sponsorship through the World Bank funded TARP project. The Centre was sited in the Section Directorate of Soil and Water, the Research, Planning and Co-ordination Department of GDRS and located at the GDRS Headquarters in Ankara.

An initial definition of the mandate of the NIC identified the following core functions (Table 1.).

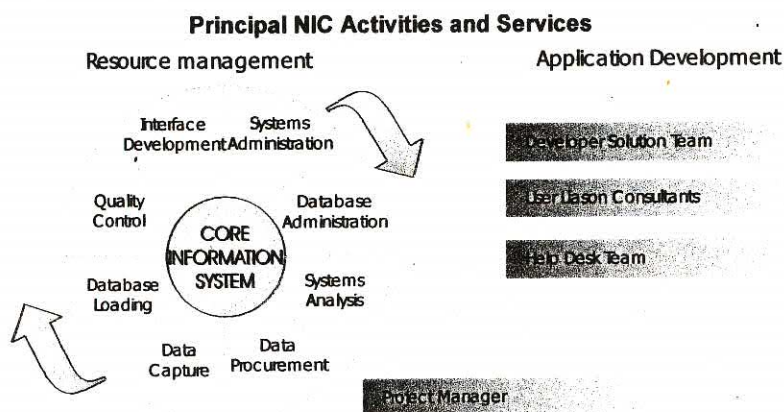
One of the key concepts behind the NIC has been the development of comprehensive in-house expertise in GIS and data management. To create such a centre of excellence NIC staff will have to assume responsibility for all aspects of the Centre's work. Out-sourcing of significant data conversion or data management tasks is not envisaged. The principal activities for the NIC team in the initial phases of the Centre are shown in Figure 1.



Table 1. Core functions identified for the NIC

1. To collect and organise both point and spatial data on natural resources and the environment
2. To develop a computerised Information System to store, manipulate and maintain such data
3. To act as a repository for publications containing rural environmental information on Turkey
4. To increase awareness of other organisations collecting and disseminating rural environmental data in Turkey
5. It is a goal to analyse and plan natural resources because of time constraints and the sensitivity of the situation. By using the GIS and RS techniques, the transformation of other map bases will greatly speed researchers, users and decision-makers in their work
6. By using the national database, preparations can be made for solving problems related to the usage of natural resources and its management. New data can be provided, the differences can be monitored and brought up to dating.
7. To facilitate and encourage the exchange of ideas among resource information agencies at national and international levels

Figure 1. Principal Activities for the NIC



One of the core information technologies to be implemented in the NIC will be the Geographical Information System (GIS) and Remote Sensing (RS). GIS and RS are a conception, which helps in decision making or management relationship techniques, and provides information about a lot of different geographical structures, and analysis and usage of human resources. Adopting a GIS and RS approach will bring a number of advantages. GIS and RS provide a great facility for users by offering the input, storage, analysis and use of data for users. The GIS will be used to create an integrated view of the variety of databases and data themes employed in the information system, spanning levels of map content, scale, detail and usage. The GIS will be used to 'spatialise' existing data, and to provide access to the data resource through data mining and analysis techniques. GIS is a versatile tool that has many applications for spatial analysis. It is a useful tool in all types of management and planning. The GIS will also play a role in presenting the information required to explain environmental policies and the impacts of decision making to

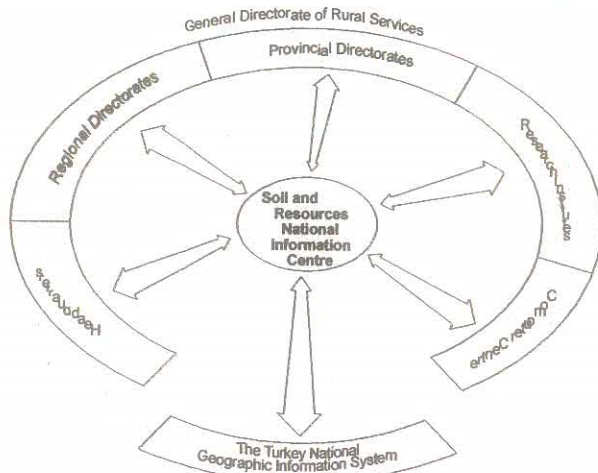


an increasingly well informed and participatory public. In this way, GIS offers a powerful tool for visualisation and presentation of the information resource.

Importantly in an information system such as this one, which spans a number of Government Department datasets as well as a host of internal data types, the GIS allows for the adoption of a shared data structure. Spatial data frameworks will allow GDRS to operate with other Government initiatives using the same information. For natural resource management, such data frameworks will include soils, geology, watercourses, topography and other natural features. Allied to this are other data frameworks including political and cadastral boundaries, geodemographics and street mapping. The GIS, as a 'data-mixer', offers the ability to integrate and inter-compare these disparate sources. Figure 2 identifies the components within GDRS to be serviced by the NIC.

Figure 2. The components of GDRS serviced by the NIC

### National Information Centre Interfaces and Information



As the Centre develops, there will clearly be many opportunities for the data holdings of the NIC to feed directly into the work undertaken by GDRS, at its Ankara campus, its 11 research facilities and in its outlying Regional and Provincial offices. Three obvious areas for application of the NIC within GDRS are shown in Table 2.

Table 2. Key Application Areas for the NIC

- |   |
|---|
| 1. The facilitation of planning and operational activities through the timely provision of quality information; |
| 2. The provision of data resources for the Research Programmes;   |
| 3. The spatial representation of the Inventory data resource for investment management research.                |

A study of the information flow and application of spatial and aspatial data within GDRS is currently being conducted. This will identify how GDRS applies the information it collects and maintains, and identify opportunities for the NIC to benefit current business practices. On an

inter-organisational level, it has been indicated that the NIC will be actively involved in the development of the Turkey National GIS.

#### 4. THE INFORMATION SYSTEM AND DATA HOLDINGS

The Soil and Water Information System was designed to include datasets using a common reference base derived from the 1:25,000 topographic mapping of the General Command of Mapping using the Universal Transverse Mercator projection. The principal datasets are identified in Table 3.

Table 3. Principal Datasets for the NIC Information System

Data Theme Category	Description / Example
Soil maps at the 1:25,000 1:100,000 and 1:200,000 scales	Pedological group level classification
Administrative Boundaries / Locations	Regional, Provincial, District, Village
Geological maps at 1:25,000 scale	Surface and sub-surface geology
Climate and Meteorology	Weather Station Records
Topography	Altitude, DEM/DTM
Cadastral data	Land Ownership/parcels
Hydrology	River networks, catchment/watershed drainage basins
Remote sensing and aerial imagery	Space imaging (NOAAH, LANDSAT, SPOT, IRS), Aerial Photography
Land use, type and capability maps	Current observed and classified
Demography	Census Records
Cartographic – Raster 1:25,000 scale	Raster basemaps for navigation
Cartographic – Vector 1:25,000 scale	Roads, Railways, Urban zones, etc.

This table presents the environmental data and associated spatial data types most sought after within GDRS operational and research activities. The list is not exclusive.

The following sections outline the main anticipated data holdings of the NIC information system. One notable absence is a comprehensive thematic land-cover dataset. A basic land use map was prepared in parallel to the soil map described below, at a scale of 1:25,000 and was completed in 1970. In addition land use brought the country up to date by obtaining readings at the scale of 1:25,000 from field studies. However, there are now plans to derive a contemporary dataset using remotely sensed imagery, combined with a field validation for a pilot area in Trakya. If this pilot proves successful, the programme could be extended to cover the rest of the country.

##### 4.1 The Turkish National Soil Map

In Turkey the real understanding of soil survey and mapping began in 1952 with the help of FAO and a team composed under the leadership of American soil consultant Harvey Oakes and a Turkish group of consultants. The group completed a reconnaissance survey. A map of Turkey with scale of 1:800,000 called ' Turkey General Soil Map ' was prepared. A report and map of Turkey's soils was completed between the years of 1952-1954. Geological and topographical maps were used to develop a reconnaissance level study of all the regions.

After this, classifying Turkey's soils maps was made. These maps were formed by the General Directorate of Soil and Water (Today known as General Directorate of Rural Services) by regulating the job of co-ordinating studies which was done at the national level. After a decision was made to prepare a small scale map of European Soils by European countries, the

General Directorate of Soil and Water decided to make use of this map study in 1966-1971. The General Directorate of Soil and Water prepared maps called the Turkey Development Soil Map (TDSM) survey study based on using a 1:25,000 scaled topographical map at the reconnaissance level. In this study maps units relating to the 1938 American Classification System of great groups with land determiners like the important phases of depth, slope, stoniness, erosion degree and similar characteristics were recorded on the map. After evaluating the data, two maps were published. The first was for every province with a scale of 1:100,000 and called The Soil Resource Inventory Map. The other map shows 17 of Turkey's 26 Great Watersheds with a scale of 1:200,000 and called Watershed Soil Map and Report. Because of the reconnaissance level of the survey, the detail level at a scale of 1:25,000 was not sufficient. In Turkey, this was the first original land study that mapped nation-wide knowledge and at the same time brought out important problems of soils and their distribution areas. Today this study is the main resource which can be applied to problems and uses of Turkey's soils.

The 'Turkey Soils Potential Survey and Non Agriculture Aims Land Usage Planning Project' was replaced with the 'Turkey Development Soil Map Surveys' by the General Directorate of Soil and Water between 1982-1984. In these report differences in soil depth, soil stoniness, soil erosion levels and distributions can be seen in all the provincial Great Soil Groups by obtaining data from actual field trips. In addition, occurrences of differences, drainage, saltiness, alkalinity problems land usage and land feasibility classes brought the country up to date by obtaining readings at the scale of 1:25,000 from field studies.

After that in 1987 maps were prepared from the results of the Turkey Development Soil Maps Surveys with a scale of 1:100,000, together with the consultation of the GDRS and the surveys, maps were prepared at the scale of 1:2,000,000 called 'Turkey Soil Zones Map'. It was published under the name of Turkey General Soil Management Plan.

#### 4.2 Inventory, Census and Small-Scale Hydrology

GDRS holds the responsibility for mapping and recording Inventory, Census and Small-Scale Hydrological features. This information is captured and managed in a purpose-built Inventory information system. It is envisaged that it will be necessary for the NIC system to access only a subset of the complete Inventory system. The data held consists of information on the activities and responsibilities identified in Table 4.

Table 4. Inventory, Census and Small-Scale Hydrology Data in the NIC System

1. Sub-districts	2. Irrigation dams
3. Villages	4. Water pipes
5. Sub-villages	6. Hydrogeological information
7. Resettlement	8. Wells
9. Bridges	10. Pumps
11. Agriculture	12. Co-operatives
13. Rural roads	14. Economic plants
15. Drinking water facilities	16. Ground and underground water wells
17. Land consolidation	18. Land development services
19. Electricity plants	20. Collector pipes
21. Income sources and settlement places for migrating families	22. Soil conservation and new settlements

#### 5. FUTURE DEVELOPMENTS

It has been estimated that 1.5 million hectares of the Turkish arable land resource suffers from production limitations due to the effects of salinity, with a further 2.8 million hectares



suffering from waterlogging. The condition of much of the available arable land has deteriorated over recent decades due to water and wind erosion. Some 63% of the total erosion recorded is categorised as severe or very severe, with 20% having moderate and 14% slight or negligible erosion (KHGM, 1987). The greatest challenge for GDRS land resource management in the future will come from salinity, waterlogging and erosion. Any comprehensive and sustainable rural policy must accommodate measures designed to ameliorate or reduce these factors. Yet, as the pace of development and the demands on the rural economy increase, the balance is harder to maintain. Furthermore, the strain placed upon GDRS resources by the recent earthquake disasters has made the process of allocating resources and identifying priorities even more difficult.

The Soil and Water National Information System offers GDRS an effective and cost-efficient management tool to meet its many and varied responsibilities. Although still in its early days, the NIC has already drawn together many of the key thematic datasets which underpin such decision-making, with considerable effort being made in identifying the most appropriate distribution mechanisms for the resulting information. The Centre has also commenced with great efficiency the compilation of the first national soil map in digital form. This will be of great importance in the direction of the rural economy, especially as Turkey accedes to the European Union and compliance is required for many environmental Directives. An immediate task facing the NIC team has been to commence the systematic capture and integration of the paper-based national soil map into the information system. The 1:25,000 soil maps of Turkey are presently being digitised. Pencil tracings and annotations on transparent material is the source of this key nation-wide data set. The legend of the soil maps represents a wide range of environmental parameters, as each unit was labelled with a compound alphanumeric symbol giving information on various soil and site attributes. There are over 5564 1:25,000 scale soil maps to cover Turkey. To create a national database from these data is a task requiring significant resources (KHGM, 1999).

There are also plans underway to continue to enhance and improve the basic soil mapping resource in Turkey. It is anticipated that a national programme of detailed surveys will be commenced to determine factors including soil type, land use, land capability and fertility levels with greater precision than before. In recognition of the limitations of the current soil mapping, which lacks fully comprehensive geo-located profile observations to validate the map separates, the GDRS' NIC plans other two specific projects. Firstly, a revised version of the 1:1,000,000 scale soil map will be compiled, which will retain the original soil lines but will re-allocate the map units according to the FAO/Soil Map of Europe classification with a soil interpreted report (KHGM, 1999). Secondly it is proposed that a new land cover and land use map be compiled using modern technology and including remote-sensing imagery.

Such newly conducted soil surveys will feed directly into the planning basis for catchment rehabilitation, soil conservation, irrigation and drainage and land consolidation projects. Also, soil and water analyses are conducted to determine the factors most limiting to agricultural yield and productivity, with farmers being provided with technical recommendations as to the appropriate use of fertilisers and other chemicals together with suitable crop rotation patterns. In these cases, it is imperative that the NIC data framework be in place to handle and manipulate these new datasets. However, at this time, the financial constraints under which the NIC will operate in the future are not yet fully defined. Indications are that the importance of the NIC is fully recognised at the highest levels within GDRS and means are being sought to provide appropriate ongoing financial support.

## 6. CONCLUSIONS

This paper has outlined the infrastructure put in place for the development of the GDRS Soil and Water NIC. This resource will be highly valuable to GDRS and to the effective and sustainable ongoing management of the Turkish rural resource. The new NIC will provide a cost-effective national centre of excellence in land information systems design and implementation,

and its work will underpin a large part of the day-to-day operation, as well as research activities undertaken in GDRS. This paper outlines the initial steps underway to create the full infrastructure required to administer the national Soil and Water Information System, as well as the data resources that it will hold. There are many challenges to be faced in the next few decades as the GDRS addresses a range of environmental threats such as salinity, waterlogging and erosion. However, the tools that the NIC will offer will be an invaluable aid in natural resource and rural management and, importantly, contribute further to the national information infrastructure following Turkey's likely forthcoming accession into the European Union.

## 7. REFERENCES

- King, D., Meyer-Roux, J., Thomasson, A.J. and Vossen, P. (1998). A Proposed European Soil Information Policy. In *Land Information Systems: Developments for planning the sustainable use of land resources*. H.J. Heineke, W. Eckelmann, A.J. Thomasson, R.J.A. Jones, L. Montanarella and B. Buckley (eds.) EUR 17729 EN, 11-18. Office for Official Publications of the European Communities, Luxembourg.
- Köy Hizmetleri Genel Müdürlüğü (KHGM), (1987)., *Türkiye Genel Toprak Amanajman Planlaması (Toprak Koruma Ana Planı)*
- Köy Hizmetleri Genel Müdürlüğü (KHGM), (1995)., *Toprak ve Su Kaynakları Araştırma Master Planı, Araştırma Planlama ve Koordinasyon Dairesi Başkanlığı*, Yayın No: 87, Türkiye Tarımsal Araştırma Projesi 3472 – TU.
- Köy Hizmetleri Genel Müdürlüğü (KHGM), (1999)., *Türkiye Toprak ve Su Kaynakları Veri Tabanının Oluşturulması Projesi*, Toprak ve Su Kaynakları Ulusal Bilgi Merkezi
- Köy Hizmetleri Genel Müdürlüğü (KHGM), (1999)., *Türkiye Genel Toprak Haritası ve Raporunun FAO-UNESCO ve Toprak Taksonomisine Göre Güncelleştirilmesi*, Toprak ve Su Kaynakları Ulusal Bilgi Merkezi



# **THE LAND RESOURCES OF TURKEY AND ACTIVITIES OF GENERAL DIRECTORATE OF RURAL SERVICES**

D.Murat Özden, Hasan Dursun, A.Naci Sevinç  
General Directorate of Rural Services, Research, Planning and Coordination Department,  
Ankara / Turkey

## **ABSTRACT**

The aim of this study is to determine Turkey's land resources and its problem according to the United Nation Convention to Combat Desertification. As well as land protection activities of General Directorate of Rural Services, land degradation types and their effects were explained.

## **1. INTRODUCTION**

Turkey is a mountainous and hilly country, average altitude is 1132 m, surrounded by the seas from the north (Black Sea), south (Mediterranean Sea) and the west (Aegean Sea). It is a peninsula which accounts for the great differences in climate, soil and the other ecological properties.

Although Turkey is in the subtropical belt having a semi-arid climate with extremes in temperatures, the diverse nature of the landscape and particularly the existence of mountains parallel to the coasts result in great differences in climatic conditions from region to region.

Average rainfall is 643 mm annually, but it is not always in the right place and the right time to meet the real need, considerably changing by years and regions.

Believing that desertification is one of the most serious common problem of the world and because of its oversensitive land conditions and urgency of activities, Turkey has signed the UN Convention to Combat Desertification and ratified by the National Assembly on 11<sup>th</sup> of February 1998.

## **2. LAND DEGRADATION and DESERTIFICATION**

In addition to natural disasters, it is known that land degradation is occurred by the human activities which are agricultural mismanagement, overgrazing, deforestation, industry and urbanization etc.

One of the main causes of land degradation is agricultural mismanagement. When the land is not used in accordance with its capability, degradation is unavoidable. Soil erosion (water or wind), salinization, waterlogging, nutrient losses, plow pan forming, structure destruction or compaction as well as farm land fragmentation are the result of agricultural mismanagement.

Overgrazing is another land degradation. Uncontrolled grazing strips the plants of the land. Animal herds compact the top soil which is the vital part of the land for vegetation. Because of those, soil erosion has been exposed and productivity of land has declined.

Forests which is the lung of the world have been degraded by fires, over harvesting, misuses for fuel wood or clearing for farm and urban uses. Those kinds of deforestation is very prevalent in the world. It can be seen in both developed and developing countries. Degradation of forests is one of the biggest disaster of our planet.

The land which has high plant production potential is degraded for urban growth, road building, mining, industry etc. In addition to those overuse of fertilizer, industrial and urban wastes have caused the soil pollution.



### 3. LAND RESOURCES of TURKEY

According to the surveys made in 1984 by TOPRAKSU which is the predecessor of General Directorate of Rural Services (GDRS), approximately 36 % of total area is under cultivation in Turkey. 21,255,248 ha of cultivated area is under dry farming, 4,354,660 ha is irrigated, 2,443,599 ha is used for perennial crops like olive, citrus, nut, tea etc. The great variety of climatic zone contribute to the diversity in agricultural production.

Because of the water deficiency and land limitation 20 % of irrigable land can be hardly irrigated. Severe effects of the water deficiency will be seen in the future. At the year 2030: 25,3 billion m<sup>3</sup> water will be used in domestic needs, 13,2 billion m<sup>3</sup> industry and 71,5 billion m<sup>3</sup> in agriculture. However, according to the observation and estimation the total technically and economically usable surface and underground water potential of Turkey is 110 billion cubic meters of which coming 95 billion m<sup>3</sup> from internal rivers, 3 billion m<sup>3</sup> from external rivers and 12 billion m<sup>3</sup> from underground water resources.

As it is seen Turkey does not have plenty of water in comparison with potential irrigable land and population density.

Grassland and pasture can be seen all over the country. However they are great importance for very hilly part of the eastern regions which animal husbandry is prevalent. Nearly 27,6 % of total area is grass and pasture land in Turkey. 646,694 ha of this is grassland, 20.858.477 ha is pasture.

Forest and bush land is totally 23,227,975 ha. It is rife with forest along the coast. In side of the county is poor with forest. Nearly 30 % of total area is forest and bush 15,184,879 ha is forest, 8,043,096 ha is bush.

5,113,051 ha of the total area of country is nonagricultural use including water surface, rocky, housing, park etc.

Land resources can be seen in the table which is distribution of land use based on capability classes.

### 4. LAND DEGRADATION in TURKEY

Land degradation in Turkey is similar to developing world. Agricultural mismanagement, overgrazing, deforestation and using valuable agricultural land for nonagricultural usage are the main human activities of land degradation in Turkey.

As it is seen in the table that some agricultural land uses are not suited to their capability classes.

Under the land use capability classification (LUCC), land is classified into one of eight namely class I to class VIII. There are three categories according to the LUCC first category is class I to IV which are suitable for cultivation and animal husbandry. This category has few limitation, it requires special conservation practices except class IV which requires very carefully management because of its severe limitations.

Second category class V to VII which are unsuitable for cultivation but only perennial plants with intensive conservation and development practices. It is suitable for under controlled grazing and forestry. This category has very severe limitations that make the land unsuitable for economic and sustainable agricultural usage.

Third category is class VIII which is suitable only for wild life, sports and turistics activities. This land is not covered with soil for commercial crop productions.

It is important for sustainable land management to use land according to the capability classes. Land use in agriculture, animal husbandry, forestry and non agricultural use should be concerned of LUCC. Otherwise land degradation is speeded up.

Because of the mismanagement of the land, some of the main degradation type in Turkey are erosion by water or wind, soil salinization and alkalization, soil structure destruction and compaction, biological degradation and soil pollution.

Some of the land problems are as follows in Turkey.

<u>Types of Problems</u>	<u>Area (ha)</u>
Water erosion	66.576.042
Wind erosion	330.000
Alkalinization / Salinization	1.518.749
Hydromorphic soil	2.775.115
Stony or rocky problem	28.484.331
Non agriculture use	894.153

Due to climatic and topographic condition soil erosion is the biggest problem in Turkey. Approximately 86 % of land is suffering from some degree of erosion.

Categories of Soil Erosion Distribution is as follows.

<u>Degree of erosion</u>	<u>Area (ha)</u>	<u>Ratio (%)</u>	<u>Criterion of degree</u>
Slightly	5.611.892	7.22	25 % of top soil eroded
Moderate	15.592.750	20.04	25-75 % of top soil eroded
Severe	28.334.938	36.42	Top soil and 25 % of sub soil eroded
Very severe *	17.366.462	28.30	Top soil and 25-75 % of sub soil eroded
TOTAL	66.906.042	85.98	

\* Wind erosion is effective on 330.000 ha of very severe degree erosion.

In addition to soil erosion 28.484.331 ha land has stony or rocky problems. There are 2.775.115 ha drainage, 1.518.749 ha alkaline or salinity problems which may be increased in some plains which are under construction of new irrigation projects. Unless it is implemented with precautionary measure. Without seeking alternatives industrial and urbanisation land use requirements have been met with valuable farm areas. Because of using for industrial needs as well as population expansion valuable farmland in the plains has been rapidly declining.

## 5. LAND PROTECTION ACTIVITIES of GDRS

In Turkey, several official organizations are directly or indirectly involved in protection of land degradation. Due to various land conditions including climate, topography, soil types, in addition social, cultural and economic structure of country, the approaches of the solution are also various.

The Ministry of Forestry deals with erosion control on upper catchment which is under forestry regime.

General Directorate of State Hydrolic Works deals with flood control and flood stabilization measures by constructing check dams and silt trap dams on main river courses and flood areas.

General Directorate of Rural Services is an organization which gives services in villages and settlement sites of 75.850 units. It helps villages and farmers on their developments in respect of social, economic and cultural issues.

In accordance with its responsibilities, Rural Services constructs roads in order to make all rural settlement site in Turkey linked with towns, cities and each others. Keeping the roads open in all seasons, making their maintenance and reconstruction of them are among the services of the organization. Organization executes services such as building bridges and art structures during the road-making activities.

Another fundamental provision is clean and healthy water for using and drinking.

GDRS performs rural and urban housing activities for the families missing their houses. In-village swere systems, mosques, loundry houses and village group technicians offices can be accepted in this framework.

Increasing the development level of country and its rural part is only possible with getting more and more yield from production areas and improving the crop quality. GDRS realizes this target by attempts specific to improving the crop quality with the healthy and sustainable usage of soil and water resources. With ventures done, the agency transfers services to an arable land of 26.5 million hectares. In this scope, in-field improvement applications are made; importance are given in land consolidation.

Erosion, rockiness and stoniness in agricultural lands of country are the problems which must be solved by GDRS. Another important factor for enlarging the agricultural production is irrigation. Rural Services is responsible for irrigating the land in its own activity area. For this purpose, GDRS constructs small reservoirs.

The agency has accomplished heavy services through its organisation structure reaching to the furthest sides of the country.

In relation to land degradation, The General Directorate of Rural Services deals with erosion control, on-farm development works and the other farm problems on agricultural land by constructing small silt trap dams, terrace, flood control and drop structure constructions and stone clearing works, by carrying out irrigation services such as land leveling, land consolidation, sub drainage and the other on-farm development services.

In addition to physical construction GDRS has made soil surveys and mapping studies, statistics inventory and soil analysis for irrigation, soil conservation and fertilizer purposes.

There are 11 Research Institutes and one International Research and Training Center, established on the basis of regions, which carry out researches concerning with soil and water to increase effectiveness of GDRS investments.

Now GDRS is serving under the responsibility of Ministry of State. The first studies to obtain information about soil property was initiated in 1960's by making reconnaissance soil surveys. The field works were completed in 1971 by TOPRAKSU which is the predecessor of GDRS. During the surveying; genetic soil groups, soil depths, land slopes, rockiness and stoniness, wetness, soil salinity and alkalinity, land cover types and land use, degree and variety of erosion alluvial and colluvial origins, land capability classes and the other properties of land were determined to prepare a general soil manegement plan, land use and especially to combat soil erosion.

For this purpose 1:25000 scale topographic maps were used. After reconnaissance surveying soil maps were prepared based on provincial and for basins. The maps for provincial and basins were printed in 1:100000 and 1:200000 scale respectively.



After completion of Turkey soil maps, erosion maps were prepared the information of erosion map was compiled from provincial soil maps. Simply erosion degrees have been shown on the map.

The main purpose of soil map were to prove the danger of erosion, to show and to start the general erosion control measures.

The soil map of Turkey was revised in 1980's by GDRS but today it needs to be developed and adapted according to new changes by considering scientific principles and new classification systems.

By using new technical instruments like computer, GIS, remote sensing etc GDRS has been working on preparing new soil map including all requirements of country and newness regarding determination of soil properties in the world.

Besides in relation to land development works GDRS gives some other social and cultural infrastructure services to the rural areas by constructing roads, bridges, for using and drinking water facilities, urban housing activities, in-village sewer systems etc. Because of its huge works capacity it is planning to be reorganized according to the sectoral structure of GDRS.

## **6. CONCLUSION**

To combat land degradation and desertification and for effective land management policies, the properties of different types of soil must be known.

At first each country should start with the inventory of land resources, as well as scientific research and international exchange of information and coordination for combatting desertification and effective land use.

Investments of conservation and development must be balanced for generation needs and sustainable life by the legal arrangement.

In Turkey, a draft new law, concerning the usage of soil and land resources including land consolidation, allocation, conservation classification sectoral and intersectoral utilization, planning for production and covering all gaps have already been completed by the GDRS suited to "Seventh Five Year Development Plan of Turkey" and sent to the prime minister's office for legalizing. Regarding conservation, development and sustainable use, the draft brings some new approach in land use and planning.

We wish that humanity is going to fulfill all the responsibilities in combatting desertification and to reach the final aims.

# USING GEOGRAPHIC INFORMATION SYSTEM and REMOTE SENSING TECHNIQUES in MAKING PRE-SOIL SURVEYS

İlhami Bayramin,

Ankara University, Agricultural Faculty, Soil Science Department, ANKARA

## ABSTRACT

As a significant and dynamic component of the earth system, soil has come to the forefront of the environmental agenda during the past decade as it has never done previously. Landforms are the product of both long term and short term processes that operate principally in response to climate, water, geology, tectonics and vegetation. A soil-forming factor is anything, which acts or has acted on a parent material of a soil with the potential for changing it. Equation of soil forming factors is very well known and soil is characterized as a function of parent material, climate, organisms, and relief and time. The equation implies that, by looking for changes in one or more of these factors as the landscape is traversed, one can accurately locate boundaries between different bodies of soil. Quantifying and knowing soil-landscape relationships will be very useful information for soil survey studies.

In this research, the challenge for soil survey interpretations was to more adequately synthesize the component parts of soil landscapes into segments of space that are meaningful to the soil user in relation to the soil-use decisions he faces, and integrate geological, and land cover information to the landform classes.

In this study, non-soil digital data were used to make preliminary soil survey maps of Beypazari area by computer. Digital Elevation Model (DEM) used for landform classification. The percentage of area where slope is flat or gentle (less than 8%, 4 classes), local relief (maximum minus minimum elevation, 6 classes) and the profile type expressed as relative percentage of flat or gentle slope areas that occur in lowlands or uplands (4 classes) were calculated. Landforms in Beypazari were grouped into 5 main types: plains, tablelands, plains with hill or mountains, open hills and mountains, and hills and mountains. The landform types were subdivided into 24 classes and 96 subclasses according to the amount of gently sloping land in the area, local relief, and profile type (the amount of gentle slope on lowlands or uplands). The same data set was also used to generate 3D view for the study area and to evaluate the results visually. Digital geological data were overlaid with the landform classification data. After overlying processes, new classes were linked to the land cover classes, obtained from Landsat TM data classification, and re-classified to determine soil profile pits. Completing computer processes, field studies were carried out with global positioning system (GPS).

The results show that digital methods were quite well to provide similar patterns for the most of the major landform types and much greater detail for classes and subclasses of landforms. Integrating geological and satellite data with landform classification increased the soil survey efficiency. Indeed, the landforms in any country or area with a DEM could be classified easily and readily. Using RS and GIS technologies and integrating DEM, satellite and digital geological data are very powerful tool for soil surveys.

## INTRODUCTION

As a significant and dynamic component of the earth system, soil has come to the forefront of the environmental agenda during the past decade as it has never done previously. Whether we are considering soil as a source and sink of greenhouse gases, a contaminant of water sources, a medium for production of food for the rapidly expanding human population, a non-sustainable resource under current management systems, or a site of environmental degradation, the community of soil scientists faces a formidable challenge to provide credible, usable and timely soil information to resource manager and policy makers. As members of the first human generation to have the tools to study the Earth as a system, we soil scientists must address seriously our obligation to provide the user community needs to make rational decisions about resource and environmental management and policy. Requests for digitized soils data have increased dramatically during the past decade as government agencies and industries have begun to include geographic information systems (GIS) capabilities in their set of resource management tools, and wish to integrate soils data layers into their resource databases (Bayramin, 1998).



## LITERATURE REVIEW

Hammond (1954) stated that "land surface configuration is simply a three-dimensional geometry, to which some consideration surface material is usually added and the geometry of finite areas of land surface is usually so complex that it cannot be effectively apprehended as a whole. The usual way of handling such complex phenomena for study is by analysis. The complex is resolved into its component parts, elements or attributes".

According to Kuhn (1970) paradigm is based on "one or more past scientific achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice." Trained soil scientists can delineate bodies of soil accurately on the landscape by directly examining less than 1/1000<sup>th</sup> of the soil below the surface. They can do this because of the validity of the soil-landscape model. A powerful paradigm, it enables soil scientists to make very accurate predictions about their world. Jenny's (1980) well-known soil forming factor equation identifies the five factors of soil formation. Soil is characterized as a function of parent material, climate, organisms, and relief and time. The equation implies that, by looking for changes in one or more of these factors as the landscape is traversed, one can accurately locate boundaries between different bodies of soil.

Our objectives of the study are; to test the use of non-soil data (DEMs, satellite images, digital geological data) for improving mapping efficiency and quality of soil maps, and to develop a pre-model for soil mapping, especially for countries who need rapid, easily applicable low cost soil mapping methods.

Soil survey map units are based on a variety of landscape properties such as soil morphology, substratum type, slope, landform and flooding frequency (Swanson 1990). These properties have been chosen because they affect the land's capabilities and its response to management. However, in the formal classification system that has been used to aid us in defining and describing these map units are based on soil properties alone. He suggested that a system of soil landform units, defined by variety of landscape properties in addition to soil properties be developed for mapping and for communicating information about soil management.

According to Hudson (1990); i) Within a soil-landscape unit, the five factors of soil formation interact in a distinctive manner. As a result, all areas of the same soil-landscape unit develop the same kind of soil. ii) Generally, the more different conterminous areas of two soil-landscape units are, the more abrupt and striking the discontinuity separating them. iii) Generally, the more similar two landscape units are, the more similar their associated soils tend to be. iv) Adjacent areas of different soil-landscape units have a predictable spatial relationship one to another. v) Once the relationships among soils and landscape units have been determined for an area, the soil cover can be inferred by identifying the characteristic soil-landscape unit.

Klingebl et al. (1987) investigated the utility of GIS-produced slope maps for soil-survey-related activities. They used 30-m DEMs to produce slope, aspect and elevation maps as pre-maps for third order soil surveys in Idaho, Nevada, and Wyoming. They questioned the use of slope-aspect pre-maps in second-order soil surveys and stated that experienced field soil scientists could improve field mapping using slope-aspect pre-maps.

Horvath et al. (1984), using Landsat data, compiled photomaps showing the spatial distribution of the optical density of the spectral characteristics of objects. They found that spectral categories (12 classes) were correlated with parent material, aspect, slope, and spatial variability. The maps compiled were considered to be only supplementary to detailed soil survey techniques.

Lec et al. (1988a) combined transformed thematic mapper (TM) data and topographic information from digital elevation model (DEM) to determine soil characteristics of hilly terrain in south western Wisconsin. They found 72% agreement between the soil map and classification used in their research. Stoner and Baumgardner (1981) concluded that characteristic variations in reflectance of surface soil properties may be related to the wetness, soil color, soil texture, soil-moisture regimes, parent material, and vegetation and are useful in separating soils at the higher categories of taxonomy. Su et al. (1989) demonstrated that DEM data could be used with Landsat TM data to benefit second order soil surveys of range land soils. Digital Elevation Model (DEM) data were merged with Landsat TM and SPOT data to delineate soil mapping units within the study area. Soil mapping units from a conventional soil survey were compared with a classified soil spectral map obtained from Landsat TM or SPOT, and DEM derived elevation, slope, and aspect data, using an overall accuracy assessment.



The overall accuracy of soil spectral classes from TM and SPOT data was improved after DEM data were merged.

Landsat TM data was used for soil survey studies in South Eastern Anatolia Region successfully, with high mapping accuracies of 68 - 94 % (Dinç, 1995). DiPaolo and Hall (1982), in reference to Landsat studies of soils, suggested that in mountain and plateau areas, factors such as elevation, slope and aspect contribute to variation in soil and vegetation and must be considered in any interpretations.

## MATERIAL

In this study, non-soil digital data were used to make preliminary soil survey maps of Beypazarı area by computer.

Landsat TM scene, acquired on 9.9.1998, 3-arc second Digital Elevation Model (General Command Mapping) and 3-arc second Digital Geological Data (Mineral Research and Exploration General Directorate) (MTA) for the study area were used.

## METHODS

All data sets were geo-referenced to UTM map projection. In the first step, Landsat TM data were classified to obtain land use and land cover classification. Land use and land cover classes were grouped by USGS system. From this classification urban or built up areas, agricultural lands, range land, forest land, water bodies, barren lands were determined. Geological formation layers for the eleven quads were merged into one data set. DEM were analyzed for landform classification. The technique and schema by Dikau et al (1991) were used for the landform classification (Table 1).

Table 1. Landform Classification Used in this Study (Dikau et al, 1991)

Landform Type	Landform Class	Landform subclass Code
Plains (PLA)	Flat or nearly flat	A1a, A1b, A1c, A1d
	Smooth plains with some local relief	A2a, A2b, A2c, A2d
	Irregular plains with low relief	B1a, B1b, B1c, B1d
	Irregular plains with moderate relief	B2a, B2b, B2c, B2d
Tablelands (TAB)	Table lands with moderate relief	A3c, A3d, B3c, B3d
	Table lands with considerable relief	A4c, A4d, B4c, B4d
	Table lands with high relief	A5c, A5d, B5c, B5d
	Table lands with very high relief	A6c, A6d, B6c, B6d
Plains with Hills or Mountains (PHM)	Plains with hills	A3a, A3b, B3a, B3b
	Plains with high hills	A4a, A4b, B4a, B4b
	Plains with low mountains	A5a, A5b, B5a, B5b
	Plains with high mountains	A6a, A6b, B6a, B6b
Open Hills and Mountains (OPM)	Open very low hills	C1a, C1b, C1c, C1d
	Open low hills	C2a, C2b, C2c, C2d
	Open moderate hills	C3a, C3b, C3c, C3d
	Open high hills	C4a, C4b, C4c, C4d
	Open low mountains	C5a, C5b, C5c, C5d
	Open high mountains	C5a, C5b, C5c, C5d
Hills and Mountains (HMO)	Very low hills	D1a, D1b, D1c, D1d
	low hills	D2a, D2b, D2c, D2d
	Moderate hills	D3a, D3b, D3c, D3d
	High hills	D4a, D4b, D4c, D4d
	Low mountains	D5a, D5b, D5c, D5d
	High mountains	D5a, D5b, D5c, D5d

### Schema of Classification

#### SLOPE

- A. More than 80 % of area gently sloping
- B. 50 - 80 % of area gently sloping
- C. 20 - 50 % of area gently sloping
- D. Less than 20 % of area gently sloping

#### LOCAL RELIEF

- 1. 0 - 30 m, 2. 30 - 91 m,
- 3. 91 - 152 m, 4. 152 - 305 m,
- 5. 305 - 915 m, 6. > 915 m

#### PROFILE TYPE

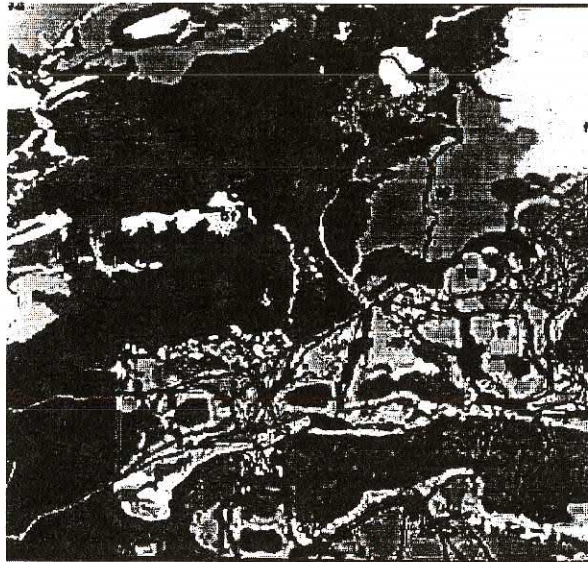
- a. More than 75% of gentle slope is in lowland
- b. 50 - 75 % of gentle slope is in lowland
- c. 50 - 75 % of gentle slope is in upland
- d. More than 75% of gentle slope is in upland

Landforms in New Mexico were grouped into 5 main types: plains, tablelands, plains with hill or mountains, open hills and mountains, and hills and mountains. The landform types were subdivided into 24 classes and 96 subclasses according to the amount of gently sloping land in the area, local relief, and profile type (the amount of gentle slope on lowlands or uplands).

DEM data were also used to generate 3D view and shaded relief images of the study area to visually compare results obtained from landform classification.

The two data sets, geological and topographic, were combined to get soil land units. Each soil land units were analyzed according to their coverage and land cover/use and according to this analyses soil profile pits were determined. Forty-six soil profiles were opened and sampled for the laboratory analyses. Soil survey studies have not been completed yet. Soil land units will be divided into sub-groups according their slopes and aspect groups. Landsat TM image data will be classified and integrated with soil land units to have meaningful soil delineation boundaries. After finishing laboratory analyses soil survey studies will be carried out preliminary soil delineation boundaries will be checked by transecting.

Figure 1. Soil Land Units and Soil Profile Pits





## RESULTS AND DISCUSSION

Slope, relief and profile layers were produced from DEM data. These layers were combined and 64 landform sub-classes out of 96 landform sub-classes were obtained for the study area. Low Mountains with 14.4% showed the largest area coverage. These landform sub-classes were re-classified to obtain main landform types of; plains, tablelands, plains with hill or mountains, open hills and mountains, and hills and mountains. Distribution of the main landform types were 4.0%, 0.8%, 6.8%, 21.5%, 67.0% respectively. To determine soil profile pits main landform types and geological layers were integrated. From this integration 59 classes were obtained. These classes were linked to Landsat TM data and 55 soil profile pits were determined (Figure 1). This selection was based on the land use and coverage. During field studies, 47 soil profiles were opened and sampled for laboratory analyses (Table 2).

Table 2. Some properties of the soil profiles.

P #	Geo.	Landform	Elev. (m)	Asp.	Slo. %	P #	Geo.	Landform	Elev. (m)	Asp.	Slo. %
2	Tha	D5d	1469	82	53	31	Qa	B3a	665	135	4
3	Tha	D4b	1036	243	7	32	Qa	B3a	498	0	0
4	Tha	D5d	1265	0	0	33	Qa	A3a	490	45	4
5	Tur	C3a	724	12	9	34	Qa	B4a	489	0	0
6	Tur	C3c	730	277	13	35	Qa	B2a	620	180	5
8	Tur	B4d	923	296	3	37	Tbg	D5b	797	71	26
9	Tur	D4b	603	45	9	38	Tha	C4d	1120	55	26
10	Tur	D4c	768	87	38	40	Qa	D5a	524	180	5
11	Tur	D4d	938	305	14	41	Qa	D4c	871	236	18
12	Tu	D5c	1375	192	15	42	PTRg	D5a	671	154	38
13	Tu	D5d	1302	315	11	43	Tur	C4a	556	219	13
14	Tu	D5a	744	48	37	44	Tur	B3a	650	254	12
15	Tb	D5a	969	345	54	45	Tor	C3b	650	201	8
16	Tb	D5a	1112	209	17	46	Ti	D4d	1626	30	9
18	Kye	D5b	949	0	0	47	Tbg	C4d	995	306	25
19	Td	D5c	1501	338	26	48	Tbg	C4a	546	24	20
22	Jks	D5a	709	251	5	49	Tu	C4a	850	196	17
23	Tur	B3a	785	63	11	50	Tk	C4a	623	235	20
24	Qa	B2a	629	180	10	51	Tor	D5c	1181	135	11
25	Tur	A2b	774	18	5	52	Qa	B2a	490	206	7
27	Qa	C4a	574	135	2	53	Tur	B4d	947	315	7
28	Qa	C4a	515	285	12	54	Tur	B2d	1018	291	8
29	Qa	C3a	586	116	7	55	Tur	B3a	799	0	0
30	Qa	C4a	581	293	12						

Tha: sandstone, mudstone, limestone

Tu: sandstone, mudstone, limestone

Kye: sandstone, shale, limestone

Ti: andesite, basalt, pyroclastic rock

Qa: Alluvium

Tur: breccia, sandstone, shale

Td: andesite, dacite, tuff

Jks: cherty limestone

Tor: breccia, sandstone, shale

Tu: pyroclastic rock

Tb: andesite, dacite

Tbg: granodiorite

PTRg: schist

Soil survey studies has not been completed yet. However, first stage field observations and results show that digital methods with geographic information systems and remote sensing techniques were quite well to provide similar patterns for the most of the major landform types and much greater detail for classes and subclasses of landforms. Integrating geological and satellite data with landform classes increased the soil survey efficiency. Using RS and GIS technologies and integrating DEM, satellite and digital geological data are very powerful tool for soil surveys. Although taxonomic classification seems to be excellent, a system of landscape units, defined by variety of landscape properties in addition to soil properties, would serve the needs of soil survey and land management better than the present system based on classification and soil series.



## ACKNOWLEDGEMENTS

The authors acknowledge Scientific and Technical Research Council of Turkey (TÜBİTAK, project no: TARP 2097) for their support during the course of this ongoing research.

## REFERENCES

- Bayramin, I., 1998. Integrating Digital Terrain and Satellite Image Data with Soils Data for Small Scale Mapping of Soils. Ph. D. Thesis. Purdue University, Agronomy Department. 121 pages.
- Dinç, A. O., 1995. Importance of Satellite Remote Sensing for Developing Countries for Mapping and Monitoring Natural Resources: Examples from Turkey. ACSM/ASPRS Annual Convention & Exposition Technical Papers. Charlotte, NC. Vol:3 pp:741-747.
- Dikau, R., Brabb, E. E., Mark, R. M., 1991. Landform Classification of New Mexico by Computer. U. S. Dept. of the Interior, U. S. Geol. Survey Report 91-634.
- Hammond, E. H. 1954. Small-scale continental landform maps: *Annals of Assoc. of American Geographers* v. 44, p: 33-42
- Horvath, E. H., Post, D. F., and Kelsey, J. B., 1984. The relationships of Landsat digital data to the properties of Arizona range lands. *Soil Science Society of America Journal*. 48, 1331-1334.
- Hudson, B. D., 1990. Concepts of Soil Mapping and Interpretation. *Soil Survey Horizons*. 31, 63-73.
- Jenny, H., 1980. *The Soil Resource; Origin and behavior*, Ecol. Studies 37. Springer-Verlag, NY.
- Klingebiel, A. A., Horvath, H., D. Moore, G. W., and Reybold, U. 1987. Use of Slope, Aspect, and Elevation Maps Derived From Digital Elevation Model Data in Making Soil Surveys *Soil Science Society of America, Soil Survey Techniques*, SSSA Special Publication, 20, 77-98.
- Kuhn, T. S., 1970. *The structure of scientific revolutions*. Univ. of Chicago Press.
- Lee, K., Lee, G. B., and Tyler, E. J., 1988a. Thematic mapper and digital elevation modelling of soil characteristics in hilly terrain. *Soil Science Society of America Journal*. 52, 1104-1107.
- Muller, E., and James, M., 1994. Seasonal variation and stability of soil spectral patterns in a fluvial landscape. *International Journal of Remote Sensing*, 15:9, 1885-1900.
- Stoner, E. R., and Baumgardner, M. E., 1981. Characteristic variations in reflectance of soil. *Soil Science Society of America Journal*, 45, 1161-1165.
- Su, H., M. D. Ransom, and E. T. Kanemasu., 1989. Detecting soil information on a native prairie using Landsat TM and SPOT satellite data. *Soil Science Society of America Journal*. 53, 1479-1483.
- Swanson, D. K., 1990. Soil Landform Units for Soil Survey, *Soil Survey Horizons*, 31: 17-21.

# NEURAL NETWORK APPROACH FOR SMALL SCALE SOIL MAPPING

Ilhami Bayramin

Ankara University, Agricultural Faculty, Soil Science Department, Ankara

## ABSTRACT

Recent advances in space and computer technologies provide the possibility to process large amounts of data (multisource), not only spectral but also other data such as elevation, slope, aspect and relief about the Earth environment. In earlier studies, Neural Network (NN) methods showed great potential in pattern recognition for multisource, remotely sensed data. They are superior to statistical methods in terms of classification accuracy. NN models have the advantage of being distribution-free, and they avoid the problem of determining the influence of the sources in a multisource data setting. New advances in NN methods facilitate solving large scale problems for which previously the computational complexities of the training methods were prohibitive. In this research, digital terrain data and Advanced Very High Resolution Radiometer (AVHRR) 10-day composite data acquired in 1992 and 1993 over Indiana and Illinois were used to test the ability of NN methods for small scale soil mapping.

## INTRODUCTION

Earth observation sensors are producing data with great potential for use in scientific and technological investigations in very large and ever increasing quantities (Atkinson and Tatnall, 1997). Artificial Neural Networks have been used for the remotely sensed imagery classification since late 1980's (Kanellopoulos and Wilkinson, 1997). Neural networks have been trained to perform complex functions in various fields of application including pattern recognition, identification, classification, speech, vision, and control systems. Today neural networks can be trained to solve problems that are difficult for conventional computers or human beings (Demuth and Beale, 1992).

Recently, there has been a resurgence of research in neural networks. Neural network models have an advantage over the statistical methods in that they are distribution-free, and no prior knowledge is needed about the statistical distributions of the classes in the data sources in order to apply these methods for classification.

The neural network methods also take care of determining how much weight each data source should have in the classification. A set of weights describes the neural network, and these weights are computed in an iterative training procedure. On the other hand, neural network methods can be very complex computationally; A lot of training samples is required for successful applications, and their iterative training procedures usually are slow to converge. Also neural network methods have more difficulty than do statistical methods in classifying patterns which are not identical to one or more of the training patterns. The performance of the neural network models in classification is therefore more dependent on having representative training samples, whereas the statistical approaches require an appropriate model of each class (Benediktsson et al. 1990).

## LITERATURE REVIEW

In remote sensing, classification is one of the main applications of neural networks. Howald (1989), McClelland et al. (1989), Hepner et al. (1990), Downey et al. (1992), all applied neural networks to classify land cover from Landsat Thematic Mapper (TM) imagery and all found varying degrees that the neural approach was more accurate than traditional statistical classification. Compare to conventional statistical methods, neural networks has significant advantages for the multi-source data classification. Benediktsson et al. (1990) successfully applied neural networks on the integrated data set of Landsat MSS imagery and topographic data sets (elevation, slope and aspect) for the land cover classification. Similar study was carried out by Peddle et al. (1994) to classify land cover in Alpine regions with multi-source data. Ersoy and Hong (1990) studied new neural network architecture called the parallel, self-organizing, hierarchical neural network (PSHNN). Multisource data set from mountainous area in Colorado, Landsat MSS data and DEM data (elevation, slope, aspect) were used to address some important problems with NN such as network complexity, learning and recall times, fault tolerance, and quality of generalization. They reported that one of the attractive



properties of PSHNN is error detection at the end of each stage neural network (SNN). This would make possible the avoidance of back-propagation errors stage to stage to learn weights, the avoidance of the requirement for differentiable and invertible non-linearities, faster learning time, since few training vectors are utilized in later stages, parallel operation of SNN's during testing, real time adaption to nonoptimal connection weights by adjusting the error detection bounds, and thereby achieving very high fault tolerance and robustness.

## **MATERIAL AND METHODS**

### **MATERIAL**

#### **DATA SOURCES**

The study area selected for this research includes central and southern Illinois and Indiana. Advanced Very High Resolution Radiometer (AVHRR) data, collected by NOAA satellites and digital topographic data derived from Digital Elevation Model (DEM) were used in this research.

The AVHRR sensor on board the NOAA-10 satellite provides global multispectral coverage in five spectral bands; 0.58-0.68  $\mu\text{m}$  (channel 1), 0.72 -1.10  $\mu\text{m}$  (channel 2), 3.55-3.93  $\mu\text{m}$  (channel 3), 10.50-11.50  $\mu\text{m}$  (channel 4) and 11.50 - 12.25  $\mu\text{m}$  (channel 5). In addition to the 5 spectral bands a Normalized Difference Vegetation Index (NDVI) data set was produced and added as a 6<sup>th</sup> band.

The 3-arc-second DEMs available through the USGS Earth Resources Observation System (EROS) Data Center provide a comprehensive coverage for the entire US. These elevation data are at a scale of 1:250,000 (cell resolution of ~100m) and are available over the Internet at no cost. In this research the 3-arc-second DEM data for Illinois and Indiana were downloaded from Internet.

In this research two different sets of reference soil maps (Soil Region Map and Major Land Resource Areas, adapted from STATSGO) were used.

### **METHODS**

#### **DATA PREPARATION**

From the files of cloud free data, three sets (1-10 April 1992, 21-30 July 1993, 21-30 September 1993) of AVHRR 10-day composite data were down-loaded from the Internet. Data over the central Midwest of the USA (including Indiana and Illinois) registered to Albers Equal Area map projection systems.

DEM derivatives of Slope (the rate of maximum change in average z value from each cell to its neighbours), Aspect (positive degrees from 0 to 360, measured clockwise from the north), Relief (the range of elevation) and Landform Class (Hammond Approach) Layers were produced using ArcInfo/Grid software.

Two different sets of reference soil maps, Soil Region Map and Major Land Resource Areas derived from STATSGO were prepared. The soil maps for STATSGO are compiled by generalizing more detailed soil survey maps. This data set is a digital general soil association map developed by the National Cooperative Soil Survey. In this research STATSGO data for Illinois and Indiana were downloaded from the Internet at no cost

Map units of STATSGO data with 200m spatial resolution were resampled to 1000m spatial resolution and reclassified (merged) into 13 classes according to their MUID (map unit identification) code to prepare an MLRA map of Central and Southern IL and IN as a reference map.

In this research in addition to the unified soil region map of Illinois and Indiana, soil region maps of Illinois and Indiana were prepared separately.

STATSGO map units were reclassified (grouped) to prepare the Soil Region Reference Map of Indiana and Illinois. These maps have not been digitized. But for this research STATSGO map units were reclassified based on information from these general maps.

#### **DATA INTEGRATION**

After the resampling of all data sets to the same spatial resolution (1000 m) and same map projection (Albers Equal Area Map Projection System), all AVHRR 10-day composite data and DEMs (aspect, DEM, relief, slope, landform) were integrated into a new data set.



## ARTIFICIAL NEURAL NETWORKS

The Back Propagation learning rule was used in this research. Back propagation was created by generalizing the Widrow-Hoff learning rule to multiple layer networks and non-linear differentiable transfer functions. In order to achieve Neural Network Classification, MATLAB Neural Network Toolbox was used in this research. Two reference maps were tested MLRA and Soil Region Map of IL-IN and two different training sampling strategies were used; 1 - Non-Random signatures; and 2 - Random signatures.

## ACCURACY ASSESSMENT

At the completion of the classification exercise it is necessary to assess the accuracy of the results obtained. This will allow a degree of confidence to be attached to those results and will serve to indicate whether the analysis objectives have been achieved. Accuracy is determined empirically, by selecting a sample of pixels from the thematic map and checking their labels against classes determined from reference data. Often reference data are referred to as ground truth. From these checks, the percentage of pixels from each class erroneously labeled into each of the other classes is calculated. These results are then expressed in tabular form, often referred to as a confusion or error matrix. Classification for training samples and for image data for all images were calculated and represented in this research. Since it is recognized that the reference maps represent at best approximation of truth, the use of terms "error or accuracy" often lead to misunderstanding or misinterpretation of classification results. For this reason, "agreement" was used instead of "error or accuracy" in this research.

## RESULTS and DISCUSSION

One of the main objectives in this research is to test the ability of NN methods for small scale soil mapping using digital terrain data and Advanced Very High Resolution Radiometer (AVHRR) 10-day composite data. One of the main tasks for the classification was choosing small-scale reference map(s). For this reason, only available digital data, STATSGO, was used to generate small-scale soil maps. Two different sets of reference soil maps, Soil Region Map and Major Land Resource Areas derived from STATSGO were prepared for both states.

Neural network classification results of integrated imagery (AVHRR 10-day composite data set and topographic data set) for both reference maps of the MLRA and Soil Region Maps will be discussed. Two different training sampling strategies were used; 1 - Non-Random signatures; and 2 - Random signatures. First, training samples were tested many times to get highest training pixel classification accuracies, latter, these training samples used for image data classification.

## RESULTS

Overall Training Pixel Classification Accuracies (TPCA) and Image Data Classification Agreements (IDCA) for both study (reference maps of MLRA & Soil Region) were presented in Table 1 and 2. In the first step MLRA reference map was tested to compare AVHRR data and integrated data of AVHRR and topographic data set. The highest training pixel classification accuracy (62.1 %) was observed with 10-day composite data set for the non-random (supervised) sampling. For the image data classification, 10-day composite data integrated topographic data set (41.9%) with random sampling gave the highest accuracy value.

Table 1. Overall TPCA & IDCA of the image data set for the MLRA study.

	RANDOM (R)		NON-RANDOM (NR)	
	10d	10d + adrs	10d	10d + adrs
TPCA	48.0	52.5	62.1	60.9
IDCA	26.1	41.9	41.0	39.7

10d: 10-day composite data set, a: aspect, d: DEM, r: relief, s: slope

After getting increasing values, integrated data set of satellite and topographic data was used for the Soil Region study. In addition to topographic data set effect of Hammond landform classification was tested. The highest TPCA (62.0%) were found in 10-day composite data integrated

Table 2. Overall TPCA & IDCA of the image data set for the Soil Region study

	RANDOM (R)		NON-RANDOM (NR)	
	10d + adrs	10d + adrsh	10d + adrs	10d + adrsh
TPCA	51.5	56.8	62.0	52.9
IDCA	44.2	37.3	43.7	41.1

10d: 10-day composite data set, a: aspect, d: DEM, r: relief, s: slope, h: Hammond Landforms

with topographic data (10d+adrs) for non-random treatment sampling algorithm. The highest IDCA (44.2%) was observed in the 10d+adrs (random) band combination. In general supervised classification gave higher results than random sampling algorithm.

Class weights (coverage %) were important factors for TPCA and IDCA results. Error Matrices were very useful to evaluate study results. IDCA error matrices of the 10d+adrs (R) image data set is presented in Table 3.

Table 52. IDCA error matrices of the 10d+adrs(R) image data set

IDCA	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
C1	0.0	0.0	0.0	77.6	0.0	2.1	0.8	0.5	0.0	0.0	7.1	0.0	11.9	0.0	0.1	0.0	0.0	0.0
C2	0.0	0.0	0.0	61.3	0.0	0.0	1.7	5.5	0.1	0.0	22.0	0.0	9.1	0.0	0.2	0.0	0.0	0.0
C3	0.0	0.0	0.0	49.8	0.1	4.1	2.3	10.2	0.3	0.0	21.4	0.0	10.5	0.0	1.3	0.0	0.0	0.0
C4	0.0	0.0	0.0	63.5	0.0	0.0	0.4	1.9	0.1	0.0	14.5	0.0	19.5	0.0	0.1	0.0	0.0	0.0
C5	0.0	0.0	0.0	40.7	4.5	0.1	0.5	2.9	0.0	0.0	2.0	0.0	49.3	0.0	0.0	0.0	0.0	0.0
C6	0.0	0.0	0.0	24.7	0.0	32.5	6.8	0.7	0.0	0.0	3.0	0.0	32.3	0.0	0.0	0.0	0.0	0.0
C7	0.0	0.0	0.0	39.9	0.0	3.0	25.1	14.2	0.2	0.0	8.1	0.0	9.5	0.0	0.0	0.0	0.0	0.0
C8	0.0	0.0	0.0	20.6	0.0	0.1	2.3	68.2	0.1	0.0	7.4	0.0	1.4	0.0	0.0	0.0	0.0	0.0
C9	0.0	0.0	0.0	35.8	0.0	0.1	19.1	43.4	1.0	0.0	0.1	0.0	0.6	0.0	0.0	0.0	0.0	0.0
C10	0.0	0.0	0.0	1.7	0.0	0.6	12.7	84.2	0.2	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
C11	0.0	0.0	0.0	12.6	0.0	0.0	0.1	0.6	0.0	0.0	83.5	0.0	2.8	0.0	0.1	0.0	0.0	0.0
C12	0.0	0.0	0.0	68.1	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	31.3	0.0	0.0	0.0	0.0	0.0
C13	0.0	0.0	0.0	7.2	0.0	0.0	0.5	0.1	0.0	0.0	2.9	0.0	89.3	0.0	0.0	0.0	0.0	0.0
C14	0.0	0.0	0.0	24.3	0.0	0.3	0.7	0.7	0.1	0.0	6.4	0.0	67.6	0.0	0.0	0.0	0.0	0.0
C15	0.0	0.0	0.0	36.4	0.0	0.0	0.0	1.7	0.1	0.0	43.5	0.0	16.9	0.0	1.3	0.0	0.0	0.0
C16	0.0	0.0	0.0	21.5	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	29.5	0.0	0.0	0.0	0.0	0.0
C17	0.0	0.0	0.0	55.0	0.0	0.0	0.0	0.5	0.0	0.0	19.0	0.0	24.0	0.0	1.5	0.0	0.0	0.0
C18	0.0	0.0	0.0	29.3	0.0	0.0	0.7	10.1	0.0	0.0	59.9	0.0	0.6	0.0	0.0	0.0	0.0	0.0
W	1.2	1.3	1.4	2.7	10.6	10.6	1.0	1.0	1.0	1.0	2.2	1.6	0.1	0.2	1.0			

IDCA error matrices of 10d+adrs(R) image data set reveal that IDCA were 0.0% for 9 classes out of 18 class. Classes of 1, 2, 3, 10, 12, 14, 16, 17, and 18 were resulted in 0.0% IDCA. Except for Class3 (14.7% area coverage), all of the classes (1, 2, 10, 12, 14, 16, 17, and 18) cover only 6.3% of the study area. Class 4 with the largest study area coverage (27.3%) gave relatively high IDCA (63.5%). IDCA of 4.5%, 25.1%, 1.0%, 1.3% were very low for Class 5, 7, 9 and 15 which occupy 11.1% of the study area. Classes of 8, 11 and 13 gave very high IDCA (68.2%, 83.5% and 89.3%). Misclassified pixels were generally in class 4 (27.3%), class 7 (5.9%), class 8 (6.3%), class 11 (14.6%) and class 13 (4.8%).

## DISCUSSION

The major objective of this study was to assess the utility of satellite multispectral images and digital topographic data as supplemental tools for the generation of small scale soil maps and recommendations for the possible improvement of existing small scale maps. The approach in this study was to use a variety of existing maps which represent in some way generalized soil patterns and properties in the states of Illinois and Indiana. These generalized representations or maps of the soils



of Illinois and Indiana were used in this study as the standard or "ground truth" with which to compare quantitatively maps or images derived from the integration and classification of satellite images and topographic data. These maps which were used as the standard for comparison include a wetlands map, Soil Survey Associations (STATSGO), Major Land Resource Areas, and Soil Region Maps.

The approach and the attempt to integrate and compare a broad range of disparate sources of spatial data are fraught with difficulties and sometimes questionable assumptions. Even so, some interesting observations and results were obtained, and much was learned in this research effort about preparation, manipulation, analysis and interpretation of spatial data sets. Although sources of error cannot always be identified, even when these sources are identified it may be impossible to quantify the amount of the error attributable to a specific source. Some of the known errors inherent in the data source or errors introduced in the preparation of data lie in the registration or co-registration process. Errors are introduced when 100 m DEM data are generalized to 1000 m data. Information is lost and/or noise is introduced in the process of merging extremely small classes with larger classes for reclassification.

Date of collection of remotely sensed data for optimal identification and delineation of meaningful variations in soil patterns and conditions can have dramatic effects on classification results. How can one interpret or evaluate quantitatively the differences in classification results from multispectral data collected over the same area but on different dates and seasons? Even with all these temporal, spectral and spatial variables, it was possible to draw some conclusions and observe trends in relationships between classifications obtained from the combinations of spectral and topographic data and existing soil maps.

The soil association map was derived or adapted from the STATSGO map. Even though the same guidelines were used in preparing STATSGO maps of Indiana and Illinois, maps of the different states lack uniformity, and soil unit boundaries at the state boundary often appear unnatural. In several cases the map unit lines near the state boundary appear to be brought to closure artificially rather than to cross the state boundary as it appears they should. The density of STATSGO map units in Indiana appears to be significantly higher than in Illinois. This might explain why quite different "accuracies" are found when a supervised classification of data (satellite and topographic data) for Indiana and Illinois are compared with a combined (both states) soil association (STATSGO) map. When the same study is made for each state separately, the "accuracy" of the classification for Illinois alone is significantly higher than for the combination of the two.

The scope of this study did not include an evaluation of the accuracy of existing maps which were used as the standards for comparison with the classifications of the study areas. For the purposes of this study, the existing maps were assumed to be "truth." Everyone who generates any natural features of the earth surface--soils, geology, vegetative cover--knows the perils of trying to represent those features accurately on a map, of assuming the map to be truth. At best any map is an approximation of what the mapper believes his/her observations to represent. The statement that a supervised classification of a spatial data set (digital satellite image, DEM) is 61% accurate suggests that the existing map is correct or right and the classification is only fair or wrong. In reality, the classified image may be a better representation of the soil patterns and variations in soil properties and conditions than is the existing map. Rather than express the difference between the existing soil map and the classified image as "classification accuracy," it would be more appropriate to express this difference in "percentage of pixels which are in agreement." Then to evaluate these results, it would be necessary to conduct a statistically sound field study to verify or assess the quality of both the existing map and the classification.

Neural Network (NN) methods showed great potential in pattern recognition for multisource, remotely sensed data and satisfactory results were observed. They are superior to statistical methods in terms of classification accuracy. NN models have the advantage of being distribution-free, and they avoid the problem of determining the influence of the sources in a multisource data setting. NN methods have the advantage to facilitate solving large-scale problems for which previously the computational complexities of the training methods were prohibitive. Very long processing time was one of the main disadvantages of the NN methods. On the other hand, they have to be trained very well to get higher accuracies.

The mapping of soils is an expensive and time-consuming enterprise. During recent years, the emergence of a broad array of new sensors and earth observation tools, access to remarkably accurate



and reliable global positioning systems (GPS), and the availability and use of GIS technology offer to the soil science community a previously unavailable set of tools for the generation of better, more accurate, and more accessible spatial soils information systems. However, there is much research and development and education yet to be done before the integration and use of these new technologies in soil classification and survey become a reality.

## REFERENCES

- ATKINSON, P. M. and Tatnall, A. R. L., 1997, Neural networks in remote sensing. *International Journal of Remote Sensing*, 18, 699-709.
- BENEDIKTSSON, J., PHILIP, H. S., and OKAN K. E., 1990. Neural Network Approaches Versus Statistical Methods in Classification of Multi-source Remote Sensing Data, *IEEE Transactions on geoscience and remote sensing*, 28:4, 540-551.
- DEMUTH, H. and BEALE, M., 1992, *Neural Network Toolbox User's Guide*. The Math Works Inc. 24 Prime Park Way, Natick, MA 01760.
- ERSOY, O. K., and HONG, D., 1990, Parallel self-organizing, hierarchical neural networks. *IEEE Transactions on Neural Networks*, 1, 167-178.
- HEPNER, G. F., LOGAN, T., RITTER, N. and BRAYANT, N., 1990, Artificial neural network classification using a minimal training set: comparison to conventional supervised classification. *Photogrammetric Engineering and Remote Sensing*, 56, 469-473.
- HOWALD, K. J., 1989. Neural network image classification. *Proceedings of the ASPRS-ACSM Fall Convention* (Falls Church, VA: ASPRS), 207-215.
- KANELLOPOULOS, I. And WILKINSON, G. G., 1997, Strategies and best practise for neural network image classification. *International Journal of Remote Sensing*, 18, 711-725.
- McCLELLAND, G. E., DeWITT, R. N., HEMMER, T. H., MATHESON, L. N. and MOE, G. O., 1989, Multispectral image-processing with three-layer back-propagation network. *Proceedings of the International Joint Conference on Neural Networks*, 1 (New York: I.E.E.E.), 151-153.
- PEDDLE, D. R., FOODY, G. M., ZHANG, A., FRANKLIN, S. E. and LEDREW, E.F., 1994, Multisource image classification II: an empirical comparison of evidential reasoning, linear discriminant analyses, and maximum likelihood algorithms for alpine land cover classification. *Canadian Journal of Remote Sensing*, 20, 397-408.

# THE VALIDATION OF PI MODEL FOR SOIL ORDERS IN ANKARA

Senay Özden, Kezban Şahin, Sebahattin Keskin  
Soil and Fertilizer Research Institute

## ABSTRACT

The aims of the study were to validate the applicability of Productivity Index Model, which is acceptable among other models of similar nature in terms of estimating likelihood relationships between erosion and productivity to the widespread soil orders in Ankara and to determine soil loss tolerance on the basis of soil orders by using Productivity Index (PI).

Study was carried out at five location in wheat and barley fields. Soil samples were taken from horizons of 35 soil series previously surveyed and mapped as Entisol, Inceptisol and Aridisol were subjected to some physical and chemical analyses. Data obtained from laboratory analyses of each location were entered into the model as data files.

Erosion rates were calculated for each series by using TURTEM (Turkey Erosion Estimation Model). By making use of 10 ton/ha/year value, which was erosion rate obtained from the studies of USLE parameters and data accrued from the aforementioned research, three version of PI model were run. In addition, soil loss tolerances were calculated by employing PI values. Three versions of PI model were evaluated on the basis of yield, crop, and soil order. According to the results, version 1, which gave the most significant correlation than others is recommended. The fact that a difference between 0.05 – 0.10 was recorded in PI values discloses that erosion has significantly affected the yield and soil conservation practises have to be taken.

## INTRODUCTION

Soil erosion depletes soil productivity, but the relationship between erosion and productivity is not well defined. Until the relationship adequately developed, selecting management strategies to maximize long-term crop production will be impossible (Brown, 1984; Lal, 1993).

The relationship between soil productivity and soil erosion has participated in important issue of soil science for centuries. Simenson stated that the first model of productivity index was used by Chinese 40 centuries ago (Kiniry at all, 1983).

The new approaches have been dealt with recently in order that the changes in soil productivity are determined regarding soil erosion and the models of this approaches have begun to be confirmed by many soil scientist (Wilson, 1991). These new approaches as follows:

1. The Erosion-Productivity Impact Calculator (EPIC) (Williams at all, 1983)
2. The Productivity Index Model (PI) (Kiniry at all, 1983).

The principle of PI Model is a function of soil condition because of the fact that productivity is a function the growth of plant root, PI model describes the profile of plant root growth and it connect the relationship the gradual of development with productivity.

## MATERIAL AND METHODS

### The Model

The Productivity Index Model provides a relatively simple method to assess the impact of erosion on crop production. For different soil depth, the sum of the multiplication of relative values of five different soil parameters state that soil stratum, which are the issue of being examined, the gradual of convenience for the growth of plant root. The basis of the original model was to define the response of a crop in terms of available water (A); aeration (B); bulk density (C); pH (D) and electrical conductivity (EC).

These factors are expressed as sufficiency ratings which range from 0 to 1. The Productivity Index (PI) equation is as follow:

$$PI = \sum_{i=1}^n (A_i \times B_i \times C_i \times D_i \times E_i \times WF_i)$$

Where WF is a weighting factor related to root distribution in each soil layer 'i', and 'n' is the number of soil layers.

In Version 1, PI is calculated as the product interaction of available water, transmission porosity, pH and electrical conductivity sufficiencies weighted according to the theoretical root distribution function.

In Version 3, PI is calculated as the minimum of transmission porosity, pH and electrical conductivity sufficiencies weighted according to the theoretical root distribution function and then modified by the sufficiency of total plant available water store.

In Version 4, PI is calculated as the minimum of available water, transmission porosity, pH and electrical conductivity sufficiencies weighted according to the theoretical root distribution function.

### The Equation Of Soil Loss Tolerances

PI may be used to estimate quantitative soil loss tolerance levels (Pierce et al., 1984) based on a soil's productivity, its vulnerability to productivity losses from erosion, an allowable reduction in productivity and a planning horizon in years.

$\nabla$  =  $P_{lo} - P_{lt}$  = The change of productivity according to time.

$d = d_0 - dt$  = the change of depth according to time

$\Delta = (\nabla / P_{lo}) * 100$  = Permissible decrease in productivity = t/cm/ha

$P_{lo}$  = PI value at the beginning

$P_{lt}$  = PI value according to time

$V = (\nabla / d) * 100$  = Vulnerability index

$T_1 = (\Delta * P_{lo} * \chi) / V * t$  = Soil loss tolerances,  $\chi$  = Bulk density, gr/cm<sup>3</sup> \* 100

### DISCUSSIONS

Disturbed and undisturbed soil samples taken from the horizons of Entisol, Inceptisol and Aridisol profiles were analysed for the purpose of determining field capacity, wilting point, EC, pH, texture (very fine sand, sand, silt, clay), organic matter. Data obtained from laboratory analyses were entered into the model as data files.

Erosion rates were calculated for each series by using TURTEM (Turkey Erosion Estimation Model) (Özden and Özden, 1997). For that purpose, R factor was obtained from published reports, K factors were determined from laboratory analysis by using TURTEM; slope length was considered 100 m and steepness of slope was taken from published reports belonging to series; P factors were assessed according to the tillage method used and C factors were calculated from data on crop management described in terms of average sowing date, harvest date, average yield of grain, and typical timing and operation of tillage or crop residue management practices.

PI's three versions were run by using erosion rates of soil series calculated from TURTEM and 10 ton/ha/year (the erosion rate) obtained from experiments pertaining to USLE parameter studies (Doğan ve Küçükçakar, 1996). Three version of PI model were evaluated on the basis of soil orders, crops and yields (Figure1-4).

At the same time, soil loss tolerances were calculated by using all the PI values. Different results were found regarding soil loss tolerance by series. The values varied from 0.9 to 48.8 ton /ha/year and 10 ton/ha/year according to erosion properties of the series and changed between 6.6-15.5 ton/ha/year.

In PI1 version, the lowest value for Kule series as 0.0228 and the highest value for Polatlı series as 0.5627 were recorded. After 100 years, Çuğlu series would have the lowest (0.000) value and Çayırılı series would have the highest value (Table1).

In PI3 version the lowest (0.04) value is of Bahçe arkası and the highest value (0.8267) is of Çayırılı series. In PI4 version, the lowest value was obtained in Kule series as



0.026. The highest value for Küçükdağ series (0.6851) was recorded. After 100 years, the same series would have the lowest and the highest values (Table1).

As to limiting factor for plant root growth, versions has given different results. For example, In PI1 and PI3, the first horizon of Aktaş series (Erosion rate is 10 ton/ha/year) while there is no aeration problem in first 15 years, after 15 year, model has shown that the water will be problem in the future in that horizons and the other horizons will have aeration and water problem, also. In PI4 version for that series the same aeration will be problem for first horizon, after 15 year, there will be no problem in the same horizon.

According to 10 ton/ha/year and erosion rate, while evaluating first version of PI, limiting factors have changed in Esenboğa, İşletmealtı, Zir ve İkizce series. It has not changed the limiting factors. In 3.version, Altınova, İşletmealtı, Esenboğa, Yüzükbaşı, Zir, İkizce serieses, some changes was obtained. Limiting factors has changed in 4. Version for Aktaş, Zir ve İkizce series. In general for 1.ve 4 version, water will be problem, in 3. version pH will be problem.

According to the results, PI1 version is more accurate than the others. The correlation coefficient between PI1 version was found around  $r=0.78$  in relation to the productivity values of wheat in the different series of Aridisol and the relationship was found to be important in 0.05 levels. The equation is  $y=1858.4+4985X$ . The first version which gave the highest correlation among the three versions is recommended. Unlike 4.version which presented similar results to 1.version, 3. versions which also gives different results showed that pH factor in the soils where there is no pH problem was a substantial factor hindering the growth of plant root when evaluating the analysis values of soil in this sense, 3. version wasn't suitable.

Differences in PI values were between 0.05-0.10 shows that practices of soil conservation should be taken because of the fact that erosion has considerably effect on productivity. In this sense, PI values of most series which were studied in the execution of project has low PI. Therefore, some management practice must be taken in order to reduce the erosion.

## SUGGESTIONS

- The results of PI model are of importance in terms of taking precaution as to crop and soil management practices against erosion and conserving soil productivity in sustainable agricultural.
- Model gives important results that in low erosion rate by years soil productivity will not reduce, and in high erosion rate, loss of soil productivity will increase.
- Negative factors affecting plant growth can be prevented by estimating limiting factors.
- In soil conservation planning, soil series should be taken in to consideration because of their different characteristics and behaviours.
- LS factors should be estimated by GIS techniques.
- Different results were found regarding soil loss tolerance by series. It is essential that soil loss tolerance and the other criterions as regards catchment should be taken into account.
- The value of soil loss tolerance obtained by model results shows the importance of evaluation in the series base. Tolerance values obtained from PI model is not enough alone to express soil loss tolerance values. Therefore overall watershed characteristics should be taken into account.

Table 1. PI values of three versions according to years, erosion rates

According to erosion rates which is 10 ton /ha/year			4 Version					3 Version					According to the erosion rates derived from TURTEM					4 Version					C (t)	Y (t)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
SOIL	ORDERS	SERIES	1 Version			2 Version		3 Version		4 Version		1 Version			2 Version		3 Version		4 Version		HD (cm)	H <sub>0</sub> (cm)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
			0 year	50 year	100 year	0 year	50 year	100 year	0 year	50 year	100 year	0 year	50 year	100 year	0 year	50 year	100 year	0 year	50 year	100 year			0 year	50 year	100 year																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
ARIDISOL	PHAEOLUK	0.1143	0.1301	0.1509	0.163	0.1858	0.1728	0.2012	0.2012	0.1143	0.1176	0.1217	0.163	0.1684	0.1798	0.1524	0.1571	0.1872	1.76	2.50	4	W																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
ARIDISOL	CAKNAKXANI	0.1178	0.1313	0.1486	0.090	0.0959	0.1028	0.1357	0.2012	0.1143	0.1280	0.1425	0.090	0.0949	0.1043	0.1473	0.1812	1.76	2.50	3	W																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
ARIDISOL	DILALL PINAR	0.0978	0.0814	0.0652	0.108	0.0878	0.0717	0.1262	0.1051	0.0841	0.763	0.9278	0.9582	0.947	1.08	1.063	1.043	1.223	0.68	0.90	120	3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
ARIDISOL	HOYLUK	0.5142	0.5112	0.5066	0.649	0.6164	0.5818	0.5766	0.5720	0.5654	0.259	0.5142	0.5141	0.5149	0.6326	0.6151	0.5766	0.5745	4.82	5.20	3	B																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
ARIDISOL	ISLETME ALTI	0.1292	0.1530	0.0000	0.178	0.2036	0.2338	0.1653	0.1940	0.2292	0.644	0.1295	0.1426	0.1627	0.178	0.1949	0.1571	0.1653	0.141	0.2077	1.3	6	4																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
ARIDISOL	KUCUKDAV	0.5304	0.5379	0.5504	0.727	0.7109	0.6851	0.6933	0.7061	0.7174	0.5304	0.5323	0.5344	0.727	0.7248	0.7226	0.6951	0.6872	0.6886	2.68	2.70	118	4																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
ARIDISOL	KUNISEKT	0.3347	0.3320	0.3293	0.595	0.5819	0.5684	0.3756	0.3731	0.3704	0.5848	0.3347	0.3340	0.3333	0.585	0.5816	0.5880	0.3756	0.3749	0.373	1.58	1.40	108	4																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ARIDISOL	ONTIHOJ	0.2616	0.2356	0.1845	0.465	0.4139	0.4071	0.2660	0.2553	0.2008	0.346	0.2616	0.2568	0.2519	0.485	0.4612	0.4567	0.2660	0.2603	0.2584	2.15	1.40	108	4																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ARIDISOL	SARISIRI	0.2762	0.2338	0.2002	0.180	0.0849	0.0907	0.3955	0.4018	0.4075	0.246	0.2762	0.2695	0.2622	0.342	0.340	0.342	0.3955	0.3902	0.3885	0.40	0.39	29	2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ARIDISOL	SIRILIFR	0.2497	0.2457	0.2350	0.340	0.1314	0.0948	0.4323	0.4249	0.4158	0.211	0.2497	0.2422	0.2342	0.340	0.3255	0.3252	0.4323	0.4268	0.4242	0.60	0.56	35	3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ARIDISOL	TANIRCIKLIK	0.4863	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.4857	0.485

(\*) CSD : Cumulative soil depth (cm), ER: Erosion rate (ton/ha/year), HD: Horizon depth(cm), H: Horizon number, C: Crop name (W: Wheat, B: Barley), Y: Yield (kg/ha)

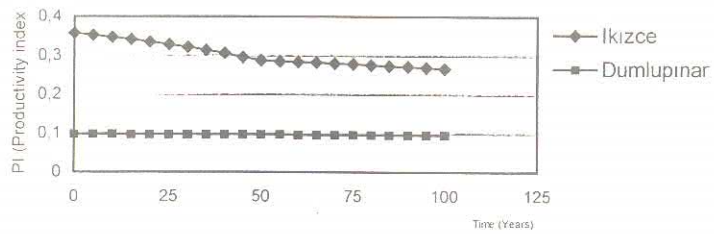


Figure1. Effect of erosion on soil productivity in PI1

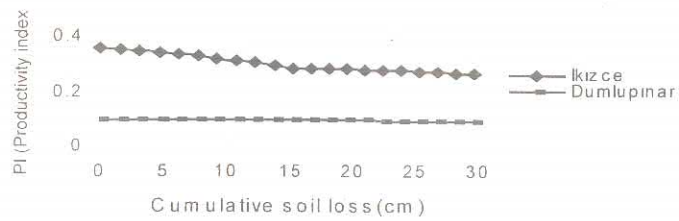


Figure2. Effect of erosion on soil productivity in PI1



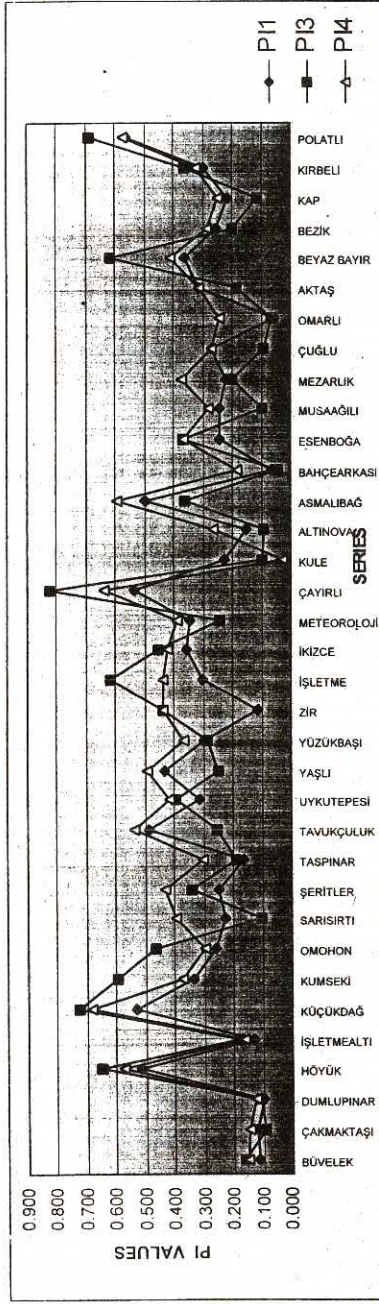


Figure 3. Comparison of PI version's initial values according to the erosion rates derived from TURTEM

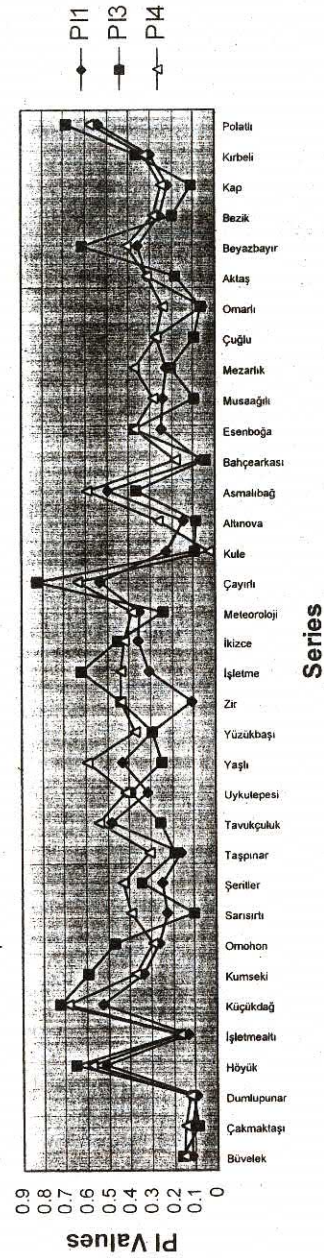


Figure 4. Comparison of PI version's initial values according to 10 ton/ha/year (the experimental erosion rate)

## REFERENCES

- Brown L.R. (1984). The global loss of top soil. *Journal Of Soil and Water Conservation* 39:162-165.
- Doğan, O. ve Küçükçakar, N. 1996. Ankara yöresinde üniversal toprak kaybı eşitliği parametreleri. Köy Hizmetleri Ankara Araştırma Enstitüsü Yayınları, Genel Yayın No:199, Rapor Seri No:105, Ankara.
- Kiniry L. N., Scrivner L.C. & Keener M.E. (1983). A Soil Productivity Index Based Upon Predicted Water Depletion and Root Growth. University of Missouri -Colombia
- Lal R. (1993). Monitoring Soil Erosion's Impact on Crop Productivity. *Soil Erosion Methods*. Soil and Water Conservation Society.
- Özden Ş. & Özden D.M. (1997). Erozyonu Azaltmak Amacıyla Yönetim Metodlarının Seçiminde Yardımcı Olacak Bilgisayar Programının Geliştirilmesi. 1995-1996 Yılı Araştırma raporu. K.H.G.M., T.G.A.E Müdürlüğü yayınları, Genel yayın no:219, Rapor seri no: R-135, Ankara
- Pierce F.J., Larson W.E., Dowdy R.H. & Graham. W.A.P. (1984). Soil Loss Tolerance: Maintenance of Long -Term Soil Productivity *Journal Soil and Water Conservation* 39 (1) : 137
- Williams J.R., Renard K.G. & Dyke P.T. (1983). EPIC A New Method For Assessing Erosion's Effect on Soil Productivity. *Journal of Soil and Water Conservation*. 38 (5) : 381-383
- Wilson J.P., Sandor S.P. & Nielsen G.B. (1991). Productivity Index Model Modified to Estimate Variability of Montana Small Grain Yields. *Soil Science Soc. Am. J.* 55:228-234.

# QUANTITATIVE DETERMINATION OF EROSION BY USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS IN THE VICINITY OF ANKARA ÇUBUK DAM LAKE

Senay Özden<sup>(1)</sup>, Nuri Munsuz<sup>(2)</sup>

<sup>(1)</sup> Soil and Fertilizer Research Institute

<sup>(2)</sup> Ankara University, Agricultural Faculty, Soil Science Department

## ABSTRACT

Due to stimulating topographic structure, erosion is a crucial problem in Turkey. In this study, objective was to determine, through quantitative modelling using RS and GIS techniques, changes resulted from occurrence of erosion by years. Materials used in the study include aerial photos of 1969 and 1995 at scales of 1:21000 and 1:4000 respectively, topographic, soil and geological maps of 1:25000 scale, Landsat 7 images, camera and triangulation information of the aerial photos. Digital elevation points produced by means of photogrammetric digitization of aerial photographs were transformed into grid model with grid interval of 0.5 meter.

Changes took place on land surface were calculated by extracting digital elevation of 1995 from the digital elevation classes of 1969 which are produced by DTMs. Quantities of eroded and accumulated material were determined and expressed as t/pixel/26 years and t/ha/year by combining variation values, pixel areas and numbers and bulk density of soil samples. Calculation have revealed that 8 t/ha/year of soil has been lost including road construction in eroded areas, whereas 18.30 t/ha/year of soil has been gained in accumulation areas in various forms. By omitting road construction area's data, 13.08 t/ha/year of soil has been lost in eroded areas that includes erosion between 1 - 25 cm.

Key Words : Erosion, gully, modelling, geographical information systems, remote sensing, Çubuk dam, image analysis

## INTRUDUCTION

The data accumulation studies realised for the purpose of modelling the soil erosion aims at the determination of the methods that can be used for the prevention of erosion and together with these methods can be adopted for the designation of the best model of land use. This can sometimes be in the form of defining the degree of erosion and sometimes in the form of constituting a model on the basin by having data about factors accumulated the factors that are controlling erosion. The high rate of resolution possessed by the remote sensing data and the developed data processing technologies have rendered possible the accumulation and evaluation of the partial data.

The unwanted accumulation of the eroded material is a very general explanation for the sedimentation problem. At the basin areas, the problem regarding the general condition of sediment control initiates with the erosion of the soil by the effect of water or wind. Within the scope of the basin protection projects, the reduction of the amount of erosion and the improvement of sedimentation problems constitute the basic objectives. For this purpose, it is necessary to acquire information including the intensity of the problems encountered. This information that are necessary can be achieved within a short period of time with the help of Geographical Information Systems (GIS) and the Remote Sensing (RS) techniques. The GIS and RS techniques are gaining a significant importance in the recent years from the viewpoint of obtaining the data used in relation with the erosion and sediment estimation models and the model studies that are operated or formed at GIS environment with the adoption of these models. The data such as the cover of vegetation, the length of the slope, the characteristics of the soil, the hydraulic parameters and the land usage are providing numerous conveniences for the transactions regarding the transfer of the present maps to a digitised medium, the processing and storage of the acquired data, the obtaining of new data from the present data via cross – examinations and for the intensive and costly field studies lasting for long periods of time.

This study has been carried out for the purpose of designating the change that has been formed by erosion from the environmental viewpoint at the areas surrounding the Çubuk Dam Lake by benefiting from the quantitative modelling for reasons as dictated above and to determine the dimensions of the erosion at this region.



## MATERIAL AND METHOD

### Material

The investigation area is approximately 1000 hectares and covers the Çubuk 1 Dam Lake and the area surrounding it. The investigation area is situated at the North of Ankara and lies in the North – South direction. The distance of the Çubuk County that gives its name to the plain, to Ankara is 40 kilometres. The area lies between the 32° 68' - 32° 88' Western longitudes and the 40° 00' - 40° 03' Northern latitudes (Çinkaya 1993). In this study, the 1:21000 scaled aerial photographs for the year 1969 and the 1:4000 scaled aerial photographs for the year 1995 in relation to the area of study and obtained from the General Directorate of Title and Cadastre the General Directorate of Ankara Water and Sewer Administration, the elevation data obtained by the digitisation of these aerial photographs by the adoption of photogrammetric methods, the triangulation information regarding the aerial photographs and the camera calibration information, the satellite images, the geological, topographical and soil maps and the studies realised by other institutions regarding the subject have been used. The project has been carried out at the GIS and RS laboratories at the Soil and Fertilizer Research Institute and by benefiting from the softwares and hardware related with the geographical information systems of the Soil and Water Resources National Information Centre Soil and Water Resources Research Section of which is affiliated with the General Directorate of Rural Services. Within the scope of the study, TNTmips 6.2, Intergraph MicroStation 95, ArcInfo 7.2.1, Erdas Imagine 8.1 and ArcView 3.1 softwares have been used. On the other hand, the base materials used in the digitisation of the aerial photographs were the 1:25000 scaled topographic maps, 1:21000 scaled aerial photographs for the year 1969, 1:4000 scaled aerial photographs for the year 1995, the coordinates of the ground control points regarding this project and the camera calibration information.

### Method

Within the scope of the study, the digital Terrain models obtained by using the elevation data acquired from the digitised aerial photographs have been used as a base. Taking horizontal cross – sections and the realisation of the volume analyses and erosion determination transactions on these bases constitute the method of the study (Welch et al. 1984, Dymond et al. 1986). In the preparation of the data that have been digitised by photogrammetric methods with the adoption of the Micro-Station 95 software, the stages involving the transfer of the aerial photographs to a digital medium through a scanning transaction, the realisation of Aerial Triangulation measurements by using the aerial photographs already transferred to a digital medium, the balancing of aerial triangulation, digitisation and the accumulation of DTM points have been followed.

## DISCUSSION

### Digital Terrain Models

Within the scope of this study, grid models have been constituted from the digital Terrain models at 50 cm grid intervals, by using the digital elevation point data obtained by the digitisation of the aerial photographs at a scale of 1:21000 for the year 1969 and of the aerial photographs at a scale of 1:4000 for the year 1995 through photogrammetric methods. The grid models have been prepared by the use of the ArcView 3D modules. The digital elevation points adopted for the modelling studies are presented in Figures 1. and 2. On the other hand, the digital elevation classes produced from this digital Terrain model are presented in Figures 3. and 4. Since the IDW method has been adopted as a program interpolation technique, the grid system has also been realised by the adoption of this method.

### Erosion Calculations

The digital elevation classes of two different dates have been transferred into the ArcInfo program and their differences are taken. The new map thus obtained (Figure 5.) is currently representing the difference acquired as a result of erosion between the years in question. Depending on the positive and negative values of the pixels obtained from this map that has been formed and also on the constant areas, a classification has been realised and the results are presented in Figure 6. While the positive values in relation to the pixels stand for the presence of erosion, those of the negative values for the pixels stand for the presence of accumulation. By the studies performed on this map, it has been determined that the amount of erosion ranges between 1 cm and 60 cm and that the amount of accumulation ranges between 1 cm and 99 cm. The positive values were mostly obtained at the

points with high steep slopes, at abandoned riverbeds and at the gully areas. At these areas, it was as well observed that there existed certain accumulation points and that especially at the upper sections of the area and at the regions where foresting has been realised, it was determined that the amount of accumulation exceeded that of the erosion. At the agricultural land located at the upper sections of the area of study, it was observed that there were no changes in general.

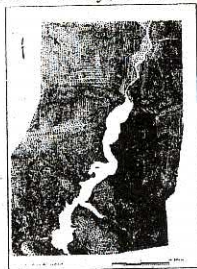


Figure 1. Digital Elevation Points (1969)

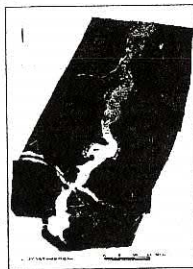


Figure 2. Digital Elevation Points (1995)



Figure 3. Digital Elevation Classes (1969)



Figure 4. Digital Elevation Classes (1995)

Within the scope of the study, the size of one pixel was organised so as to be at a value of 50 x 50 cm, while the area of the pixel was 0.25 m<sup>2</sup>. The difference in elevation against each of the pixel numbers is calculated in terms of cm and these values are multiplied by 0.25 m<sup>2</sup>, which is the area of a single pixel. Therefore, the values thus obtained were converted into m<sup>3</sup>. After this, the amount of soil lost at the pixel is converted into tons by multiplying the achieved value with 1.33 g/cm<sup>3</sup> that represents the average of the specific gravity values found for the soil samples taken from the area of study. By multiplying the pixel numbers belonging to the elevation differences with the ton values, the amount of loss that was formed during a period of 26 years was determined. By the accumulation of these values, it was calculated that the amount of soil loss formed at the entire erosion pixels in a period of 26 years were 97326.19 tons. By the division of this value as calculated above to 26, it was found out that the amount of soil loss realised in a period of one year were 3743.315 tons. The total number of pixels for the eroded areas was determined as 8180267. By multiplying the pixel number with the pixel area, it was found out that the area of the land under the effect of erosion was 204.52 hectares, and that an erosion at a value of 8.00 tons/hectares/year was observed annually at the area subject to erosion, which is found by dividing the amount of soil lost annually from the pixels to the area of the pixels. Widespread soil group forming in at the area of study is the brown soil group at a rate of 94 %.

Upon the comparison of the value of erosion obtained with that of the 10 tons/hectares/year erosion value that represents the value of the soil loss attained experimentally for the brown soil group in uniform parcel studies, it was observed that there exists a conformity between these values (Doğan and Küçükçakar 1996).

As can be observed from the erosion map, the area of erosion arising from the construction of roads that is regarded to be unnatural was subtracted from the total erosion values, and thus only the amounts of soil loss belonging to the natural areas of erosion were calculated. For this purpose, the pixel numbers of the areas that were subjected to erosion at an amount ranging between 1-25 cm were added and the total number of pixels were found out to be 7967843. By multiplying this number with 0.25 m<sup>2</sup> that represents the area of a single pixel, it was found out that the area that was subjected to erosion at an amount ranging between 1-25 cm was 199.19 hectares. It was thus determined that within a total period of 26 years, a total amount of 67752.11 tons of soil was lost from these pixels and that an amount of soil at an annual rate of 13.08 tons/hectares/year is removed. The three - dimensional images of the area formed by imparting an exaggeration to the digital elevation data have been displayed (Figure 8.) and by also overlapping, the observation of the colour differences thus formed as well as the positive and negative changes has been rendered over the surfaces.





Figure 5. Map of Extracted Digital Elevation Classes



Figure 6. Classified Variation Map of Terrain Surfaces



Figure 7. Classified Erosion Map

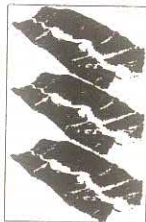


Figure 8. 3-Dimensional Image and overlapped surfaces



Figure 9. Orthophoto of Study Area (1969)

### Cross – Sections

These models of two different dates that were transferred to the Erdas Imagine program have been coincided on top of each other by the adoption of the later stack analysis. On the new layer thus obtained, horizontal cross – sections were taken at different points. The horizontal cross – section points are shown on the image in TIF format as presented in Figure 9. The report files of the horizontal cross – sections were transferred into the Excel program, the graphical representations of the elevation differences arising due to the erosion encountered at the area were drawn and these unscaled graphical drawings are presented through Figures 10 - 17.

As can be observed from the examination of the cross – sections, various changes have been realised on the surface of the land during a period of 26 years depending on the characteristics of the topography. This abandoned river bed that was selected as one of the horizontal cross – sectional areas, as can be observed from the figure presented below (Figure 10 ), is one of the areas suffering from the greatest amount of erosion. Despite the abundance of erosion at the area, there exist scarce locations where there are no changes or where there are accumulation points, due to reasons such as the isolated covers of vegetation on the surface that reduces the erosion of soil or the presence of stones or coarse materials that are difficult to be moved by the surface flow. Since the area of study is not a basin that is bounded by the water separation line, even though it is not possible to monitor the changes at the upper and lower sections of the basin that would mean erosion, the following horizontal cross – sections have been taken for the purpose of examining the differences that have been formed from the viewpoint of erosion, ranging from the upper sections of the area towards the lower portions of the area where the slope is increasing. By taking cross – sections at the points of the area that can be defined as the upper, intermediate and the lower sections of the same area, the differences in the changes observed alongside a slope depending on the steepness of slope are presented in the sample horizontal cross – sections provided in figures 11, 12 and 13. At the areas where the above – presented horizontal cross – sections are taken, it was observed that the amount of accumulation, rather than the amount of erosion, was too much. The reasons for this are the foresting and terracing studies realised at the area and the fact that the location represents a accumulation point for the soil originating from the upper sections of the basin. Upon the examination of the cross – section 6 taken at the lowest section of the area, it was determined that the amount of erosion was much more than the amount of accumulation and that there exists an erosion despite the presence of a cover of vegetation at especially the locations where the steepness of the slopes are increasing towards the vertical. At the



area of study, within the horizontal cross – section samples taken from the surface of the lake vertically towards the crest, it is clearly observed that the area of the lake is narrower at the upper sections of the lake due to sediments, while the surface of the lake is wider towards the crest; in addition it is observed especially in horizontal cross – section samples numbered (figures 14, 15) 5 and 6 that the soil coming via erosion after the year 1969 are accumulated at the upper sections of the lake and at the boundary area. Even though the degree of change within the horizontal cross – section samples taken parallel to the area of the lake seem to be very little, it is as well observed that there exists a certain amount of accumulation at the hillsides and a certain amount of erosion at the gullies between the hills ( Figures 16, 17 ).

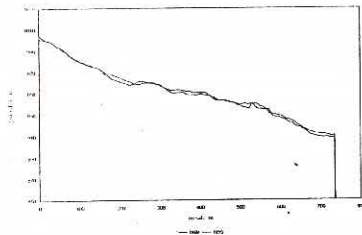


Figure 10. Cross-section 1

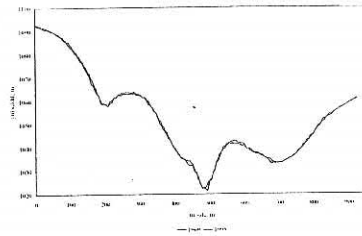


Figure 11. Cross-section 2

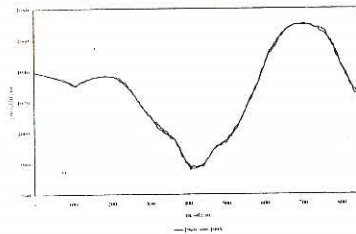


Figure 12. Cross-section 3

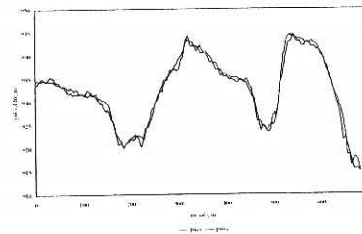


Figure 13. Cross-section 4

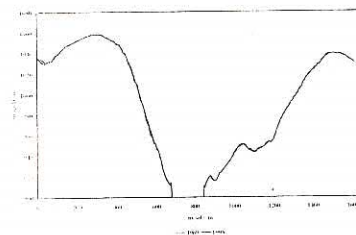


Figure 14. Cross-section 5

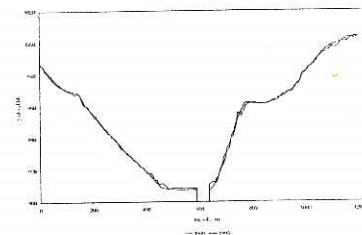


Figure 15. Cross-section 6

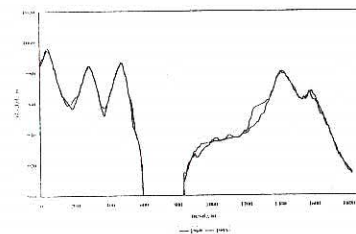


Figure 16. Cross-section 7

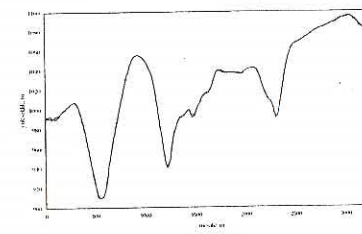


Figure 17. Cross-section 8

The horizontal cross – sections are especially reflecting the change that has occurred at the base of the gullies in an excellent manner. The area left between the two horizontal cross – sections and the depth measurements to be realised at the field , as well as the volume of the soil moving from that point can be easily calculated; and besides, the progresses developed at the gullies can be calculated in a much less time period when compared to traditional field studies, by taking points with GPS at pre-determined time intervals and by adopting these data together with the others.

## RECOMMENDATIONS

The quantitative modelling, which during the recent years presents a significant importance among the methodologies adopted for the designation of erosion and that has achieved major advancements in accordance with the improvements obtained in the computer technologies, is gaining an increasing importance. This investigation, which presents a difference from the viewpoint of the methodology approaches from the studies that have been realised in our country until today, is representing a first with this aspect.

In this modelling study, the basic foundations of which are formed by aerial photographs, the frequent difficulties encountered regarding appropriate area and appropriate scale of photographing are arising due to the differences in the subjects of studying of the institutions responsible from the taking of aerial photographs in our country and the scale of the photographs in relation to these subjects, as well as the absence of the taking of photographs at regular intervals. In accordance with these problems, the scales of the aerial photographs that can be obtained are possessing different scales, while it was impossible to obtain appropriate photographs for past periods.

Despite the difficulties dictated above, the fact that the recent advancements regarding photogrammetry in our country are being followed and that they are carried out successfully has rendered positive contributions to the study. By the help of the digitisation realised in accordance with the sensitivity of the study, the differences between the details of the scale were minimised.

The area selected in accordance with the supply of photographs is rendering difficulty the studying of the entire parameters in the attempt to provide an explanation for the erosion and accumulation points. From the viewpoint of the better studying of the results of the erosion and accumulation, it is necessary to handle such studies on the basis of the basins bounded by the water separation line. Therefore, the source of the incoming soil can be more clearly explained and also the factors affecting accumulation as well as the erosion can be better interpreted.

In order to be able to test the results of the studies, the execution of similar studies in the following years at the areas involving more frequent field observation values is gaining an increasing importance. In parallel with this statement, the increasing of the studies to be executed all over the country on the subject of constituting a database in our country shall render the acceleration of the studies on the basis of mostly databases such as the remote sensing and geographical information systems, as well as the increasing of the number of the related studies. This methodology that can generate reliable results within short period of time in the subjects such as the gully erosion that necessitate more comprehensive field studies, provide an opportunity for monitoring the changes that arise within short time intervals.

## REFERENCES

- Çinkaya, N. 1993. Ankara metropoliten alanı içerisinde kalan Çubuk vadisi ve çevresinin arazi kullanım planlaması. Yüksek Lisans tezi (basılmamış). Ankara Üniversitesi, Ankara.
- Doğan, O. ve Küçükçakar, N. 1996. Ankara yöresinde üniversal toprak kaybı eşitliği parametreleri. Köy Hizmetleri Ankara Araştırma Enstitüsü Yayınları, Genel Yayın No:199, Rapor Seri No:105, Ankara.
- Dymond, J. R. and Hicks, D. L. 1986. Steepland erosion measured from historical aerial photographs. Journal and Water Conservation. 41-4; 252-255.
- Welch, R., Jordan, T. R. and Thomas, A. W. 1984. A photogrammetric technique for measuring soil erosion. Journal of Soil and Water Conservation. 39; 191-194.

# THE DETERMINATION OF RELATIONSHIPS BETWEEN PHYSICAL PROPERTIES OF SOME GREAT SOIL GROUPS IN THE ANTALYA REGION AND WATER EROSION UNDER SIMULATED RAINFALL

Kezban Şahin<sup>(1)</sup>, Zeki Alagöz<sup>(2)</sup>

(1) Toprak ve Gübre Araştırma Enstitüsü, Ankara, Turkey

(2) Akdeniz Üniversitesi, Ziraat Fakültesi, Toprak Böl., Antalya, Turkey

## ABSTRACT

The experiments were carried out to determine relationships between water erosion and some physical properties of Terra Rossa (Red Mediterranean Soil/Alfisol) and Brown Forest Soils (Inceptisol) in the Antalya region under the simulated rainfall conditions. For this purpose, soil samples taken from the two different regions were brought to the study area and sieved through an 0.8 cm mesh and placed in the flume to form a layer of 10 cm deep over the gravel layer which was placed in 5 cm thickness on the base of the flume. A flume with a diameter of 500x80 cm and a longitudinal gradient of 8 % was designed. Two rainfall simulators with multiple nozzles producing 3.4 mm. average raindrop in diameter, 51 mm/hour rainfall intensity and 0.55 ton-m/4m<sup>2</sup> total kinetic energy were used. A total of 60 minutes rainfall, 30 min + 10 min break + 30 min, was applied on the soil, and runoff and soil losses were determined. The results of the study showed that both soils are susceptible to soil erosion, whereas Brown Forest Soil is more prone to erosion than Terra Rossa Soil.

## INTRODUCTION

Today soil erosion is a major problem in Turkey and all over the World. It causes degradation of soils and the environmental pollution. About 75 % of soils in Turkey have been affected by water erosion in different intensities. In the Antalya region it appears as a serious problem due to harsh conditions and high amount of precipitation that fall mainly in winter season (57 %). 551767 ha (32.4 %) area of the land in this region is influenced by the water erosion due to destruction of the natural plant cover and/or agricultural practices applied on very steep slopes. Severely eroded areas of 800283 ha (47.1 %) are mainly used as pasture, natural plant cover which was forest and dry agricultural lands before degradation.

It is a thought that simulated rainfall studies is a useful tool to predict the properties of soils that should be considered in the conservation practices to combat soil erosion. Few studies carried out in the region to determine the relationship between soil properties and erosion. Hence, increases in researches about soil erosion is very important in terms of soil conservation studies.

Soils properties are important factors governing the susceptibility of soils to erosion. Olson and Wischmeier (1963) stated that responses of soils to water erosion depend on their composition. Because of differences in their inherent properties, soils exhibit different degrees of susceptibility to the forces generated by erosion agents. All other forces remaining the same, differences in erosion up to 30- fold have been observed due to differences in soil properties. In a study of Bhatia et al (1985) it was found that erosion ratio and dispersion ratio were significantly positively correlated alluvial soils of the Budelkhand and Vindhyan regions of Utter Pradeshi.

Plot studies at the Hilton experimental site, Shropshire (U.K), showed that small reductions in soil organic matter content markedly increased erodibility and erosion rates (Fullen, 1991).

Sanroque et al. (1991), studied that the relationships between soil erodibility and chemical properties were studied in 12 soils from Valencia (Spain) using a laboratory rainfall simulator. Organic matter content and structural stability were the two properties most correlated with soil erodibility.

Sejonnig and Rickson (1994), carried out some experimental studies about susceptibility of some Danish soils to water erosion under simulated rainfall, and found that surface runoff and soil loss were greatest for sandy soils but they were reduced by clay content and soil porosity.

The main goal of this study was to determine the relationships between some physical properties of two great soil groups, Red Mediterranean Soil and Brown Forest Soil in the region, and



water erosion under the simulated rainfall. Results obtained from the study will be a tool to use in soil conservation practices.

## 2. MATERIALS & METHODS

### 2.1. Soils and erosion indices

In the study two great soil groups, Terra Rossa Soil (Red Mediterranean Soil/Alfisol) which covers 26 % (5473332 ha.) of the catchment and the other is Brown Forest Soil (Inceptisol) which occupies 15.9 % (326246 ha) of the catchment, were chosen considering the covered area and agricultural importance. Disturbed soil samples taken from the surface of the both soils on the flume were used to perform the analyses of Organic Matter, CEC, Exchangeable Cations,  $\text{CaCO}_3$  equivalent and pH as described in Kacar (1995).

After determination of the texture of the samples (Uzunoglu, 1992), some erosion indices were calculated such as Clay Ratio (CR) (Bouyoucos, 1935), Silt Ratio (SR), % of Aggregates Smaller than  $50\mu\text{m}$  (Taysun, 1977), Dispersion Ratio (DR) (Lal, 1990), Structure Stability Index (SSI) (Tüzüner, 1990), Erosion Ratio (ER) (Özden, 1992), K Factor (Wischmeier & Smith, 1978).

### 2.2. Experimental study

Disturbed soil samples taken were sieved through an 0.8 cm mesh. After some gravels were placed on the flume in 5 cm. depth, the soils were placed on the gravel layer as a 10 cm thick layer and then watered to obtain field capacity after 48 hours waiting time. Before the study, surface of the soil layer was disturbed in a 3-4 cm depth and then soil samples were taken to use in some physical and chemical analyses.

A flume with a diameter of 500x80 cm and a longitudinal gradient of 8 % was designed. Two rainfall simulators with multiple nozzles (Gardena Polo 280) producing 3.4 mm. average raindrop in diameter (Laws, 1941), 51 mm/hour rainfall intensity and 0.55 ton-m/  $4\text{m}^2$ / hour total kinetic energy (Doğan & Gücer), were placed on the both side of the flume. A rainfall intensity of 51 mm/h was chosen, considering the rainfall intensity in the region.

A total of 60 minutes rainfall (30 min +10 min break + 30 min) was applied on the flume and runoff and soil losses were determined. Transported soil materials were deposited in the collector in the bottom of the flume, while sediment in suspension was collected in buckets which were placed under the collector.

## 3. RESULTS & DISCUSSION

Analyses results showed that major differences in the soils in terms of physical and chemical properties were organic matter content and texture (Table 1 and 2.)

Table 1. Some chemical properties of soils used in the experiment

Great Soil Group	PH	$\text{CaCO}_3$ (%)	O.M. (%)	CEC Me/100g	$\text{Ca}^{++}$ Me/100g	$\text{Mg}^{++}$ Me/100g	$\text{K}^+$ Me/100g	$\text{Na}^+$ me/100g
Terra Rossa Soil	7.76	0.83	1.53	37.25	33.4	0.74	0.81	0.23
Brown Forest Soil	7.85	0.83	3.11	40.54	24.2	9.1	0.17	0.17

Table 2. Textural properties of soils used in the experiment

Great Soil Groups	Texture	Sand %	Silt %	Clay %	Very F. Sand %
Terra Rossa Soil	C	25.4	31.6	43	2.8
Brown Forest Soil	SCL	56.9	14.3	28.8	1.0

Sand fraction was dominant in the Brown Forest Soil, whereas clay was more than others in the Terra Rossa Soil which had affected the erosion indices determined (Table 3.)

Both of the soils were in the susceptible category for soil erosion in terms of clay ratio (CR), silt ratio (SR), structure stability index (SSI), aggregate percentage of less than 50  $\mu\text{m}$ , erosion ratio (ER) and the factor of K. However, as there have also been some differences between the soils in terms of indices of CR, SR, SSI, ER and K factor, Brown Forest Soil was more susceptible to soil erosion than Terra Rossa Soil. Especially ER value of Terra Rossa Soil was half of that of Brown Forest Soil, and percent of aggregate less than 50  $\mu\text{m}$  for Terra Rossa Soil was more than that of Brown Forest Soil. Therefore, it is found that the previous soil is more resistant than the latter one in terms of transportation of particles by surface runoff. This is consistent with the study of Meyer and Harmon (1984) which showed that poorly aggregated high-silt soils were most erodible and the high-clay soils were least erodible.

Table 3. Some erosion indices of soils

Great Soil Groups	Clay Ratio	Silt Ratio	Structure Stability Index	Dispersion Ratio	Agg. <50 $\mu\text{m}$ . (%)	Erosion Ratio	K Factor
Terra Rossa Soil	0.34	0.73	43.74	41.37	58.63	35.51	0.12
Brown Forest Soil	1.32	0.49	20.43	52.55	47.45	69.88	0.13

The results obtained showed that total soil loss from Terra Rossa Soil was less than Brown Forest Soil. The rate of surface runoff formed in Terra Rossa Soil was 96 lt / 4m<sup>2</sup> which is 47 % of the total application of 204 l/4m<sup>2</sup> of rainfall, causing a total of 1249 g/ 4m<sup>2</sup> soil loss, whereas in Brown Forest Soils, runoff occurred as 138 lt/4m<sup>2</sup> which is 68 % of the total rainfall of 204 l/4m<sup>2</sup> applied and the total soil loss was 2144 g/ 4m<sup>2</sup>. It can be seen from these figures that Terra Rossa Soil was more resistance to soil erosion than Brown Forest Soil (Table4).

These results are consistent with the results obtained by Taysun (1977) and Dokumacı (1987). They showed that Terra Rossa Soil, a great soil group, is fairly resistant to water erosion, whereas Brown Forest Soil is not so). As can be seen from the study, it is that the mainly textural and structural properties enable Terra Rossa Soil to be resistant against water erosion.

Consequently, it is possible to conclude from the results that physical properties of soils, especially texture and degree of aggregation and their stability, and indices obtained using physical properties are important parameters to explain strengths of soils against water erosion.

Table 4. Runoff and amount of transported soil material obtained from the suspension  
And collector.

	Terra Rossa Soil (Alfisol)		Brown Forest Soil (Inceptisol)	
	Runoff (lt/4m <sup>2</sup> )	Soil loss (g/4 m <sup>2</sup> )	Runoff (lt/4m <sup>2</sup> )	Soil loss (g/4 m <sup>2</sup> )
Rainfall I. (First 30 minute)	33.6	301.3 (in suspension)	66.9	328.1 (in suspension)
Rainfall II. (Second 30 min.)	62.4	352.7 (in suspension)	72.1	105.9 (in suspension)
Total soil loss (in suspension)	-	654.0	-	434.0
Total soil loss (in collector)	-	595.0	-	1710.0
<b>TOTAL</b>	<b>96.0</b>	<b>1249.0</b>	<b>138.0</b>	<b>2144</b>

#### 4. REFERENCES

- Bhatia K. S., Narain B. and Nath J. (1985). Erodibility of some Uttar Pradesh soils in relation to their nutritional behaviour. Indian Forester. (111): 610-614.
- Bouyoucos G. J. (1935). The clay ratio as a criterion of susceptibility of soil to erosion. J. Am. Soc. Agron. Madison. 27: 738-741.
- Doğan D. ve Güçer C. (1976). Su erozyonunun nedenleri oluşumu ve üniversal denklem ile toprak kayıplarının saptanması. Topraksu Genel Müdürlüğü, Merkez Topraksu Araştırma Enstitüsü Müdürlüğü yayınları. Genel Yayın No:21, Teknik Yayın No:24: ANKARA.
- Dokumacı T. (1987). İzmir ili ve çevresinde bulunan bazı Terra-Rossa topraklarının önemli fiziksel özellikleri ve bunun erozyon ile olan ilişkileri üzerinde bir araştırma. Yüksek lisans tezi. Bornova-İZMİR.
- Fullen M. A. (1991). Soil organic matter and erosion processes on arable loamy sand soils in The West Midlands Of England. Soil Technology. 4:19-31.
- Lal R. (1990). Soil properties and erodibility. Soil Erosion In Tropics; Principles and Management. pp.60-99.
- Laws J.O. (1941). Measurements of the fall velocity of water drops and raindrops. Papers, Hydrology. 709-721.
- Meyer L.D. and Harmon W.C. (1984). Susceptibility of agricultural soils to interrill erosion. Soil Science Society Of America Journal, 48:1152-1157.
- Olson O.C. and Wischmeier W. H. (1963). Soil erodibility evaluations for soils on the runoff and erosion stations. Soil. Sci. Soc. Am. Proc. 27:590-592.
- Özden Ş. (1992). Doğu Anadolu Bölgesinde yaygın bazı büyük toprak gruplarının aşınımına duyarlılığı üzerine bir araştırma. Atatürk Üniversitesi Fen Bilimleri Enstitüsü Toprak Anabilim Dalı. Yüksek lisans tezi. ERZURUM
- Sanroque P., Rubio J. L. and Izquierdo, L. A. (1991). Relationship of soil erodibility with other soil physical and chemical properties determined by a laboratory simulator in soils from Valencia, Spain. Revue-D'ecologie-Et-De-Biologie-Du-Sol 27(2):135- 146.
- Schjonning P. and Rickson J. (1994). Soil erodibility in relation to soil physical properties. Conserving soil resources: European perspectives. Selected Papers From The First International Congress of The European Society For Soil Conservation. 78-86.
- Taysun A. (1977). Bornova ve civarında mevcut büyük toprak gruplarının bazı fiziksel özellikleri ile bunların erozyonla olan ilişkileri üzerinde araştırmalar. Doktora Tezi. Bornova- İZMİR.



Tüzüner A. (1990). Toprak ve Su Analiz Laboratuvarları El Kitabı. T.C Tarım ve Köy İşleri Bakanlığı Köy Hizmetleri Genel Müdürlüğü. ANKARA.

Uzunoglu, S. (1992). Toprak Bünyesi ve Analiz metodları. T.C. Tarım ve Köy İşleri Bakanlığı, Köy Hizmetleri Genel Müdürlüğü, Toprak ve Gübre Araştırma Enstitüsü Müdürlüğü Yayınları, genel yayın No: 184, Teknik yayın No: T-64. ANKARA

Wischmeier W. H. and Smith D. D. (1978). Predicting rainfall erosion losses. A Guide To Conservation Planning U.S.D.A. Agriculture Handbook. No: 537.

## CHANGES IN VEGETATION AND SOIL PROPERTIES ALONG A SLOPE

Taşkın Öztaş<sup>1</sup>, Ali Koç<sup>2</sup>, Binali Çomaklı<sup>2</sup>

<sup>1</sup> Atatürk University, Faculty of Agriculture, Department of Soil Science, Erzurum-Türkiye

<sup>2</sup> Atatürk University, Faculty of Agriculture, Department of Field Crops, Erzurum-Türkiye

### ABSTRACT

Differences in soil formation along a hillslope result in significant differences in soil properties, plant production, and vegetation. The objective of this study was to determine changes in vegetation and soil properties along a slope in rangelands. Four study sites with three landscape positions; summit, backslope and footslope, were selected. In each landscape position, botanical composition, the rate of canopy coverage, the degree of rangeland quality, and some important surface soil properties were determined. The rate of grasses in botanical composition varied from 39.5 % to 84.0 %, and on the average, it was lowest at summit and highest at footslope positions. However, the rates of legumes at summit positions were lower than those of the other positions in two range sites. The rate of canopy coverage changed between 19.6 % and 45.2 %. The highest rates were obtained in footslope positions, but the lowest rates in summit. The degree of range quality varied between 3.2 and 5.5. Although, there was no significant differences among the positions regarding range quality degree, it was generally lowest at the summit positions. Clay content of surface samples was lowest at the backslope in all sites. But, there was no significant differences in clay contents of the summit and footslope positions. Changes in bulk density did not show significant trend along the slopes. It was generally higher in backslope and footslope positions than that of the summit position. Soil moisture content at soil sampling, organic matter content, and available P were generally higher at the footslope positions than those of backslope and summit. The CaCO<sub>3</sub> content of soil was lowest at footslopes in all sites.

### INTRODUCTION

Soil erosion, which is one of the most important causes leading to desertification, is a serious problem in many countries. Today, over 500 million tons of productive soil and large amounts of plant nutrients are lost mostly by water erosion every year in Türkiye.

Since the factors determining runoff and erosion are a consequence of complex interactions of vegetation and soil characteristics (Thurrow et al., 1986), soil erosion occurs at widely varying rates over the landscape, and even along a typical landscape profile within a small area (Foster, 1988).

Differences in soil formation along a hillslope result in significant differences in soil properties (Brubaker, et al. 1993), plant production (Jones et al., 1989) and vegetation (Bragg, 1978). Soil properties and vegetation can also be altered over time under different land uses and management systems.

In rangelands, grazing and more particularly overgrazing and its attendant effect of depletion of plant cover and litter and trampling of the soil is the most important factor contributing to erosion (Branson et al., 1981). The grazing lands of Türkiye are subject to quite heavy, uncontrolled grazing pressure and the forage production capacities of these lands are gradually decreasing, therefore, ultimately reflecting typical examples of land degradation all over Türkiye (Tükel and Hatipoğlu, 1996).

This study was conducted to determine botanical composition and changes in soil properties with topographical positions in selected rangelands.

### MATERIAL AND METHODS

Four study sites representing typic rangeland conditions of Erzurum province were selected. All sites, except Palandöken range site, have been subjected to heavy and nearly 9 months grazing pressure by livestock. Sheep fescue was the dominant species in all sites. The study sites have never been cultivated and located on gentle to steep slopes. Slope gradient varied from 2 to 4 % at summit, 30 to 45 % at backslope and 4 to 6 % at footslope. Each site had different direction,

and elevation at the range sites changed between 1770 and 2610 m (Table 1). All sites had similar topographical positions; summit, backslope and footslope.

Table 1. Elevation of Different Landscape Positions at the Range Sites.

Location	Direction	Elevation , m			
		Summit	Backslope	Footslope	Mean
Güzelyurt	East-faced slope	2050	1970	1900	1970
Kösemehmet	West-faced slope	2020	1850	1770	1880
Umudum	South-faced slope	2300	2150	2050	2160
Palandöken	North-faced slope	2610	2500	2400	2500

Three soil samples were collected from surface layer (0 – 10 cm) of each position, mixed and analyzed for some physical and chemical properties. Particle size distribution was determined by the hydrometer method (Gee and Bauder, 1986), bulk density by the core method (Blake and Hartge, 1986), soil moisture content at sampling by the gravimetric method, organic matter by the Walkey Black method (Schnitzer, 1982),  $\text{CaCO}_3$  content using the Scheibler calcimeter (McLean, 1982) and plant available-P by the Olsen method (Olsen and Sammers, 1982).

Botanical composition of the range sites was determined by the line intercept method developed by Canfield (1941). Measurements were taken over a 60 m long transect and the basal area was considered in the measurements. Using the botanical composition values (de Vries et. al., 1951), the range quality degree was determined for each range site. Range condition classification was performed based on the range quality degrees as; 0-2 is very poor, 2.1-4.0 is poor; 4.1-6.0 is moderate; 6.1-8.0 is good, and 8.1-10 is very good (Gökkuş et al., 1995).

The LSD test was used for multiple comparison procedures (Smith and Dowdy, 1983).

## RESULTS AND DISCUSSION

### Changes in Soil Properties

Clay content of soils was the lowest at the backslope positions of all sites (Table 2). This may due to severity of erosion on these sites. Although, clay contents of soil at footslope positions were generally higher than those of summit, except Umudum range site, there was no significant differences among them.

Changes in bulk density values did not show significant trend along the slopes. However, it was generally higher in footslope positions. This may be an effect of soil compaction as a result of higher soil moisture contents of footslope positions as compared to the others. Higher soil moisture contents at footslope positions were expected because of runoff and seepage effect from the upper slopes.

$\text{CaCO}_3$  contents of the range site soils were quite different from each other, which may be attributed to parent material.  $\text{CaCO}_3$  content of soil was the lowest at footslope positions in all sites. This indicates that footslope positions get excess water from the upper positions, which leached  $\text{CaCO}_3$  from the surface layer.

Organic matter content of soils was less than 2.1 % in the first three sites (Table 2). However, it was greater than 2.0 % in all positions of the Palandöken range site. Organic matter content was the highest at footslope positions which may directly related to higher surface cover rates in these sites, because of higher amounts of available water content for plant growth.

The range sites were not so different from each other respect to available -P content which varied from 3.2 to 6.1 kg- $\text{P}_2\text{O}_5$ /da. Similar to the variation of organic matter content, plant-available-P content was the lowest at backslope positions in all sites. These results indicated that the supply of nutrients in the study sites was generally not enough for optimal plant growth.



Table 2. Some Physical and Chemical Properties of the Range Site Soils.

Properties	Particle Size			Bulk Density g/cm <sup>3</sup>	Moisture %	Org. Matter %	CaCO <sub>3</sub> %	Ava-P P <sub>2</sub> O <sub>5</sub> /da
	Sand %	Silt %	Clay %					
Position	Güzelyurt							
Summit	34	37	29	1.54	4.8	1.6	6.4	4.1
Backslope	36	39	25	1.53	4.4	0.9	8.2	3.2
Footslope	31	32	30	1.67	7.3	1.7	4.1	4.7
	Kösemehmet							
Summit	29	36	35	1.44	6.1	1.2	13.2	5.2
Backslope	29	39	32	1.48	4.0	1.4	13.6	3.6
Footslope	25	39	36	1.51	6.9	2.1	10.9	4.4
	Umudum							
Summit	21	41	38	1.39	2.6	0.9	5.2	3.1
Backslope	26	38	36	1.42	3.2	1.1	5.7	3.2
Footslope	20	44	36	1.48	3.2	1.4	4.2	3.5
	Palandöken							
Summit	21	37	42	1.12	9.6	3.5	1.2	6.1
Backslope	25	33	42	1.24	7.3	2.1	1.3	3.9
Footslope	18	35	47	1.21	11.2	4.2	0.2	5.4

### Changes in Vegetation

Botanical compositions of the range sites given based upon basic plant groups were shown in Table 3, 4 and 5. The rate of grasses in the botanical composition varied between 39.5 % and 84.0 %. It was lowest at footslope positions of Güzelyurt, Kösemehmet and Umudum rangelands. In contrast, the rate of grasses increased from 49.7 % at summit position up to 84.0 % at footslope position of the Palandöken rangeland. On the other hand, the rates of legumes in botanical composition of summit positions were less than those of the other positions in Güzelyurt and Umudum range sites.

Table 3. The Rate of Grasses in Botanical Composition of the Range Sites.

Location	Footslope	Backslope	Summit	Mean *
Güzelyurt	39.5 C	47.1 BC	46.5 BC	44.4 B
Kösemehmet	46.3 BC	52.3 BC	50.5 BC	49.9 B
Umudum	41.5 C	43.7 BC	51.0 BC	45.4 B
Palandöken	84.0 A	62.4 B	49.7 BC	65.4 A
Mean	53.0	51.4	49.4	

\* Means shown by the same letter were not different.

The rates of other species, mostly invader species, were the highest at the summit positions of the three range sites. However, it was highest at the footslope position of Kösemehmet. Since, the increase of the rate of invader species in botanical composition of a site refers overgrazing (Holechek et.al., 1995), it could be concluded that the grazing pressure on the first three range sites was extremely higher than that of Palandöken range site.

Table 4. The Rate of Legumes in Botanical Composition of the Range Sites.

Location	Footslope	Backslope	Summit	Mean*
Güzelyurt	18.2 AB	9.6 AB	5.3 B	11.0
Kösemehmet	15.7 AB	5.1 B	16.3 AB	12.4
Umudum	22.2 A	18.5 AB	6.1 B	15.6
Palandöken	6.1 B	15.8 AB	11.2 AB	11.0
Mean	12.9	14.9	9.7	

Table 5. The Rate of Other Species in Botanical Composition of the Range Sites.

Location	Footslope	Backslope	Summit	Mean*
Güzelyurt	42.4 A	43.3 A	48.2 A	44.6 A
Kösemehmet	48.0 A	31.8 AB	33.3 AB	39.0 A
Umudum	36.3 AB	37.9 AB	42.9 A	37.7 A
Palandöken	9.8 C	22.2 BC	39.2 AB	23.7 B
Mean	34.1 b	33.8 b	40.9 a	

\* Means shown by the same letter were not different.

The rate of canopy coverage was lower than 45 % in all sites, and got down to 19.6 % at the backslope position of Güzelyurt range site (Table 6). The rate of canopy coverage was the highest at footslope position in all sites, except Kösemehmet. This may be a result of severity of erosion due to overgrazing.

Table 6. The Rates of Soil Canopy Coverage at the Range Sites.

Location	Footslope	Backslope	Summit	Mean*
Güzelyurt	25.3 de	19.6 f	19.9 ef	21.6 C
Kösemehmet	26.9 bcd	27.9 cd	31.9 bc	29.8 B
Umudum	34.9 b	26.8 cd	25.2 de	29.0 B
Palandöken	45.2 a	32.3 bc	34.3 b	37.2 A
Mean	33.7 A	26.7 B	27.8 B	

\* Means shown by the same letter were not different.

The degree of range quality changed between 3.2 and 5.5 (Table 7). The Palandöken range site had the highest range quality degree among the study sites. This indicates that the grazing pressure was less in the Palandöken range site as compared to the other range sites.

Table 7. Range Quality Degrees.

Location	Footslope	Backslope	Summit	Mean*
Güzelyurt	3.38 CD	3.60 CD	3.72 CD	3.57 C
Kösemehmet	4.01 BCD	4.20 BC	4.04 BCD	4.08 B
Umudum	3.20 D	3.51 CD	4.15 BCD	3.62 BC
Palandöken	5.51 A	4.76 AB	3.68 CD	4.65 A
Mean	4.03	4.02	3.90	

\* Means shown by the same letter were not different.

## CONCLUSION

The results of this study indicated that vegetation and soil properties along a hillslope had great differences. Clay content, bulk density, soil moisture at sampling, organic matter content and plant available P were generally higher at footslope positions as compared to the other positions. This means may that clay particles, organic matter and plant-available P were lost by erosion which occurred at more severe rates on the summit and backslope landscapes. However, the reason for high bulk density values at footslope positions was that the grazing pressure on footslopes was almost higher than upper landscape positions. On the other hand,  $\text{CaCO}_3$  content of soil was lowest at footslope positions of all range sites, which was attributed to leaching effect.

The range condition classes indicated that the range sites were either in poor or moderate class. Also, the canopy coverage rates reached the critical value, which was considered as 30 % (Marshall, 1973), for rapid water erosion in most parts of the range sites, even it was went below the critical value in some positions. Therefore, grazing pressure on these sites must be reduced by introducing effective range management systems.

Grasses are the dominant species in the climax plant community of rangelands with good quality (Holechek et al., 1995). However, in our research sites, except the Palandöken, the rate of grasses in botanical composition was lower than 50 %, which was a good indication of overgrazing



in these sites. If the current pressure on rangelands is continued, the rate of grasses in botanical composition gets lower and lower every year, as a trend of natural plant succession. All of these changes will cause low productivity and decline in biodiversity of our rangelands, and finally desertification.

All of these results showed that the rangelands around Erzurum province are under overgrazing pressure, as in all around Türkiye. Therefore, the utilization of rangeland according to management principles must be established, soil erosion must be controlled, and degraded rangelands must be taken into rehabilitation programme. Finally, the regulations foreseen in rangeland act which was legitimised in 1998 must be put in to practice.

## REFERENCES

- Blake, G.R., K.H. Hartge. (1986). Bulk density. In *Methods of Soil Analysis*. Klute A. (ed). Part I. 2<sup>nd</sup> ed. Agron. Monogr. 9 ASA and SSSA, Madison, WI. p. 363-375.
- Bragg, T.B. (1978). Effect of burning cattle grazing and topography on vegetation of the Choppy sand range site in the Nebraska sandhills prairie. *Proceedings of the First. International Rangeland Congress*. p. 248-253.
- Branson, F.A., Gifford, G.F., Renard, K.G., Hadley, R.F. (1981). *Rangeland hydrology*. Second ed. E.H. Reid (ed). Soc. Range Management Kendall/Hund Publ. Com. Iowa.
- Brubaker, S.C., Jones, A.J., Frank, K., Lewis, D.T. (1993). Regression models for estimating soil properties by landscape position. *Soil. Sci. Soc. Am. J.* 58: 1763-1767.
- Canfield, R.H. (1941). Application of the line interception method in sample range vegetation. *J. Forest*, 39: 388-394.
- De Vries, D.M., De Boer, T.A., Dirver, J.P.P. (1951). Evaluation of grassland by botanical research in the Netherlands. In *Proc. United National Sci. Cong. On the conservation and utilization of resources*. 6: 522-524.
- Foster, G.R. (1988). Modeling soil erosion and sediment yield. In *Soil Erosion Research Methods*. R. Lal (ed.). SWCS. p. 97-117.
- Gee, G.W., Bauder, J.W. (1986). Particle-size analysis. In *Methods of Soil Analysis*. A. Klute (ed) Part I. 2<sup>nd</sup> ed. Agron. Monogr. 9 ASA and SSSA, Madison, WI. p. 383-409.
- Gökkuş, A., Koç, A., Çomaklı, B. (1995). Çayır-mer'a uygulama klavuzu. Atatürk Üniv. Zir.Fak. Yay.No: 142, Erzurum, 139 s.
- Holechek J.L., Pieper R.D., Herbel C.H. (1995). *Range management principles and practices*. Prentice Hall, Inc, 526 p.
- Jones, A.J., Mielke, L.N., Bartles, C.A., Miller, C.A. (1989). Relationship of landscape position and properties to crop production, *J.Soil Water Conserv.* 44: 328-332.
- Marshall J.K. (1973). Drought, land use and soil erosion. In *the environmental, economic and social significance of drought*. (Ed: J.V. Lovett), Angus and Robertson Publ., Inc. p. 55-77.
- McLean, E.O. (1982). Soil pH and lime requirement. In *Methods of Soil Analysis*. A.L. Page et al. (eds) Part II. 2<sup>nd</sup> ed. Agron. Monogr. 9. ASA and SSSA Madison, WI. p.199-223.
- Olsen, S.R., Sommers, L.E. (1982). Phosphorus. In *Methods of Soil Analysis*. A.L. Page et al. (eds) Part II. 2<sup>nd</sup> ed. Agron. Monogr. 9. ASA and SSSA Madison, WI. p. 403-427.
- Schnitzer, M., (1982). Total carbon, organic matter, and carbon. In *Methods of Soil Analysis*. A.L. Page et al. (eds) Part II. 2<sup>nd</sup> ed. Agron. Monogr. 9. ASA and SSSA Madison, WI. p. 539-577.
- Smith, S., Dowdy, S. (1983). *Statistics for research*. John Wiley Sons. Inc. New York.
- Thurrow T.L., Blackburn, W.H., Taylor C.A. (1986). Hydrological characteristics of vegetation types as affected by livestock grazing syztems. *Edwards Plateau, Texas. J. Range Manag.* 39 (6): 505-509.
- Tükel, T., Hatipoğlu, R. (1996). Turkish grazinglands; Causes for misuse and likely measures of preventing degradation. *Int. Conference on Land Degradation*. June 10-14, Adana - Türkiye p. 53.



# INTERNATIONAL CONVENTIONS ON DESERTIFICATION & SUSTAINABLE DEVELOPMENT: PROBLEMS OF INADEQUATE INFORMATION CIRCULATION & URBAN-RURAL DIFFERENCES AS CONSTRAINTS ON LOCAL INVOLVEMENT IN AGENDAS TO COMBAT DESERTIFICATION

John Muhammed Jamil Brownson

Northern Rim Institute (Missoula, MT-USA) & Visiting Associate Professor of Geography  
Fatih University, College of Science and Literature Karaagac Yolu, Buyukcekmece, 34900 Istanbul,  
Turkey, Tel: office +90 212 889 08 10 — private +90 532 682 18 19

E-mail: [jam\\_bro@hotmail.com](mailto:jam_bro@hotmail.com)

## ABSTRACT

Places that face potential desertification share another common problem—a lack of information, resources, and connections to broader programs and agendas. Desertification has both biophysical and human dimensions, which include policy, planning, and socio-technical change. Scientific means exist to differentiate human from external factors of biosphere change in arid regions, separating drought from desertification, global climate from locally generated environmental change, and urban from rural environmental impacts. Technical measures exist to prevent, rehabilitate, or modify desertification where human settlement and economic activities are partly the cause. But few global programs effectively coordinate efforts with localities. Many such localities lack relevant information and resources to apply existing socio-technical procedures. They also suffer from inadequate distribution and access to expertise and information, technical and financial resources, public and administrative awareness and priorities, power to formulate and enact policy, and ability to organize and implement programs for increasing social learning and effective action. This paper identifies those problems as having rural and urban dimensions and the lack of an urban emphasis in agendas to combat desertification. It analyses relations between global agendas, programs, and local needs and infrastructure, concluding that systemic readjustments are needed to more effectively deliver assistance to localities. Proposed readjustments include suggestions for a global outreach policy and strategic plan to develop communication resources into an interactive network and information delivery system. Urban dimensions of desertification and urban roles in agenda and program development are emphasised as pivotal to providing focus and resources on the human aspects of local problems and solutions.

## INTRODUCTION

The causes of desertification and mitigation of its effects—problem & solution—raise innumerable complex questions. This paper offers a context within which to analyse institutional processes, and in which to develop a framework for information strategies that might more effectively coordinate research into causes and efforts to mitigation effects of desertification. The information age requires new approaches to manage and convert information into accessible knowledge with multi-levels applications. My research points to a critical nexus at which too much information, organization, and action meets too little of the same. As data and discourse relating to desertification inundate the global information networks and research communities, linkages lag producers and consumers often bypassing end users. At present no systematic mapping of the desertification discourse, information, and action structure is available, thus we are unable to easily identify **who is funded by whom to do what, where, and how.**

To map such a structure starts with a good relational database, which requires time, effort, and resources to design a system, ascertain what information and kinds of output are needed, then to collect and organize the data. Using computer graphics, it is then possible to map the information as diagrams, organizational and flow charts. Adding a GIS program it is also possible to locate the home base and territories of activity of each organization and lot their overlaps. While a number of desertification related databases presently serve the needs of particular institutions and specific topics, for example, *Mediterranean Desertification and Land Use* (MEDALUS) Spatial Database, among many others, there is no systematic linking of such databases, or an information *map* of the knowledge-action terrain. Therefore, identifying the key players and best venue for such a project answers questions about how to navigate the information highways and byways, and to store, manage, and retrieve practical data. The next step logically follows—to formally propose the project to

potential supporting institutions. One necessary caveat: the purpose is not to replace any existing or future database or access link, rather it is to map what exists and provide the broadest access and user-friendly interface as a tool for researchers, organizations or individuals in search of information on all facets of desertification. The next steps are, however, more complex. First, an evaluation and monitoring mechanism must be part of the data collection and management process. Second, a "user-friendly" interface must be designed to effectively disseminate and deliver information to end users. Last, the system must also be able to train and educate potential users to make practical use of it.

Aside from information sprawl and lack of coherence, mapping the desertification information environment must encourage broader accountability. This problem is not so much a matter of regulation, but of external monitoring, evaluation and feedback independent of any funding, or political process. Such a process would most effectively be linked to the database program. Likewise, a database needs constant maintenance to accurately reflect real time change, but professional expertise in information management remains scarce and often a low budget priority for many organizations. But such dynamic electronic libraries and their cyber-librarians are crucial to effective policy research and mitigation strategies. In society as in cyberspace, to transform basic daily life skills into integrated problem solving thought requires a new social learning, drawing on the past and what is contemporary, to assess trends, and to be able to convert information into action. Such behavioural shifts must also take place within an increasingly complex and multi-layered system of political, economic, and socio-technical information, investment, policy, organization, and action, much of which poorly interfaces with ordinary people and the ongoing normative rhythms of everyday life. The challenge here is not to fracture daily life rhythms, nor to supersede the often competing and conflicting agendas among institutions that comprise a web of organizations and discourses. Rather, the situation requires making sense of agendas and to arrange them in some logical mapping that can assist in their communicative and pragmatic usefulness for mitigating real world problems of degradation in biodiversity, landscapes, and socio-economic conditions due to factors of desertification. Both desertification and management of complex information systems are worldwide problems, but most of the arid world remains unable to either study itself or fund such studies. Less socio-technically and economically developed countries have both less resources to use in combating desertification, and less capability to do so. Thus, to mitigate the causes and effects of desertification requires a worldwide effort to combine resources, raise awareness, and mobilise participation.

## MATERIALS AND METHODS

Both a history and an institutional structure underlie the discourse of desertification, beginning with French scientist and explorer, Louis Lavauden, who coined the term in 1927. But desertification was not popularised until 1949 when André Aubréville used it to refer to largely human-induced land degradation in semi-arid and subhumid zones with annual precipitation between 700 and 1,500 millimetres (Aubréville, 1949). Since then, desertification has often been loosely used to describe conditions of drought, land degradation, and underdevelopment. Currently, its most widely accepted definition comes from the *United Nations Convention to Combat Desertification* (UNCCD) — "'desertification' means land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climate variations and human activities" (UNCCD Secretariat, 1999). By the 1970s, the term desertification was in common scientific use, and was widely used in relation to the disastrous 1968–1973 Sahelian drought, and in Stockholm during the *UN Conference on the Human Environment*. By 1973 the need for concerted efforts were recognized and a range of multilateral and bilateral donors, as well as UNESCO, FAO, WMO (*World Meteorological Organization*), contributed to the formation of the *Comité Permanent Inter-états de Lutte Contre la Sécheresse dans le Sahel* (CILSS). Then in 1974, the UN General Assembly voted to convene the 1977 landmark *UN Conference on Desertification*, which produced a *Plan of Action to Combat Desertification* (PACD) to be carried out through UNEP's anti-desertification programme.

Prior to PACD, desertification research remained the domain of natural scientists studying climate and environmental change, most notably through the *International Biological Programme* (IBP) of the United Nations. This worldwide converge of science into biome based research groups was a pivotal event in the organizational progress of human scientific endeavour. By bringing together scientists and researchers from multi-sectoral and multinational affiliations to focus on understanding basic mechanisms of the primary biomes, the IBP laid the groundwork for the enhanced level of



scientific understanding, theory, methodology, and cooperation that exists today. Its worldwide interdisciplinary research into basic biome ecosystems established a platform of information and understanding of ecological processes and their variety within a spatial distribution of large-scale ecosystems, or biomes. Following this success UNESCO established the *Man and Biosphere (MAB)* program that identified and sought protection for critical genetic core areas of ecosystems under the label of Biosphere Reserves. Today we see a third phase of the process, the *International Geosphere-Biosphere Programme (IGBP)* and in particular its focus on Global Change. But however effective this process is at identifying baseline ecological data and understanding of ecosystems, biomes, and environmental problems, that process was not mandated to offer a framework or process to solve problems. It took an alliance among other scientific researchers, in particular the social sciences, and economic development oriented agencies to build the bridge necessary to take integrated and unified action in researching and addressing processes of desertification. Thus international awareness of the human aspects of desertification caused a different framework to evolve from the natural science based IBP-MAB-IGBP series.

Taking the linked issues of desertification, environment, and economic development into the political arena prompted the series of UN discussions and actions that resulted in the *Convention to Combat Desertification (UNCCD)*. While the CCD is a framework agreement among UN member states, it required compliance at that level, thus mandating country-signatories to form *National Action Programmes (NAPs)*. Within each NAP national governments are further mandated to integrate NGO's and other representatives of civil society, scientific and research communities, and local authorities into the framework and process. Thus, problems that arise from human impact on the environment, and reciprocally, from impact of environmental change on human life, have found convergence within an institutional framework. To facilitate the CCD, the *United Nations Development Programme (UNDP)* is supporting policy and strategy in dryland development and desertification control through its *Office to Combat Desertification and Drought (UNSO)*. In particular, UNSO has established a programme and plan of action to strengthen the role of women in the implementation of the CCD at the local, national, subregional, regional and global level, a crucial factor in support of the CCD's strong commitment to women's equal participation. And of all the potential elements of local participation that can enormously impact the struggle to combat desertification, women are the most important. Not only in their role as primary labourers and household managers, but as child bearers and primary caretakers, the liberation, education, and participation of women can change the entire framework of human-environmental relationships in societies affected by or at risk of desertification.

Analysing the international structure of organizations involved in desertification issues, United Nations Organizations are first among equals, followed by other inter governmental organizations. Next, are international NGOs that directly respond to desertification or place it high on their agendas, such as OECD, OCSE. Within this secondary rank and yet unique, we must situate the European Union (EU) and its various organisations, which are the most important set of actors between the UNOs, INOs, national governments, and intra-national organisations. Although history records many governmental alliances, the European Union structure is unparalleled as an experimental political framework, especially in the inclusion of international local and regional representation in the European Parliament. At another level, some regional inter-governmental organizations focus on aspects of desertification, including the *Arab League*, *Organization of African States*, and *Organization of Islamic Countries*. In addition, elements of the former Soviet Union, recast into the *Confederation of Independent States (CIS)*, overtly and covertly involves desertification prone newly independent Central Asian states, and quasi-autonomous regions. But despite global shifts towards greater influence by private sector and International Organizations (INOs), nation states continue to be the most important players. Then within each country a variable number of governmental and non-governmental players range from Ministerial to local community levels. One of the major problems for lesser-developed states, however, is the lack of a strong and well-organized civil society or civil service. For a variety of reasons, highly centralised state systems, irrespective of how efficient or inefficient, discourage development of formal social institutions that may modify their power over citizens and interest groups, including local government. Nevertheless, holistic development involves a fully participant and interactive civil society working in tandem with governance and public authority at all levels. Without such integrative processes that include citizen participation and



representation outside of a strictly governmental apparatus, it seems unlikely that such countries can experience the social change necessary for economic shifts to more sustainable uses of the environment. Thus the most important aspect of this process involves co-operation in information sharing and management, and experimentation in implementation. While the UNCCD rightly takes the lead framework for integrating many processes through national action programmes, not every government can or desires to put together the mix of power sharing participation called for in the UNCCD guidelines. Therefore, private sector and NGO and research sectors must work together to both share information and to influence government on these issues, and policy research and studies must establish networks involving local authorities, who often have little practical authority in heavily centralised state systems.

## DISCUSSION

Globally, most discourse represents desertification as more acute in lesser-developed rural areas. Thus, most global priorities are addressed towards rural problems of human needs resulting from overpopulation and the corresponding need for more intensive extraction of marginal natural resources — soil, water, vegetation, etc.— to support pastoral and agricultural economies. But current data shows that urbanisation is most dynamic in arid regions, including a rapidly growing population and age structure much younger than the global average. A lack of information and broader connections to existing desertification policy and action programs, and theoretical solutions are also readily identifiable. One problem is what to do at the international level to penetrate national barriers to action and to connect with those public agencies that are responsible and assist with organisational and informational resources. Secondly, how can such responsible organizations penetrate further into individual societies to connect with national NGO's and assist them in similar ways. Finally, deeper social penetration is necessary to connect with local authorities and public institutions, especially communities that lack traditions and mechanisms to develop formal public organizations.

While it is necessary to recognize the UNCCD as the global focus for the study of all facets of desertification, and application of remedies, we must also acknowledge their limits. First, the UNCCD operates through the National Action Programs (NAP) of nation states, acting as a facilitator for both individual NAP's and dialogue among them, as well as an umbrella for restructuring and coordinating donor programmes. As we have seen, each nation state varies in its capability of action, and in its priorities, often-placing political territorial issues or political economic issues above concerted efforts at combating desertification whether internally or through co-operative action with its neighbours or within other international arenas. Moreover, the UNCCD agenda aims to bring more transparency and integration among government, local authorities, civil society, private sector economy, and NGO's within each country and its NAP framework. This ideal, however important, may be highly unrealistic in countries where a weak civil society faces a strong centralising governmental authority. Throughout this paper I have purposely avoided naming specific countries, intending to draw a rather general picture and offer a generic model, so, I will conclude with some recommendations for that model. The UNCCD's agenda specifies that each NAP should plan to address issues at national, regional, and sub-regional levels. But in the face of poor distribution of governance and democratic institutions among many of the countries of Africa and Asia, the question arises of how to involve local authorities when they are appointed by central governments rather than elected at their respective levels of spatial organization. The developed world has come to expect a degree of local voice in decision making through election of local officials, irrespective of their ties or lack of ties to whatever governmental apparatus rules the country. Where local authorities are appointed by the central state apparatus, rather than elected locally, their integration with local communities and the ability of those local communities to express themselves is limited. Thus, while various funding and diplomatic mechanisms can be used to induce national governments towards more open and democratic processes, other more direct means are necessary to connect local communities and authorities to the outside world.

In addition to NGO's that represent various specific environmental and development issues, some represent professional organizations, and perhaps of greatest interest here, local governmental authorities. In this case, irrespective of whether local authorities are appointed or elected, they should be invited to participate in the international arena of organizations which represent them. Such NGO's

as the *International Union of Local Authorities* (IULA) and *International Council for Local Environmental Initiatives* (ICLEI), the *African Sustainable Cities Network* (ASCN), all of which are affiliated with *Agenda 21 Best Practices*. In addition, a number of regional and international professional organizations represent urban and regional planning professionals, such as the *International Society of City and Regional Planners* (ISoCaRP), *International Federation of Housing and Planning* (IFHP), the *Arab Societies of Civil Engineers, City Planning Division*, and so on.

Here we come to the crux of the problem—how to inform and involve localities (by localities, I mean an ensemble of authorities, civil society, public and private sectors). How best can we communicate options for participation in such international organizations as exist to assist and represent members, and how best can localities be motivated to participate. We thus face a problem of international outreach on one hand and local mobilisation on the other hand. Despite opportunities and benefits that may be gained through international connections and organizational liaison, some localities may not be so motivated to do so. Thus, a double burden exists on the international community to reach out and educate localities about benefits, and to motivate and facilitate participation. Moreover, there is a need within all such international organizations to create specific interest sections relevant to problems of desertification. That is, the international community involved in desertification issues needs to reach out and promote awareness of desertification among all such international organizations as are relevant to participation by localities afflicted by desertification. Here strong overlaps exist between combating desertification and sustainable development. In this case, *Agenda 21 Best Practices* forms the core for such linkages, as a broad ensemble of international, regional, and national organizations are involved in the Best Practices process. As well, where localities are unaware or not involved in Agenda 21 Best Practices processes and linkages to international efforts, convergence and cooperation between organizations promoting Best Practices and those combating desertification may more effectively inform and involve localities in both processes. Here, overlap between this process and RIOD. Moreover, another link emerges with the voice of local government, which became part of the formal record of a UN General Assembly meeting for the first time during the 1997 *UN General Assembly Special Session (Earth Summit +5)* to review progress since the 1992 *UN Conference on Environment and Development*. The UN General Assembly Special Session met on behalf of the world community of local government and in particular, on behalf of the *World Assembly of Cities and Local Authorities Coordination* (WACLAC).

In conclusion, wide ranges of institutional structures interlace with the twin objectives of combating desertification and sustainable development of affected and potentially affected ecosystems. Although the UNCCD takes a lead role in coordinating strategy, it must share the stage with a varied ensemble of other players, from other UN and multi-national organisations and international NGOs, to regional, national, local, and alternative organisations. To better understand the global efforts, investments, and interventions in localities within the parameters of desertification criteria, some structure is needed to map both problems and resources, and link databases. In addition, this structure needs innovative information management, monitoring, evaluation, and outreach capability. In tandem with this structured process, international partnership and matchmaking among participants, especially localities, can help provide needed transparency lacking in countries with centralised, command and control political systems. Lastly, investment in local data gathering can facilitate technology transfer, education, and economic alternatives to localities presently suffering from a lack of options. And finally, only such international partnerships in local planning and projects can assist women to become stakeholders with equity, dignity, and full participation in the sustainable development process.

## REFERENCES

- Aubreville, A. 1949 *Climat, forêts et desertification de l'Afrique tropicale*. Societe-d'Editions Geographiques, Maritimes et Coloniales. Paris, 351 pp.
- Secretariat, "United Nations Convention to Combat Desertification: In those countries experiencing serious drought and/or desertification particularly in Africa, text with annexes. 1999, Bonn, Germany
- United Nations Desertification Control Programme Activity Centre, 1987, *Rolling back the desert*, United Nations Environment Programme, Nairobi, 17pp.
- World Bank, 1984, *Towards sustained development in sub-Saharan Africa: a joint programme of action*, Washington, DC.



# STATUS OF THE SALINE AND SODIC SOILS OF THE LOWER MERİÇ VALLEY IN IPSALA FLOOD PLAIN

Cemil Cangir, Duygu Poyraz

University of Thrace, Department of Soil Science, Tekirdağ, Turkey.

## ABSTRACT

The investigation area is located in the province of Edirne, between near the Gala Lake approximately 10 kilometres from Enez County to Ipsala District. The Lower Ipsala Flood Plain is spread on a basin extending in the northeast- southwest direction between the old Rodop Massive at its northwest and Gölcük Massive at its southeast formed as a result of folding of Oligocene deposits. Alluvial erosional and sedimentary forms are very rich in variety. The north side of plain have nonsalty and low salty soils; salt rates are increase through to the South Basin which have heavy soils. Salinity of the soils is major problem. This salt comes from both natural sources and human activities. The condition is aggravated by poor soil drainage, improper irrigation methods, poor water quality, and insufficient disposal sites for water that leaches salts from the soils. Problem caused by soil salinity are compounded when a high water table impedes root development and concentrates salts in the already limited root zone. Firstly rice and secondly sunflower grow on the salty soils. Also sugerbeet, maize, wheat, tomato and pepper grow on the low salty soils.

26 soil samples which effected from different salt rates, were taken from the Plain for this research and results of physical and chemical analysis were presented by tables and Figure. With this study, it is aimed to determine whether changes have occurred on the soil salinity conditions in the 12 years.

## MATERIAL AND METHODS

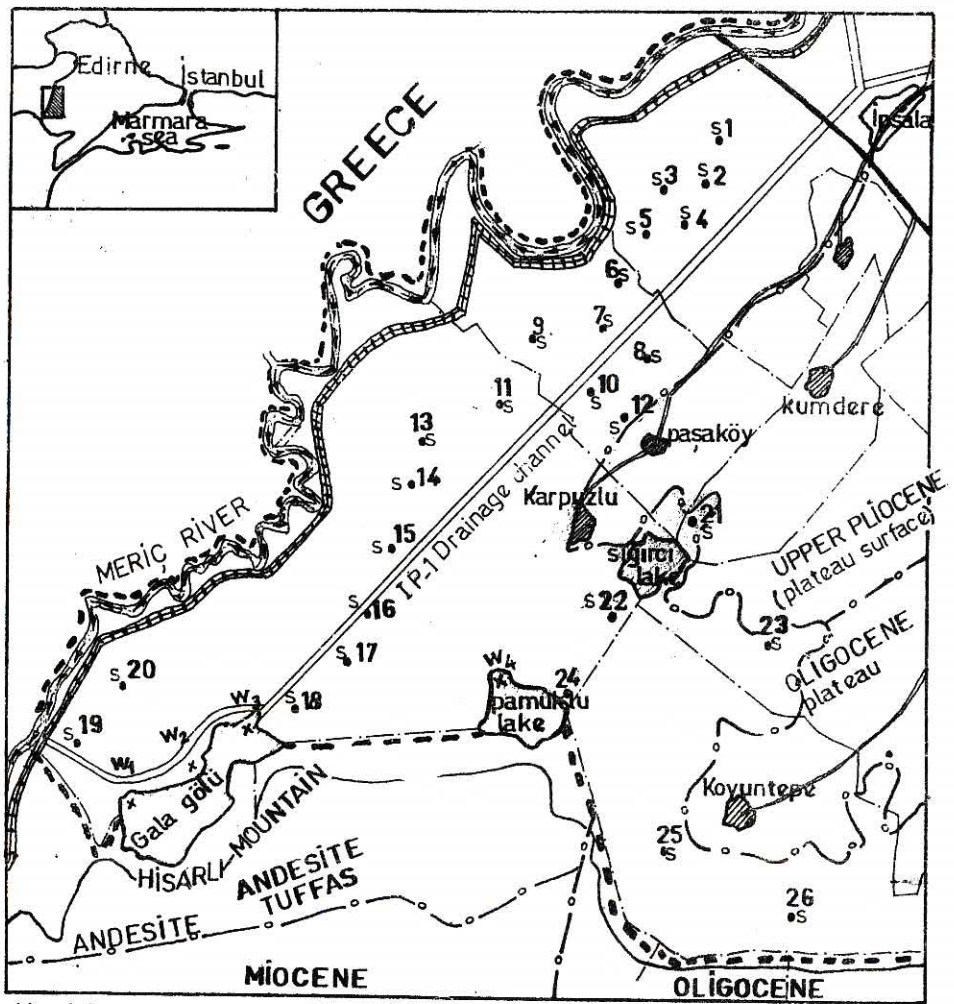
Soils samples were taken from Ipsala Flood Plain for determine the differences between the salty soils of a catena throughout 25 kilometre near the IP-1 drainage channel. In addition water samples (w1, w2, w3 and w4) were taken 4 different places in Gala Lake (Map 1). The Soils studied represented old river levee, river bank, crevasse rent, point bars, crevasse- splay deposits, clay plug, back swamp deposits, and terraces. The soils and water samples were examined according to Jackson (1958), Richards (1954), Soil Survey Laboratory Staff (1992), and Black (1965).

## DISCUSSIONS

The average annual precipitation is about 607.0mm, the total evaporation is 1311.7 mm, the average relative moisture is 76%, the average wind speed is 3.2 m/s, the average soil temperature in 50 cm is 15.5°C, and the average annual temperature is 13.8 °C in Ipsala.

According to the Soil Taxonomy, the soils are generally described as Typic Hydraquent, Vertic Fluvaquent, Typic Epiaquent, Vertic Xerofluvent, Aquic Xerofluvent, Vertic Halaquept, Vertic Haploxerept, Aquic Haploxerept, Ustic Salaquent, Halic Haploxerert. Textures of the soils of the investigation area are mostly clayey and mostly heavy clayey. The soils taked part in the north side of the flood plain were clay loam in texture. According to the laboratory results lime percentages between 0.7 to 5.0; organic matter percentages between 0.60 to 4.24; cation exchange capacity values between 13.78 to 43.91 cmol/kg; available phosphorus values between 7.8 to 19.2 kg/ da; available potassium values between 22.7 to 84.2 kg/da. Cation Exchange capacity of the studied soils were generally found high values. It has been determined that the salinity was an increase between 2% to 515% except 3 places which have clay loam and loam textural classes, from 1987 to 1999 (Table 1, 2, 3, 4, and Figure 1). Increase the saline soil conditions reduce the quality and productivity of considerable areas of rice and sunflower products in Ipsala flood plain. Especially in the southern area, poor drainage conditions contribute to the salinity of soils. We were determined by survey and the results of laboratory analysis that the villagers were applied to much phosphorus fertilizer (Table 1). At planting time and the basal dressing of N were applied as nitrate form for rice. This wrong application system will explain to villagers. The available potassium of the rice soils are sufficient levels.





Map 1. Location of the study area and soil(s) and water(w) sample sites.

The water analysis results of Gala Lake was given in table 5. The lake is connected with an outlet to the Meriç River and then reaches Aegean sea. The area of the Lake is 5.6 km<sup>2</sup> and elevation is 2.00 m. It is an alluvial- embankment type lake and one of the main fishery resources in this region. The main problems of the lake are determined as filling of the Lake with sediment, and the deterioration of water quality as a result of drainage water. The water analysis results were showed that in recent years, the drainage water of the IP-1 main drainage canal has caused chemical pollution in the lake.

Table 1. Some physical and chemical analysis of the soils.

Sample Number	Depth cm	Particle Size %			Textural Classes	CaCO <sub>3</sub> %	SOM %	CEC cmol/kg	Available	Available
		Sand	Silt	Clay					P <sub>2</sub> O <sub>5</sub> kg/da	K <sub>2</sub> O kg/da
1	0-20	33.0	38.7	28.3	CL	3.2	1.74	17.09	<b>18.4</b>	<b>61.0</b>
2/1	0-25	31.7	29.2	39.1	CL	2.6	2.32	28.81	<b>19.2</b>	<b>65.3</b>
2/2	25-60	33.3	31.5	35.2	CL	3.4	1.16	25.06	<b>9.9</b>	<b>32.5</b>
3	0-30	27.7	41.9	30.4	CL	1.4	<b>3.25</b>	30.18	<b>14.6</b>	<b>52.8</b>
4	0-30	28.3	31.5	40.2	C	1.4	1.10	26.38	<b>13.2</b>	<b>54.2</b>
5/1	0-35	14.8	34.3	50.9	C	0.9	2.14	36.77	<b>16.1</b>	<b>84.2</b>
5/2	35-60	24.0	27.2	48.8	C	1.1	0.87	30.72	<b>9.1</b>	<b>62.3</b>
6	0-30	38.6	26.7	34.7	CL	1.0	2.32	26.61	<b>13.6</b>	<b>40.7</b>
7/1	0-20	16.5	40.8	42.7	SiC	1.0	<b>3.52</b>	36.67	<b>10.3</b>	<b>54.9</b>
7/2	20-50	21.7	38.5	39.8	CL	0.8	2.10	33.42	6.4	<b>40.7</b>
7/3	50-70	21.7	34.0	44.3	C	0.8	0.72	32.18	8.7	<b>42.6</b>
8	0-30	36.5	37.8	25.7	L	0.6	1.61	20.47	<b>10.4</b>	27.4
9/1	0-50	26.8	37.8	35.4	CL	1.3	1.74	23.79	<b>15.7</b>	<b>53.6</b>
9/2	50-90	24.2	44.9	30.9	CL	0.8	0.60	19.43	<b>11.1</b>	<b>43.4</b>
10	0-30	45.6	30.6	23.8	L	0.7	1.27	18.56	<b>10.7</b>	<b>33.6</b>
11	0-30	19.9	33.2	46.9	C	1.0	1.16	27.71	<b>16.4</b>	<b>78.6</b>
12	0-30	45.7	35.7	<b>18.6</b>	L	1.0	1.63	13.78	8.8	22.7
13/1	0-45	11.9	30.1	58.0	C	1.4	<b>3.77</b>	43.91	<b>17.6</b>	<b>39.9</b>
13/2	45-60	13.1	27.2	59.7	C	1.0	2.90	40.66	7.8	<b>40.7</b>
14	0-30	8.0	35.6	56.4	C	1.7	1.45	37.17	<b>14.3</b>	<b>59.6</b>
15	0-30	20.5	51.2	28.3	CL	2.7	2.32	22.93	<b>11.8</b>	<b>47.4</b>
16	0-30	29.7	39.6	30.7	CL	0.9	2.73	20.89	<b>16.3</b>	<b>51.5</b>
17	0-30	19.4	47.7	32.9	CL	1.4	2.90	23.63	<b>13.2</b>	<b>45.7</b>
18	0-30	14.5	27.9	57.6	C	5.0	<b>4.24</b>	39.35	<b>17.2</b>	<b>63.6</b>
19	0-30	19.2	20.1	<b>60.7</b>	C	0.8	<b>3.83</b>	41.41	<b>19.2</b>	<b>71.0</b>

Table 2. Chemical and physical properties of the some waterlogged soils in winter.

Sample Number	Depth cm	Particle Size %			Textural Classes	pH 1/2.5 H <sub>2</sub> O	CaCO <sub>3</sub> %	CEC cmol/kg	Ex. Na <sup>+</sup> cmol/kg	ESP %	Salt %
		Sand	Silt	Clay							
20	0-25	13.7	37.8	48.5	C	7.25	1.8	43.76	6.11	<b>13.96</b>	<b>0.525</b>
21	0-25	16.5	36.8	46.7	C	7.40	11.4	39.61	2.24	5.66	<b>3.456</b>
22	0-25	63.3	17.5	<b>19.2</b>	SL	8.02	0.8	10.43	0.56	5.37	<b>0.198</b>
23	0-25	13.5	34.2	52.3	C	7.55	1.6	38.47	1.23	3.20	<b>0.698</b>
24	0-25	13.4	20.4	<b>66.2</b>	C	7.85	4.6	46.12	3.17	6.87	<b>0.800</b>
25	0-25	7.2	54.2	38.6	SiCL	<b>8.15</b>	11.8	21.49	2.57	<b>11.96</b>	<b>0.656</b>
26	0-25	22.6	21.8	55.6	C	8.05	2.5	41.88	3.75	8.95	<b>0.896</b>



Table 3. Changes of the some soil characteristics after 6 years period since 1987.

Sample Number	Depth cm	pH			H <sub>2</sub> O			Salt (%)			ESP (%)			SAR (%)		
		1987	1993	1999	1987	1993	1999	1987	1993	1999	1987	1993	1999	1987	1993	1999
1	0-20	7.95	7.67	7.48	0.038	0.052	<b>0.078</b>	3.98	2.80	3.06	2.72	1.93	2.10			
2/1	0-25	7.74	7.84	7.80	0.043	<b>0.091</b>	<b>0.104</b>	2.34	1.57	3.78	1.63	1.22	2.76			
2/2	25-60	7.72	7.63	7.72	0.050	<b>0.084</b>	<b>0.117</b>	2.87	1.55	2.94	2.11	1.34	2.25			
3	0-30	8.10	7.65	7.84	0.051	<b>0.092</b>	<b>0.087</b>	2.83	1.80	1.73	1.98	1.14	1.49			
4	0-30	8.13	7.64	7.92	0.045	<b>0.090</b>	<b>0.102</b>	3.62	1.95	2.81	2.83	1.30	2.28			
5/1	0-35	7.49	7.28	7.14	0.030	<b>0.108</b>	<b>0.091</b>	1.60	2.11	3.37	1.47	1.55	2.54			
5/2	35-60	7.90	7.62	7.57	0.019	<b>0.110</b>	<b>0.117</b>	4.19	3.84	4.02	3.20	2.92	2.97			
6	0-30	7.25	7.12	7.43	0.022	<b>0.085</b>	<b>0.074</b>	3.19	3.34	3.77	2.32	2.77	2.82			
7/1	0-20	7.30	7.04	7.82	<b>0.128</b>	<b>0.120</b>	<b>0.136</b>	2.46	1.33	2.00	2.34	1.05	1.67			
7/2	20-50	7.35	7.20	7.34	<b>0.410</b>	<b>0.220</b>	<b>0.357</b>	2.14	1.88	2.73	2.07	1.27	2.04			
7/3	50-70	7.45	7.10	7.28	<b>0.496</b>	<b>0.105</b>	<b>0.244</b>	3.67	1.90	2.32	3.04	1.39	1.96			
8	0-30	7.10	7.25	7.19	0.035	0.040	0.037	3.27	2.89	3.00	2.63	2.23	2.73			
9/1	0-50	8.13	7.97	8.05	0.048	<b>0.135</b>	<b>0.144</b>	3.63	6.75	7.49	2.74	5.24	5.55			
9/2	50-90	<b>9.10</b>	<b>8.85</b>	<b>8.96</b>	0.032	<b>0.118</b>	<b>0.138</b>	<b>16.47</b>	<b>15.74</b>	<b>17.34</b>	<b>13.92</b>	<b>12.57</b>	<b>15.09</b>			
10	0-30	7.45	7.52	7.50	<b>0.083</b>	<b>0.090</b>	<b>0.072</b>	4.25	5.18	4.82	3.27	3.82	4.02			
11	0-30	6.95	7.70	7.54	0.067	0.057	<b>0.075</b>	3.69	4.22	4.00	2.96	4.12	3.17			
12	0-30	6.70	7.11	7.20	0.045	0.032	0.037	2.77	3.12	2.50	2.14	2.75	2.37			
13/1	0-45	7.80	7.37	7.75	0.051	<b>0.110</b>	<b>0.174</b>	8.01	7.72	5.88	6.71	5.64	4.43			
13/2	45-60	<b>8.20</b>	<b>8.15</b>	<b>8.17</b>	<b>0.250</b>	<b>0.306</b>	<b>0.417</b>	<b>15.07</b>	<b>10.14</b>	<b>13.47</b>	<b>12.47</b>	<b>8.14</b>	<b>10.71</b>			
14	0-30	<b>8.66</b>	<b>8.54</b>	<b>8.38</b>	<b>0.108</b>	<b>0.102</b>	<b>0.128</b>	<b>15.42</b>	<b>16.17</b>	<b>15.83</b>	<b>13.12</b>	<b>13.70</b>	<b>13.55</b>			
15	0-30	7.00	7.26	7.41	<b>0.256</b>	<b>0.292</b>	<b>0.285</b>	2.07	3.44	2.97	1.78	2.50	2.16			
16	0-30	8.10	8.02	7.97	0.048	<b>0.093</b>	<b>0.127</b>	6.16	7.12	6.87	4.45	5.63	5.77			
17	0-30	7.29	7.36	7.28	<b>0.128</b>	<b>0.175</b>	<b>0.202</b>	9.04	8.95	8.68	7.23	6.97	6.84			
18	0-30	7.92	8.11	8.00	<b>0.602</b>	<b>0.610</b>	<b>0.648</b>	7.15	8.46	8.96	6.35	6.30	6.84			
19	0-30	7.01	<b>8.15</b>	8.10	<b>0.643</b>	<b>0.590</b>	<b>0.656</b>	9.63	<b>13.39</b>	<b>12.65</b>	8.12	<b>11.32</b>	<b>10.49</b>			

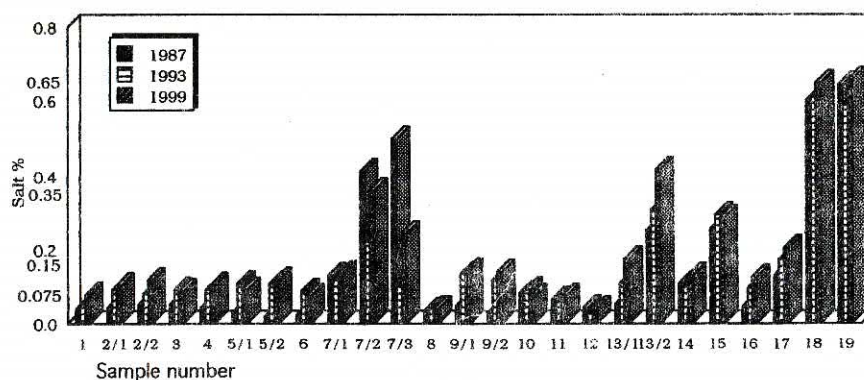


Figure 1. Changes at salinity levels in the long term in Ipsala Flood Plain.

Table 4. Changes of the soil salinity after 6 years period since 1987.

Sample Number	Depth cm	Salt %			Increase	Rate %	
		1987	1993	1999	*1987-1993	**1993-1999	***1987-1999
1	0-20	0.038	0.052	<b>0.078</b>	36.8	50.0	<b>105.3</b>
2/1	0-25	0.043	<b>0.091</b>	<b>0.104</b>	<b>111.6</b>	14.3	<b>141.9</b>
2/2	25-60	0.050	<b>0.084</b>	<b>0.117</b>	68.0	39.3	<b>134.0</b>
3	0-30	0.051	<b>0.092</b>	<b>0.087</b>	80.4	-5.4	<b>70.6</b>
4	0-30	0.045	<b>0.090</b>	<b>0.102</b>	<b>100.0</b>	13.3	<b>126.7</b>
5/1	0-35	0.030	<b>0.108</b>	<b>0.091</b>	<b>260.0</b>	15.7	<b>203.3</b>
5/2	35-60	0.019	<b>0.110</b>	<b>0.117</b>	<b>478.9</b>	6.4	<b>515.8</b>
6	0-30	0.022	<b>0.085</b>	<b>0.074</b>	<b>286.4</b>	-12.9	<b>236.4</b>
7/1	0-20	<b>0.128</b>	<b>0.120</b>	<b>0.136</b>	-6.2	13.3	6.3
7/2	20-50	<b>0.410</b>	<b>0.220</b>	<b>0.357</b>	-46.3	62.3	-12.9
7/3	50-70	<b>0.496</b>	<b>0.105</b>	<b>0.244</b>	-78.8	32.4	-50.8
8	0-30	0.035	0.040	0.037	14.3	-7.5	5.7
9/1	0-50	0.048	<b>0.135</b>	<b>0.144</b>	<b>181.3</b>	6.7	<b>200.0</b>
9/2	50-90	0.032	<b>0.118</b>	<b>0.138</b>	<b>268.8</b>	16.9	<b>331.0</b>
10	0-30	<b>0.083</b>	<b>0.090</b>	<b>0.072</b>	8.4	-20.0	-13.3
11	0-30	0.067	0.057	<b>0.075</b>	-14.9	31.6	11.9
12	0-30	0.045	0.032	0.037	-28.9	15.6	-17.8
13/1	0-45	0.051	<b>0.110</b>	<b>0.174</b>	115.7	58.2	<b>241.2</b>
13/2	45-60	<b>0.250</b>	<b>0.306</b>	<b>0.417</b>	22.4	36.3	<b>66.8</b>
14	0-30	<b>0.108</b>	<b>0.102</b>	<b>0.128</b>	-5.6	25.9	18.5
15	0-30	<b>0.256</b>	<b>0.292</b>	<b>0.285</b>	14.1	-2.4	11.3
16	0-30	0.048	<b>0.093</b>	<b>0.127</b>	93.8	36.6	<b>164.6</b>
17	0-30	<b>0.128</b>	<b>0.175</b>	<b>0.202</b>	36.7	15.4	<b>57.8</b>
18	0-30	<b>0.602</b>	<b>0.610</b>	<b>0.648</b>	1.3	6.2	7.6
19	0-30	<b>0.643</b>	<b>0.590</b>	<b>0.656</b>	-8.2	6.2	2.0

\* Increase rate of salinity between the period 1987- 1993

\*\* Increase rate of salinity between the period 1993- 1999

\*\*\* Increase rate of salinity between the period 1987- 1999



Table 5. The analysis results of water samples which taken from 4 different places, in Gala and Pamuklu Lake.

Analysis	Sample number (In February)								*b)	*c)	**
	w1		w2		w3		w4				
	1984 a)	2000	1984 a)	2000	1984 a)	2000	1984 a)	2000			
pH	7.9	7.48	7.8	7.86	7.6	7.95	7.3	8.08	6.5-8.5	<6-9<	6.5-8.5
EC $\mu$ s/m	1546	11610	1546	2040	1270	1900	883	3560	-	-	-
TDS****	394	6810	418	1300	503	1090	611	2040	500	5000	-
SS****	87	80	59	140	15	80	120	97	-	-	30
NO <sub>3</sub> -N mg/l	3.5	7.0	3.5	0.5	5.3	14.0	6.6	0.87	5	>20	5
NH <sub>4</sub> -N mg/l	0.02	1.4	0.03	0.7	0.02	0.7	0.02	0.0	0.2	>2	0.2
Ca <sup>++</sup> mg/l	62	437.4	66	136.6	60	97.2	54	111.2	-	-	800
Mg <sup>++</sup> mg/l	57.1	115.1	58.4	30.5	48.6	24.2	30.4	45.6	-	-	14
Na <sup>+</sup> mg/l	149.5	2050	149.5	252.5	120.8	281.3	87.4	795.8	125	>250	85
K <sup>+</sup> mg/l	4.7	47	5.1	10.5	4.7	8	3.9	66.3	-	-	50
SO <sub>4</sub> <sup>-</sup> mg/l	100.0	342.7	100.0	149.8	80.0	186.7	55.2	283.2	200	>400	90
Cl <sup>-</sup> mg/l	319.7	3415.5	328.7	462.9	252.1	498.8	151.3	989.0	25	>400	170
CO <sub>3</sub> <sup>-</sup> mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-
HCO <sub>3</sub> <sup>-</sup> mg/l	210	1165.1	220	219.6	215	67.4	150	175.1	-	-	-
PO <sub>4</sub> <sup>+++</sup> mg/l	0.08	0.70	0.1	0.64	0.1	0.92	0.2	1.50	0.02	>0.65	15
Mn <sup>++</sup> mg/l	-	0.11	-	0.31	-	0.12	-	0.09	100	>300	1
Cu <sup>++</sup> mg/l	-	1.21	-	6.70	-	3.58	-	0.60	20	>200	0.02
Cd <sup>++</sup> mg/l	-	0.08	-	0.11	-	0.09	-	0.10	3	>10	-
Zn <sup>++</sup> mg/l	-	0.40	-	14.62	-	19.82	-	1.42	200	>2000	-
Fe <sup>+2,+3</sup> mg/l	1.6	0.76	0.8	1.0	0.8	0.73	0.8	1.15	300	>5000	0.7
*****	-	C4S3	-	C3S1	-	C3S1	-	C4S2	-	-	-

a) The water samples are analysed by State Hydraulic Works (SHW) in 1984.

\*b) for 1<sup>st</sup> class water, according to environmental law

\*c) for 4<sup>th</sup> class water, according to environmental law.

\*\* - According to law 1380 on water production.

\*\*\* TDS- Total dissolved solids (mg/l).

\*\*\*\* SS- Suspended solids (mg/l).

\*\*\*\*\* - The classification of Gala and Pamukçu Lake waters samples according to Salinity and sodium adsorption ratio (SAR).

## REFERENCES

- Black, C. A., 1965. Methods of Soil Analysis. Part II. American Society of Agronomy, Inc., Publisher. No:9. Madison, Wisconsin.
- Cangir, C. and Girgin, A., 1989. The Barren Soils of Ipsala (Edirne) flood plain. 10<sup>th</sup> Congress of Soil Science Society of Turkey. Volum:5. pp:13/1-9.
- Göçmen, K., 1976. Alluvial Geomorphology of the lower Meriç Valley Flood Plain and its Delta. Publications of Istanbul University: 1999. Publications of Geographical Institute: 80. Faculty of Letter's Press. Istanbul.
- Jackson, M. L., 1958. Soil Chemical Analysis. Prentice Hall Inc. Englewood Cliffs, N.J. U.S.A.
- Richards, L. A., 1954. Diagnosis and Improvement of saline and alkali soils.
- Soil Survey Laboratory Staff., 1992. Soil Survey Laboratory Methods Manual. Soil Conservation Service, National Soil Survey Center. Soil Survey Investigations Report No:42. Version 2.0. USDA.

# ECOLOGICAL CHANGES IN MANYAS LAKE RELATED TO BORON POLLUTION AND WATER REGIME

Sevinç Arcaç<sup>1</sup>, Koray Haktanır<sup>1</sup>, Mümtaz Kibar<sup>1</sup>, Orhan Dengiz<sup>1</sup>

<sup>1</sup> Department of Soil Science, Faculty of Agriculture, University Ankara, Ankara

## ABSTRACT

Manyas Lake known as bird paradise is a natural reservation and a recreation area. This region is a unique place which has A-class diploma that is awarded by European Council for wetlands for which an access requires a special permission of scientific purpose. The lake is an important reproduction habitat for *Pelecanus crispus* and *Phalacrocorax pygmeus* which are liable to extinction. The fact that the lake is rich in deep fauna and planktones, due to outstanding amount of bird's fertilizers makes it possible for diverse and intensive fish population to sustain their lives.

In this study, changes resulted from human activities in water quality and boron pollution were examined. Results of the research reveal that depending on escalating pollution, water quality of the lake is deteriorating and lake water is intensively consumed for various purposes. Data obtained from the research and observations showed that boron and salt pollution as dominant phenomenon, together with increasing chemical pollution has created serious problems. In addition, both the lake and the streams which carry pollutants to the lake were found to be apt to be salty. Particularly, boron and salt levels of Sığircı stream which affects the surrounding of National Park is so high that the contents may limit plant growth. Because of the rise at certain periods in the water level of the lake which results in overflow upon willow trees (*Salix alba*) and unwanted chemical factors, vegetation which is used as bird habitat has vanished.

## INTRODUCTION

Lakes provide variable uses to human society from drinking water supply to recreational activities, or from industrial use to fishery. However, the lakes in recent years are threatened by increasing pollution as a result of human activities in lake catchment areas.

Lake Manyas is one of the most important world wide natural reserves for migratory birds and wildfowl species. The northeastern part of the lake is a well known bird sanctuary, and called as Kuşçenneti National Park.

The lake is one of the important reproduction area of our country for the threatened Dalmatian Pelican (*Pelecanus crispus*) and Pygmy Cormorant (*Phalacrocorax pygmeus*). Among the other bird species breeding in the area, there are 2000 pairs of Cormorants (*Phalacrocorax carbo*), 150 pairs of Black Crowned, Night Heron (*Nycticorax nycticorax*), 100 pairs of Squacco Heron (*Ardeola ralloides*), 250 pairs of Grey Heron (*Ardea cinera*), 10 pairs of Glossy Ibis (*Plegadis falcinellus*), 200 pairs of Spoonbill (*Platalea leucorodia*) and, 150 pairs of Turtle Dove.

There are some environmental problems faced with in the Lake Manyas in terms of water quantity and quality. The water level has increased uncontrolled in recent years, due to the project applied for using the water potential of the catchment. Moreover the water quality deterioration has been initiated in the lake since it is located in a region, which is very important in terms of agricultural and industrial activities in Turkey.

On the other hand, the behaviour of aquatic systems should be well understood, in particular when there is a large number of different uses and pollution sources, before different water use, requirements are met. In such cases a suitable approach for an integrated use of water and land resources including potential adverse impacts of pollutant as well as nutrient inputs to the water body is needed. The production of the natural environment is possible, then by the development and implementation of management goals and strategies suitable to handle environmental uses for the selected water body effectively. In turn, development of effective environmental management strategies usually require recognition of the existing environmental problems. Formulation and implementation of corrective policies also need considerable amount of technical support.

In recent years, an environmental deterioration has been observed both in Kuşçenneti and in the aquatic life of the Lake Manyas. The higher water levels might be the reason for these undesired results. Another important undesirable phenomena related to the lake is the increasing pollution levels especially around Kuşçenneti.



## MATERIALS & METHODS

### General Description of the Study Area

Lake Manyas is located in the province of Balıkesir with the coordinates of 40°10' N and 28° 00' E, having an average altitude of 18 m above the mean sea level. The lake is fed with Kocacay stream coming from the south, Sigirci stream coming from the north and rain falling on the lake area. The main outlet of the lake is Karadere. A schematic layout of the lake and its catcment can be seen Figure 1.

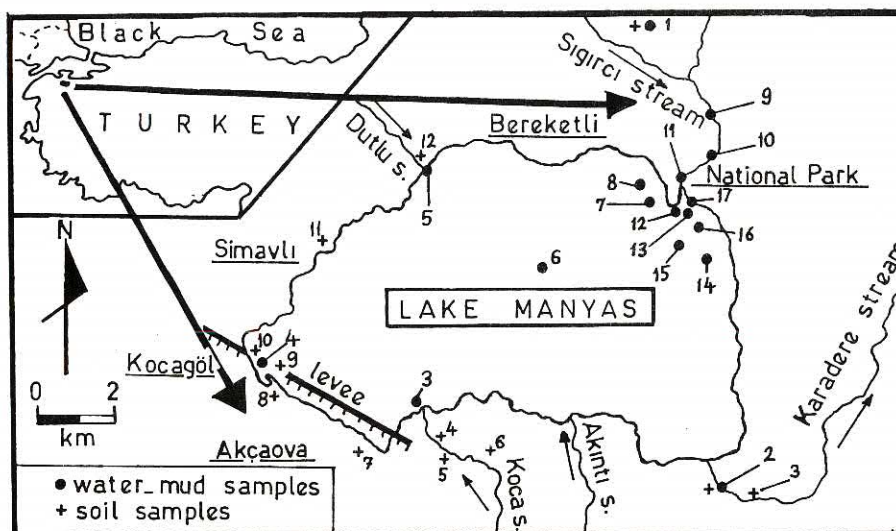


Figure 1. Lake Manyas and its catcment

Lake Manyas is an eutrophic wetland from the standpoint of ecology and an argilotrophic (clayey) wetland from the standpoint of limnology. Since it contains colloidal clay, its water is always turbid. The depth of the deepest place of the lake is about 4 meters and the avarage depth is 1 to 2 meters (Anonymous, 1998). The dominant climate of the area is continental. The climate can be described as hot with low precipitation in summer and cold with high precipitation in winter.

The annual inflows from the subcatchment sum up to 75.54 million m<sup>3</sup>. The annual precipitation to the lake surface is about 100.00 million m<sup>3</sup>. The total average annual inflow to the lake is 828.13 million m<sup>3</sup> (Celtemen, 1998) (see Figure 2).

Lake Manyas is one of the most important worldwide natural reserves for migratory birds and wildfowl species. The northeastern part of the lake, called Kuşçenneti with a total area of 64 ha, was first observed in 1938 by Prof. Curt Kosswig and declared as a National Park in 1959. Then it was awarded by "Class A Wetland Diploma" by the European Council in 1976 and the given diploma was renewed four times. In 1993, the lake was included into the list of wetlands covered by the well-known Ramsar Convention, which become effective in 21 December 1976. The aim of the convention is to prevent the decline of wetland habitats globally and maintain their ecological functions and wild life. The signatory countries agree to include wetland conservation in national planing, to promote sound utilization of wetlands, to create wardened nature reserves, and to facilitate wetland-based research (Erdem, 1995). Consequently, it becomes very important to properly manage the Lake Manyas in order to sustain its use for different purposes.

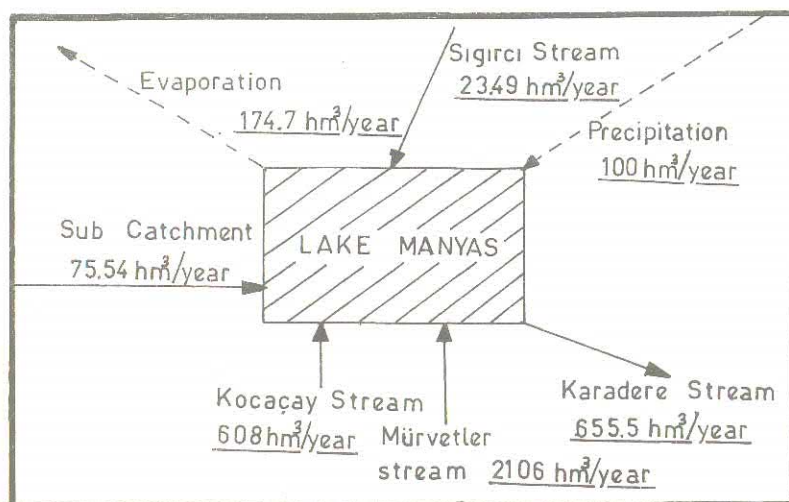


Figure 2. Hydrological scheme of Lake Manyas

#### Methods (Water quality of the lake)

The water quality has been monitored two times in the lake itself during the year 1998 at seventeen different locations. Those locations were selected in such a way that 11 of them are located at the in-lake mixing points of the tributaries and the other one is located at the middle of the lake.

The parameters measured in the samples obtained from the lake are pH, electrical conductivity, hardness, chloride (Cl), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), carbonate ( $\text{CO}_3$ ), bicarbonate ( $\text{HCO}_3$ ) and boron (B) (Rump and Krist, 1992).

After water samples were put into jars, for calcium and magnesium analysis, nitric acid ( $\text{HNO}_3$ ) was added to the water samples to lower acidity below pH 2, thereby preventing the possibility of Fe and Mg being bound. Samples brought to the laboratory were analyzed within 24 hours. Water parameters were analyzed as indicated by standard methods (APHA, 1992).

The parameters measured by the field instruments were temperature, depth, dissolved oxygen, pH, electrical conductivity, secchi depth.

In order to understand whether the data taken from two different levels at the same station, are significantly different from each other or not.

#### RESULTS & DISCUSSION

According to the data of May 1998 and October 1998 pertaining to the lake and the streams, pH values and seasonal changes in pH are not such as to hamper biota. However, from the standpoint of limit values, lake water is of class III by Water Quality Criteria For Inland Water Based on Water Pollution Regulation.

Electrical conductivity values of the water samples vary in the lake and the streams. Spring and autumn measurements give similar results (Table 1 and 2). Lake water is medium salty. However, water samples of Sigirci and Dutlu streams were found excess salty in the same seasons. Due to its direct relation with the National Park Area and unwanted characteristics of its water in relation to both terrestrial vegetation and water organisms, Sigirci stream together with other factors might create hampering impact.

The limit values of the dissolved oxygen of the lake water in May correspond to class I, but in October limit values remain between class I and II (Table 1 and 2). Although water quality of class IV was determined in Sigirci stream which carries heavy load of pollutants in spring, because of rich surface phytoplankton population, abundance of oxygen occurs in October.



Table 1. Physico-chemical data of Lake Manyas and contributing streams (May 1998)

Sampling No	Lake depth (m)	Sampling depth (m)	Temperature (°C)	Secchi depth (cm)	pH	EC (µS cm <sup>-1</sup> )	DO <sup>1</sup> (mg l <sup>-1</sup> )	PO <sub>4</sub> <sup>3-</sup> (mg l <sup>-1</sup> )	Boron (ppm)	CO <sub>3</sub> <sup>2-</sup> (mg l <sup>-1</sup> )	HCO <sub>3</sub> <sup>-</sup> (mg l <sup>-1</sup> )	Cl <sup>-</sup> (mg l <sup>-1</sup> )	Na <sup>+</sup> (mg l <sup>-1</sup> )	K <sup>+</sup> (mg l <sup>-1</sup> )	Ca <sup>2+</sup> (mg l <sup>-1</sup> )	Mg <sup>2+</sup> (mg l <sup>-1</sup> )	Total Hardness (mg l <sup>-1</sup> )	TH	dH <sup>2</sup>
1	-	surface	26	-	4.7	2300	2.7	-	2184	-	140	125.24	18.2	13.65	78	734.73	3350	235	187.15
2	-	surface	26	-	8.2	380	5.9	-	-	-	183	38.76	14.5	0.27	67	-	190	19	10.61
3	2.00	surface	27	-	7.6	460	2.9	-	0.11	-	323	26.98	16.8	0.27	67	16.91	200	29	16.20
4	-	surface	26	-	8.3	700	8.7	-	0.13	-	275	80.51	51.8	4.58	-	65.21	280	28	15.64
5	-	surface	26	-	9.2	360	5.0	-	0.43	-	165	29.82	13.6	0.27	49	10.12	170	17	9.49
6	2.60	surface	24	21	8.8	340	7.5	-	0.24	-	134	23.78	19.32	0.78	49	7.73	157	15.6	8.72
7	-	surface	22	-	8.7	330	7.5	-	0.35	-	140	26.98	20.7	0.78	49	11.27	170	17.0	9.49
8	1.90	surface	24	14	8.6	340	7.9	-	0.35	-	146	23.78	18.17	0.78	47	10.69	160	16.0	8.94
9	-	surface	25	21	8.6	360	6.9	-	0.94	-	146	20.87	20.5	0.78	45	11.27	160	16.0	8.94
10	2.00	surface	27	3-5	8.5	350	7.7	-	0.62	-	153	26.98	18.2	0.78	47	10.12	160	16.0	8.94
11	-	surface	30	-	7.7	620	2.5	-	0.66	-	146	23.78	19.3	1.56	49	11.27	170	17.0	9.49
12	1.90	surface	27	-	8.7	350	7.4	-	3.47	-	268	53.68	51.8	12.09	71	25.87	280	28	15.64
13	1.80	surface	22	24	8.5	360	8.0	-	0.72	-	165	17.89	18.2	0.78	44	11.85	160	16	8.94
14	1.50	surface	24	22	8.7	360	8.4	-	0.33	-	146	23.86	19.3	0.78	49	10.12	170	17	9.49
15	1.50	surface	24	22	8.6	350	7.9	-	0.47	-	146	17.89	18.2	0.78	47	10.12	160	16	8.94
16	1.50	surface	26	28	8.8	350	9.1	-	0.15	-	189	23.78	18.2	3.51	49	11.27	170	17	9.49
17	1.50	surface	23	25	8.8	330	9.2	-	0.37	-	177	71.56	16.8	0.27	49	22.54	220	22	12.29
18	1.15	surface	23	-	8.3	330	8.0	-	0.32	-	146	14.91	18.2	0.27	47	13.52	175	17.5	9.77
19	-	surface	26	-	8.6	390	9.2	-	2.36	-	140	26.98	18.2	0.78	49	10.12	170	17	9.49

<sup>1</sup> Dissolved oxygen<sup>2</sup> Permanganate consumption<sup>3</sup> French hardness<sup>4</sup> Deuschland hardness

Table 2. Physico-chemical data of lake Manyas and contributing streams (October 1998)

Sampling No.	Lake depth (m)	Sampling depth (m)	Temperature (°C)	Section depth (cm)	pH	EC (µS cm <sup>-1</sup> )	DO <sup>1</sup> (mg l <sup>-1</sup> )	pH <sup>2</sup> (mg l <sup>-1</sup> )	Boron (mg l <sup>-1</sup> )	CO <sub>2</sub> (mg l <sup>-1</sup> )	HCO <sub>3</sub> <sup>-</sup> (mg l <sup>-1</sup> )	Cl <sup>-</sup> (mg l <sup>-1</sup> )	Na <sup>+</sup> (mg l <sup>-1</sup> )	K <sup>+</sup> (mg l <sup>-1</sup> )	Ca <sup>2+</sup> (mg l <sup>-1</sup> )	Mg <sup>2+</sup> (mg l <sup>-1</sup> )	Total Hardness (mg l <sup>-1</sup> )	FI <sup>3</sup>	dH <sup>4</sup>
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	Surface	20	-	8.5	360	7.8	14.2	1.9	-	244	320	36	10	32	50.4	116	29	16
3	-	Surface	20	-	8.5	400	7.1	11.1*	2.0	-	323	266	50	11	36	60	136	34	19
4	-	Surface	20	-	8.6	400	8.2	12.6	1.2	-	262	391	47	10	48	43.2	120	30	17
5	-	Surface	24	-	8.5	800	7.7	16.4	1.1	24	451	710	85	38	88	105.6	264	66	37
6	1.66	Surface	26	38	8.8	360	6.9	7.9	1.1	18	446	355	35	9	80	48	160	40	22
7	1.31	Surface	26	36	8.9	360	7.3	7.9	1.4	12	414	355	39	9	32	36.6	93	23	13
8	0.71	0.71	26	25	8.9	360	7.9	8.5	2.9	18	561	337	32	9	32	38.2	96	24	13
9	-	Surface	19	-	8.7	2120	8.8	71.1	15.8	-	1757	1686	157	50	140	127.2	352	88	49
10	-	Surface	19	-	7.9	2200	7.8	35.6	15.6	-	1952	1651	167	59	128	122.4	332	83	46
11	0.49	0.49	26	21	8.9	560	8.0	11.1	14.7	30	244	479	62	20	93	108.2	272	68	38
12	1.10	1.10	26	23	8.9	400	6.7	10.1	5.9	18	500	337	38	12	28	43.2	100	25	14
13	0.56	0.56	26	24	8.9	480	8.2	9.8	11.2	36	451	302	54	18	48	45.6	124	31	17
14	0.78	Surface	26	28	8.8	440	7.9	10.4	7.0	48	464	355	51	16	60	36	120	30	17
15	-	-	26	-	8.7	380	7.6	9.8	6.5	18	390	338	44	12	80	48	160	40	22
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

No Sampling (due to water recession)

<sup>1</sup> Dissolved oxygen  
<sup>2</sup> Permanganate consumption  
<sup>3</sup> French hardness  
<sup>4</sup> Deutschland hardness



According to the permanganate values of the lake water which is the indicator of the chemical oxygen demand of water, measurements of various sites in the lake reveal that lake water is of class I by Water Pollution Regulation, whereas, waters of Sığircı stream is of class IV. This suggests that Sığircı stream which has most influence on Manyas (Bird) Lake, transfers considerable amount of organic pollutants to the region. Boron levels of the surface and deep water samples are below the certain concentration that might be phytotoxic. However, in October 1998, in the marshy area close to the National Park high level of boron was determined. It is likely that flows of high boron-loaded Sığircı stream through delta opening reaches the marshy area. Therefore, National Park area which is under the influence of Sığircı stream has been very often in contact with the high concentration of boron (Table 1 and 2).

Examination of water samples, from the view point of the change in chloride shows that lake water of class I determined in May 1998 by Water Pollution Regulation, was transformed to class III in October 1998. Various streams incorporating into the lake have chloride concentration up to  $1686 \text{ mg l}^{-1}$  that excess the level of  $400 \text{ mg l}^{-1}$  fourfold, being the parameter of class IV. Whereas, chloride concentration below  $70 \text{ mg l}^{-1}$  can be suitable for plants. Data obtained show that both the lake and the streams carrying pollutants to the lake are apt to be salty. Particularly, in Sığircı stream concentration are high enough that might confine plant growth. Keeping in mind that even salt-resistant plant may subject to slight or medium damage at the concentration of  $280 \text{ mg l}^{-1}$  and up (Rump and Krist, 1992), it can be well understood how an important risk there is in the region. Boron values of the soils samples taken from Simavlı meadow soil are 1.77 ppm, from the vicinity of Ergili Regulators are 1.44 ppm which reflect high and medium boron levels in the soils respectively (Table 3). For instance boron level between 0.7-1.5 ppm is not secure for some plants. Therefore Simavlı meadow soils are considered toxic for most plants. Soil samples of Kocaçay, Hamamlı and Dutlu streams involve boron problem. The fact that extremely high level of boron is determined within the National Park, particularly in the vicinity of Sığircı stream where the vegetation is severely deteriorated and the areas close to Park Quay indicate a great risk for the vegetation. Examination of the bottom mud samples reveal medium level of salt and high level of boron concentration in Sığircı stream which consistent with the water quality of the stream, if the existent situation lasts this problem will become aggravated. On the other hand, boron pollution of October 1998 is far beyond acceptable limits (Table 4 and 5).

Boron concentration increases from the centre of the lake towards shore bringing about high concentration of boron (in the immediate vicinity of Pelican nests and National Park Quay and its surrounding). This indicates a potential threat towards the lake by way of Sığircı stream.

Apart from the extreme rising and subsiding in the lake level, in recent years particularly following the year 1993, an abrupt permanent rising has attracted attention. This may be because of the fact that by bringing the south right shore line embankments nearer to the lake shore, they were reconstructed at the altitude of 15 meter. It seems that the main problem has a close relationship with the keeping water movements of a natural ecosystem under control. The environmental problems faced with in the Lake Manyas are both qualitative and quantitative. The natural life has been affected adversely in recent years, due to the conditions caused by various man-made activities around the lake.

The periodical fluctuation of water to support natural needs of waterfowl could not be achieved, and the higher water level most probably caused damages on plantation. In recent years, an environmental deterioration has been observed both in Kuş cenneti and in the aquatic life of the Lake Manyas. The higher water levels might be the reason for these undesired results. Another important undesirable phenomena related to the lake is the increasing pollution levels especially around Kuşcenneti. The feeding stream of Kuşcenneti, namely the Sığircı stream, are being polluted by uncontrolled domestic and industrial wastewater discharges. The towns and the increasing industrial activities around Sığircı stream have been adversely impacting the water quality of the stream for several years. The organic and inorganic pollutants have been carried by water and they accumulated in the sediments of Kuşcenneti. In addition due to intensive agricultural activities fertilizer and pesticide utilization in highly fertile farmlands have affected the water quality in the some part (Table 6).

The water quality measurements carried out in different parts of the lake, especially in Kuşcenneti, have shown that the water is highly polluted with respect to different quality parameters. The parameters with alarming levels of boron and chloride. Our studies showed that the boron concentrations in sediment, soil and water also exceed the standards stipulated by the regulations. Another threat for the lake is soil erosion that has been accelerated in recent years due to improper land use.

Table 3. Boron results in soil (May 1998)

Sampling No	Boron (ppm)
1	278.87
2	1.23
3	3.18
4	0.77
5	0.48
6	0.46
7	0.64
8	0.44
9	0.81
10	0.54
11	1.01
12	0.51
13	4.85

Table 4. Some characteristics of the bottom mud in Lake Manyas (May 1998)

Sampling No	pH*	EC (mS cm <sup>-1</sup> )	Boron (ppm)	Ca (me 100 g <sup>-1</sup> )	Mg (me 100 g <sup>-1</sup> )
6	7.56	2.00	1.14	3.78	1.13
7	7.50	3.00	2.53	1.90	1.67
8	7.09	3.20	1.00	1.51	1.57
9	7.14	6.00	5.38	8.64	3.38
10	7.05	7.00	4.66	5.53	4.41
12	7.12	3.20	1.94	3.48	3.25
13	7.32	5.00	1.25	3.06	4.31
14	7.07	3.00	1.06	2.85	1.85
15	7.15	4.00	2.77	3.18	2.27
16	7.10	4.00	3.67	3.54	1.43
17	7.31	2.00	1.64	2.08	1.37

\* Saturated paste

There exist intensive industrial activities in the catchment of the lake and the wastewater produced at different steps of manufacturing are given to the receiving water bodies without any treatment, in most of the cases. The number of industries located in the area is around 40 and 24 of them cause severe quality deterioration in the nearby water bodies. The largest industry in terms of its production is Etilbank Borax and Boric Acid Factory with a total wastewater discharge of 6300 m<sup>3</sup>/day from different units. The amount of wastewater given to Sığircı stream is approximately 1700 m<sup>3</sup>/day (Celtemen, 1998). There are some towns and villages located along the tributaries. All of them have sewage system without any treatment. The domestic wastewater of these settlement areas are being discharged to the nearby water bodies directly. The evaluation based on the 90 % probability values show that the water quality is very poor in Sığircı stream which is flowing through Kuşçenneti. Boron parameter has values exceeding class IV standards in the regulation (Water Pollution Control Regulation). Boron is already in high amounts in the water.

Since there are farmlands around the stream basin, intensive use of fertilizers also affects the water quality adversely (Table 6). For there is no measurement about the pesticides, it is difficult to estimate the levels of pollution and toxicity in the water. However, it is known that many different types of pesticides are being used in the area.

Table 5. Some characteristics of the bottom mud in Lake Manyas (October 1998)

Sampling No	pH*	EC (mS cm <sup>-1</sup> )	Boron (ppm)	Ca (me 100 g <sup>-1</sup> )	Mg (me 100 g <sup>-1</sup> )
1	7.70	1.00	0.92	0.99	0.76
2	7.84	1.20	0.98	4.15	1.43
3	7.74	1.60	1.39	4.42	0.98
4	7.47	3.60	17.45	2.81	0.97
5	7.54	3.00	4.62	5.40	2.53
6	7.56	3.40	2.43	4.86	2.33
7	7.76	3.00	3.14	5.60	3.93
8	7.72	2.80	3.15	2.61	2.11
9	7.57	4.80	18.67	7.37	4.50
10	7.67	3.60	18.07	3.57	0.94
11	7.64	3.40	2.09	7.68	3.43
12	7.76	3.20	3.14	5.16	1.96
13	7.73	2.60	5.14	5.07	2.71
14	7.84	3.20	4.46	6.38	2.84

\* Saturated paste

Table 6. Nutrient budget of Lake Manyas (tons/years)

Parameter	Kocaçay stream	Sığircı stream	Mürvetler stream	Karadere stream
o-PO <sub>4</sub>	46.74	271.34	9.88	214.76
Total P	163.84	571.81	29.12	1325.16
NH <sub>3</sub> -N	317.33	6816.7	13.45	430.52
NO <sub>2</sub> -N	105.74	4.47	41.63	167.77
NO <sub>3</sub> -N	1827.27	272.47	580.26	2525.35
COD*	-	35302.41	-	-
BOD <sub>5</sub> **	4324.19	10790.61	925.77	43595.98
B	756.41	3035.78	5.22	7135.82
As	51.79	69.63	21.86	639.38

\* COD: Chemical oxygen demand

\*\* BOD<sub>5</sub>: Biological oxygen demand

As it can be seen from the table that the pollutant load of the lake is extremely high due to the man-made activities in its catchment area. If the above table is examined, it can be concluded that the main contributor in terms of pollution is Sığircı stream. Especially, the parameters of B and COD need more concern to figure out the present situation of the lake and its natural life. The pollution is originated primarily from domestic and agricultural activities in Kocaçay. The similar types of pollution sources are valid for Mürvetler stream and Karadere, but in the case of Sığircı stream, of primary concern for natural life, the pollution is mainly due to industrial activities along with domestic one.



## CONCLUSIONS

High level of boron, chloride, organic and inorganic pollutants being transported by Sığircı stream which affects the whole National Park, particularly when water level is high and covers the park area, has been severely effective leading to phytotoxic characteristics over the soils of the region and the bottom mud properties. The research team concludes that the foregoing chemical negativeness is associated with the water regulation being anthropogenically affected and causes a synergistic impact through the agency of flooded vegetation. Vegetation, particularly under flood was observed to be highly affected. Due to altitude, where the water influence does not become effective, vegetation could gradually survive. Although the complete demise of the vegetation, particularly in the immediate vicinity of the Sığircı stream, may not be ascribed to a single factor, hazardous impacts of boron, chloride and other chemicals stemming from excess water being the basic negativeness, manifested themselves simultaneously. The possibility of the nutrients deriving from widespread poultry practices being transported to the lake is high. This is an important factor affecting the rapid change of water quality. It has been understood that an important water reservoir is vanishing, due to the rapid change in water quality of the lake which once used by the people of the region as a source of potable water in the 1960's.

## RECOMMENDATION

In order to prevent water pollution in the lake, and particularly within the park boundaries, the required measurements should be taken to rehabilitate the quality of Sığircı stream carrying boron, chloride and other wastes of industrial origin, and Dutlu stream transporting mostly solid and liquid wastes of poultry activities and household wastes. The main factor limiting vegetative life in the National Park is that a water management plan which is able to create a condition which reflects the ecosystem of 1990's, the healthy life of which was dependent upon natural water rhythm and seasonal movements, hasn't been yet established. Therefore, as emphasized in the previous management plan project (1997), a programme taking into consideration all the aspects of the volume-area-altitude relations should be implemented, in order to ensure that the lake level will be maintained to the extent that it will conserve ecological values (Erkakan, 1997). Taking the results of the study and field observations into account, it can be stated that unless the deteriorating effects of the changing water regime and the hampering impacts of the phytotoxic soil-water-mud combination caused by increasing chemical pollution, the main ones being boron and salt, are removed, a healthy vegetation will not sustain its life. The fact that a nursery of 16 000 willow (*Salix alba*) trees was established in the months following 1998 can be considered a superficial approach to the problem. Such activities should be on a scientific basis and be done within a specific time period.

## REFERENCES

- American Public Health Association (1992). Standard methods for the examination of water and wastewater. APHA, AWWA-WPCF, Washington DC.
- Anonymous (1998). Lake Kuş. Republic of Turkey Ministry of Environment, General Directorate of Environmental Protection, Ankara.
- Celtemen S.P. (1998). Development of a water quality management plan for Lake Manyas. Ph D. Thesis. Ankara.
- Erdem O. (1995). Bird paradises of Turkey. Ministry of Environment, General Directorate of Environmental Protection, Ankara.
- Erkakan F. (1997). Manyas Lake watery areas administration plan project. Republic of Turkey, Ministry of Environment, General Directorate of Environmental Protection, Ankara.
- Rump H.H., Krist H. (1992). Laboratory manual for the examination of water, wastewater and soil. VCH, D. 6940 Weinheim, Federal Republic of Germany.



# WATER QUALITY AND ECOLOGICAL PROPERTIES OF BURDUR LAKE

Sevinç Arcak<sup>1</sup>, Ahmet Altındağ<sup>2</sup>

Department of Soil Science, Faculty of Agriculture, Ankara University, Ankara

Department of Biology, Faculty of Science Ankara University, Ankara

## ABSTRACT

Due to its water quality class of C<sub>4</sub>S<sub>4</sub> and the lack of hydraulic altitude, Lake Burdur is not suitable for the purpose of irrigation and the generating hydro- electrical energy. Burdur lake has an international reputation for its unique property of giving shelter to about 75 % of world white headed duck (*Oxyura leucocephala*) population. Within the context of the study, water quality parameters, phytoplankton, zooplankton and lake fauna observations were tried to perform for the period of two years. Zooplanktonic organisms identified in the lake are *Hexarthra fennica* and *Brachionus plicatilis* of Rotifera group. These organisms are dominant in the lake and the characteristic species of salty surrounding areas. It was also determined that *Brachionus plicatilis* is a pollution indicator of low alkaline brackish waters. In addition, *Amphiprora alata* which belongs to *Bacillariophyta* division of phytoplanktonic group was proved to be dominant species of salty and brackish waters.

The overall water quality parameters used for the determination of the quality of the lake and its vicinity include; temperature (°C), secchi depth, pH, EC, dissolved oxygen, ammonia, permanganate consumption, carbonate, bicarbonate, chloride, sodium, potassium, calcium, magnesium, ortho-phosphate and boron.

## INTRODUCTION

Burdur Lake is an internationally well known wetland of class A where about 150 000 waterbird inhabit regularly every year and 70 % of the world *Oxyura Leucocephala* population, total population of which is estimated to be 150 000 winter. It is an important Bird Area (Grimmett and Jones, 1989) and was one of five Turkish wetlands listed as Ramsar Sites when Turkey become the 83 rd party to the Ramsar Convention (Convention on wetlands of International Importance, especially as waterfowl Habitat) in 1994. The lake being a closed watershed, it has no outlet that results in salty and brackish water. Main streams contributing to the lake are Bozçay, Ulupınar, Bayındar, Büğdüz, Karna, Çerçin, Keçiborlu. The aforementioned streams carry pollutants to the lake deriving from sewer systems of the settlements and industrial facilities located in the vicinity.

The Lake Burdur is one of the deepest lakes of Turkey. In observations made in this area it's stated that the lake has oligotrophic character and poor by foodstuff. Aquatic plants can not be seen in the lake water, because the amount of sodium sulphate and chlorine in the lake water, because the amount of sodium sulphate and chlorine in the lake water is high. Since the lake water do not freeze in winter, some species of ducks from crowded groups here wide and open water surface create a secure condition for the birds which pass the winter here. Shallow areas at the south-west and north-east parts of the lake and muddy plains near the shores provide possibility with their rich food stuff for birds to feed (Green, et al., 1996; Green and Anstey, 1992).

For protection of the living areas of the species, International Waterbirds and Wetlands Searching Association and Waterbirds and Wetlands Association has been executing and International Searching and Protection program since 1989 Turkey and Russia come first among the countries which are given most importance. Protecting the Lake Burdur is very important for this species to be able to continue its generation (Anonymous, 1998).

The aim of the study carried out in 1998-1999 is to determine water quality and ecological properties of Burdur Lake.

## MATERIALS & METHODS

### Site Description

Burdur Lake is a closed-basin (endorreic), saline lake of c. 140 km<sup>2</sup> at 845 m above sea level in south-west Anatolia, Turkey (37° 43' N, 30° 15' E, Figure 1) divided between the provinces of Burdur to the south and Isparta to the north. It is 30 km long by up to 7 km wide and lies on a geological fault in a earth-quake zone. The water has a high salt and soda content and never freezes. The lake has a catchment area of 6150 km<sup>2</sup> and is fed by several rivers, many with erratic water flow.

The maximum depth was 110 m, it is now either 42 m or 85 m (Salathe and Yazar, 1992). Burdur city has c. 60 000 inhabitants and lies on the eastern shore. There are numerous small towns in the catchment, which has a total of 150 000 inhabitants. Sugarbeet and cereals are grown in flat alluvial plains at both ends of the lake. Vines, roses (for perfume production) and fruit trees are grown in terraces on gentle slopes above the lake.

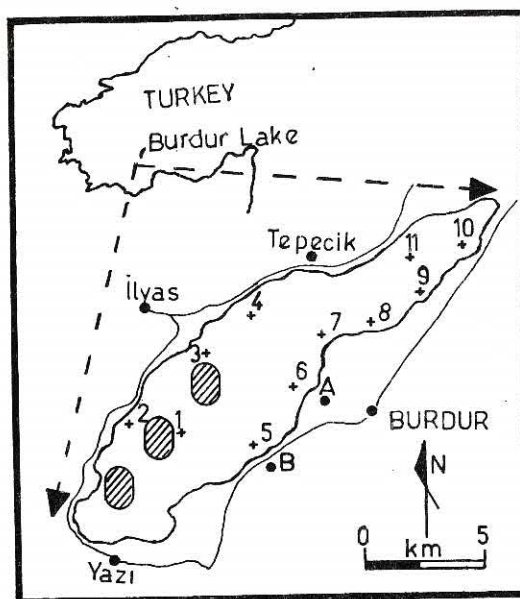



Figure 1. Location and map of Burdur Lake. A. sugar factory outflow B. milk factory outflow, (+) water and phytoplankton sampling stations,  white-headed duck wintering area

#### Methods of Water Quality Analysis

The water samples were collected during 1998-1999 inclusive at fourteen stations (Figure 1). The water quality parameters were analysed using the described methods by APHA. The parameters measured in the samples obtained from the lake are pH, electrical conductivity (EC), secchi depth,  $\text{NH}_3\text{-N}$ ,  $\text{NO}_2\text{-N}$ ,  $\text{NO}_3\text{-N}$ , hardness,  $\text{o-PO}_4$ , Cl, Na, K, calcium (Ca), magnesium (Mg), dissolved oxygen (DO), temperature ( $^{\circ}\text{C}$ ), alkalinity ( $\text{CO}_3^{2-}$  and  $\text{HCO}_3^{-}$ ) and potassium permanganate consumption (PV). The parameters measured by the field instruments were temperature, depth, secchi depth, DO, pH and EC. Water parameters were analysed as indicated by standard methods (APHA, 1992).

The zooplankton and phytoplankton samples were collected from 10 different stations of Lake Burdur (Figure 1), by using Hydro-Bios Kiel brand plankton scoop net having pore size  $55\mu\text{m}$  and mouth width 25 cm. Vertical and horizontal hauls were made at 10 m depth for 5 minutes. The specimens were preserved in 4 % formaldehyde immediately after collection and subsamples examined microscopically (Lund et al. 1958).

## DISCUSSION

### Bird Counting

Total bird number counted in October is 343 619. This is the highest value ever recorded so far in the lake. The lake has given shelter to about 150 000 birds between November 1997 and January 1998. 121 bird species were recorded in April 27, 1997. The lowest bird counting amount was recorded as 58 in March 1, 1998. Counting of April and June 1997 have shown that birds don't prefer

the lake for feeding and stay. Number of waterfowl showed an abrupt increase in August 1997. Along the winter months 800 *Oxyura leucocephala* were defined. The highest number recorded in bird counting is 889 in January 1998, 1451 *Oxyura leucocephala* were counted in January 1999. (Can, 1999).

#### Water Quality Studies

Temperature of the lake water ranged from 18 °C to 22 °C in June 1998, from 14 °C to 17 °C in October 1998, from 17 °C to 22 °C in May 1999. There is difference between surface and depth measurements. Decrease depending on depth especially in spring months is due to spring cycle. pH was found between 9.1-9.5 in spring, 9.1- 9.3 in autumn periods. Electrical conductivity was found between 22 000  $\mu\text{Scm}^{-1}$  - 26 000  $\mu\text{Scm}^{-1}$  in spring, 30 200  $\mu\text{Scm}^{-1}$  - 31 000  $\mu\text{Scm}^{-1}$  in autumn (Table1, 2 and 3).

Secchi disc depth measurements were between 1.50 m – 3.22 m in spring, 3.10-4.20 m in autumn. Secchi depth measurements of the depth of 3-4 m . Corresponded to oligo-mesotrophic level. Dissolved oxygen values depending on depth ranged gradually from 6.2 to 9.5  $\text{mg l}^{-1}$  in spring, from 7.6 to 9.0  $\text{mg l}^{-1}$  in autumn.

Nitrate and nitrite nitrogen were found zero. Increasing ammonia nitrogen was also determined in the lake. Orthophosphate phosphorous was defined as 0-0.291  $\text{mg l}^{-1}$ , calcium values were between 18-39  $\text{mg l}^{-1}$ , magnesium 1159-1499  $\text{mg l}^{-1}$  in spring, 60-180  $\text{mg l}^{-1}$  and 2254-2432  $\text{mg l}^{-1}$  in autumn respectively.

Results obtained have shown that formation of ammonia in the lake is due to chemical reduction and  $\text{N}_2$  - synthesizing plankton. High content of ammonia is a phenomenon caused by industrial and urban waste waters. Potassium, sulfate and chloride values are at their heights levels. From the view point of sodium, chloride and pH values of its water, Burdur Lake is classified as IV. The fact that the lowest dissolved oxygen values were recorded in the samples taken around the mouth of the sewer system and MİS Dairy Facility is the indicator that the lake waters get mixed up with organic pollutants of anthropogenic origin. These organic waters are decomposed by aquatic microorganisms leading to decrease in oxygen level of the lake.

The ecological character and conservation value of Burdur Lake is significantly threatened by a range of factors, as is typical of wetlands of importance for waterbirds in Turkey (Grimmett & Jones, 1989) and throughout the Mediterranean region (Hollis, 1992). Many current changes could have a negative impact on the white-headed ducks even if the problems of illegal hunting are solved. The distribution and abundance of their food solved. The distribution and abundance of their food supply is likely to be affected by man- induced changes. Enhanced sediment, organic and inorganic inputs to the closed lake system may have already changed its ecological character. The lake is undergoing eutrophication, which generally leads to a loss of biodiversity in wetlands, although it increases the numbers of certain species (Nilsson, 1978).

In the long term, the input of acidic effluents from the industrial complex could cause major ecological change by exhausting the buffering capacity of the lake. Textile industry effluent is very acidic (Mason, 1981) and could markedly reduce lake pH. It has been suggested that a significant lowering of the pH of the lake would result in the release of hydrogen sulphide in toxic quantities, owing to the naturally high levels of sulphur compounds in the lake (Timur et al., 1988). The bird-strike problem has not been considered during planning of the airport, and there is a possibility of hydrocarbon and other pollution entering the lake.



Table 1. Physico chemical data of Burdur Lake ( June 1998)

Sampling No	Depth (m)	Temp. (°C)	Secchi disc depth (m)	pH	EC (µS cm <sup>-1</sup> )	DO <sup>1</sup> (mg l <sup>-1</sup> )	NH <sub>3</sub> (mg l <sup>-1</sup> )	Perm. <sup>2</sup> Cons. (mg l <sup>-1</sup> )	Total hardness (mg l <sup>-1</sup> CaCO <sub>3</sub> )	Anions (mg l <sup>-1</sup> )				Cations (mg l <sup>-1</sup> )			
										CO <sub>3</sub> <sup>2-</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>
1	Surface	19		9.2	23600	9.5	2.24	14.22	5023	1440	1891	4643	6230	5443	98	19.6	1194
	60.25	18	3.22	9.2	24000	8.6	2.20	6.32	6027	990	274	5968	9739	6382	55	29.4	1429
2	Surface	21		9.2	24000	8.1	2.38	6.00	5537	660	518	5975	2076	2911	185	29.4	1311
	34.28	18	2.86	9.1	22400	7.5	2.35	23.38	5782	1380	2013	170	5801	2025	39	19.6	1376
3	Surface	22		9.2	24000	8.0	2.31	13.58	6346	900	183	4111	3427	3039	43	39.2	1499
	14.58	22	2.86	9.2	22000	7.4	2.31	20.22	5756	1440	1800	4643	1123	2658	45	19.6	1370
4	1.58	22	-	9.1	22800	7.7	2.26	11.06	6615	780	1464	6059	2198	3039	82	39.2	1564
5	Surface	22		9.5	24000	7.6	2.24	7.90	6199	1170	2315	6429	1627	3039	55	19.6	1476
	3.62	20	1.86	9.2	24000	7.2	2.23	4.48	4925	1560	3172	4832	259	3348	55	39.2	1159
6	Surface	22		9.2	24000	7.4	2.30	12.32	5929	1230	122	6429	816	2785	50	19.6	1411
	16.16	20	2.39	9.2	24000	7.2	2.19	9.16	6125	1470	641	6834	130	3015	45	29.4	1452
7	Surface	20		9.2	24000	6.4	2.31	6.32	6005	1440	2562	4608	830	2658	55	29.4	1423
	14.06	20	2.36	9.1	24200	6.2	2.33	1.58	5756	480	641	3262	5962	2911	55	29.4	1364
8	Surface	18		9.2	24200	7.5	2.23	4.10	6174	1410	1861	4753	1387	2658	39	39.2	1458
	2.12	18	1.65	9.1	24400	7.2	2.16	4.74	5243	840	1189	4867	2309	2911	55	29.4	1241
9	Surface	19.5		9.2	23600	8.2	2.26	15.8	5317	1470	1586	4753	922	2785	51	29.4	1258
	5.08	18	3.11	9.2	24000	7.5	2.23	9.48	5390	1560	1342	4796	1022	2785	50	29.4	1276
10	0.5	19	-	9.2	24200	9.3	2.23	18.96	4949	1350	1922	4718	317	2658	55	29.4	1170
Bugdiz stream	-	24	-	8.5	800	6.6	1.82	7.90	466	60	305	78	158	57	7	78.4	71
Ince stream	-	17	-	8.3	600	8.0	1.83	2.00	441	36	415	46	29	13	1	39.2	88
Bozcay stream	-	19.8	-	8.3	1820	9.0	1.94	22.12	490	-	738	139	706	266	7	78.4	159
Ozdere stream	-	23	-	8.9	1000	6.5	1.85	39.50	742	90	1006	320	120	335	6	39.2	155

<sup>1</sup> Dissolved oxygen<sup>2</sup> Permanganate consumption

Table 2. Physico chemical data of Burdur Lake ( October: 1998)

Sampling No	Lake depth (m)	Sampling Depth (m)	Temp (°C)	Scechi disc depth (m)	pH	EC (µS cm <sup>-1</sup> )	DO <sup>1</sup> (mg l <sup>-1</sup> )	NH <sub>3</sub> (mg l <sup>-1</sup> )	PV <sup>2</sup> (mg l <sup>-1</sup> )	α-PO <sub>4</sub> (mg l <sup>-1</sup> )	Total hardness (mg l <sup>-1</sup> CaCO <sub>3</sub> )	Anions (mg l <sup>-1</sup> )				Cations (mg l <sup>-1</sup> )			
												CO <sub>3</sub> <sup>2-</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>
1	40-80	Surface	17	4.15	9.2	30400	7.9	6.29	14.40	0.087	4000	840	1189	5999	22272	10888	74	70	2317
		10.0	14		9.1	30200	9.0	6.12	10.80	0.078	4100	900	915	5680	25392	12222	70	80	2254
		Surface	17	3.55	9.3	30300	8.4	6.80	11.52	0.061	4180	1080	1190	5787	24240	11777	74	100	2346
2	4-80	4.70	17		9.3	30400	7.8	6.29	14.40	0.087	4200	900	1251	5822	25302	12222	74	120	2346
		Surface	18	4.00	9.2	30400	7.6	5.95	12.60	0.042	4100	960	1129	5822	24240	11777	74	100	2311
3	11-25	9.00	17		9.3	30400	8.0	6.80	13.32	0.067	4220	1050	915	5716	25680	12222	70	130	2358
		Surface	17	3.52	9.3	30400	8.4	6.29	11.52	0.050	4200	1020	1037	5929	23424	11333	74	60	2381
4	6-30	4.25	16		9.2	30500	8.6	5.95	10.80	0.037	4260	1050	1007	5645	24720	11555	70	70	2409
		Surface	14	4.20	9.1	30400	9.0	5.95	16.20	0.035	4100	1140	976	5787	23184	11333	79	180	2360
5	14.00	6.00	17		9.2	30400	8.5	6.80	12.60	0.043	4080	1020	1220	5716	25152	12222	78	110	2394
		Surface	17	3.50	9.2	30300	8.2	4.93	14.40	0.037	4240	1230	946	7242	22368	11777	78	100	2381
6	15.82	3.50	16.5		9.1	30500	8.0	5.61	10.44	0.059	4240	1050	1007	7065	23328	12000	84	140	2358
		Surface	16.5	3.45	9.2	30600	8.3	5.95	10.08	0.043	4220	1170	976	5467	24912	11777	78	90	2392
7	6.00	5.00	16		9.2	30700	8.4	5.95	12.60	0.067	4080	1170	1068	5999	24432	12000	74	110	2294
		Surface	17	3.10	9.2	30500	8.6	4.25	12.60	0.037	4260	1050	1220	5467	25584	12000	74	80	2404
8	3.20	3.10	16		9.2	31000	10.2	5.10	7.56	0.050	4300	1080	1220	7419	21408	11333	78	70	2432
		Surface	16	3.15	9.2	30600	9.0	6.80	10.80	0.063	4260	1230	1403	5183	24384	11555	74	70	2409
9	6.00	4.60	16		9.2	30600	8.0	6.29	14.40	0.054	4120	1200	976	5467	24528	11777	70	120	2300
		Surface	16	1.50	9.2	30800	7.8	5.44	16.20	0.041	4260	1200	1220	6177	24624	12222	74	80	2404
10	1.50	1.10	15.5		9.2	31200	6.6	4.59	5.40	0.041	4120	840	976	5467	25634	12000	70	110	2317
Bugdüz stream	-	-	11	-	8.5	1100	10.4	0.85	3.6	-	610	80	458	36	1104	92	8	200	236
Özdere stream	-	-	16	-	8.9	3000	8.6	0.68	28.44	-	610	150	305	36	1152	556	8	120	242
İncedere stream	-	-	15	-	8.3	800	8.8	-	11.16	-	670	300	610	675	586	37	4	100	328
Bozçay stream*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

<sup>1</sup> Dissolved oxygen<sup>2</sup> Permanganate consumption

\*: Due to dryness

Table 3. Physico chemical data of Burdur Lake (May 1999)

Sampling No	Lake depth (m)	Sampling depth (m)	Temp. (°C)	Secchi disk depth (m)	pH	EC ( $\mu\text{S cm}^{-1}$ )	DO <sup>1</sup> (mg l <sup>-1</sup> )	NH <sub>3</sub> (mg l <sup>-1</sup> )	Perm. <sup>2</sup> Cons. (mg l <sup>-1</sup> )	o-PO <sub>4</sub> (mg l <sup>-1</sup> )	Total hardness (mg l <sup>-1</sup> CaCO <sub>3</sub> )	Boron (mg l <sup>-1</sup> )	Anions (mg l <sup>-1</sup> )				Cations (mg l <sup>-1</sup> )			
													CO <sub>3</sub> <sup>2-</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>
1	50	Surface	19		9.4	26000	8.8	6.78	12.64	0.110	5625	16.8	492	831	5254	16796	9518	62.5	20	1350
2		17.55	11	1.50	9.5	24000	7.8	5.27	13.27	0.104	5525	14.3	456	939	5325	15417	9000	61.5	20	1314
3		Surface	21		9.4	22400	11.8	12.7	9.48	0.266	5525	16.3	540	793	2556	16527	7711	61.3	22	1313
4		Surface	22		9.5	22000	7.4	11.9	5.69	0.102	5625	16.5	600	793	2840	7208	3428	62.5	20	1338
5		Surface	21		9.4	22800	8.4	11.5	6.95	0.201	5525	16.2	480	915	1331	11023	6868	61.3	16	1316
6	11.00	Surface	17	2.10	9.4	26000	9.0	6.54	6.63	0.092	5500	16.5	510	854	5506	12772	7831	62.5	20	1308
7	8.0	Surface	10		9.4	24400	6.2	6.37	6.32	0.138	5625	16.0	516	842	5325	11118	6868	60.0	18	1339
8	12.75	Surface	17	2.15	9.4	25000	8.8	5.52	9.48	0.156	5875	16.8	540	885	5431	12402	7470	62.5	20	1398
9		Surface	17		9.4	23000	8.8	6.12	7.90	0.092	5625	16.6	546	878	5360	15021	8795	63.8	16	1340
10	7.00	Surface	17	1.87	9.4	25000	8.6	5.18	9.48	0.092	5875	16.7	564	824	5325	12304	7349	62.5	22	1397
11		5.0	15		9.3	24000	8.4	4.67	6.95	0.139	5750	16.3	690	555	5360	12890	7711	62.5	36	1358
		Surface	20	1.00	9.4	26000		7.65	6.32	0.275	5750	16.6	522	848	5396	14649	8554	61.3	24	1366
	4.32				9.4	24400	7.4	5.85	6.32	0.104	5625	16.4	480	946	5325	10608	6627	63.8	36	1328
		Surface	19	1.83	9.3	24800	8.2	6.37	6.32	0.104	5625	17.0	564	769	5325	16381	9398	62.5	12	1343
	3.70	2.5	19		9.4	25000	7.8	6.88	4.42	0.291	6000	16.4	450	946	5360	15228	8675	62.5	32	1421
	0.92	Surface	21		9.3	23400	7.6	6.29	0.63	0.104	6250	16.8	540	769	5431	14866	8434	63.8	22	1487
		Surface	21		8.9	540	6.0	9.43	0.32	0.095	245		36	268	36	2	40	1.25	26	14
Bıgüç stream		Surface	19		8.7	900	6.4	10.0	22.1	0.250	305	0.29	120	158	36	1795	329	3.75	100	306
İnce stream		Surface	17		8.8	800	7.4	11.5	0.95	0.152	485		136	512	36	1435	31		210	391
Borçay stream*																				
Özdere stream*																				

<sup>1</sup> Dissolved oxygen.<sup>2</sup> Permanganate consumption

\*: Due to dryness



### Phytoplankton

A total of 41 genera of phytoplankton identified in samples collected from Burdur lake. From these, 18 belong to Bacillariophyta, 16 to Chlorophyta, 6 to Cyanophyta and Chrysophyta and one to Euglenophyta and Dinophyta divisions. The dominant genera of the lake were observed Bacillariophyta- Chlorophyta and Cyanophyta- *Amphipora* sp., *Synedra* sp. and *Cyclotella* sp. belong to Bacillariophyta- *Spirogyra* sp. and *Cladophora* sp. belong to Chlorophyta and *Oscillatoria* sp. belong to Cyanophyta divisions (Table 4).

Pytoplanktons were studied at various stations of Lake Burdur (Figure 1.). Most of the species (16) were observed at station 4 and very few (2 sp.) at station 9. *Amphipora* sp. were found dominant species of the lake and are the characteristic species of brackish and salty waters (Germain, 1981). In addition, *Scenedesmus* sp. and *Pediastrum* sp. of belonging to Chlorophyta division are reported dominant species of eutrophic lakes (Hutchinson, 1967, Harper 1992), *Synedra* sp. has been reported characteristic species of eutrophic lakes (Hutchinson, 1967). Among Cyanophyta- *Microcystis*, *Chloococcus*, *Spirulina*, *Oscillatoria* etc. species are found abundant in still waters. *Microcystis* inhabits in mesotrophic lakes, however some species of *Oscillatoria* and *Anabaena* are in a recorded very polluted waters.

### Zooplanktonic Organisms

From the groups of zooplanktonic organisms in Burdur Lake, a total of 18 taksons (Copepoda 3, Cladocera 5, Rotifera 10) were determined. In addition, from the Özdere (stream) which is connected with Burdur Lake, a total of 23 species of zooplanktons (Copepoda 3, Cladocera 6, Rotifera 14) were examined. The dominant group of the lake is Rotifera and species belonging to his group (*Brachionus plicatilis* and *Hexarthra fennica*) were noted at all the sampling stations. In present study, species belonging to Rotifera (*Cephalodella catellina*, *C. gibba*, *Colurella adriatica*, *Lecane lamellata*, *Keratella quadrata*, *Synchaeta oblonga*, *Polyarthra vulgaris*), Cladocera (*Diaphanosoma brachyurum*, *Daphnia magna*, *D. Longispina* and *Alona* sp.), Copepoda (*Cyclops* sp. and *Harpacticoid* Copepod *Canthocampus* sp.) have been reported first time and are new for this lake (Table 4).

Of the dominant species, *Arctodiaptomus burduricus* has been observed endemic species of Lake Burdur (Kosswig, 1956). Among other dominant groups *Brachionus plicatilis* and *Hexarthra fennica* are reported characteristic species of salty waters (Hecky and Kilham, 1973; Sharma 1983, Bayly, 1976 and Koste 1978), however, according to Sharma (1983) *B.plicatilis* found in low alkaline and salty waters and is a characteristic pollution indicator species. Saksena (1987) has reported *B.plicatilis* indicator species of eutrophic lakes.

Besides, *Hexarthra fennica*, *B. plicatilis*, *Keratella quadrata*, *Lecane* sp. are eurythermal and euryhaline species of the lake (Berzins and Pejler 1989). According to Koste (1978) a rotifer- *Colurella adriatica* is a euryhaline species and generally found in waters with pH 5.5-10.5. The pH of the Lake Burdur ranges between 8.5-9.6 and is suitable habitat for this species. *Keratella quadrata* and *Polyarthra vulgaris* are the eurythermal species and inhabits in both salty and freshwaters and are known as cosmopolitan species. *Polyarthra vulgaris* mostly found in waters with high oxygen concentrations (Koste, 1978).

### Fish Fauna

During the study at Burdur Lake, a total of 20 *Aphanius* sp. were captured live and examined. The species *Aphanius burduricus* already present in the lake was re-identified as *Aphanius anatoliae*. However, taxonomic position of this species was not determined properly.

Table 4 . Distribution phytoplankton samples of Lake Burdur by stations and their frequency of occurrence

PHYTOPLANKTON	1 <sup>st</sup> Sta.	2 <sup>nd</sup> Sta.	3 <sup>rd</sup> Sta.	4 <sup>th</sup> Sta.	5 <sup>th</sup> Sta.	6 <sup>th</sup> Sta.	7 <sup>th</sup> Sta.	8 <sup>th</sup> Sta.	9 <sup>th</sup> Sta.	10 <sup>th</sup> Sta.	Ozdere Stream
<b>Cyanophyta</b>											
<i>Oscillatoria</i> sp.	2x	1x		3x		3x			1x	2x	3x
<i>Nostoc</i> sp.			1x								
<i>Aphanizomenon</i> sp.			1x								
<i>Chroococcus</i> sp.				1x							
<i>Microcystis</i> sp.			1x								
<i>Anabaena</i> sp.		1x			1x						
<b>Chlorophyta</b>											
<i>Scenedesmus</i> sp.	1x										1x
<i>Cosmarium</i> sp.				1x							1x
<i>Cylindrocapsa</i> sp.		1x									
<i>Dictyosphaerium</i> sp.	1x					1x	1x	1x			
<i>Cladophora</i> sp.		1x									
<i>Stigeoclonium</i> sp.				1x							1x
<i>Pediastrum</i> sp.			1x								
<i>Ankistrodesmus</i> sp.		2x									2x
<i>Spirogyra</i> sp.			1x								
<i>Chlorocella</i> sp.						1x					
<i>Zygnema</i> sp.	1x										
<i>Oedogonium</i> sp.		1x									1x
<i>Chlosterium</i> sp.		1x		1x							
<i>Mangotia</i> sp.				1x		1x					
<i>Flormidium</i> sp.			1x								
<i>Oocystis</i> sp.											
<b>Bacillariophyta</b>				1x	1x	2x		1x	1x		1x
<i>Amphora</i> sp.			1x								
<i>Achnanthes</i> sp.				1x		2x		1x		1x	
<i>Gyrosigma</i> sp.				1x							3x
<i>Nitzschia</i> sp.				1x						1x	1x
<i>Navicula</i> sp.	1x			3x		2x					
<i>Amphipleura</i> sp.			1x								1x
<i>Amphiprora</i> sp.	3x	3x	2x	3x	3x	2x				1x	1x
<i>Cyclotella</i> sp.	1x			2x							1x
<i>Synedra</i> sp.	1x			1x							1x
<i>Surirella</i> sp.	1x			1x							1x
<i>Melosira</i> sp.		1x									1x
<i>Spirulina</i> sp.			1x	1x						1x	3x
<i>Diatoma</i> sp.			1x								
<i>Rhoicosolenia</i> sp.				1x							1x
<i>Gamphonema</i> sp.							1x				1x
<i>Cymbella</i> sp.		1x									
<i>Cyriatopleura</i> sp.			1x	1x							1x
<i>Fragilaria</i> sp.											
<b>Chrysophyta</b>											1x
<i>Dinobryon</i> sp.											
<b>Euglenophyta</b>											1x
<i>Euglena</i> sp.	1x			1x	1x						
<b>Dinophyta</b>											
<i>Ceratium</i> sp.	1x	1x	1x								
<b>ZOOPLANKTON</b>											
<b>Rotifera</b>											
<i>Brachionus plicatilis</i>	3x	3x	2x	3x	3x	3x	3x	3x	1x	3x	2x
<i>Hexarthra fennica</i>	2x	3x	2x	3x	3x	2x	3x	3x			1x
<i>Keratella quadrata</i>	1x		1x	1x	1x	1x	1x				1x
<i>Synchaeta</i> sp.	2x	2x	3x	1x	1x	1x					
<i>Colurella adriatica</i>	2x	1x		2x	1x	2x		2x		2x	
<i>Polyarthra vulgaris</i>	1x	1x									1x
<i>Lecane lamellata</i>				1x							1x
<i>Lecane luna</i>											1x
<i>Lecane lunaris</i>						1x	2x				2x
<i>Cephalodella catellina</i>							1x				1x
<i>Cephalodella gibba</i>											1x
<i>Trichotria pocillum</i>											
<i>Asplanchna</i> sp.		1x									1x
<i>Notholca acuminata</i>				1x							1x
<i>Notholca squamula</i>											1x
<i>Testudinella patella</i>											1x
<i>Euchlanis dilatata</i>											



Cladocera	1 <sup>st</sup> Sta.	2 <sup>nd</sup> Sta.	3 <sup>rd</sup> Sta.	4 <sup>th</sup> Sta.	5 <sup>th</sup> Sta.	6 <sup>th</sup> Sta.	7 <sup>th</sup> Sta.	8 <sup>th</sup> Sta.	9 <sup>th</sup> Sta.	10 <sup>th</sup> Sta.	Ozdere Stream
<i>Daphnia magna</i>	1x	1x									3x
<i>Daphnia longispina</i>		1x									1x
<i>Ceriodaphnia</i> sp.											1x
<i>Diaphanosoma brachyurum</i>						1x	1x				1x
<i>Chydorus ovalis</i>		1x									1x
<i>Chydorus sphaericus</i>											1x
<i>Alona</i> sp.	1x										1x
<b>Copepoda</b>											
<i>Arctodiaptomus burduricus</i>	2x	3x	2x	1x	3x	2x			2x	2x	1x
<i>Cyclops</i> sp.	1x	1x		1x		1x	1x				1x
<i>Canthocamptus</i> sp.						1x				1x	1x
<i>Nauplius + Copepodit</i>	2x	1x	1x	1x	3x	1x		2x			1x
<b>Ostracoda</b>											
<i>Cypris</i> sp.	1x				1x	3x					

(1x= Rare, 2x= Frequent, 3x= Wide Spread)

## CONCLUSIONS

However, Burdur Lake lacks of quality and hydraulic potential in terms of water resources, it is of great importance due to having two endemic fish species. From the view point of the protection of the species, life in the lake should be sustained. Due to environmental factors and water chemistry of the lake, less frost incident takes place in the region than other wetlands that makes possible more than 100 000 birds be able to winter in the region. Because region has a unique ecological conditions, *Oxyura leucocephala* which is believed to have a population of 30 000 –32 000 worldwide and confronted with extinction, maintains its life in the lake. In spite of unwanted physio-chemical properties of its waters relating to irrigation, lake offers an opportunity of benefiting from its recreational and aesthetical properties to the people living in the region. Gradual depletion that can be readily monitored on the water level of the lake must be investigated in connection with the climatic characteristics.

It is very important that the threats facing the lake are addressed, particularly to conserve its endemic species and population of white-headed ducks. Measures required to solve these problems need not conflict with the needs and activities of the local human population around the lake. Since the lake is an important leisure area in the summer, and thousands of people live on the lake shores all year round, there is a common interest that further degradation of the lake should be prevented.

Treatment plants should be fitted to the sugar factory, milk factory and Burdur sewage system to minimise the quantity of pollutants entering the lake. Remedial action is required at the sulphur mine to minimise the leaching of inorganic pollutants into the lake from old mine workings. There is a need to establish an adequate programme of site wardening to eliminate waterbird hunting at Burdur Lake.

## REFERENCES

- American Public Health Association (ed.) (1985). Standard methods for the examination of water and wastewater. APHA, AWWA – WPCF, Washington DC.
- Anonymous (1998). Lake Burdur. Republic to Turkey Ministry of Environment, General Directorate of Environmental Protection 1-28, Ankara.
- Arcak, S., Haktanir, K., Arcak, Ç., Altındağ A. (1999). Management project of wetlands final report of the subproject of the wetland management plan of Burdur Lake. Republic of Turkey Ministry of Environment, Ankara.
- Bayly, I.A.E. (1976). The plankton of lake Eyre. Aust. J.Mar. Freshwater Res., 27: 661-665.
- Berzins, B., Pejler, B. (1989). Rotifer occurrence in relation to oxygen content. Hydrobiol. 183: 165-172.
- Can, O. (1999). Ornithological Monitoring and Counting. Society for the protection of Nature.
- Germain, H. (1981). Flore Des diatomées, Diatomophycees, Societe Nouvelle Des Editions Boubee II. Place Saint-Michel, 235 p.75006 Paris.
- Green, A.J. Anstey, S. (1992). The status of the white-headed duck *Oxyura leucocephala*. Bird Conserv. Int., 2, 185-200.



- Green, A.J., Fox, A.D., Hilton, G., Hughes, B., Yazar, M., Salathe, T. (1996). Threats to Burdur Lake ecosystem, Turkey and its waterbirds, particularly the white-headed duck. *Biological Conservation* 76, 241-252.
- Grimmett, R.F.A., Jones, T.A. (1998). Important bird areas in Europe. *Int. Counc. Bird Preseru. Tech. Publs.* No.9.
- Grimmett, R.F.A., Jones, T.A. (1989). Important bird areas in Europe. *Int. Counc. Bird Preserv. Tech. Publs.* No.9.
- Hecky, R.E., Kilham, P. (1973). Diatoms in alkaline, saline lakes: Ecology and Geochemical. *Limnol. Oceanogr.* 18: 53-71.
- Hollis, T. (1992). The causes of wetland loss and degradation in the Mediterranean. In *Manag Hutchinson, G.E. (1967). A treatise on limnology. Introduction to lake biology and the limnoplankton, John Wiley, USA. 2. McGraw Hill, N.Y., Vol.2. 1115 pp. ing Mediterranean wetlands and their birds. Proc. Symp., Grado, Italy, 1991. Ed. C.M. Finlayson, G.E. Hollis, T.J. Davis. IWRB Spec. Publs, No. 20, 83-90.*
- Kosswig, C. (1956). Über Makro-und Mikropopulationen des Zahnkarpfens *Anatolichtys*, *Zool. Anz.*, 156: 74-90.
- Koste, W. (1978). Die Radertiere Mitteleuropas I. Textband, 673 p. Berlin, Stuttgart.
- Lund, J.W.G., Kipling, C., Gren, E.D. (1958). The inverted microscope method of estimating algal numbers and the statistical basis of estimations by counting, *Hydrobiologia*, 11:113-170.
- Mason, C.F. (1981). *Biology of freshwater pollution*. Longman, Colchester.
- Nilsson, L. (1978). Breeding waterfowl in eutrophicated lakes in south Sweden. *Wildfowl*, 29, 101-110.
- Saksena, N.D. (1987). Rotifera as indicators of water quality *Acta Hydrochim. Hydrobiol.* 15:481-485.
- Salathe, T., Yazar, M. (1992). Towards a management plan for Lake Burdur. DHKD and Station Biologique de la Tour du Valat, Arles (Unpublished report).
- Sharma, B.K. (1983). The Indian species of the genus *Brachionus* (Eurotatoria: Monogononta: Brachionida) *Hydrobiol.* 104-31-39.
- Timur, M., Timur, G., Özkan, G. (1988). A study on physical and chemical changes in Burdur Lake, and its effects on living organisms. *Akdeniz Üniversitesi Su Ürün. Müh. Derg.* 1, 75-144 (in Turkish).

# THE EFFECT OF WATERTABLE ON SOIL POLLUTION

Mikayilov Fariz<sup>1</sup> and Fatih Er<sup>2</sup>

<sup>1</sup>University of Selcuk, Agricultural Faculty, Department of Soil Science, 42031, Konya, TURKEY

<sup>2</sup>University of Selcuk, Çumra Meslek Yüksekokulu, 42500, Çumra, Konya, TURKEY

## ABSTRACT

To prevent of the system of soil ecology from pollution is the main part of the general problems on protection of environment. Because of watertable or antropogenic reasons, water transpiration mechanism of the chemical materials in the system of water, soil, plant fertilizer atmosphere must permanently be examined and known, because pollution is a bio-physical and geo-chemical process and the pollution of soils effect the productivity in a negative way. For this reason the source of pollution and its degree and reasons must be known well and the estimation of pollution must be taken in to consideration, which is very important to increase the productivity of soil. The aim of this work is to examine the transportation mechanism of the chemical materials in watertable and estimate its quantity by using mathematical modeling.

## INTRODUCTION

Soil salinity is one of the oldest challenges encountered by irrigated agriculture. Managing soil salinity remains an important problem in many regions (Ghassemi, et al., 1995). Salts are transported as solutes with water in soils, and therefore hydrological regimes of irrigated soils and landscapes govern direction and intensity of salinization.

As the knowledge about solute transport has accumulated, the solute transport models have been developed that accounted for a number of processes in salt affected soils (Van Genuchten and Dalton 1986). Hydrodynamic dispersion, molecular diffusion, and heterogeneity of the flow regime are the primary mechanisms of the solute movement in soil pore space. Chemical, biological, and microbiological processes account for local changes in solute concentrations. Both analytical and numerical solutions of the equations in solute transport models are studied and used. Numerical solutions allow for the flexibility in boundary and initial conditions to encompass real field situations. Analytical solutions usually assume a steady-state water flow and constant in time and space dispersivity coefficient, and therefore the applicability of these solutions is limited (Leij and Toride, 1998). However, analytical solutions can be useful to provide initial estimates of alternative salinization and desalinization scenarios when implemented over large temporal and spatial scales (Toride et al., 1993). A large number of analytical solutions have been reported for one-dimensional non-equilibrium solute transport (Lassey, 1988; Leij and Toride, 1998 & Sardin, et al., 1991). A semi-infinite porous medium was considered most often. Solute transport in the finite column or layer was received relatively less attention (Mikayilov, 1989; Van Genuchten and Alves 1982). The problems mentioned above and their investigations and solutions are presented properly in following literatures (Jury et al., 1991). Analytical solutions for solute transport in a finite layer are of interest when the concentration of a soluble salt or an ion is monitored on both top and bottom of the layer. When the salt transport in soil occurs in presence of shallow ground water, observations of salt concentrations in ground and irrigation water coupled with water balance estimation can provide necessary data to apply the analytical solution for the finite soil layer to assess salt transport in soil at field scale. The purpose of this work was to develop an analytical solution for the two-region solute transport model in finite layer that would take in account the effect of groundwater salinity on the soil salinity.

## SOLUTE TRANSPORT EQUATION

The two-site non equilibrium solute transport model is given by (Karakaplan et al., 1999; Bayrakli, et al., 1996; Lapidus and Amundson 1952; Mironenko and Pachepsky 1984 ; Van Genuchten and Wagenet 1989):

$$\theta_m \frac{\partial C}{\partial t} + \theta_{im} \frac{\partial N}{\partial t} = \theta_m D \frac{\partial^2 C}{\partial x^2} + \theta_m W(t) \frac{\partial C}{\partial x}, \quad \{(x, t) | x \in (0, L), t \in (0, \infty)\}, \quad (1)$$

$$\theta_{im} \frac{\partial N}{\partial t} = k_1 C - k_{-1} N, \quad (2)$$

Here  $\theta_m$  and  $\theta_{im}$  are the volumetric contents of mobile and immobile water, respectively;  $\theta_m + \theta_{im} = \theta$  is the volumetric water content;  $C(x, t)$  and  $N(x, t)$  are solute concentrations in mobile and immobile pore water,  $\text{mol m}^{-3}$ ;  $W(t)$  is the evapotranspiration rate,  $\text{m s}^{-1}$ . The hydrodynamic dispersion  $D$  is assumed to be proportional to the pore velocity  $D(t) = \lambda |v(t)|$ , the effect of molecular diffusion is ignored;  $\lambda$  is the hydrodynamic dispersion coefficient,  $\text{m}$ ;  $k_1$  &  $k_{-1}$  are first-order rate constants,  $\text{s}^{-1}$ ; the inequality between  $k_1$  and  $k_{-1}$  accounts for effects of the anion exclusion. The initial conditions are

$$C(x, 0) = C_0(x), \quad N(x, 0) = N_0(x), \quad \text{when } t = 0 \text{ for } 0 < x < L \quad (3)$$

Where  $L$  is the water table depth,  $\text{m}$ . The boundary conditions are:

$$\text{if } x = 0: \frac{\partial C}{\partial x} = 0, \quad x = L: D \frac{\partial C}{\partial x} = -W(t)[C(L, t) - C_2(t)] \quad (4)$$

Here  $C_2(t)$  are solute concentrations in the ground water.

## ANALYTICAL SOLUTION

The Laplace transform will be used to obtain the analytical solution. The following dimensionless variables and parameters will be employed:

$$y = \frac{x}{L}, \quad \tau = \frac{Dt}{L^2}, \quad \delta = \frac{\theta_{im}}{\theta_m}, \quad \beta_1 = \frac{k_1 L^2}{\theta_m D}, \quad \beta_{-1} = \frac{k_{-1} L^2}{\theta_m D}, \quad a = \frac{WL}{2D}, \quad (5)$$

The auxiliary variables  $w$  and  $u$  will replace concentrations  $C(x, t)$ ,  $N(x, t)$  and  $C_2$  according to the following equations:

$$C(y, \tau) = C_2(\tau) + w(y, \tau)e^{-a\tau} \quad \text{and} \quad N(y, \tau) = kC_2(\tau) + u(y, \tau)e^{-a\tau}, \quad k = k_1/k_{-1} \quad (6)$$

Using the dimensionless parameters and new variables, Eq. (1)–(4) can be re-written as:

$$\frac{\partial w}{\partial \tau} + \delta \frac{\partial u}{\partial \tau} = \frac{\partial^2 w}{\partial y^2} - a^2 w(y, \tau) + \psi_0(y, \tau), \quad \{0 < \tau < \infty, 0 < y < 1\} \quad (7)$$

$$\frac{\partial u}{\partial \tau} = \beta_1 w - \beta_{-1} u - ke^{a\tau} \frac{\partial C_2}{\partial \tau}, \quad (8)$$

$$w(y, \tau) = w_0(y) \quad \text{and} \quad u(y, \tau) = u_0(y), \quad \text{when } \tau = 0 \text{ for } 0 < y < 1 \quad (9)$$

$$\text{if } y = 0: \frac{\partial w(y, \tau)}{\partial y} - aw(y, \tau) = 0, \quad \text{if } y = 1: \frac{\partial w(y, \tau)}{\partial y} + aw(y, \tau) = 0 \quad (10)$$

Here

$$w_0(y) = [C_0(y) - C_2(0)]e^{a\tau}, \quad u_0(y) = [N_0(y) - kC_2(0)]e^{a\tau}, \quad \psi_0(y, \tau) = \left[ -(1 + k\delta) \frac{\partial C_2}{\partial \tau} \right] e^{a\tau}, \quad (11)$$

The Laplace transforms of the introduced variables are:

$$W(y, p) = L[w(y, \tau)] = \int_0^\infty w(y, \tau) e^{-p\tau} d\tau, \quad U(y, p) = L[u(y, \tau)] = \int_0^\infty u(y, \tau) e^{-p\tau} d\tau, \quad (12)$$

$$\Psi_0(y, p) = \int_0^\infty \psi_0(y, \tau) e^{-p\tau} d\tau = \left\{ -(1 + k\delta) \left[ p \bar{C}_2(p) - C_2(0) \right] \right\} e^{a\tau}, \quad \bar{C}_2(p) = \int_0^\infty C_2(\tau) e^{-p\tau} d\tau \quad (13)$$

Transforming of Eq. (7) and (8) with initial condition (9), we obtain:



$$pW(y, p) - w_0(y) + \delta p U(y, p) - \delta u_0(y) = \frac{d^2 W(y, p)}{dy^2} - a^2 W(y, p + \psi_0(y, p)),$$

$$pU(y, p) - u_0(y) = \beta_1 W(y, p) - \beta_{-1} U(y, p) - ke^{\alpha} \left[ p \bar{C}_2(p) - C_2(0) \right].$$

Excluding  $U(y, p)$  from these two equations results in:

$$\frac{d^2 W(y, p)}{dy^2} - q(p)W(y, p) + W_0(y, p) = 0, \quad \{0 < y < 1; \operatorname{Re} p > 0\} \quad (14)$$

Here, for the sake of brevity,

$$W_0(y, p) = \frac{\delta \beta_{-1}}{p + \beta_{-1}} u_0(y) + w_0(y) + \psi(y, p)$$

$$\psi(y, p) = \psi_0(y, p) + \frac{k \delta p}{p + \beta_{-1}} \left[ p \bar{C}_2(p) - C_2(0) \right] e^{\alpha y} \quad (15)$$

$$q(p) = p + \frac{\delta \beta_1 p}{p + \beta_{-1}} + a^2 = p + \beta_{-1} - \frac{d_1}{p + \beta_{-1}} + d_2, \quad d_1 = \delta \beta_1 \beta_{-1}, \quad d_2 = a^2 + \delta \beta_1 - \beta_{-1}$$

Applying Laplace transform to the boundary conditions (10) and (11), we obtain:

$$y = 0: \frac{dW(0, p)}{dy} - aW(0, p) = 0, \quad y = 1: \frac{dW(1, p)}{dy} + aW(1, p) = 0 \quad (16)$$

Respectively. Eq. (14) has a general solution (Karakaplan et al., 1999):

$$\begin{aligned} W(y, p) = & \int_0^y W_0(\xi, p) \left\{ \frac{(q + a^2) ch[(1 - y + \xi)\sqrt{q}] + 2a\sqrt{q} sh[(1 - y + \xi)\sqrt{q}]}{\Delta\sqrt{q}} \right\} d\xi + \\ & + \int_y^1 W_0(\xi, p) \left\{ \frac{(q + a^2) ch[(1 + y - \xi)\sqrt{q}] + 2a\sqrt{q} sh[(1 + y - \xi)\sqrt{q}]}{\Delta\sqrt{q}} \right\} d\xi + \\ & + \int_0^1 W_0(\xi, p) \left[ \frac{(q - a^2)}{\Delta\sqrt{q}} \right] ch[(1 - \xi - y)\sqrt{q}] d\xi \\ \text{or } W(y, p) = & \int_0^1 W_0(\xi, p) G_{1,2}(y, \xi; q(p)) d\xi + \int_0^1 W_0(\xi, p) G_3(y, \xi; q(p)) d\xi \quad (18) \end{aligned}$$

The expression for  $U(y, p)$  is:

$$\begin{aligned} U(y, p) = & \frac{\beta_1}{p + \beta_{-1}} \int_0^1 W_0(\xi, p) G_{1,2}(y, \xi; q(p)) d\xi + \frac{\beta_{-1}}{p + \beta_{-1}} \int_0^1 W_0(\xi, p) G_3(y, \xi; q(p)) d\xi + \\ & + \frac{1}{p + \beta_{-1}} u_0(y) - \frac{ke^{\alpha y}}{p + \beta_{-1}} \left[ p \bar{C}_2 - C_2(0) \right] \quad (19) \end{aligned}$$

Here the Green's functions  $G_{1,2}(y, \xi; p)$  and  $G_3(y, \xi; p)$ ,  $G_4(y, q(p))$  are defined as

$$G_{1,2}(y, \xi; q) = \begin{cases} \frac{2a\sqrt{q} sh(z_1\sqrt{q}) + (q + a^2) ch(z_1\sqrt{q})}{\Delta\sqrt{q}}, & 0 < \xi < y < 1, \quad z_1 = 1 - y + \xi \\ \frac{2a\sqrt{q} sh(z_2\sqrt{q}) + (q + a^2) ch(z_2\sqrt{q})}{\Delta\sqrt{q}}, & 0 < y < \xi < 1, \quad z_2 = 1 + y - \xi \end{cases} \quad (20)$$

$$G_3(y, \xi; q) = \frac{(q - a^2) ch(z_3\sqrt{q})}{\Delta\sqrt{q}}, \quad z_3 = 1 - y - \xi \quad (21)$$

$$\Delta = 4a\sqrt{q}ch(\sqrt{q}) + 2(q+a^2)sh(\sqrt{q}) \quad (22)$$

Inverting the Laplace transforms (20) and (21), we find the auxiliary variable  $w(y, \tau)$ ,  $u(y, \tau)$  and using (5), (6), we arrive to the expression for  $C(x, t)$  and  $N(x, t)$ :

$$C(y, \tau) = C_2(\tau) + e^{-ay} \sum_{n=1}^{\infty} K_n(y) \Omega_0(\tau, \lambda_n) \int_0^1 [C_0(\xi) - C_2(0)] X_n(\xi) e^{a\xi} d\xi +$$

$$+ \delta e^{-ay} \sum_{n=1}^{\infty} K_n(y) \Omega_1(\tau, \lambda_n) \int_0^1 [\beta_{-1} N_0(\xi) - \beta_1 C_2(0)] X_n(\xi) e^{a\xi} d\xi +$$

$$+ e^{-ay} \sum_{n=1}^{\infty} K_n(y) \int_0^{\tau} \Omega_0(z, \lambda_n) \left[ \int_0^1 \psi(\xi, \tau - z) X_n(\xi) d\xi \right] dz \quad (23)$$

$$N(y, \tau) = N_0(y) e^{-\beta_{-1}\tau} + \beta_1 \int_0^{\tau} e^{-\beta_{-1}z} C_2(\tau - z) dz +$$

$$+ \delta \beta_1 e^{-ay} \sum_{n=1}^{\infty} K_n(y) \Omega_2(\tau, \lambda_n) \int_0^1 [\beta_{-1} N_0(\xi) - \beta_1 C_2(0)] X_n(\xi) e^{a\xi} d\xi +$$

$$+ \beta_1 e^{-ay} \sum_{n=1}^{\infty} K_n(y) \Omega_1(\tau, \lambda_n) \int_0^1 [C_0(\xi) - C_2(0)] X_n(\xi) e^{a\xi} d\xi +$$

$$+ \beta_1 e^{-ay} \sum_{n=1}^{\infty} K_n(y) \int_0^1 X_n(\xi) \left[ \int_0^{\tau} \psi(\xi, \tau - z) \Omega_1(z, \lambda_n) dz \right] d\xi \quad (24)$$

Where  $\pm \lambda_n$  are roots of transcendental equation:  $(\lambda^2 - a^2)tg\lambda = 2a\lambda$  and

$$\Omega_0(\tau, \lambda_n) = [ch(\rho_n \tau) - \rho_n^{-1} \gamma_n sh(\rho_n \tau)] e^{-(\gamma_n + \beta_{-1})\tau}, \quad \Omega_1(\tau, \lambda_n) = \rho_n^{-1} sh(\rho_n \tau) e^{-(\gamma_n + \beta_{-1})\tau}$$

$$\Omega_2(\tau, \lambda_n) = [ch(\rho_n \tau) + \rho_n^{-1} \gamma_n sh(\rho_n \tau)] e^{-(\gamma_n + \beta_{-1})\tau} - e^{-\beta_{-1}\tau} (\rho_n^2 - \gamma_n^2)^{-1}$$

$$\gamma_n = 0.5(\lambda_n^2 + d_2), \quad \rho_n = \sqrt{\gamma_n^2 + d_1}, \quad d_1 = \delta \beta_1 \beta_{-1}, \quad d_2 = a^2 + \delta \beta_1 - \beta_{-1} \quad (25)$$

$$K_n(y) = 2[\lambda_n \cos(\lambda_n y) + a \sin(\lambda_n y)] / (\lambda_n^2 + a^2 + 2a)$$

## DISCUSSIONS

We have described the solute transport as the transport in a system with physical non equilibrium with two regions of water with different mobility. Pointed out that models of systems with chemical non equilibrium, i. e. systems that consider sorption on some sites to be governed by first-order kinetics, can be put in the same dimensionless form as models of system with physical non equilibrium (Nkedi-Kizza, et al., 1984 and Van Genuchten and Wagenet, 1989). Therefore, solutions developed in this paper can be applied when the adsorption of the solute occurs in the soil that does not have distinct separated mobile and immobile water. This can be true for some pollutants rather than salts.

## REFERENCES

- Bayrakli, F., Mikayilov, F.D. and Mamedov, A.I. (1996). Mathematical modeling of soil salinity. 1st Inter. Conf. on "Land Degradation" Proceedings: pp. 1 - 8, 10 - 14 June, ADANA.
- Ghassemi, F., Jakeman, A. J. and Nix, H. A. (1995). Salinisation of land and water resources: human causes, extent, management and case studies. CAB International, Wallingford, and Oxon
- Jury W., Gardner W.R., Gardner W.H. (1991). Soil Physics. 5th ed. John Wiley and Sons, NEW YORK
- Karakaplan, S., Mikayilov, F.D. and Sariyev, A. (1999). Tuzlu Toprakların Islahının Bazı Problemleri. "GAP I. Tarım Kongresi", ŞANLIURFA Cilt: II, s. 1019 - 1026.
- Lapidus, L. and Amundson, N.R. (1952). A descriptive theory of leaching. Mathematics of adsorption beds. J. Phys. Chem., 56: 984 - 988.

Leij, F.J., and N. Toride.(1998). Analytical solutions for non equilibrium transport models. P.117 - 155.

In: Physical non equilibrium in soils : modeling and application / edited by H. Magdi Selim, Liwang Ma. Ann Arbor Press, Chelsea, Mich.

Mikayilov, F. D. (1989). Modeling of salt transport in soils and grounds in leaching and irrigation conditions. Ph.D. Thesis. Institute of Agrochemistry and Soil Science. BAKU(In Rus.)

Mikayilov, F.D. (1997). Studies of the salt transfer processes in the heterogeneous media on the basis of mathematical modeling, *Eurasian Soil Science*, MOSCOW 11: 1390 – 1395. .

Mironenko E.V., and Y. A. Pachepsky.(1984). Analytical solution for chemical transport with non equilibrium mass transfer, adsorption and biological transformation. *J.of Hyd.*, 70:167-175.

Nkedi-Kizza, P. J., J. W. Biggar, H. M. Selim, M. T. van Genuchten, P. J. Wierenga, J. M. Davidson, and D. R. Nielsen. (1984). On the equivalence of two conceptual models for describing ion exchange during transport through an aggregated oxisol. *Water Resour. Res.*, 20: 1123-1130.

Sardin, M., D. Schweich, F. Leij, and M. Th. van Genuchten. (1991). Modeling the non equilibrium transport of linearly interacting solutes in porous media: a review. *Water Resour. Res.*, 27:2287-2307.

Toride, N., F.J. Leij and M.Th. van Genuchten. (1993). A comprehensive set of analytical solutions for non equilibrium solute transport with first-order decay and zero-order production. *Water Resour. Res.* 29:2167-2182.

Van Genuchten, M. Th., and Wagenet, R. J. (1989). Two-site/two-region models for pesticide transport and degradation: Theoretical development and analytical solutions. *Soil Sci. Soc. Am. J.*, 53(5): 1303-1310.

Van Genuchten, M. Th., and Alves, W. J. (1982). Analytical solutions of the one dimensional convective dispersive solute transport equation. USDA Tech. Bull. 1661, U.S.Govt. Printing Office, WASHINGTON, DC.

Van Genuchten, M. Th., and Dalton, F. N. (1986). Models for simulating solute movement in aggregated field soils. *Geoderma*, 38:165 183



## PERFORMANCE ASSESSMENT OF GEDİZ BASIN USING SECONDARY DATA

Göksel Geçgel<sup>\*</sup>, Atila Girgin<sup>\*</sup>, Müslüm Beyazgül<sup>\*</sup>, Charlotte de Fraiture<sup>\*\*</sup>  
and Hammond Murray-Rust<sup>\*\*</sup>

<sup>\*</sup>Tarımsal Hidroloji Araştırma ve Eğitim Merkezi, 35660 Menemen, İZMİR, TURKEY

Phone: +90 232 831 10 52 – 831 05 12, fax: +90 232 831 10 51 – e-mail: [thaem@khgm.gov.tr](mailto:thaem@khgm.gov.tr)

<sup>\*\*</sup>International Water Management Institute, P.O. Box 2075 Colombo Sri Lanka, Phone: +94-1-867404  
fax: +94-1-866854, e-mail: [H.Murrayrust@cgiar.org](mailto:H.Murrayrust@cgiar.org)

### ABSTRACT

This study provides an overview of the developments in irrigated agriculture in the Gediz basin over the last 15 years. The analysis is based on data derived from DSI and the Met Dept. These data and underlying assumptions were checked using information collected by IWMI-GDRS during fieldwork and surveys conducted during the 1998 irrigation season. Further, a LANDSAT image covering the basin was used to compare irrigated area reported by DSI/WUA and actual irrigated areas. It was concluded that the DSI data were accurate enough for the analysis made in this study. Concluding remark; despite the reduction in surface water farmers were able to increase land and water productivity.

### INTRODUCTION

This study focuses on the large scale irrigation systems. As part of the GDRS-IWMI program data on climate, cropping pattern, irrigation water use, yields and prices were collected from secondary sources. The data were analyzed making use of the irrigation performance indicators developed by IWMI (Perry 1996, Molden et al. 1998). The accuracy of the data was checked by comparing them with field observations during the 1998 irrigation season

Main objectives of the study are given below :

- ◆ To obtain a general overview of developments in irrigation practices and agricultural performance in the Gediz Basin. This information provides the setting for in-depth studies on tertiary canal level concerning irrigation practices and groundwater use by individual farmers.
- ◆ To evaluate the accuracy and usefulness of secondary data in irrigation performance assessment studies and trend analysis.

### MATERIALS AND METHODS

In the Gediz Basin there are 7 large scale irrigation schemes and a few hundred small scale irrigation systems. This study focuses on the large scale irrigation systems. As part of the GDRS-IWMI program data on climate, cropping pattern, irrigation water use, yields and prices were collected from secondary sources. The data set covers a time span of 15 years (1984-1998). Until 1995 the main data source is DSI, the government agency responsible for the operation and maintenance of the large irrigation schemes. In 1995 the management was transferred to the newly formed Water Users Associations. Several WUA offices were visited to collect data for the period 1995-98.

Details of the systems in the study are given below:

Table 1. Main irrigation scheme and associations in Gediz basin

Irrigation association	Scheme	Sheet name	Command area (ha)	Main crop	Location
Sarigol	Sarigol	Sarig	1,927	Grapes	Upper valley
Bag	Alasehir	SarBag	4,486	Grapes	Upper valley
Alasehir Uzuni	Alaschir	Uzum	6,930	Grapes	Upper valley
Sahlihli Right Bank	Adala-Salihli	SahRB	9,101	Grapes and cotton	Main valley
Sahlihli Left Bank	Adala-Salihli	SahLB	9,237	Grapes and cotton	Main valley
Ahmetli	Turgutlu	Ahmet	3,275	Grapes	Main valley
Gokkaya	Turgutlu	Gokka	997	Grapes	Main valley
Turgutlu	Turgutlu	Turgut	12,102	Grapes	Main valley
Sarikiz	Manisa	Sarik	13,702	Cotton	Main valley
Mesir	Manisa	Mesir	13,679	Cotton	Main valley
Gediz	Manisa	Gediz	10,962	Cotton	Main valley
Menemen Right Bank	Menemen	MenRB	6,365	Cotton	Delta
Menemen Left Bank	Menemen	MenLB	16,500	Cotton	Delta
Total			109,263	Grapes and cotton	Basin

Note: the smallest of the 7 large scale systems (Akpinar, 1000 ha) was excluded from the analysis due an incomplete and inconsistent data set.

The data were analyzed making use of the irrigation performance indicators developed by IWMI (Perry 1996, Molden et al. 1998). The accuracy of the data was checked by comparing them with field observations during the 1998 irrigation season. Further, a LANSAT image from the Gediz Basin was used to compare irrigated areas and cropping patterns with the reported data given by DSI and Water Users Associations.

## DISCUSSION

### Surface water supply

After 1989 the amount of surface water supplied from the reservoirs in the basin dropped substantially due to a severe and prolonged drought. During the period 1985-88 the total amount of surface water supplied to the six schemes fluctuated between 700 and 800 million cubic meter, while in the period 1989-93 the total surface supply varied between 100 and 200 million m<sup>3</sup>. During the driest year (1992) the overall water supply was as low as 15% of the supply before the drought. Over the last four years the situation is improving again: in 1995 the supply was at 45% of the pre-drought level, while in 1997 the water supply was 50%.

The surface water supply per scheme varies according to the location of the scheme in the basin. The graph below indicates the water supplied from the reservoirs expressed as water layer on the command areas, per zone. The basin is divided in three zones: the upper valley, main valley and the delta.

The graph clearly shows the enormous drop in water supply which was most pronounced in the main valley, covering 66% of the irrigated area. However care should be taken while interpreting the water supply data as reported by the DSI. The DSI only reports the releases from the reservoirs during the irrigation season (July-September) and doesn't take into account the reuse of drainage water or water originating within the catchment below the reservoir. For example, the Manisa scheme (nearly half of the area in the main valley) receives drainage water which is not visible from the DSI data and consequently, the water supply in main valley will be higher than appears from the graph. Unfortunately, data or estimates of drainage water reuse are not available. Despite this uncertainty in data it is clear that there was a considerable reduction in surface water supply. In the next paragraphs the responses of water managers and farmers to this reduction will be examined.

### **Responses to drought**

Possible responses to drought include:

- a) reduce the irrigated area
- b) change in cropping pattern
- c) reduce field application and stress crops
- d) pump ground water

### Irrigated area

During the period before the drought around 80% of the total command area was irrigated with water releases from the reservoirs. After 1989 this percentage dropped to 50% while it went up again to around 60% in 1997 and 1998. The graph below shows the percentage of the command area irrigated by surface water, per zone in the basin. In the delta the irrigation intensity is highest (80% over the last three years), and in the middle part of the basin lowest (55%).

From the graph it is clear that the irrigated area was reduced during the drought. However, it should be noted that the DSI only keeps records of the area irrigated by surface water issued from the reservoirs. Area exclusively irrigated by groundwater does not appear in the published records and no information is available about groundwater use. It might be that in reality the total area irrigated did not decrease at all because the area exclusively irrigated by groundwater - invisible in the records - replaced the area under surface irrigation. This subject is further explored in paragraph 2.3

### Changes in cropping pattern

The main crops grown in the basin are grapes and cotton. Cotton is mainly grown in the delta while grapes is the predominant crop in the upper valley. As can be seen from the graphs below, the area cultivated with cotton in the upper and main valley is gradually decreasing while the area with grape is increasing. The reduction in area with cotton is most outspoken in the upper valley where practically no more cotton is grown after 1992. In the delta cotton remains the predominant crop, cultivated on 70% of the irrigated area because soils are more suitable for cotton than for grapes. Overall in the basin, the percentage of the irrigated area with cotton remains more or less on the same level, around 50%. In absolute terms the area decreases from 52,350 ha (49% of command area) in 1984 to 35,475 ha (32% of command area) in 1996.

The coverage of grapes, the second important crop in area, is steadily rising from 20% to nearly 35% of the irrigated area. In absolute terms the area roughly doubles from 11,760 ha in 1984 (11% of the command area) to 23,600 ha in 1998 (22% of irrigated area).

One could argue that the change from cotton to grapes was induced by water shortage since grapes are less susceptible to yield reduction due to crop stress than cotton. However, crop choice is influenced by many factors and water availability is only one of them. Grapes is a perennial crop that requires high initial investment, and it is unlikely that farmers replaced cotton for grapes just because of a (temporary) drought. Other factors such as prices and markets probably played a more important role in crop choice. Both cotton and grapes prices and yields show an increasing trend over the last decade, but the increase for grapes is more pronounced than for cotton.

### Reduce water layer and stress crops

If farmers chose to reduce the water layer applied and stress the crops, one would expect a reduction in yield. However, the general trend in cotton yield is a rising line from 2.3 ton/ha in 1984 to 3.0 ton in 1996. Grape yields improved from 4.0 ton/ha to about 5.5 ton/ha in 1996. Therefore, from the DSI data there is no evidence that farmers reduced the water layer and stressed crops.

There are considerable differences in cotton yields between the systems. In the delta (Menemen) where cotton is the main crop, yields are high compared to the yields in the upper valley where cotton is hardly grown. In lower parts of the basin (Menemen and Manisa) where grapes are hardly grown, the yields are low in comparison to those in the upper part of the valley where grapes are the main crop. Those



differences might be caused by variations in soil or micro-climate and explain why in the lower part of the valley grapes are hardly grown despite the better prices for grapes.

### **Groundwater use**

#### Groundwater in conjunction with surface water

After 1989, the first year of the drought, farmers started investing in tubewells to supplement surface water supply. Unfortunately, there are no data available about the number of wells and the amount of groundwater pumped, since the irrigation agency only kept records of water releases from the reservoir. In this study the amount of groundwater used in conjunction with surface water is estimated, assuming that the irrigation efficiency before and after the drought remains on the same level. For the period after 1989-91 the groundwater supply is estimated as the difference between gross irrigation requirements and surface water supply. According to this estimation method, in the period 1990-94 about 60% of the water supply came from groundwater. After 1994 this amount decreases to 30% due to increased surface water supply.

#### Area irrigated exclusively by groundwater

From field observations:

Farmers continue using groundwater in conjunction with surface water, but also irrigate considerable area exclusively with tubewells. Reasons:

- convenient: always water available at desired time and amounts
- cheaper than surface water: WUA increased the surface water fees considerably over the last few years to cover their operation and maintenance costs. According to some farmers the costs to pump are less than the surface water fees by the WUA. However, most farmers don't account for investment and amortization costs

### **Trends in land and water productivity**

#### The total production

The total production of irrigated agriculture in the main irrigation schemes in the Gediz basin, expressed in 1995 constant Turkish Lira, remained more or less on the same level over the last decade despite the enormous reduction in surface water supply. The first year of the drought (1989) the production dropped due to reduced area, but thereafter it increased steadily. Firstly because the irrigated area increased after farmers started investing in tubewells and secondly because yields and prices improved.

Figure 1. The surface water supply

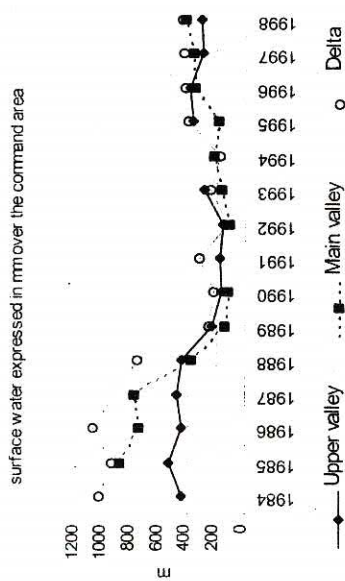


Figure 2. The percentage of the command area irrigated

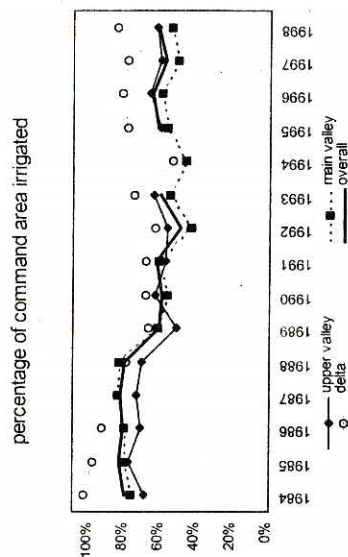


Figure 3. The percentage of irrigated area with cotton

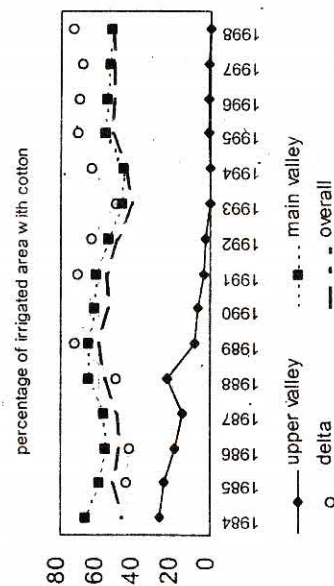


Figure 4. The percentage of irrigated area with grapes

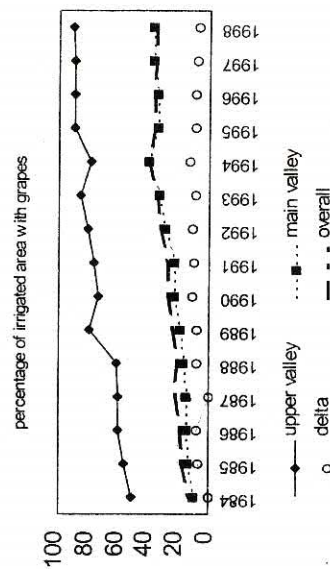


Figure 5. The total production in Gediz basin

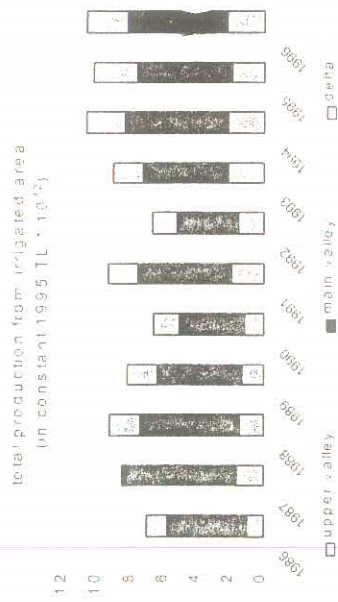


Figure 6. The production per unit command area in Gediz basin

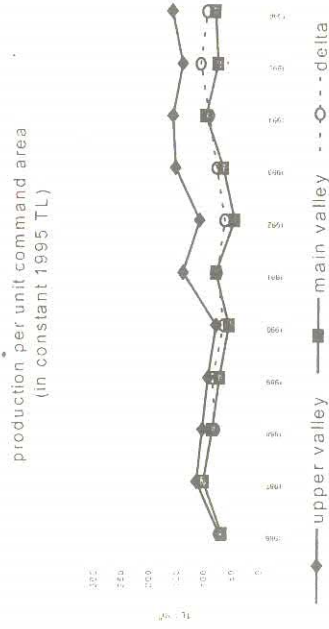


Figure 7. The production per unit irrigated area

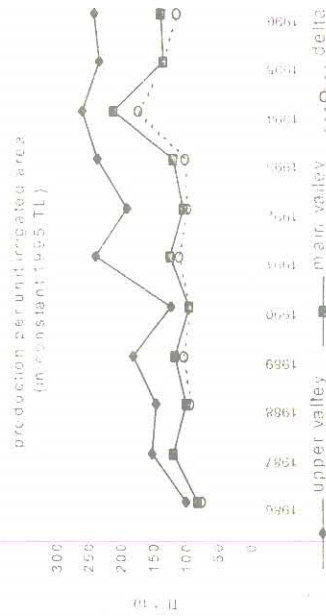
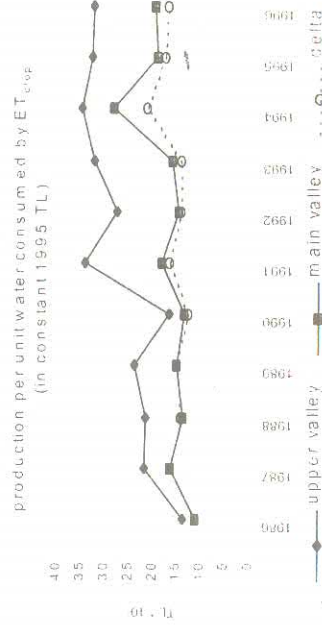


Figure 8. The production per unit of water consumed by evapotranspiration





#### Land productivity

The production per unit of irrigated area is steadily increasing due to improved yields and prices of the two main crops (grapes and cotton). This increase is most pronounced in the upper part of the basin where cotton gradually was replaced by grapes. As mentioned before compared to cotton, grape prices and yields improved more. In the delta the production expressed in monetary terms is lower due to bigger cotton area.

The production per unit command area increases slightly. At one hand the production per area irrigated increases. At the other hand percentage of the command area that is irrigated (with surface water) is decreasing. These opposite factors result in a slightly increasing output of the systems. The differences between upper and lower part of the valley are less pronounced than in case of the production per unit of irrigated land. In the

upper part farmers switched increasingly to a higher yielding crop such as grapes, but at the same time reduced the area irrigated. In the lower valley farmers continue to grow cotton with lower output per hectare, but they only slightly decreased the area irrigated with surface water.

#### Water productivity

The production per unit of water consumed by evapotranspiration roughly follows the same pattern as the production per unit irrigated area. Changes in yields and prices are the main determinants of water productivity trends, because the  $ET_{crop}$  remains more or less on the same level (variations in climate over the years are negligible). The rise in water productivity is of the same level of magnitude as in land productivity.

#### Concluding remark

Despite the reduction in surface water farmers were able to increase land and water productivity.

### **ACKNOWLEDGMENTS**

This study was conducted as part of a collaborative research program between the General Directorate of Rural Services (GDRS) in Turkey and the International Water Management Institute (IWMI) and is funded by the Government of Turkey as part of the World Bank assisted Turkish Agricultural Research Project (TARP).

### **REFERENCES**

- Anonymous, (1984-1998). Irrigation and crop records. General Directorate of State Hydraulic Works. Ankara, Turkey.
- Anonymous, (1984-1998). Menemen climatic data. Research Institute of General Directorate of Rural Services. Menemen, Turkey.
- Anonymous, (1995-1998). Menemen Left Bank and Salihli Right Bank Water Users Associations records. Unpublist, Menemen and Salihli, Turkey.
- Anonymous, (1984-1998). Salihli climatic Data. State meteorological Services (DMI). Unpublist, Ankara, Turkey.
- Murray-Rust H., Beyazgül M., Kayam Y., Girgin A., Svendsen M., Brewer J. Assessment of O&M Tasks of Irrigation Associations. Unpublist, Menemen, Turkey
- Molden D., Sakthivadivel R., Perry, J.C., Fraiture, C., Kloezen, W.H. (1998). Indicators for comparing Performance of Irrigated Agricultural Systems. IIMI Research Paper No:20. Colombo, Sri Lanka: International Irrigation Management research Institute.
- Perry C.J. (1996). Quantification and measurement of a minimum set of indicators of the performance of irrigation systems. Colombo, Sri Lanka: International Irrigation Management Institute. Duplicated.
- Smith M., (1991). CROPWAT Irrigation Management Land and Water Development Division Food and Agriculture Organization. Via Terme di Caracalla, Rome, Italy

# THE EFFICIENCY OF IRRIGATION ORGANIZATIONS IN TOKAT PROVINCE AND SOCIO-ECONOMIC FACTORS AFFECTING THE PARTICIPATION OF PRODUCER TO THESE ORGANIZATIONS

H. Bahadır Arslankurt, Halil Kızılaslan, Nuray Kızılaslan, Kemal Esengün

## ABSTRACT

This research was conducted in 246 farms in 1997-98 production period to investigate the efficiency of irrigation organizations and of the socio-economic factors influencing the involvement of farmers to these organizations in Tokat province.

The factors effecting the involvement to both irrigation cooperatives and irrigations unions were put forward in this study. Chi-square, variance analysis and t-test were used as statistical analysis methods with regard to the features of the data. Apart from these, the factors effecting the involvement to irrigations cooperatives and irrigation unions, and the factors effecting the use of these organizations were examined with an econometric approach.

According to the research results, there were statistically significant differences between the irrigation cooperatives and irrigations unions with respect to the following issues; the distribution of producers according to family structures, the acceptance and application of developed agricultural technology, the level of consciousness in being organized, the level of social involvement, being visited by the extension officials, the level of involvement to the organization, being whether informed or not about organizations, information about foundation demand, involvement to the meetings held by the organizations, the level of expertise, the state of sharing irrigation cooperatives and irrigation unions, the number of parcel, the level of use of the organizations, the amount of annual sale.

## INTRODUCTION

Until 1980s, agricultural sector has been protected and supported in Turkey as being almost in every country. Development of technology and society has changed and expanded the usage place of agricultural products and led to gain an international status of agricultural markets. In addition, intensive capital caused the emergence of multi-national big firms in agricultural input/output markets. On the contrary, agricultural farms which are small scale and can be affected by natural conditions continuously have been transformed to the sandwich under the pressure of big firms emerged in process after and before agricultural production (Çıkin et al., 1992).

Agricultural sector has to create an organization policy to be able to reduce the pressure of big firms, reflect its bargaining power to the agricultural input/output market and prepare this circumstance. Cooperatives are the most important instrument applied successfully in developed countries in this subject. As a matter of fact, 75% of farmers Union in the EU countries are cooperatives (Çıkin, 1998). Being organized of farmers in the USA has started towards end of the 1800s to be able to protect the damage of being weak and disorganized (Torgerson, 1992).

Agricultural development in the word has been achieved as isochronal to the development of cooperative movement. On the contrary, the speed of establishment of cooperatives in Turkey has developed more rapidly than cooperative idea. This has caused the living of negativiness in cooperative movement and waste of resources (Çıkin, 1992).

This situation has widespread the thoughts about to education of people strictly about cooperative, spread of the concept of cooperative, making extension to help managers in the solutions of problems of cooperatives.

In this study, two of agricultural organizations-irrigations cooperatives and irrigations unions have been investigated. In the research; determination of socio-economic characteristics of group being members of cooperatives and unions, of the socio-economic factors influencing the involvement (participation) of farmers to these organizations and direction of extension strategies related to these have been aimed.

## MATERIAL AND METHODS

Original data have been used in the study. Other material used are thesis, books, periodicals. In the determination of sample size, the method proposed by Neyman has been used (Yamane, 1967).



Data collected by survey have been transformed to the variables by means of index and weightness to be able to reach the aim of the research (Kızılaslan, 1997). Percentage calculations was used in the study.

At the stage of the evaluation of data, for coded variables chi-square test was used to determine whether the difference among the level of participation to both cooperative and unions are statistically significant or not according to variables (Düzgüneş, 1975).

In addition, Variance analysis has been used to determine whether the difference among group's means is significant or not in the situation of being more than two groups. If there is a difference, the control of Last Significance Difference (LSD) has been done to determine the source of difference emerging from which groups.

Hypothesis Test About the Difference Between Two Population Means: Matched Pairs has been used in the test of difference among the average of two groups (Yıldız and Bircan, 1992).

In addition, the factors affecting the participation to both irrigation cooperatives and irrigation unions were evaluated with an econometric approach and for this aim the method of multi-linear regression analysis used. In the significance of multi-determination coefficient F test has been done. Student-t test was used to determine whether regression coefficient is statistically significant or not.

In addition, step-wise operation has been done to determine the best regression model representing the relationship between dependent and independent variables (Düzgüneş et al., 1987).

## DISCUSSION

This study is a summary of a research. In the study, the subjects such as the socio-economic characteristics of farmers being member of both irrigation cooperatives and irrigations unions, their relations with extension staff, and the efficiency of these organizations have been investigated. The research was conducted in total 246 farms (80 farms for irrigation cooperatives and 166 farms for irrigation unions).

As a result of analysis, it has been found that there was no statistically significant difference among the age of farmers who are the member of both irrigation cooperatives and irrigations unions. 7.5% of farmers being a member of irrigation cooperative are new farmer. 13.75% of whom has medium experience. The ratio of having advanced experience is 78.75%. Contrary to irrigation unions, the ratio new farmer, having medium experience and advanced experience are 6.02%, 13.86%, and 80.12%, respectively for irrigation unions. As a result of chi-square analysis done to determine whether there is a significant difference of professional experience of farmers participating to both irrigation unions, it has been found that there was no statistically difference at  $P < 0.05$  significance level.

25% of farmers being member of irrigation cooperatives and 36.14% of farmers being member of irrigation unions have democratic family type. The ratio farmers having patriarchal family type is 75% for irrigation cooperatives and 63.86% for irrigation unions. According to chi-square analysis, there was no statistically difference in terms of authority situation in the family for both irrigation cooperatives and irrigation unions.

The ratio of modernist, medium modernist and traditional farmers who are member of irrigation cooperatives were 13.75%, 81.25%, and 5% respectively 32.53% of farmers who are member of irrigation union was modernist. Rest of them was medium modernist (54.82%) and traditional farmer (12.65%) among member of irrigation unions. There was statistically difference at  $P < 0.05$  significance level between irrigation cooperatives and irrigation unions in terms of acceptance and application of modern agricultural technology.

Farmers who are member of irrigation unions have high level of tendency related to cooperation with each other more than those who are member of irrigation cooperatives. The farmer has 86.75% high, 6.63% medium, 6.62% low level of tendency related to cooperation. On the contrary, the latter has 70% high, 23.75% medium and 6.25% low level of tendency related to cooperation. As a result of chi-square analysis, it has been found that the difference was no statistically significant between irrigation cooperatives and irrigation unions in terms of tendency level of farmers to cooperation each other.

Farmers who joined the irrigation cooperatives as member have high (51.25%), medium(43.75%), and low(5%) level of consciousness in being organization. For irrigation unions, these figures are 27.81%, 54.82%, and 18.07%, respectively. It has been determined that there were



statistically significant difference between irrigation cooperatives and irrigation unions with respect to the level of consciousness in being organization.

The majority (89.16%) of farmers in irrigation unions have medium level of social involvement. The ratio of farmers having high level of social involvement is less than 1%. The rest (10.24%) have low social involvement. Farmers who are member of irrigation cooperatives have high (65%), medium (32.50%) and low (2.50%) level of social involvement. As a result of chi-square analysis, it has been determined that there was statistically difference at  $P < 0.05$  significance level between irrigation unions in terms of social involvement level.

The usage level of communication tools by farmers in irrigation cooperatives is 78.75% medium, 3.75% high, and 17.50% low. The ratio for irrigation unions are 72.29% medium, 24% low, and 3.61% high. The difference among groups was not statistically significant.

Although 15.85% of farmers think migration from rural areas to urban areas, the rest (84.15%) of them do not want to migration. It has been determined that there was no statistically difference among groups with respect to whether farmers willing to migration from rural areas or not.

In research area, 82.52% farmers in irrigation unions have high, the rest (17.48%) have medium and low living standards. There was no statistically difference at  $P < 0.05$  significance level between the irrigation cooperatives and irrigation unions with respect to farmer living standards.

46.25 % of farmers who are member of irrigation cooperatives have been visited by extension officials compared to 28.92% in irrigation unions. There was statistically difference level between irrigation unions and irrigation cooperatives in terms of being visited of farmers by extension officials. Both 45% of farmers in irrigation cooperatives and 49.40% of farmers in irrigation unions have explained that extension officials have interested in agricultural issues of the farmers.

Farmers in irrigation cooperatives have 48.75% high, 47.50% medium, and 3.75% low involvement level to cooperatives. On the contrary, only 3.01% of farmers have high involvement level to unions. The rest have medium (12.65%) and low (84.34%) involvement level. Although cooperatives are willing organizations, the involvement of farmers to the unions is compulsory and controlled. Therefore, the involvement level of farmers to irrigation cooperatives is higher than irrigation unions. As a result of analysis, it has been found that there was statistically difference at  $P < 0.05$  significance level between irrigation unions and irrigation cooperatives with respect to level of involvement to the organizations.

62.50% of farmers who are member of irrigation cooperatives and 92.17% of farmers who are member of irrigation unions had to idea about irrigation unions. As a result of chi-square analysis, it has been determined that the difference among groups was statistically significant. This means that irrigation cooperatives knowledge (inform) their members by extension service more efficiently than irrigation unions.

In irrigation cooperatives the sources of information related to organization of farmers are their friends (23.33%), agricultural credit cooperatives and Pankobirlik (20%), their relatives (10%), television (3.33%), newspaper (3.33%), and muhtar who is a manager of village (3.33%). On the contrary, farmers who are member of irrigation unions get information from state officials (46.15%), agricultural credit cooperatives and Pankobirlik (30.77%), their friends (7.69%), television (7.69%), and muhtar (7.69%).

65% of farmers in irrigation cooperatives think that it can be good if foundation demand related to organization comes from state. The rest of them (35%) think foundation demand should come from themselves. These figures for irrigation unions are 86.75% from the farmer, 13.25% from the latter. From about information it can be concluded that irrigation unions work as an organ of government away from democratic farmer organization.

In irrigation cooperatives, majority (81.25%) of farmer involve to the meetings held by the cooperatives regularly. 15 % of them attend to meetings sometimes. 2.50 % of them have not attended to the meetings so far. 1.25 % of farmers have explained that no meeting was held so far. The involvement rate of farmers to the meetings held by irrigation union is very low (7.83%), 78.31 % of farmers have explained that no meeting was held by union so far. 3.01 % of them involve to the meetings sometimes. 10.84 % of farmers do not involve to the meetings due to some reasons. As a result of chi-square analysis, it has been determined that the difference among groups was statistically significant. This situation emerges from involvement compulsory of only member of council and chief.

Although farmers in irrigation unions have 36.49 da land, average land size in irrigation cooperatives is 67.06 da. Unlike irrigation unions, farmers member of irrigation cooperatives have large farm size. As a result of variance analysis done to determine whether there is a difference with respect to farm size, it has been determined that the difference among groups was statistically significant.

It has been determined that 87.50 % of farmers in irrigation cooperatives and 98.20 % of farmers in irrigation unions have benefited from the organization. Average annual benefiting from organizations at the different level of involvement of farmers to the irrigation organizations has been investigated. Although farmers have different involvement, there was no significant differences at the level of benefiting of farmers in irrigations cooperatives. Unlike irrigation cooperatives, although farmers have different involvement, there was significant differences at the level of benefiting of farmers unions. LSD test has been done to determinate whether the difference among means of groups is significant or not. As a result it has been found that the difference was no statistically significant. As a result of t test, the difference between irrigation cooperatives and irrigation unions with respect to Gross Production Value and it has been found that difference was statistically significant.

Nearly 95 % of farmers in both irrigation cooperatives and irrigation unions were directed to the markets. Variance analysis has been done to determine whether there is a difference among farmers member of different irrigation organizations with respect to the ratio direct to the markets. As a consequence it has been determined that there was no statistically significant difference among groups with respect to the ratio to the markets. In addition, as a result of t test the difference among means of groups was statistically significant.

Socio-economic factors affecting the level of involvement to irrigation organizations have been examined as a whole with an econometric approach. It has been tried to determine the level of effects of socio-economic factors in the involvement of farmers to the organizations. In addition, it has been aimed to determine the significance level of socio economic factor as independent variable. In the research; Y is dependent and X is independent variable. Where:

Y= the level of involvement to the irrigation organizations,  $X_1$  = Size of the farm (holding),  $X_2$  = Total gross production value,  $X_3$ = The amount of annual sale of agricultural products,  $X_4$  = The ratio of directed to the markets,  $X_5$  = Number of the parcel,  $X_6$  = The level of benefiting from organization,  $X_7$  = Acceptance and application of developed agricultural technology,  $X_8$  = The level of tendency of cooperation,  $X_9$ = The level of consciousness in being organized,  $X_{10}$ = The level of modernization,  $X_{11}$ = The level of social involvement,  $X_{12}$ = The level of meclination to foreign culture,  $X_{13}$ = The usage level of communication,  $X_{14}$ = Living standard,  $X_{15}$ = The ability of empathy,  $X_{16}$ = Age of the farmers,  $X_{17}$ = The level of expertise.

The factors affecting the level of social involvement of farmers to the irrigation organizations and relationship among socio-economic factors have been determined by the method of multi-linear regression analysis. Multi-linear regression equation has been estimated for irrigation cooperatives and irrigation unions separately.

Multi-linear regression equation for irrigation cooperatives is as follows:

$$Y = 1.17 + 0.00542X_1 - 0.00000001X_2 + 0.00000001X_3 + 0.0013X_4 + 0.0109X_5 + 0.00000001X_6 + 0.025 X_7 + 0.0652 X_8 + 0.633X_9 + 0.005X_{10} - 0.072X_{11} - 0.0079X_{12} + 0.027X_{13} + 0.006X_{14} + 0.093X_{15} + 0.0142X_{16} + 0.227X_{17}$$

$R^2$  of the above equation is 0.501. This means that 50.10 % of changes in the level of involvement to the cooperative have been explained by 17 independent variables.  $F_{\text{calculated}}$  (3.61) is greater than  $F_{\text{table}}$  (3.02) at 0.01 significance level. There fore,  $H_0$  is rejected. Multi determination coefficient ( $R^2$ ) is statistically significant. Standard error of equation (S) is 1.346.

The factors, except for the level of the consciousness in being organization, were found statistically significant between 35 % and 95 % significance level although socio-economic factors are significant in the involvement of farmers to irrigation cooperatives.

Step-wise operation has been done to determine the multi-linear regression equation representing the relationship between dependent variable and independent variables at least variable. As a result of step-wise following equation has been found:



$$Y = 3.708 + 0.616X_9$$

$R^2$  of the new equation is 0.4583. This means that 45.83 % of changes in the level of involvement to the cooperative have been explained by the changes in the level of consciousness in being organization ( $X_9$ ). This result shows that the level of consciousness of farmers about cooperatives is very important factor in the involvement of farmers to the cooperatives. Therefore, determination of tendency of farmers is very important to achieve efficiency in the involvement of farmers to the cooperatives.

Multi-linear regression equation for irrigation unions is as follows:

$$Y = 2.94 - 0.00552X_1 - 0.00000001X_2 + 0.00000001X_3 + 0.00639X_4 + 0.0327X_5 - 0.00000001X_6 - 0.0186X_7 - 0.0864X_8 + 0.275X_9 + 0.0069X_{10} + 0.327X_{11} + 0.0164X_{12} - 0.0183X_{13} - 0.0092X_{14} + 0.205X_{15} - 0.0263X_{16} - 0.240X_{17}$$

$R^2$  of the above equation is 0.315. This means that 31.50 % of changes in the level of involvement to the union have been explained by 17 independent variables.  $F_{\text{calculated}}$  (4.01) is greater than  $F_{\text{table}}$  (2.90) at 0.01 significance level. Therefore,  $H_0$  is rejected. It said that multi determination coefficient ( $R^2$ ) is statistically significant. Standard error of equation (S) is 1.303.

Although socio-economic factors are important in the involvement of farmers to the irrigation unions, the factors, except for size of holding, the level of tendency of cooperation, the level of consciousness in being organization, social involvement, the ability of empathy, and age of farmers have been found statistically significant between 23 % and 93% significance level.

As a result of step-wise following equation has been found:

$$Y = 2.0444 + 0.266X_9 + 0.193X_{15} + 0.0097X_4 - 0.023X_{16} + 0.282X_{11} - 0.091X_8$$

$R^2$  of the new equation is 0.3007. This means that 30.07 % of changes in the level of involvement to the irrigation unions have been explained by the level of consciousness in being organization ( $X_9$ ), ability of empathy ( $X_{15}$ ), the ratio of returned to the market ( $X_4$ ), age of the farmers ( $X_{16}$ ), social involvement ( $X_{11}$ ), and level of tendency of cooperation ( $X_8$ ).

These results show that socio-economic factors are very important factor in the decision making of farmers to involvement both irrigation cooperatives and irrigation unions. In the subject of organization, there is a need to determine the socio-economic characteristics of farmers in the region by using objective data. For irrigation cooperatives and irrigation unions, knowing how much effective role of farmer characteristics in the involvement of them to these organizations by extension officials can increase the success of the service. It should not be forgotten that only these factors are not important but also other factors should be taken into consideration in the involvement of farmers to these organization.

Rapid rural development relate to knowledge to be transformed to the society. It is not false to say that there is an accelerator role of knowledge in the development. The rapid extending of knowledge is very easy in organized society. That is, organized society can take knowledge easy and put into practice it easily. Therefore, there is a need to complete organization to be able to achieve development in rural society. However, extension service is important before starting organization studies. Consciousness of farmers by extension officials about organization is needed in order to prevent the lose of confidence of people in the future. Before starting consciousness of people, determination of present situation of rural society and making extension services suitable to extension principles can lead to positive results.

The participation of farmers is needed in all stages (e.g. planning of irrigation, investment and decision making on planning) to achieve efficiency in irrigation. In the subject of active participation of farmers to organizations, efficient organization related to the management of irrigation system should be put on the agenda.

Extensionist foundations should give an importance to being organized within their own structure. In addition, the deficiency of technical equipments and knowledge of extension officials should be compensated. After this, on the one hand, the relationship between extension officials and target population should be increased. It is a condition that an extension official should know farmer



unions (e.g. irrigation cooperatives, agricultural development cooperatives, and irrigation unions) as the most perfect tool to reach its own target. Because they help reaching of extension to more people successfully.

Irrigation organizations particularly irrigation unions should have democratic and transparent structure. Members should not be seen as a customer. Farmers should have an associate by achieving the participation of them to the unions. They should take part in each stage of activities of unions and accept irrigation unions as their own property instead of "step son" or "a state foundation such as DSI".

Policies should be formed suitable to market conditions and more realistic in respect of financial. For example, realistic price policy in irrigation water such as demanding of price according to the amount of used water should be followed. If these organizations are transformed to democratic, transparent and participatory position, irrigation unions can be a foundation not only determining the price of irrigation water but also directing agricultural input/output markets and "supporting not supported".

#### REFERENCES

- Çıkın, A., (1992). "Tarım kesiminde kooperatif örgütlenme ve tarımsal kooperatifçilik politikası". 2000 Yıllarına Doğru Türkiye Tarım Sempozyumu, Ankara.
- Çıkın, A., (1998). "Tarımda kooperatifçilik". Kooperatif Dünyası Dergisi, Yıl:28, Sayı:329, Ağustos 1998, Ankara.
- Düzgüneş, O., (1975). İstatistik Metodları, AÜZF, Yayın No: 578, Ankara.
- Düzgüneş, O., ve Ark., (1987). Araştırma ve Deneme Metodları, AÜZF Yayın No:1021, Ders Kitabı: 295, Ankara.
- Kızılaslan, N., (1997). "Tokat ili merkez ilçede tarımsal kalkınma kooperatiflerine katılımı etkileyen sosyo-ekonomik faktörler üzerine bir araştırma". Doktora Tezi(Yayınlanmadı), GOP Üniversitesi Fen Bilimleri Enstitüsü, Tokat.
- Torgerson, R., E., (1992). Implications of Pasific Coast Producers/Del Monte foods arrangement: a group action. Agricultural Bargaining: In a Competitive Word, 37<sup>th</sup> National and Pasific Coast Bargaining Cooperative Conference, December 3-5, Nevada, USA.
- Yıldız, N., H., Bircan, (1992). Uygulamalı İstatistik, III.Baskı, AÜ Yayın No:704, ZF Yayın No: 308, Ders Kitapları Seri No: 60, Erzurum.

# INVESTIGATION OF BORON CONCENTRATION OF SOME IRRIGATION WATERS USED IN AYDIN REGION FOR PLANT NUTRIENT AND SOIL POLLUTION

Gönül (Bilgehan) Aydın, Saime Seferoğlu  
AD.U. Agricultural Faculty Soil Science Dept. Çakmar AYDIN

## ABSTRACT

Soil and plant boron content of irrigation water was researched on Great Menderes Basin. It was tried to determined that accumulation of boron, come from irrigation water, in the soil profile, its effect on some soil characteristics, and its relation with the amount of boron in plant. According to results, it was obtained that boron content of irrigation water was so high in particular Germencik where there was a ground thermal water reservoir. Boron has been accumulated more than plant requirement in the areas irrigated by this water. High boron content in soil was led to toxic effects as dried plant. Besides, there was a direct relationship between soil and plant boron content. Boron content of irrigation water was relatively low in rainy season while it was high in dry season.

## INTRODUCTION

Some irrigation water resources .especially those in areas where geothermal waste waters are discharged, have high boron concentrations .Some of the branches of B.Menderes river contain great amounts of Boron up to 21.1 mg /lt Since Boron is considerably less mobile in soil, it accumulates there and then unproductivity occurs because of over use of water which is in boron

Plants need Boron in different concentrations as a nutrient. While some plants need much more Boron, others are less tolerant of Boron. For example, cereal plants need much more Boron, grass plant, potato and strawberry require Boron less than 1.0 ppm; tobacco, cotton, Tomato, carrot, onion and some fruits need Boron between 0.1-0.5 ppm; apple, clover, peppermint, beet, and cabbage need Boron more than 0.5 ppm (Kovancý,1979)

When 21.1 ppm Boron concentration which some irrigation waters contain are considered, it is seen that this concentration is even much more than the need of the highest Boron demanding plants. Therefore , toxic effect is extensively encountered in citrus fields, which are less tolerant of Boron , of study area Because waters with high Boron content flow into B.Menderes river over years, Boron concentrations of irrigation waters, soils irrigated with those irrigation waters and plants have been determinate with this study.

This research results will enable us to take measure for currently threatened areas and to predict future changes, determine probable changes in these concentrations levels in coming years

## MATERIAL AND METHOD

B.Menderes Basin is located between 37°and 38°northern latitudes and 27° and 29° eastern longitudes. Its an important agricultural source for Aydın province and lies from Denizli border to Aegean sea. The basin has 23900 km<sup>2</sup> of area.In the research area from east to west (Aegean Sea) of the basin, 36 sampling points have been selected among citrus fields where Boron toxicity is seen, From selected points, 142 soil samples in 0-30 and 30-60 cm depths in two different periods (before and after irrigation), 44 water samples from irrigation waters in these fields and 36 plant samples after irrigation have been taken.

## METHOD

After having brought to laboratory, 146 soil samples, 44 water samples and 36 plant samples have been prepared to analyse. Soil samples have been sieved with 2 mm sieve after drying water laboratory conditions. Plant samples firstly have been washed with demineralized water, then dried at 60-70 °C for 24 hours and ground and finally sieved with 2 mm sieve (KACAR,1972)

## **Analysis (Method / Instrument)**

### **In soil samples**

Texture (Hydrometer, Bouyoucos, 1951), pH, (pH meter glass electrode within a suspension of 1 / 2.5 soil water ratio Anonim 1980)  $\text{CaCO}_3$ , (Calsimeter Allison and Moode 1965) Total soluble salts, (Electrical resistance of Saturated soil) Organic matter, (Walkey-Black Anonim 1980), Available phosphorus, (spectrometer using Olsen method Anonim 1980), Exchangeable Potassium, Calcium, Sodium, (Flame photometer in an extract obtained with 1 N  $\text{NH}_4\text{OAc}$  pH 7,1 Richard 1954), Exchangeable Magnesium, (Atomic Absorption Spectrophotometer Kacar 1962), Boron, (Azomethin-H Wolf 1936)

### **In Water Samples**

pH, (pH meter glass electrode), Electrical Conductivity, (EC meter microsiemens / cm), NaCl, (EC meter mg/l), Boron, (Azomethin-H Wolf 1936)

### **In Plant Samples**

pH, (pH meter glass electrode), Electrical conductivity, (EC meter microsiemens/ cm), NaCl, (EC meter mg/l), Boron, (Azomethin-H Wolf 1936)

## **RESULTS AND DISCUSSIONS**

Some physical and chemical analysis belonging to soil samples are given in table 1. Some soil properties such as texture, lime content and organic material content are of great importance, since they affect the movement of Boron in soil. When the results of analysis are examined, it can be seen that pH values are neutral on surface but increase from surface to deeper strata due to increase in alkalinity. According to EC values, there is no salinity problems in soil.

Organic materials of soils were found low in general. Lime contents were generally found high in both 0-30 cm and 30-60 cm in strata.

When relationships between Boron contents of the soils and some soil characteristics were examined, some statistically significant relationships were found.

Negative relationship at 0.05 significance level between sand contents and Boron concentrations were found. This situation shows that Boron coming with irrigation water can easily seep downward in soil profile because sand is incapable to hold any element and is highly permeable. A positive relationship at 0.05 level between clay and silt contents and boron concentrations were observed.

Statistically positive relationships were obtained between electrical conductivity values and Boron concentrations at 0.01 level and between lime and Ca and Mg contents of soils at 0.05 level

### **Assesements of Results of Analysis of Water and Plant Samples**

Because Ayдын has abundant geothermal resources and these resources contain high concentrations of Boron, great amounts of Boron containing waters flow into B.Menderes river, especially from geothermal power plants. Moreover, Boron pollution in domestically used waters which originates from ground waters supplies or from industrial effluents through irrigation waters is threatening both human and animal health.

It has been previously shown in researches carried out by State Hydraulic Works (DSY) that Boron concentrations in both some streams and some ground waters of the region have reached hazardous levels. According to some research results, high Boron concentrations up to 11.8 ppm have been detected in some branches of B.Menderes river. Some analysis results on water and plant samples are given in table 2

pH's of water samples were determinate between neutral and average alkaline. It is given in literature that permissible pH values for drinking water is between 7.0 -8.5 for agricultural irrigation and animal watering

Electrical conductivity ( $\text{EC} \cdot 10^6$ ) values were measured between 392-2420  $\mu\text{S} / \text{cm}$  Referring to u.s.s. salinity Lab. Staff (1954), water samples of 750 - 2250 micromhos / cm are accepted as high saline water and those of 250 - 750 micromhos / cm as average saline water

NaCl contents of water samples ranged from 212 to 1237 mg / l



Table 1. The Results of Some Physical and Chemical Analysis of Soils

Sample No	Depth (cm)	Sand %	Clay %	silt %	Texture	pH	EC <sub>e</sub> ( $\mu\text{S}/\text{cm}$ )	$\text{CaCO}_3$ %	Organic Matter %	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	B (ppm)
1	0-30	65.36	9.20	25.44	S L	7.61	154	1.52	1.07	22.72	100	650	72	25	1.39
2	30-60	67.36	9.20	23.44	S L	7.68	142	1.68	0.27	15.60	95	620	69	40	1.17
3	0-30	63.36	11.20	25.44	S L	6.84	240	0.96	0.94	47.20	155	695	166	45	1.48
4	30-60	59.36	11.20	29.44	S L	6.94	267	1.68	0.27	48.70	125	675	294	40	0.98
5	0-30	55.36	27.20	17.44	S CL	7.93	839	11.78	1.47	27.60	315	1015	160	230	3.04
6	30-60	60.64	27.20	12.16	S CL	8.09	834	10.55	1.47	16.30	285	1080	138	250	3.21
7	0-30	45.36	23.20	31.44	L	7.92	1334	14.70	0.40	39.50	325	920	498	275	3.88
8	30-60	43.36	23.20	33.44	L	7.99	1981	15.24	0.20	30.00	300	860	365	375	6.25
9	0-30	33.36	23.20	43.44	L	7.46	1280	15.55	0.27	71.01	405	1295	435	130	4.34
10	30-60	29.36	19.20	51.44	S L	7.50	1727	15.06	0.99	46.20	360	132	367	280	5.77
11	0-30	66.08	11.92	22.00	S L	7.60	459	2.52	1.21	46.20	190	790	173	75	3.42
12	30-60	68.08	9.92	22.00	S L	7.42	417	2.08	0.80	32.50	170	740	140	75	2.58
13	0-30	68.08	11.92	20.00	S L	7.41	461	4.08	1.21	86.30	195	860	279	120	3.98
14	30-60	66.08	11.92	22.00	S L	7.72	376	4.63	1.07	68.80	175	790	273	95	3.75
15	0-30	64.08	13.92	22.00	S L	7.39	305	1.80	0.67	34.20	215	920	194	40	2.42
16	30-60	66.08	15.92	18.00	S L	7.63	232	3.24	0.63	18.00	180	840	123	30	1.73
17	0-30	68.08	13.92	18.00	S L	7.87	345	2.08	0.80	23.20	175	730	131	80	3.16
18	30-60	70.08	11.92	18.00	S L	7.88	299	3.20	0.67	20.20	150	745	51	75	2.38
19	0-30	66.08	13.92	20.00	S L	7.56	333	4.08	1.34	50.80	255	845	190	40	2.38
20	30-60	62.08	13.92	24.00	S L	7.66	407	3.80	1.20	35.70	315	715	111	105	3.54
21	0-30	59.52	11.20	29.28	S L	7.18	287	1.44	1.61	102.30	210	815	181	70	3.33
22	30-60	65.52	13.20	21.28	S L	7.68	366	5.59	0.80	22.90	135	755	81	150	2.42
23	0-30	67.52	11.20	21.28	S L	7.29	320	1.00	1.88	89.60	220	755	122	80	2.54
24	30-60	67.52	11.20	21.28	S L	7.54	425	1.04	0.40	34.10	130	690	166	90	2.00
25	0-30	67.52	11.20	21.28	S L	7.69	372	2.40	1.21	20.20	155	615	168	110	2.42
26	30-60	69.52	11.20	19.28	S L	7.94	254	2.56	0.94	11.50	100	600	146	85	1.73
27	0-30	63.52	13.20	23.28	S L	7.70	681	4.63	1.34	19.10	175	735	261	180	3.10
28	30-60	59.52	11.20	29.38	S L	7.94	332	1.76	0.67	11.70	125	680	169	110	1.98
29	0-30	71.52	9.20	19.28	S L	7.40	326	3.20	0.94	29.70	175	655	171	100	2.87
30	30-60	79.52	9.20	11.28	LyS	6.93	237	3.12	0.67	15.30	155	670	137	65	2.32
31	0-30	63.68	9.04	27.28	S L	6.83	371	4.63	0.54	27.90	145	575	104	95	1.82
32	30-60	65.68	7.04	27.28	S L	6.91	306	4.95	0.13	16.70	105	670	112	90	1.63
33	0-30	53.68	17.04	29.28	S L	6.86	812	3.12	2.55	85.40	260	890	281	75	5.31
34	30-60	59.68	15.04	25.28	S L	6.77	451	2.16	0.67	25.40	170	640	158	100	2.31
35	0-30	59.68	19.04	21.28	S L	7.11	472	8.55	2.01	30.60	145	830	195	160	2.65
36	30-60	63.68	11.04	25.28	S L	6.86	348	1.94	0.80	69.10	220	630	149	85	2.01
37	0-30	67.68	15.04	17.28	S L	7.20	531	5.31	0.94	30.90	185	680	203	135	2.65
38	30-60	67.68	15.04	17.28	S L	7.05	389	4.95	0.34	25.40	170	725	214	90	2.29
39	0-30	69.68	11.04	19.28	S L	7.25	530	2.76	1.41	35.30	135	655	249	145	3.36
40	30-60	69.68	11.04	19.28	S L	7.13	710	3.12	1.07	39.60	110	645	182	190	3.26
41	0-30	55.68	14.32	30.00	S L	6.45	520	2.14	1.07	41.30	180	605	123	100	2.71

Sample No.	Depth (cm)	S %	Clay %	Min %	Texture	pH	LC (4S cm)	CaCO <sub>3</sub> %	Organic Matter %	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	B (ppm)
42	30-60	67.68	10.32	22.00	S L	6.57	450	2.88	1.21	27.10	165	725	147	110	2.02
43	0-30	69.08	10.32	20.00	S L	6.71	442	3.28	1.74	20.50	160	640	127	101	2.07
44	30-60	65.68	12.32	22.00	S L	6.91	341	12.70	0.19	18.10	130	730	187	105	2.33
45	0-30	49.68	10.32	34.00	L	7.00	373	2.50	1.33	23.50	225	930	301	65	2.14
46	30-60	49.68	10.32	34.00	L	7.03	391	12.38	1.30	13.50	215	1485	480	100	1.87
47	0-30	61.68	10.32	28.00	S L	6.70	348	2.50	0.94	33.80	255	1190	224	70	3.15
48	30-60	65.68	10.32	24.00	S L	6.77	327	1.68	0.57	21.90	280	1180	171	50	2.09
49	0-30	53.68	14.32	32.00	S L	7.22	376	3.31	1.21	29.70	215	1350	326	115	3.61
50	30-60	65.68	10.32	24.00	S L	7.16	207	2.32	0.40	15.80	150	1155	243	120	2.06
51	0-30	78.24	5.96	15.80	L S	6.50	195	1.76	0.40	29.00	95	980	189	60	1.37
52	30-60	76.24	5.96	17.80	L S	5.82	210	9.80	0.27	24.50	80	585	176	60	1.21
53	0-30	68.24	11.96	19.80	S L	7.24	704	3.92	2.55	64.40	270	1360	375	190	4.28
54	30-60	68.24	11.96	19.80	S L	6.98	475	3.44	1.07	50.70	190	1300	320	120	2.87
55	0-30	52.24	15.96	31.80	L	7.22	568	6.23	1.34	36.60	240	1530	454	155	3.16
56	30-60	62.24	13.96	23.80	S L	7.53	529	5.83	1.34	24.80	215	1520	436	135	2.67
57	0-30	64.24	13.96	21.80	S L	5.84	159	2.40	2.14	24.30	120	1005	434	50	1.72
58	30-60	66.24	11.96	21.80	S L	6.66	199	2.48	1.67	40.40	115	985	371	40	1.65
59	0-30	70.24	9.96	19.80	S L	7.51	312	1.40	1.34	32.03	140	900	264	120	2.95
60	30-60	70.24	11.96	17.80	S L	6.28	278	1.60	1.21	23.70	170	805	149	135	2.40
61	0-30	53.68	15.60	30.72	L	7.26	766	2.48	0.40	18.60	265	1445	338	150	4.51
62	30-60	55.68	15.60	28.72	S L	7.18	615	3.32	1.21	24.10	250	1525	360	140	4.89
63	0-30	43.68	21.60	34.72	L	7.18	348	3.20	2.01	21.80	265	1755	456	40	3.96
64	0-30	55.68	15.60	28.72	S L	6.70	450	3.32	2.55	11.50	265	1345	354	155	5.06
65	30-60	49.68	14.60	25.72	S L	6.79	362	1.60	1.34	67.30	270	1320	329	90	3.56
66	0-30	49.68	19.60	30.72	L	7.26	950	9.11	1.70	68.90	400	1680	321	100	1.33
67	30-60	51.68	18.60	29.72	L	7.18	528	9.50	1.34	32.00	275	1865	321	70	1.39
68	0-30	65.68	7.60	26.72	S L	7.25	228	17.38	1.34	23.70	165	1465	149	30	3.10
69	30-60	67.68	7.60	24.72	S L	7.14	186	15.99	1.34	56.80	150	1405	144	20	2.63
70	0-30	69.68	9.60	29.72	S L	7.34	108	15.82	2.01	47.20	185	1305	266	100	4.80
71	30-60	60.40	10.32	29.28	S L	7.03	269	14.98	2.14	46.60	185	1335	269	100	4.20
72	0-30	62.40	12.32	25.28	S L	7.24	291	2.24	1.34	54.10	265	1120	312	120	2.18
Min	0-30	32.36	5.96	15.80	S L	6.45	109	0.96	0.27	11.50	95	615	72	25	1.37
Max	30-60	79.36	5.96	11.28	S L	5.82	142	0.89	0.20	11.50	80	585	51	20	1.17
Min	0-30	78.24	5.20	43.44	S L	7.93	134	17.38	2.55	102.30	405	1755	498	275	5.96
Max	30-60	70.52	2.20	51.44	S L	8.09	1981	15.90	2.14	69.10	360	1865	480	375	6.25
Opt	0-30														
Opt	30-60														



Table 2. The Results of water and plant Samples

Water No	Plant No	pH	EC ( $\mu\text{S/cm}$ )	NAACO ( $\text{mg/L}$ )	Water B (ppm)	Plant B (ppm)
1	1	7.10	439	212	0.33	61
2	2	7.25	1610	807	0.33	88
3	3	7.20	938	458	0.35	675
4	4	7.25	1246	616	0.79	364
5	5	7.25	1137	564	0.72	594
6	6	7.27	1113	547	0.92	677
7	7	7.24	699	340	0.38	547
8	8	7.24	392	189	0.33	297
9	9	7.28	1038	496	0.45	546
10	10	7.26	691	336	0.36	753
11	11	7.28	1516	749	0.80	152
12	12	7.26	620	301	0.33	152
13	13	7.28	1482	735	0.70	305
14	14	7.30	1556	775	0.43	640
15	15	7.28	1209	601	0.37	531
16	16	7.30	1112	544	0.64	584
17	17	7.29	1238	613	0.85	644
18	18	7.30	1306	645	0.96	678
19	19	7.30	1425	728	5.01	627
20	20	7.27	1227	619	2.22	758
21	21	7.30	1252	630	4.98	449
22	22	7.31	1050	523	2.13	431
23	23	7.30	918	446	2.35	786
24	24	7.29	782	380	0.47	278
25	25	7.30	2150	1087	2.61	957
26	26	7.27	1026	503	0.35	430
27	27	7.83	796	388	0.33	490
28	28	8.44	643	312	0.45	610
29	29	8.21	2420	1237	1.55	81
30	30	8.07	982	482	0.48	471
31	31	8.28	984	483	0.37	771
32	32	7.86	2140	1065	0.87	721
33	33	8.68	556	269	0.33	957
34	34	8.27	828	402	0.32	906
35	35	8.38	1395	691	1.37	123
36	36	7.86	423	204	0.35	122
37		7.72	1104	543	0.39	
38		7.79	1162	573	0.39	
39		7.08	1751	876	0.33	
40		8.17	988	485	2.50	
41		8.13	1739	868	6.41	
42		6.98	1519	756	2.22	
43		7.98	505	244	0.33	
Min		7.10	392	212	0.33	61
Max		8.68	2420	1237	6.41	957

Boron concentrations of water samples ranged from 0.33 to 6.41 ppm Seefeld (1936) classified irrigation water in terms of their Boron concentrations in such way that waters containing Boron less than 0.33 ppm is "very good" for plants which are susceptible to Boron, the range 0.33 - 0.67 ppm is "good", the range 0.67-1.0 ppm is "usable" (for unsusceptible plants), the range 1.0-2.0 ppm is "inadvisable" and finally those greater than 2.0 ppm is "unusable". When compared to criteria given above, none of samples have a quality to fall in "very good" category.

Referring to Kovancý (1979), principally waters which contain Boron more than 1.0 ppm can cause pollution in soils resulted from Boron depending on permeability of soils. Therefore, it has been found that 50% of samples taken from research area is good, approximately 29% of them can be used in unsusceptible plants and the rest 21% in unusable for irrigation.

Boron concentrations fluctuate throughout year, higher in some months and lower in some months. For example, some of samples taken in September had higher Boron concentrations than those taken in June. It has been seen that from 'The irrigation water analysis of DSY' for years, Boron concentrations of irrigation waters from June to September were higher than those of other months in a year. Boron contents show higher values in summer that irrigation intensifies due to intense use of



irrigation waters with Boron content in summer months, too much boron accumulates in soil. Because this application is continued every year, accumulated boron in soil firstly causes toxicity in plants, then in later years makes soils unproductive and completely unproductive. Boron contents of plants taken from research area were found between 61-957 ppm. Referring to Reuter and et al., Boron concentrations above 260 ppm in plants are considered toxic. Based on explanations given above and result of analysis, Wery few of plant samples had enough Boron, but approximately 19% of them had high amounts of Boron and 80% had Boron at toxic level As a result , it has been observed that almost all citrus fields which has been studied in this project is suffering from intense Boron toxicity.

A statistically positive relationship at 0.05 level has been obtained between Boron content of soils and of plants. A similar relationship between irrigation water, soil and plant Boron contents was obtained in a study carried out by (Akbař 1998) in Söke and Menemen plains

Since citrus is one of the plant which are susceptible to Boron, the damage which is currently seen in citrus fields will likely be observed in coming years in cherry, fig vineyard, cotton and wheat fields which are important for the region. That the mobility of Boron in soils is very slow makes hard its removal from soil. Consequently, because the region has abundant geothermal water resources which contain high amounts of Boron and these ground waters are brought to surface and used for various purposes such as power generation, heating or thermal spring and then discharged to B. Menderes river, it is being exposed to intense Boron pollution therefore, in order to prevent Boron pollution and hence unproductivity in soils, it is necessary not to discharge waters with high Boron content to irrigation waters

## REFERENCES

- Akbař F.(1998). Deę. Bor Kons.lu Sul. Sularının Menemen ve Söke Ovası Topraklarında Yetiřtirilen Pamuk Bitkisine Etkileri. Ege Bölgesi I. Tarım Kongresi.. Cilt I. 439-445. AYDIN
- Allison L. E., Moode, C.D. (1965). Methods of Soil Analysis. Part 2. Agronomy Series. No. 9. American Society of Agronomy. Wisconsin Series. 1379-1396.
- Anonymous 1. (1971). Köy İşleri Břk. Toprak-Su Genel Müd. Aydın İli Toprak kaynaęı Env. Haritası. No 16. Toprak Etüdleri ve Haritalama Dairesi, Arazi Tasnif Şub.. ANKARA,
- Anonymous 2 (1997-1998). Int. Office for Water. French-Turkish Co. Agree.an Rivers Integrated Water Resour Use Planning and Management. Integr. Develop and Pollution Control.
- Anonymous 3. (1980).Soil and Plant Testing and Analysis as a Basis of Fertilizer Recommendation, F.A.O. Soils Bulletin 38/2 95.
- Anonymous 4.(1981). The Analysis of Agricultural Materials.R.B. 427 Replaces Technical Bulletin 27 Her Majesty's Stationary Office, LONDON,
- Bouyoucus G.J. (1951). A Recalibration of the Hydrometer for Making Mechanical Analysis of Soils. Agron. J. 43.434-438.
- Kacar B. (1962). Plant and Soil Analysis. Univ. of Nebraska, College of Agriculture. Dept. Of Agronomy, Lincoln, Nebraska, U:S:A:
- Kellog C.E.(1952). Our Garden Soils. The Macsiltan Company. NEWYORK,
- Kovancı İ. (1979). İç Ege Bölgesi Sulama Sularının Bitki Beslenmesi Açısından Kimi Nitelikleri ve Kimyasal İçerikleri Üzerine Bir Arařtırma. No. 364. EÜZF. Of. Ü. İZMİR, S: 87.
- Reuter D.J and Robinson J.B. (1986). Plant Analysis an Interpretation Manual Incata Press. MELBOURNE, SYDNEY.
- Richards L.A. (1954). Diagnosis and Improvement of Saline and Alkali Soils. U.S. Agriculture Handbook. No. 60. 159.
- Sauchelli V. (1969). Trace Elm. in Agr. Van Nostraned Reinhold Company, NEWYORK.
- Scofield C.S. (1935)., The Sal.of Irrigation Waters. Smith Inst. Ann. Report, 275-287.
- Wolf B. (1936)., The Determination of Boron in Soil Extrac.Plant Materials, Composts, Manures, Waters and Nutrient Solutions. Soil Sci. and Plant Anl., 2(5):363-374.

# DESERTIFICATION: DEVELOPMENT FACTORS AND CONSERVATION IN THE MOUNTAIN AREAS OF THE SOUTH CENTRAL ASIA

Kasirov Kokul Khasanovich<sup>1</sup>, Akhmadov Khukmatullo Mahmudovich<sup>2</sup>

<sup>1</sup>Tajik Association for Woods and Wild Animals Protection, Dushanbe, Tajikistan 734025

<sup>2</sup>Tajik Forest Research and Development Institute, Dushanbe, Tajikistan 734055

## ABSTRACT

The problem of the soil degradation (desertification) in the mountainous regions of the Central Asia with arid climate is very important. The ecosystem of the landscape mountains is very fragile and its inconsiderable infringement leads to the destruction of natural environment, having catastrophic consequences. The intensive development of the soil degradation in different highly geomorphologic- climatic zones depends on the complex natural- human factors. In the valley zone the soil degradation is presented by all varieties of dynamic processes (the gully erosion, irrigation erosion, interlay erosion, surface erosion, landslide etc.) The main reason of the intensive development is human factor. The natural desertification is more intensively going in the low mountain zone than in the valley zone and the index of the human erosion decreases.

The maximum index of natural soil washout and rainoff observed in the middle mountain zone. The influence of the human factors in the high mountain zone is decreasing and of the nature factors is increasing. The soil degradation is displayed differently in the different parts of the high mountain zone. One of main factors of the soil degradation in the natural belts is intensive grazing, mass-cultivation of the very steep slopes and the deforestation.

All mountain areas of the South Central Asia may be divided into 24 eroded regions and for each of them the complex antierosion methods is offered which will promote further decrease of the soil degradation.

## INTRODUCTION

For each natural zone prevailing causes of soil degradation development are different. The impact of factors of dynamic processes development increases and decrease from one zone to another. The impact of anthropological, geological, factors on erosion processes decrease from valley zone to high-mountain zone. The relief of locality is reversibly increases. The maximum index of climatic, soil, vegetation factors of desertification development is observed in middle-mountain zone; high-mountain and valley zones the impact of these factors decreasing quickly. That's why coming from complex of natural factors we distinguish zones of natural and anthropological soil erosion. The problem of different factors' interaction and their impact on soil degradation for the conditions of mountain relief are very actual. The destruction or ignoring of one environment stability factor may cause catastrophic consequences and development of the series of dynamic processes. Thus, it is possible to recommend real anti-erosion measures basing on analyze of complex of desertification development factors.

## MATERIALS AND METHODS

The impact of anthropological and natural factors has been studied by natural (the estimation of erosion by the size of rill erosion volume and on the rainoff plots; the estimation of long standing erosion intensity; the estimation of erosion by the degree of accumulation pond; the estimation of erosion by the module of flowing deposit), laboratory and analytical-statistical methods.

## RESULTS

The erosion processes development depends on complex of natural and anthropologic factors. Among numerous causes of soil erosion, in each case there are prevailing causes distinguished, although it's a result of geomorphologic, geologic, climatic, soil-vegetation and economic conditions' impact. The nature of their combination determines the danger and intensity of one or other type of soil erosion.

The most expedient classification of erosion factors would be:

- a) promoting factor – negative human economic activity;
- b) energetic factors – climate and relief;



- c) the interfering factor – vegetation; also partially the soil properties;
- d) changing – soil and land surface;

The geomorphologic factor (relief of district) is one of the most significant. It has an impact on the nature of drain formation, speed and kinetic energy of the drain, i.e. affects by means of flowing down water. The erosion development degree in this process depends on the steepness, length, slope exposition their form, the deepness of local erosion basins, the area of water-collection, negative relief forms, at the bottom of which ravines usually develop etc.

In the conditions of Tajikistan, the slope exposition affects greatly on surface drain and soil erosion, especially during the period of spring thawing of snow. The south-exposed slopes usually (except the high-mountains) more eroded and have more washouts, ravines (Table 1-2).

The investigation showed that the increase of the mountain slope 2, 3 and 4 times caused the soil washout to increase accordingly to 21%, 49%, and 69%. The investigations also showed that on the slopes with steepness  $5-7^{\circ}$  the soil washout was 27 t/ha;  $15^{\circ}$  – 176,  $28^{\circ}$  – 372 t/ha, i.e. with doubling of slope steepness the soil washout increases 6,5 times, and with four-multiplying – 14 times.

The water-collection areas of negative relief forms promotes the gully development. On the south exposed slopes gullies develop with water-collection area of negative relief forms over 1 ha, and rarely gullies developed with smaller area. Convenient places for gully development are hollows, dips and dip-like downturns, which mouths are of above local bases of erosion – these are “hanging” negative relief forms.

The appearance and development of erosion depend on mountain rocks, or their anti-erosion stability. For example, on sands with good water permeability the gully erosion is low developed. Only in irrigated lands some small anthropologic gullies are observed. Here, the wind erosion is widely spread. Compared to the sands and sandy soils, the loams easily destroyed by the of thawed and rain water flows. In the river terraces combined by alluvial deposits, plane and linear erosion is developed. The soils formed on deluvial and proluvial deposits, also are subject to the different intensity erosion.

Thus, the majority of erosion forms are observed in loams, less – in alluvial, proluvial, and deluvial deposits and even less – in poorly - washed away dense basement rocks. The modern geologic processes – landslides, suffosion, solifluction, abrasia, karst and pseudo-karst, and also endogene processes play significant role in the development of soil erosion.

The erosion process development is much predetermined by the climatic conditions with precipitation having significant role here.

Besides the average annual and daily amount of precipitation, its intensity has a great impact on the soil erosion development. The raise of the intensity increases the kinetic force of raindrops, destroying the soil structure and decreasing its water-permeability. As a result, the water collected on the surface flows down and washes away the upper soil layer, leaving the jet washouts and rills.

The winds also have a significant influence on the development of erosion processes. They blow off from the adjacent fields into the gullies not only the snow cover, but also the soil itself. The collected snow in gullies melts as the weather gets warm, slowly washing away the gully slopes.

Unlike other factors causing the erosion process development, the vegetation cover plays main soil-protecting role; the drain and soil washout on the slopes with rich projective covering are much lesser, than on the slopes with rare vegetation.

The development and intensity of erosion processes depend on the anti-erosion stability of soils and the fact, that soil cover of Tajikistan is very diverse.

Depending on anti-erosion stability the soils of Tajikistan could be classified this way: gray-lands, mountain brown, high-mountain steppe and meadow-steppe lands. In section of geomorphologic zones, by the degree of susceptibility to the erosion, the soils could be placed in the following order: middle-mountain soils, hilly-foothills and low-mountain soils, high-mountain soils and valleys.

The natural factors may create the conditions for natural soil erosion, but not causing its development. The main factor, promoting the intensive erosion process development, is wrong economic activity. As a result of intensive development slope grounds the erosion has spread widely. The main reason of this is overusing of lands without implementation of anti-erosion measures



(ignoring of norms and techniques of irrigation, intensive overgrazing, improper road placement, imperfection of crop land development technologies etc.)

Table 1. The soil washout depending on slope exposition, length and steepness (1974-1987 y.)

The observation sites And soils	Slope steepness ( <sup>0</sup> )	North exposition			South exposition		
		Slope length (m)					
		30	60	100-120	30	60	100-120
Vakhsh Region, dark-gray soils	5	0.2	1.7	54.3	0.7	2.6	172.1
	8	0.7	2.4	99.4	1.3	4.3	297.6
	16	1.9	12.4	207.6	2.1	27.6	472.4
Gilantau region, mountain-brown carbonate soils	8	0.4	1.3	54.7	0.7	2.1	107.4
	12	0.9	2.7	94.8	1.1	4.6	235.7
	16	1.7	18.6	173.9	1.4	52.6	372.0

Table 2. The influence of precipitation and slope steepness on soil washout (t/ha)

The observation site	Slope steepness (°)	Amount of precipitation (mm)			
		20	30	40	60
Gissar region, Varzob river	9	0.175	9.5	21.7	54.9
	18	0.28	18.1	69.4	351.4
Low-mountains of South Tajikistan, Tairsu River	7	0.27	10.4	19.6	43.4
	14	0.15	19.4	58.8	260.4

All mountain areas of the South Central Asia may be divided into 24 eroded regions and for each of them the complex antierosion methods is offered which will promote further decrease of the soil degradation and can stabilize further sustainable development.

The effectiveness of the AEM depends on combination of the nature factors. There is a complex of AEM for each high-natural zone (fig. 1).

However implementation the AEM do not always give the expected results. For more effective introduction of the AEM, it is necessary accomplish the complex of measures on softening and preventing of erosion processes (tabl.3). The basis here is sustainable development of country and financial support placed at the base of triangle. Depending on significance basic measures are placed in different parts of the triangle. Besides "the base" other main factors softening and preventing the desertification are three components placed in three sides of the triangle. Only observance of all these AEM will promote the softening and preventing of desertification.

Combat to Desertification in the valley zone must be carried out in two directions: first - raise of soil resistance to wash out; second - correct using of the irrigated lands and application of progressive soil protective irrigation techniques. The main effective the AEM must be: cessation of cultivation of one-year cultures on the steep slopes (more than 12 degrees); the use of eroded lands under perennial grass and gardens; deep cultivation across the slope; introduction of modern surface methods irrigation; minimizing the excessive water and other. The gullies lands must be fill-up. It is proposed to plant the 2-10 rows shelter belts of dry-steady trees in the wind erosion zone. Arrangement of trees and quantity of rows depended on of directed and speed of the wind.

For protection of the soil degradation in the low mountain zone (500(900)-1500 m ab. L.s.) necessary to take the system agro-meliorative measures and forest-meliorative measures. This zone use as rainfed for a long time, therefore all AEM must be directed to the further stopping and relation of the erosion processes. Here necessary to take the complex of the AEM - prophylactic measures, agro-meliorative measures, hydro-technical measures ect.

The middle mountain zone (1500-2500 m above s.l.) using as summer pasture. The areas of the rainfed lands are insignificant. Therefore the main AEM is pasture-meliorative measures and

agro-meliorative measures. Here specially must be sparely attention afforestation of the steep slopes.

In previous years buffer zones and „hanging „ gardens have been widely used in the low mountain and middle mountain zones of Tajikistan. Now such application is very rare.

The high- mountain zone (more than 2500 m above s.l.) in the main using as the summer pasture and therefore pasture meliorative measures play the important role. Application of the insignificant standards of mineral fertilizer and regulation of grazing are very effective specially. Other AEM are small effective.

The high- mountain zone (more than 2500 m above s.l.) in the main using as the summer pasture and therefore pasture meliorative measures play the important role. Application of the insignificant standards of mineral fertilizer and regulation of grazing are very effective specially. Other AEM are small effective.

TABLE 3 The Effectiveness of different groups of anti-erosion measures

Name of groups Anti-erosion Measures	Natural-economical zones			
	Valley	Low mountain	Middle mountain	High mountain
	Expected effectiveness of anti-erosion measures			
Anti-erosion organization of the Territory	+++	+++	+++	+++
Agro-technical measures	++	++	+++	+++
Agronomical measures	+++	+++	+++	+++
Agro-meliorative measures	+++	+++	+	-
Meadow-meliorative measures	+	++	+++	+++
Forest meliorative measures	+1	+2	+++	-
Forest-hydro-technical measures	-	++	+++	++
Pasture meliorative measures	-	+++	+++	+++
Hydro-mechanical measures	+	++	+++	++
Including:				
Bank reinforcement constructions	+++	++	+	-
Fill-up of gullies	+++	++	+3	-
Bottom constructions	+	+++	+++	+
Terracing	-	++	+	-
Water detaining constructions	+	++	++	++
Water leading constructions	+	++	+++	++
Water collection constructions	+	+++	+++	+

Effectiveness of measures

Note: 1-highly effective with irrigation

2-effective with creation near gullies of shelter belts of dry-steady trees

3-limited because of costly gully fill-up works

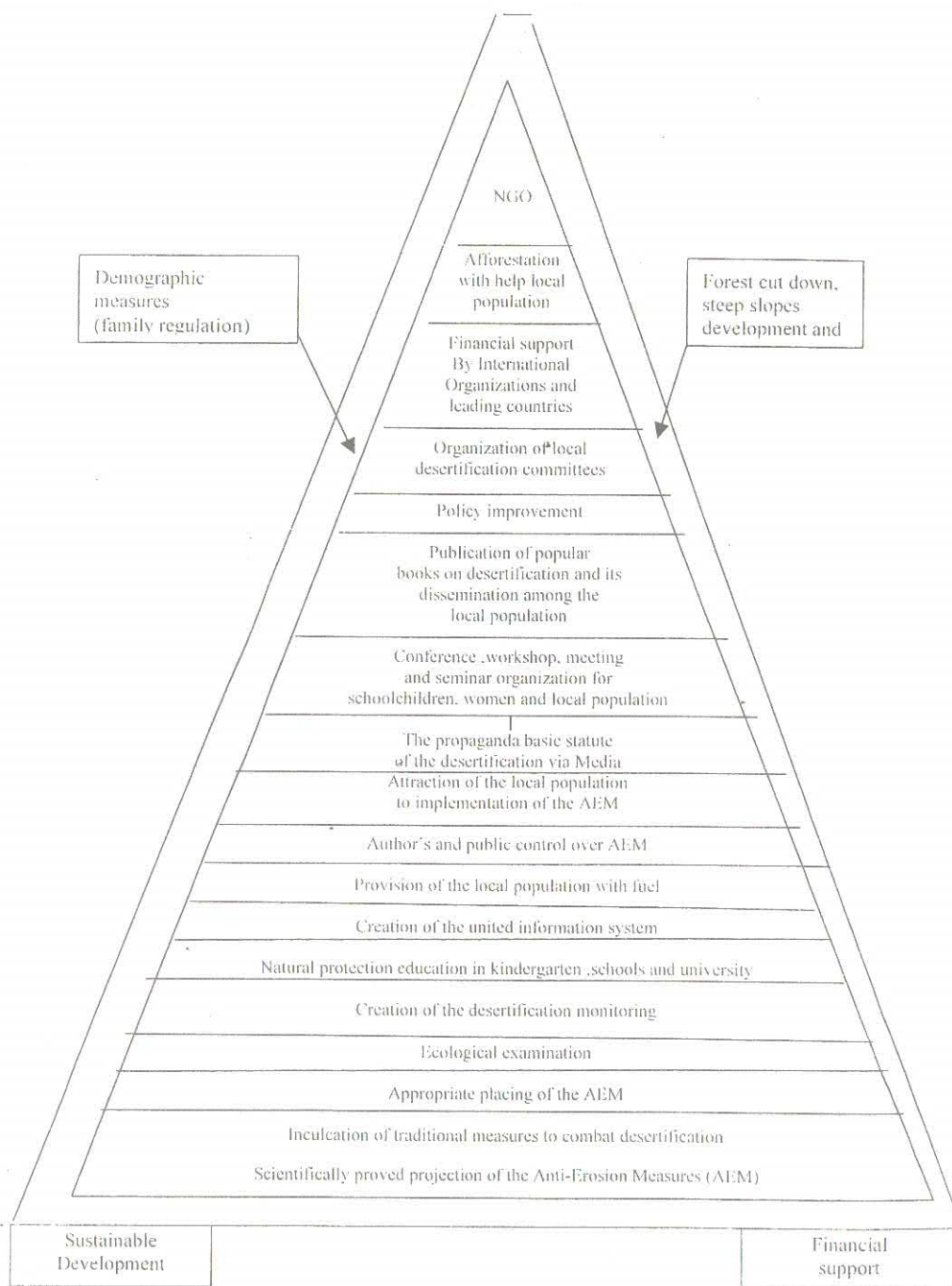
+ low effective

++ effective

+++highly effective

## DISCUSSION

The implementation of AEM in mountain conditions is an important problem. The mechanic transportation of AEM from European part of the former USSR into the mountain territory often caused intensive soil erosion development. For the mountain territory it is necessary to recommend complex of measures as simple transportation of AEM from one zone to another is low effective. The best effect for the mountain territory render local, often ignored AEMs such as, buffer zones, „hanging gardens“. During the USSR period, the terracing was widely spread, but from our point, this kind of farming in mountain territories is low effective. Terraces often may serve as places for gully formation. We recommend 1 – 2 m<sup>2</sup> plots for tree planting, which much lessens the erosion process and give good effect.



**Figure 1** The scheme of basic measures to softening and preventing of the desertification and their arrangement to importance.



## THE SPREAD OF DIFFERENT TYPES OF DESERTIFICATION IN THE MOUNTAIN ZONE OF THE PAMIRS ALAI.

<sup>1</sup> Akhmadov Khukmatullo Mahmudovich., <sup>2</sup> Kasirov Kokul Khasanovich

<sup>1</sup> Tajik Forest Research and Development Institute, Dushanbe, Tajikistan 734055

<sup>2</sup> Tajik Association for Woods and Wild Animals Protection, Dushanbe, Tajikistan 734025

### ABSTRACT

For the Pamirs Alai mountain system the highly geomorphologic-climatic zone is typical. Depending on complex of natural human conditions all the territory of the Pamir Alai divided is to the four zones- valley, low mountain, middle mountain and high mountain, where the process of the soil degradation has the different development. In the valley zone the soil degradation is presented by all varieties of dynamic processes. Depending on how long the lands have been irrigated they can be divided into five categories: irrigated lands, newly irrigated and perspective irrigated lands. In the resulted of the breaking techniques and norms of watering on the irrigated lands the soil erosion, landslide, gully erosion, irrigated erosion etc. Take place intensive development. The density of gullies on the newly irrigated lands comes to 46 unites per square kilometer and the index of the length of gullies - to 7.6 km. per square kilometer. The maximum intensity of the development of the gully erosion - to 654 m per year. Easily eroded mountain rocks, immense human load, the week shocks of earthquakes and otter factors are the reasons of the intensive development of erosion. This lead to the formation of gigantic gullies and powerful landslide. In the valley zone the surface natural erosion is very weakly developed. The wide erosion is widely spread in the south and north of Tajikistan. The natural soil degradation is more intensively going on the low mountain zone than in the valley zone and the index of the human erosion decrease. The density of natural gullies and its total length increase. The washout of soil and rainout of the arable lands and winter pastures comes to 17 thousands ton per ha. The highest index of the soil washout can be watched in the Pistacia zone and is areas of different species of vegetation and it comes to 4.0 -13.0 tons per ha. The intensive development of the degradation depends on the complex of natural factors and on the peculiarity of the growth of Pistacia. Besides the intensive development of the erosion is connected with the discrepancy of the index of the precipitation and dynamics of the leaf surface. The maximum index of natural soil washout and rain off is observing in the middle mountain zone. The intensity of the development of the human erosion decrease. This is connected with the peculiarity of the nature factors and the decreasing of the area of cultivated lands. The soil degradation in the nut forests with the plenitude 0,6 is almost absent (0,003-0,005 tons per ha) but then the plenitude is 0,1-0,3 its index comes to 0,7-4,0 tons per ha. However, the soil washout in the juniper forests comes to 0,6-100,0tons per ha. The smallest index of the erosion is observed under the grassy vegetation. The influence of the human factors in the high mountain zone decreasing and of the nature factors is increasing. The soil degradation is displayed differently in the different parts of the high mountain zone. Here the soil washout comes to 0,6-5,0 tons per ha. The wind erosion is widely spread around the Pamirs lakes. After the breaking-up of the USSR and the civil war in the Tajikistan new factors of the soil degradation development appeared. It were not typical for the investigated areas. The lack of fuel becomes the reason of cutting of valuable mountain forests. It increases the development of erosion processes and expands the areas of "futile" lands. There are Haloxylon forests in the south part of the Republic which protect soil from wind erosion. However, because of lack of fuel they are cut down. Barkhans and dunes are moving to the agriculture areas. Now these lands have turned to the sandy areas. The population growth in the valley zones of the Republic compelled the people to cultivate the former abandoned lands in the mountains and to cut the unique mountainous forests for agricultural needs. The incorrect cultivation of these lands causes the intensive development of erosion and landslide, gully erosion particularly and the formation of "moon" landscape. The problem of insufficient food after the civil war in the mountainous areas of Tajikistan became very important. It forced the population to cultivate very steep slopes (till 35 degrees) under cereal cultures which resulted in the intensive development of erosion and destroyed the fertile horizon of the soil during the short period of time (2-3 years). It leads to change of the landscape. On these slope the line erosion and the landslides are intensively developing. The washout of soil comes to 17 thou sand tons per ha. In the result of intensive grazing in all zones the "sheep paths" are formed. The straight line of the slopes turned is turned into the micro stepped slopes and the biodiversity is fully changes. The maximum quantity of "sheep paths" comes to 14 thousand units per km square. All of aforementioned factors that strengthen the development of the desertification in the mountainous territory gives us the foundation to define the new type of desertification, that is the high mountainous desertification. On the base of space photos the series of maps were made : map of the erosion; the degree of land degradation; of the density, areas, length and intensity of the development of the gully erosion; of the soil washout; of the potentially eroded lands. For the first time for the mountainous territory of the Central Asia we established the connection between the mountain rocks, slope steepness, slope gully and the appearance of the

vegetation on their surface. All mountainous territory were divided into seven categories by the degree of the index of negative relief forms and into 12 categories by the degree of the degradation. On the fundamental rocks under the influence of dynamic processes special forms, called "obburida" [ob- water (tajik), burida - to cat (tajik)] are forming. For the highly geomorphologic zones the different methods of protection from degradation are offered.

## INTRODUCTION

The Pamirs-Alai mountain system covers the whole territory of Tajikistan, south and western parts of Uzbekistan, and south of Kyrgyzstan. Depending on height-nature climatic conditions the whole mountain system divides into 4 zones. The soil degradation, salting and other dynamic processes flow differently. For each zone characteristic types of desertification are distinguished. The development of soil erosion, salting, raise of the underground water level, landslides depend on the complex of nature anthropological factors. However for each zone it is possible to define prevailing factors, which cause the intensive development of dynamic processes. The changes of modern land surface take place under the influence of the soil degradation (desertification), such as water, wind, gully, surface and another kinds of erosion, internal erosion, landslide, karst etc. The soil degradation is wide-spread in the mountain ecosystems and annually this area increases. 97,9 % of territory of the Pamirs Alai (in the area of Tajikistan) is subjected to soil degradation. In 1973 this index came to 68%. During 60-80 the years many soil degradation problems were investigated. However, a lot of questions of the dynamic processes (particularly desertification and these influence on sustainable development) for the mountainous territory still remain unstudied and require the detailed exploration using modern methods and applications of space photos. These questions are of principle meaning in the process of projecting anti-erosion measures and solution of the social-economic processes.

## MATERIAL AND METHODS

The research conducted over the whole territory of the Pamirs-Alai in field, experimental, expeditionary and laboratory conditions. The expeditionary methods (methods by S.S. Sobolev, 1949) allowed to measure the soil washout by investigation of volume of rill erosion on the elements of the relief forms. The rain off and soil washout have been studied in the permanent plots rain off, length 5-30m., width 3-5m., slope steeples 5-28 degrees and on different slope exposition. The dynamic of development of gully erosion had been studied by the stationary method during 25 years on 250 gullies in all geomorphologic zones. The spreading of the soil degradation (surface, rill, gully, irrigation and another varieties of erosion) have been studied in the base of space photos, our worked up methods for the mountain territory. The biodiversity have been investigated on the strongly eroded rangelands in different usage period by the metric method. (Ahmadov 1987)

## RESULTS

Depending on complex factor in the different highly - natural belts the land desertification goes differently. In the valley zone the soil degradation is presented by all varieties of dynamic processes. The main reason of the intensive development is human factor. Depending on how long the lands have been irrigated, all irrigated lands can be divided into 5 categories, where in the result of their incorrect use the gully erosion irrigate erosion, interlay erosion, surface erosion, landslides etc. intensively develop. The density of gullies in the valley zone comes to 16 units per square kilometer and the index of the length of gullies 7.6 km per square kilometer. The maximum intensity of the development of the gully erosion 654 m per year. Besides the above mentioned factors the exit of the under ground water, easily eroded mountain rocks and the shocks of earthquakes promote of the further intensive development of the soil degradation. The surface natural erosion is very weakly developed here. The wind erosion is widely spread in the south and north of Tajikistan, where the dunes and barchans are frequent to appear. The annual speed of their movement is up to 50 meters.

The natural soil degradation is more intensively going in the low mountain zone than in the valley zone and the index of the human erosion decreases. The density of natural gullies and their total length increases. The washout of soil and rain off of the arable lands and winter pastures comes to 17 thousand ton per ha. The highest index of the soil wash out can be watched in the Pistachio zone and in the areas of different species of vegetation and it comes to 4.0 - 13.0 tons per ha. The intensive development of the soil degradation depends on the complex of natural factors and on the peculiarity



of the growth of Pistachio. Besides, the intensive development of the erosion is connected with the peculiarities of the index of the precipitation's and dynamic of the leaf surface.

The maximum index of natural soil wash out and rain off observed in the middle mountain zone. The intensity of the development of the human erosion decreases. This is connected with the peculiarity of the nature factors and the decrease of the areas of cultivated lands. The soil degradation in forests with the plenitude 0.6 is almost absent (0.003 - 0.005 tons/ha), but when the plenitude is 0.1 - 0.3 its index comes to 0.7 - 4.0 tons per ha. However, the soil washout in the Juniper forest comes to 0.6 - 1.0 tons per ha. The smallest index of the erosion is observed under grassy vegetation (tabl.1). However in spite of this the soil wash out process several hundreds times larger than soil formation process.

The influence of the human factors in the high mountain zone is decreasing and of the nature factors is increasing. The main cause of the desertification development in high mountainous zone is the climatic factor. Low precipitation (50-300 mm as snow), strong winds, the temperature regime and other parameters promote the intensive desertification development. The relief and geological structure itself also assist the soil degradation process. The majority of soil cover in the high mountainous zone belong to the unstable to the wind erosion kind of soils. Even the insignificant index of vegetation cover causes the desertification to decrease. However, during the last period there's an intensive cut down of Teresken bush has taken place, the plant which is the only soil protector from the wind erosion. This process causes the dry up of lakes, spring disappearance, development of sandy massifs (barkhans and dunes) that concur new territories. Very often the sand storms and hurricanes can be observed, which raise up in the air sand and salt from the dry salty lakes. All sandy massifs situated around the lakes and along the river valleys at the heights of 3,500-4,000 meters above the sea level. The intensity of barkhans and dunes spread goes up to the 10 meters per year. The rate of sand particles blow out in this area makes 7-20 mm per year.

**TABLE 1**

Rainout (meter cube per ha) and soil washout (tons per ha) on the plots with afforestation and vegetation (Gissar mountain range, winter-spring pasture zone).

YEARS	EXPERIMENTAL VARIANTS					
	Afforestation without grassy vegetation and bedding.		Afforestation and grassy vegetation with covering vegetation 70-100%		Afforestation and grassy vegetation with CV-95% and ground ramparts	
	1	2	1	2	1	2
1987	347,5	27,6	127,2	0,09	17,7	0,019
1988	290,6	21,5	105,7	0,08	16,2	0,015
1989	350,1	28,6	105,5	0,13	12,1	0,013
1990	335,2	24,2	106,2	0,07	11,6	0,014
1996	300,5	22,9	120,4	0,08	15,4	0,020
1997	370,9	32,4	134,3	0,09	13,3	0,015

The soil degradation is displayed differently in the different parts of the high mountain zone. Proceeding from the development factors the following types of erosion have been distinguished for Eastern Pamirs: water, wind, surface, nival; and for Western Pamirs and Central Tajikistan - surface, linear, pasture erosion. In the most part of the high mountainous zone, made up of low-washout rocks the erosion-denudation forms of relief are spread. We named them obburida [ob(tajik) - water, burida (tajik)-cut].

Depending on the complex of nature factors in different parts of high mountainous zone the soil washout comes to 10 - 1200 tons/ha.

The high mountain regions are used as summer pastures, thus causing the intensive development of pasture erosion.

When working out the desertification maps for high mountain zones, the space photos have been used, which allowed us to improve the desertification mapping methods.

One of main factors of the desertification in the natural belts is intensive grazing (tabl.2) In the result of the intensive grazing in all zones "sheep paths" are formed. The straight line slopes are turned



into the microstepped slopes and the biodiversity fully changes. The maximum quantity of "sheep paths" comes to 14 thousand units per square km (tabl.3).

The intensity of development of natural gullies various in wide scale. The maximum increase of gullies comes to 82,5 m, minimum-0,2m, and annual-3,4 m.

The cosmic information is very valuable cartographical materials for study a lot of dynamic processes including soil degradation or desertification. Analysis and comparison of the space photos (SPh) with traditional soil – erosion materials show that in the SPh the water erosion, wind erosion, gullies erosion, irrigation erosion and other dynamic processes with greater exactness and authenticity discern. Dependence on colors, phototones, structure, texture ect. among of soil degradation processes in SPh could be distinguish different degrees of erodeness lands. On the basis of above mentioned signs were compile the map of the soil degradation.

**TABLE 2**

The soil washout (ton per ha) by different cover vegetation and steep slope.

REGION OF THE OBSERVATION	COVERING VEGETATION (%)											
	5			30			60			100		
	Steep slope degree											
	5-7	10-15	20-30	5-7	10-15	20-30	5-7	10-15	20-30	5-7	10-15	20-30
Terikhlitan mountain range (Pictachio zone, winter pasture)	1,7	12,5	172	1,1	11,6	163,7	0,4	1,6	3,6	0,04	0,07	0,13
Gissar mountain range (spring-summer pasture)	2,4	17,8	166	2,1	13,9	144,3	0,6	1,9	4,7	0,02	0,05	0,07
Bakhsh mountain range (spring-autumn pasture)	3,7	24,6	187	1,9	14,6	170,5	0,5	1,8	4,5	0,03	0,06	0,1
Darvaze mountain range (summer pasture)		11,4	94,5	—	9,1	87,8	—	1,7	2,7	—	0,02	0,03

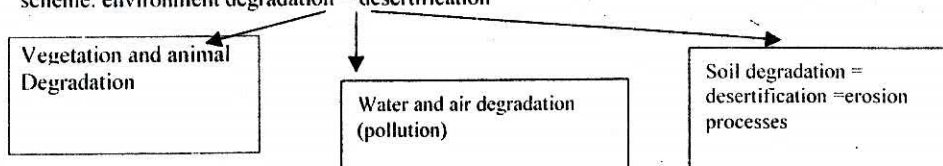
**TABLE 3**

Quantity of the "sheep paths", soil washout and steep slopes in Tajikistan

Steep slopes Degree	Quantity of the "sheep paths" ( thousand units/km <sup>2</sup> )	Soil washout ( tons/ha )	The density of Gullies ( units/km <sup>2</sup> )	The length of Gullies ( km/km <sup>2</sup> )
5-7	less than 1,0	1,2-21,1	0,1-0,2	1-2
10-12	1,403,2	35-72	0,5-0,7	5-7
15-17	2,3-6,8	64-400	0,9-2,4	7-20
20-22	4,5-8,7	250-1200	1,4-3,2	16-32
25-27	6,7-9,6	470-1800	1,7-4,7	24-47
30-32	9,1-11,2	800-2700	2,4-7,4	36-62
35-37	12,5-14,7	1300-3800	1,7-6,2	16-74
More than 40	14,2-17,4	2700-5200	1,9-8,2	20-84

## DISCUSSION

Definition of the different types of the desertification is discussion. More than 150 shapes of the soil degradation distinguish oneself in the former soviet literature. However, for the last time, in connection with adoption of the International nature protection Conventions the soil degradation identified with the desertification. Therefore it is necessary definition of the dynamic processes by scheme: environment degradation = desertification



The soil degradation (desertification) divides into the under (a) ground water, (b) salination, (c) swampy, (d) soil degradation (138 types) and (e) other dynamic processes. However, peculiarity of the nature condition of the mountain lead to formation of the specific types of soil degradation – (1) negative erosion denudation form of the relief (obburida) and (2) high mountain wind erosion. Besides numerous specific form of the degradation distinguish oneself for each high nature zone.

## REFERENCES

- Ahmadov, H.M. (1980) Razvitie erozii v gornikh territoriyah Yuga Sredney Azii. Dushanbe : 48 p.  
Sobolev, S.S. (1949) Razvitiye erozionnih processov v Evropeyskoy chasti SSSR. Moscow-Leningrad. Vol. 1: 305 p.

# EROSION RISK MAPPING OF DALAMAN BASIN LOCATED IN WEST MEDITERRANEAN REGION USING CORINE METHOD

<sup>1</sup>Orhan Doğan <sup>2</sup>Mehmet Emin Özel <sup>2</sup>Hülya Yıldırım <sup>1</sup>Nurgül Küçükçakar

<sup>1</sup>Ankara Research Institute of Rural Services

<sup>2</sup>Turkish Scientific and Technical Research Organization (TÜBİTAK)  
Marmara Research Center Space Technologies Department (MAM)

## ABSTRACT

CORINE METHODOLOGY is a standart method used by the countries of the European Community to determine the erosion risks and qualities of the lands. Using the methodology, countries of the European Community sharing the coasts of Mediterranean Sea have completed their erosion risk maps and classification of their lands. However, land classification studies using CORINE Methodology in Turkey are very limited. On the other hand, having erosion risk map of Turkey using Corine Methodology will be helpful for the integration of future scientific studies between European Community and Turkey which will be a full member in the near future. This study can be accepted as a pilot project in this concept. A pilot erosion mapping study has been conducted in Dalaman River Basin with the financial support from TEMA (The Turkish Foundation for Combatting Soil Erosion Reforestation and the Protection of Natural Habitats) foundation and cooperation of TÜBİTAK-MAM (Turkish Scientific and Technical Research Organization-Marmara Research Center Space Technologies Department) and KHAEE (Ankara Research Institute of Rural Services). The pilot study aimed at use of Remote Sensing (RS) and Geographic Information System (GIS), which have recently shown rapid progress. Erosion mapping and determination of state of erosion using GIS have been realized by applying three different methods (CORINE, ICONA and USLE). In this paper, the studies conducted based on CORINE method will be explained. According to the method, more than 1/3<sup>rd</sup> of the basin soils (36 %) has highly erodible texture, the soil depth of more than half of the basin (57 %) is less than 75 cm and half of the basin soils has stoniness problem. When potential erosion risk was considered, only 16 % of the basin soils has low, 45 % has moderate and 35 % has high erosion risk. On the other hand, according to the Actual Erosion Risk, which is determined by considering vegetation cover, 27 % of the basin soils has low, 40 % has moderate and 29 % has high level of actual erosion.

## INTRODUCTION

Erosion in Turkey as in the whole world, is one of the most important ecological problems threatening the natural resources of the country. Turkey is located at the Southwest / Central Asian-North African belt which a big portion of it is under most eroded and deserted lands. According to the sediment measurements made on 26 large basins, the amount of sediment transported to seas and lakes is about 500 million tons per year (EİE-General Directorate of Electric Power Resources Survey and Development Administration, 1993). Conservation of ecological balance, land use planning and a good management of natural resources may be possible by having a good knowledge of the present status and problems of soil and plant cover.

Soil erosion is of vital importance in the Mediterranean basin, especially at the coastal parts due to some physical and socio-economical conditions. Some of the characteristics of Mediterranean basin like; rough and disordered lands, climate characterized by arid and heavy thunderstorm periods following each other very often (specifically heavy rainfalls occuring during the periods of poor vegetation cover) poor soil structure, low organic matter content of the soil and shallow soils are among the physical factors increasing the severity of erosion. Socio-economical factors, on the other hand, comprise the damaging of rangelands and forestlands to gain areas for cultivation, forest fires ending up with the disappearance of natural vegetation cover and misuse of agricultural lands. The determination of soil erosion with its all aspects is very difficult and studies related with this subject are very limited and insufficient.

## MATERIAL AND METHOD

### Material

### Description of the Study Area

Dalaman river basin, where the project was conducted, is located in the Mediterranean region of Turkey. The basin has so many diverse characteristics as of climate, topography, land slope, soil



structure, vegetation cover, vegetation density, settlement areas and other social and economical properties that are important factors in the analysis of erosion.

### **Climatic Characteristics of the Basin**

The altitude of Dalaman basin starts from the sea-level and reaches to 2420 m as gone to the northern parts. The width of the basin is 45 km and it is 113 km long. The coastal part of Dalaman basin has a typical Mediterranean climate with warm and rainy winters, and dry and hot summers and the climate gradually becomes harsher as approached to the northern parts of the basin (TOPRAKSU 1972, 1973). Annual average rainfall in Dalaman county is 1035 mm and as approached to the northern parts of the basin, this amount decreases gradually and becomes as low as 547.7 mm in Acipayam and 527.3 mm in Tefenni counties. High altitudes and northern parts of the basin are mostly snowy during winter months. Nearly 82 % (845.1 mm) of the average total rainfall (1035 mm) in Dalaman county is recorded during November-March period. For that reason, winter and fall rainfalls at this part of the basin mostly have very high erosive power. Although the erosive power of the rainfall in Dalaman county is very high (162.9) according to Fournier Index, it is very low in Acipayam. In addition, "rainfall erosivity index" which is a function of rainfall and temperature has a high value (3) in Dalaman county and a moderate value (2) in Acipayam county. At the same time, although "rainfall erosivity index R" calculated using USLE model was found as 350 t.m/ha for Dalaman county, it was found as low as 26.3 t.m/ha for Acipayam county.

### **Mapping Method**

CORINE Method in erosion mapping analyses the following some factors for the determination of actual erosion risk (Doğan and Küçükçakar, 1994). These factors are;

- 1- Vegetation cover
- 2- Land Slope
- 3- Meteorological conditions
- 4- Soil Properties

In compliance with the method, first the vegetation cover density of the study areas was determined with the help of data from satellite images followed by the ground truth analysis at the basin. Because land slope plays an important role in soil movements resulting in erosion, Digital Elevation Model (DEM) of the basin was constructed with the help of GIS. Using the Digital Elevation Model of the basin, slope values were calculated at each pixel.

Basic soil properties like soil structure, soil depth and stoniness, which are important as of erosion were analysed in the laboratory. As a result of these analysis, an average soil erodibility parameter was determined for each soil polygon and the soils of the basin were classified in three categories as low, moderate and high erodible soils.

Among the parameters having impact on erosion, temperature and precipitation were analysed together and precipitation Index and Bagnouls Gaussen aridity index were calculated as described in the methodology.

Basic soil properties like soil structure, soil depth and stoniness, which are important as of erosion were analysed in the laboratory. As a result of these analysis, an average soil erodibility parameter was determined for each soil polygon and the soils of the basin were classified in three categories as low, moderate and high erodible soils.

Among the parameters having impact on erosion, temperature and precipitation were analysed together and Fournier precipitation index and Bagnouls Gaussen aridity index were calculated as described in the methodology. Both indices were analysed together and "erosivity" parameter was determined for the basin. "Soil erodibility" parameter which reflects the soil characteristics, "erosivity" which determines the impact of precipitation and temperature and "land slope" which is an important factor affecting erosion were considered all together to reach to "Potential Erosion Risk" map of the basin. At the last step of the method, by incorporating the vegetation cover larger, the "Actual Erosion Risk" values were determined for the basin.

## **RESULTS AND DISCUSSION**

Erosion risk of Dalaman basin according to CORINE method has 4 different classes. The characteristics of the basin, as determined by the method, can be listed as follows:

- (a) Soil samples taken from 702 sampling points were analysed in the laboratory of Ankara Research Institute of Rural Services. According to the results:
  - (i) Soils of more than 1/3<sup>rd</sup> of the basin (36 %) have highly erodible texture.
  - (ii) The depth of soils of more than half of the basin (57 %) is less than 75 cm.
  - (iii) Soils of the half of the basin (50 %) have a serious stoniness problem.
  - (iv) If all three (texture, depth and stoniness of the soils) were evaluated together, the area covered by highly erodible soils reaches to 56 % of the basin.
- (b) According to the climatological data, 90 % of the rainfalls recorded in the basin is moderately and 8 % is highly erosive.

Dalaman basin, which is located between 36° 38' 55" and 37° 40' 55" North Latitudes and 28° 39' 20" and 29° 49' 55" East Longitudes of West Mediterranean Region, has a drainage area of 4481 sq.km. Long years average discharge of Dalaman basin is about 43.8 m<sup>3</sup>/s. According to data (30-year) from E.I.E's Akköprü measurement station (closest station to the sea), about 1 106 450 ton/year of sediment is transported to the sea from 87 % of the total area of the basin. Sediment yield of the basin is about 247 t.y<sup>-1</sup>.sq.km<sup>-1</sup> (E.I.E. 1994).

### **Soils of Dalaman Basin**

According to the soil surveys made by TOPRAKSU, Non-calcerous Brown Forest Soil Group has the largest portion (29 %) in the basin. These soils have A (B) C profile. The depth of these soils range between 40-70 cm. Natural plant cover generally consists of deciduous forest trees. This group is followed by Red Brown Mediterranean Soil Group with a portion of 25 %. The soils of this group have ABC profile.

Brown Forest Soil Group is the third largest group (17 %) in the basin. The soils of this group have A (B) C profile and the depth of the soils ranges between 50-90 cm. The profile of brown forest soils under Mediterranean climate is completely calcerous. The other Great Soil Groups cover less than 10 % of the basin area and consist of a wide variety of soil groups from Kolluvial to Rendzina with descending ratios of area coverage.

### **Topographic and Drainage Characteristics of Dalaman Basin**

The topographic and drainage characteristics of the basin can be summarized as in the following table.

- (c) Nearly 3/4<sup>th</sup> of the basin (72 %) has high slope steepness (15 % or more), which is subject to high erosion rate. About 1/5<sup>th</sup> of the basin (20 %) has low slope steepness (5 % or less) on which erosion can be controlled through some vegetative studies. The rest 8 % has moderate slope steepness (8 % - 15 %). Erosion rate on this type of land can be reduced by agricultural practices like contour tillage, strip-cropping and rational crop rotation methods.
- (d) When Potential Erosion Risk of the basin was examined (according to CORINE method); (without taking plant cover into account) only 16 % of the soils has low erosion risk. About 45 % of the soils has moderate and 35 % has high potential erosion risks. Vegetation cover density is one the most important factor preventing erosion. When this factor is taken into account, about 27 % of Dalaman basin has low, 40 % has moderate and 29 % has high erosion risks. As can be seen, the existence of plant cover has highly reduced the potential erosion risk at the basin.

Basin Characteristics	Unit	Value
Area	km <sup>2</sup>	5120
Perimeter length	km	435.75
Length	km	113.0
Width	km	45.3
Gravelius Coefficient		1.705
Schumm Coefficient		0.715
Roundness ratio		0.339
Rectangular equivalence of the basin L <sub>A</sub>	km	191.05
Rectangular equivalence of the basin L <sub>B</sub>	km	26.81
Maximum height	m	2420
Minimum height	m	0
Relief	m	2420
Relative Relief	%	0.562
Average height	m	1038
Average slope	%	16.41
Slope Index	%	9.57
Median height	m	1000
Length of main waterway	km	170.26
Length of total waterway	km	843.0
Drainage density	m/km <sup>2</sup>	164.65
Length of overland flow	km <sup>2</sup> /m	0.0031
Waterway Frequency		0.046
Bifurcation Ratio		3.25
Slope of main waterway profile	%	0.74

## REFERENCES

- COMMISSION OF THE EUROPEAN COMMUNITIES, 1992, "CORINE Soil Erosion Risk And Important Land Resources." Luxembourg.
- DMI, 1989 Türkiye Klima Atlası, DMI Yayınları. Ankara.
- DOĞAN, O., KÜÇÜKÇAKAR, N. 1994 "Erozyon Haritalamasında Bazı Metodolojiler", Köy Hizmetleri Ankara Araştırma Enstitüsü Yayınları, Ankara.
- E.I.E. (1994) Sediment Yıllığı
- TOPRAKSU GENEL MÜDÜRLÜĞÜ, 1972. Muğla İli Toprak Kaynağı Envanter Raporu. Yayın No: 243, Rapor Serisi: 31, Bakanlık Yayınları:159, Toprak Etüdleri ve Haritalama Dairesi Arazi Tasnifi Şubesi, Ankara.
- TOPRAKSU GENEL MÜDÜRLÜĞÜ, 1972. Burdur İli Toprak Kaynağı Envanter Raporu. Yayın No: 265, Rapor Serisi: 52, Bakanlık Yayınları: 180, Toprak Etüdleri ve Haritalama Dairesi Arazi Tasnifi Şubesi, Ankara.
- TOPRAKSU GENEL MÜDÜRLÜĞÜ, 1973. Denizli İli Toprak Kaynağı Envanter Raporu. Yayın No: 244, Rapor Serisi: 32, Bakanlık Yayınları: 160, Toprak Etüdleri ve Haritalama Dairesi Arazi Tasnifi Şubesi, Ankara.



# SOIL PROPERTIES AND SOIL ERODIBILITY CHANGES ALONG A SLOPE

<sup>1</sup> İrfan Oğuz

<sup>1</sup> Ö. Faruk Noyan

<sup>1</sup> Rural Services Tokat Research Institute PO Box : 256 Tokat/Türkiye

## ABSTRACT

In this research, changes in the physical and chemical properties and erodibility of the soil, along a certain slope, have been studied by making statistical comparisons of different analysis realized in a homogeneous sloped field. Soil samples have been taken from different depths (0 - 20 and 20 - 40 cm).

It was observed that, with the increase of the distance to the upper slope; while salt, clay, potassium oxide and wilting point contents were increasing; sand, pH and  $\text{CaCO}_3$  contents of the soil were decreasing. While the soil erodibility was high in the upper slope, it was decreasing towards the lower slope. Main identifying characteristic of soil erodibility was the soil texture. No statistical link was found between the organic matter, bulk density, specific gravity, aggregate stability, macropore, field capacity and the distance with the upper slope.

## INTRODUCTION

Soil properties may not only vary from one field to another, but also vary in the different parts of the same field. One of the reasons for physical and chemical changes in the soil was soil erosion.

This study has been realized at Ugrak Catchment, which is a seven square km area, and 16 km from Tokat. The purpose of the study was to find out the changes in the soil characteristics in a sloped field along the slope. Basin's 74.7 % is farmland, 15.8 % pasture, 6.3 % forest, 3.2 % scrub. Wheat - fallow system has been applied where dry farming took place. Grain, sugar beet, clover and leguminous vegetables were planted where irrigated farming was applied.

Wheat - fallow planting system has been applied in the field, which was a dry farming field, the research was run. The field's productivity is very low with a wheat productivity of 1490 kg/ha, because the climate conditions which are not optimal, as well as traditional farming applications.

## MATERIALS & METHODS

The research area has a 6 % homogenous slope towards southwest. The field has a thin granular structure between 0 - 20 cm depth, and thick cornered block structure between 20 - 40 cm depth. The research area has a clay texture, has slightly alkali reactions, has a few organic matter, has very little phosphorous content, has more potassium, has little  $\text{CaCO}_3$  content and has no salt.

The hydraulic permeability was found very high among the identified physical properties. The bulk density of the soil varied between  $0.97 \text{ g/cm}^3$  and  $1.52 \text{ g/cm}^3$ . The average specific gravity has been found as  $2.64 \text{ g/cm}^3$ . Aggregate stability has been changed between 0.03 mm and 0.07 mm. The field capacity and wilting point varied between 30.37 %- 33.43 %, and 21.63 % and 25.05 % respectively.

The soil erodibility of the field has been calculated with the help of a statistical equation developed by Wischmeier and his friends (Erodibility Equation), and by adjusting the "K" factor in order to find the protection effect of the particulars bigger than 2 mm, the actual "K" factor has been found (Anonymous, 1983). According to this finding the field's average K factor value is 0.075 as a very little erodible soil.

The annual potential soil loss calculated with USLE is 1.35 ton m/ha, which is in the acceptable soil loss range.

Soil samples have been taken and sent to the laboratory for further analysis, with 10 m distance intervals, from 0 - 20 cm and 20 - 40 cm depth, beginning from top to lower parts in the same slope. Salt content, pH,  $\text{CaCO}_3$ , phosphorous, potassium, organic matter, texture, hydraulic permeability, bulk density, specific gravity, aggregate stability, field capacity and wilting point have been determined (Tuzuner 1990).

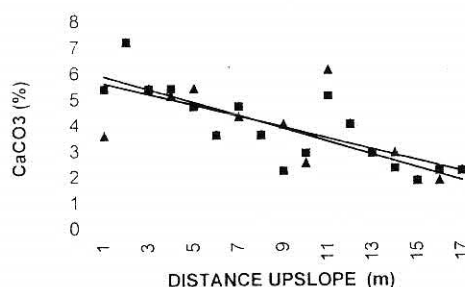
## DISCUSSION

In order to find out the change in different soil specifications subject to the slope, Minitab Statistics Software has been used and the simple correlation coefficients found out by the statistical analysis are listed in Table 1 below.

Table1. Simple correlation coefficients between the slope and soil parameters.

Soil properties	Soil depth (cm)	
	0-20	20-40
	R	
Soil Erodibility	-.600	-.555
Salt	.502	.460
PH	-.457	-.642
CaCO <sub>3</sub>	-.830	-.708
P <sub>2</sub> O <sub>5</sub>	-.298	.051
K <sub>2</sub> O	0.529	0.732
Organic Matter	0.0003	0.396
Texture		
Sand	-.0245	-.0537
Clay	0.658	0.611
Silt	-.0379	-.0142
Bulk Density	0.283	0.113
Specific Gravity	0.270	0.419
Aggregate stability	0.242	0.101
Field Capacity	0.124	-.0018
Wilting Point	0.536	0.306
Macroporosity	0.078	0.008

According to the Table 1, the highest correlation was found for CaCO<sub>3</sub>. This has been followed by clay, one of the soil's textural parameters.



The research field's CaCO<sub>3</sub> content varied between 1.8 % and 6.1 %. When comparing the soil samples taken from 0 - 20 cm and 20 - 40 cm depths, for the CaCO<sub>3</sub> content, it was found that in the upper parts the CaCO<sub>3</sub> content was less in the deep soil compared to the surface of the soil. However in the lower parts of the field the content of CaCO<sub>3</sub> content was higher in the deep soil compared to the surface of the soil. This can be related to the runoff in different parts of the field and the water infiltrated in to the soil. The rainfall, which can not be infiltrated upper slope, moves towards the lower slope. In the lower parts of the field water is accumulated and infiltrated. While the evaporation in the upper parts of the field, which contained less humidity, and the CaCO<sub>3</sub> was increasing, the leaching was efficient in the lower parts, where the humidity was higher.

The CaCO<sub>3</sub> content in the sloped field, depending on the slope distance, has significantly changed and decreased with the distance to the upper slope. While going down from the upper slope of the field towards lower slope, the reason of the significant decrease in the CaCO<sub>3</sub> content was the decrease in the soil thickness in the upper parts with the effect of previous erosion and the soil was gathered in the lower parts. This caused the thickness in the lower parts, and with this effect the main material containing CaCO<sub>3</sub> was left in the deeper segments.

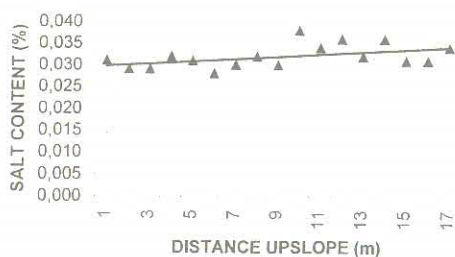


Figure 2. Difference in salt content along the slope

The salt content of the research field has varied between 0.026 % - 0.044 %. Though there was not a significant relation in the 0 – 20 cm soil depth, the salt content of the field has increased, towards the lower slope, according to the statistical relation found for 20 – 40 cm soil depth. However this had no effect on agricultural production. The salt leaching with the rainfall, from the upper parts of the field towards the lower parts, caused high salt content.

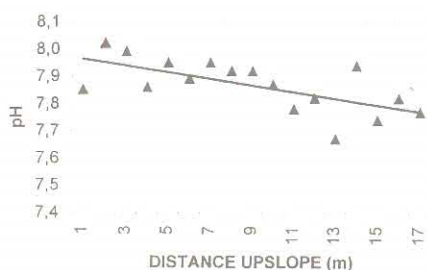


Figure 3. Difference in pH value along the slope

The pH of the research area has changed between 7.67 and 8.02. Correlation for the 0 - 20 depth soil was not found, however for the 20 - 40 cm soil depth a negative relation was found from the upper slope towards the lower slope. The low pH value in the lower parts of the field compared to the upper slope was related to the  $\text{CaCO}_3$  content and increasing clay content adsorbing active hydrogen ions (Sezen, 1991). In the lower slopes the decrease in  $\text{CaCO}_3$  content led to the decrease in pH value. In the upper parts where the  $\text{CaCO}_3$  content was higher, higher pH values, caused by  $\text{CaCO}_3$  were observed.

In the texture of soil samples taken, sand, clay, and silt were found. According to this, sand content varied between 32.64% - 41.52 %, clay content varied between 39.17 % - 49.95 %, and silt content varied between 12.93 % - 25.86 %.

Through the slope no relation for silt was found, however between 20 - 40 cm depth for sand negative, between 0-20 and 20 - 40 cm depth for clay positive correlation was found.



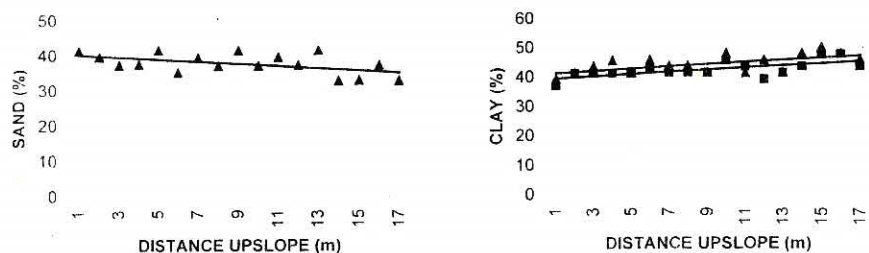


Figure 4. Difference in sand and clay contents along the slope

Sand content increased through the slope, for 20 - 40 cm depth, towards the upper slope. Though the change was very small, this significantly decrease for 20 - 40 cm depth was caused by the soil's gained richness in sand with the loss of thin material in this sloped field by the past erosion.

The clay content has been increased for both study depths while going away from the higher slope. The clay content of the deep soil (20 - 40 cm) compared to the higher soil (0 - 20 cm) was higher. The increase in the clay content with respect to the distance to the upper slope was caused by the thin material, which was carried and gathered towards the lower parts of the field.

In the soil samples taken to determine the changes between the distance to the upper slope and the productivity, in the field the study was made, phosphorus, potassium and organic material contents were found.

The phosphorous content of the field varied between 18.3 and 93.9 kg/ha. No important relation was found between the  $P_2O_5$  content and the distance to the upper slope. We think that, this resulted from the fertilizer containing phosphorous, which was widely used in the past years.

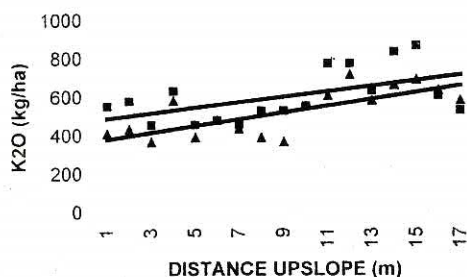


Figure 5. Difference in  $K_2O$  content along the slope

The potassium content varied between 408.8 and 773.6 kg/ha. In both soil depths the  $K_2O$  increased with the distance to the upper slope. The  $K_2O$  content of the upper soil was higher, compared to the deeper soil. The  $K_2O$  carried with the eroded soil caused the  $K_2O$  content to increase in the lower parts of the soil.

Organic matter content varied between 0.84 % and 1.69 %. No important relation was found between the organic matter and the distance to the upper slope.

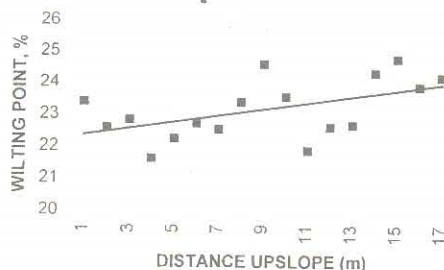


Figure 6. Difference in Wilting Point value along the slope

The wilting point values of the field varied between 21.63 % and 25.05 %. The wilting point has increased when the distance between the upper slope and the wilting point has increased. This increase was parallel to the clay increase seen in the lower slope. The wilting point value has increased with respect to the clay quantity increase in the lower slope.

No statistical relation was found between the other physical properties of the soil; i.e. bulk density, specific gravity, aggregate stability, makropore, field capacity and the distance to the upper slope.

In order to determine the soil erodibility along the slope, simple regression analysis have been realised. To define the important elements the stepwise equations are shown in Table 2 and 3 below.

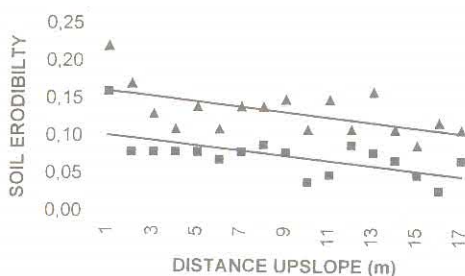


Figure 7. Difference in soil erodibility along the slope

The soil erodibility has varied between 0.03 - 0.16, for both soil depths, along the slope. The soil erodibility has decreased for both soil depths with respect to the increase in distance to the upper slope. The soil erodibility of the top soil was less than the lower soil. While the slope's upper parts were easily erodible, the lower parts were more resistant to erodibility.

According to the stepwise regression analysis made for the two soil depths, clay content determines the soil erodibility 76 %. The erodibility was less in lower slope where the clay content was high, and the erodibility was high where the in the upper slope where the clay content was less.

Table 2. Stepwise regression model for effects of soil physical properties on the soil erodibility.

No. Variables	Regression Equation	R <sup>2</sup>
1	0.451 - 0.008 CL <sub>10</sub>	77.99
2	0.297 - 0.010 CL <sub>10</sub> + 0.009 WP <sub>10</sub>	85.83
3	0.418 - 0.012 CL <sub>10</sub> + 0.010 WP <sub>10</sub> - 0.002 Si <sub>10</sub>	89.63
4	0.457 - 0.013 CL <sub>10</sub> + 0.011 WP <sub>10</sub> - 0.003 Si <sub>10</sub> + 0.640 S <sub>30</sub>	91.18
5	0.925 - 0.013 CL <sub>10</sub> + 0.011 WP <sub>10</sub> - 0.003 Si <sub>10</sub> + 1.03 S <sub>10</sub> - 0.053 pH <sub>30</sub>	93.54

Abbreviations CL, WP, Si, S, pH, CF and SE refer to clay, wilting point, silt, salt, pH, coarse fragment, soil erodibility, respectively; and 10 and 30 refer to the 0 - 20 cm and 20 - 40 cm soil layer, respectively.

Table 3. Stepwise regression model for effects of soil physical properties on the soil erodibility (for 20 - 40 cm soil depth)

No. Variables	Regression Equation	R <sup>2</sup>
1	0.528 - 0.008 CL <sub>30</sub>	76.37
2	0.566 - 0.008 CL <sub>30</sub> - 0.002 CF <sub>30</sub>	92.17
3	0.474 - 0.007 CL <sub>30</sub> - 0.002 CF <sub>30</sub> + 0.276 SE <sub>10</sub>	95.81
4	0.396 - 0.008 CL <sub>30</sub> - 0.002 CF <sub>30</sub> + 0.234 SE <sub>10</sub> + 0.005 WP <sub>10</sub>	97.79

Refer to Table 2 for abbreviations.

## REFERENCES

- Anonymous (1978). Predicting rainfall erosion losses. Agr. Handbook No 537, Washington
- Anonymous (1983). USDA Soil Conservation Service National Soils Handbook.
- Demiralay I. (1977). Toprak fiziği ders notları. Atatürk Üniversitesi Ziraat Fakültesi (Teksir), Erzurum
- Martz L.W. (1992). The variation of soil erodibility with slope position in a cultivated Canadian Praire landscape. Earth Surface Process and Landforms, 17:6, p 543-556, Canada
- Minitab (1996). Release 11 for windows Minitab inc, USA
- Lal R. (1998). Soil erosion research methods. Soil and Water Conservation Society, Iowa
- Oguz I., Durak O. (1998). Çekerek havzası büyük toprak gruplarının bazı özellikleri ile su erozyonu ilişkileri ve havza topraklarının erozyon duyarlılık değerlendirmesi. Toprak ve su kaynakları araştırma yaylığı 1997. Yayın no:106. Ankara
- Sezen Y. (1991). Toprak kimyası. Atatürk Üniversitesi Ziraat Fak. Yayınları No 127, Erzurum
- Troeh F.R., Hobbs J.A., Donahue, R.L. (1999). Soil and water conservation. Prentice Hall, New Jersey
- Tüzüner A. (1990). Toprak ve su analiz laboratuvarları el kitabı. Köy Hizmetleri Genel Müdürlüğü Yayınları, Ankara
- Williams R.D., Naney J.W., Ahuja L.R. (1985). Soil properties and productivity changes along a slope. ASAE Publication 8-85, Michigan



# COMPARISON EFFECT OF CONVENTIONAL TILLAGE AND NO TILLAGE PRACTICES ON SOME CHEMICAL, BIOCHEMICAL AND MICROBIOLOGICAL PROPERTIES OF EROSION PLOTS SOILS

Nesime Cebel<sup>1</sup>, Michael Mullen<sup>2</sup>, Michael Kircner<sup>2</sup>

<sup>1</sup>Toprak ve Gübre Araştırma Enstitüsü, <sup>2</sup>Department of Plant and Soil Sciences, University of Tennessee, Knoxville, TN, USA

## ABSTRACT

Minimum tillage is a general term that may be applied to any of the numerous practices that require fewer trips across the field than are required by conventional methods of preparing a seedbed. A plowed surface left rough and containing appreciable plant residue allows water to infiltrate more rapidly, has greater surface and plow-layer storage, and is less easily eroded than a pulverized soil surface.

In this study conventional tillage and no tillage system was compared by some chemical, biochemical and microbiological properties of soils. Soil samples were collected from erosion plots next to each other that cultivated with two systems for long years at the Milan No-till Research Station in Milan, Tennessee. In these samples pH, C%, S%, N%,  $\text{NH}_4^+\text{-N}$ ,  $\text{NO}_3^-\text{-N}$  and Mehlich-extractable Ca, Cu, Fe, K, Mg, Mn, Na, P, Zn and enzyme activities of dehydrogenases, acid and alkaline phosphatases, arylsulfatase,  $\beta$ -glucosidase and microbial biomass were determined. According to results No-till practices provides better soil features than Conventional tillage.

## INTRODUCTION

Conservation tillage was recently defined as a system in which either crop residues are retained on or near the soil surface, a rough soil surface is maintained, or both to control soil erosion and to achieve good soil-water relations (Allmaras, R. R. et al. 1985; Mannering and Fenster 1983).

Numerous research workers (Meyer, Wischeimer, and Daniel, 1971; and Van Doren and Stauffer, 1944) have found that crop residues and other forms of surface mulches are very effective in reducing soil erosion and the velocity of runoff.

Nutrient cycling in soils involves biochemical, chemical, and physiochemical reactions, with the biochemical processes being mediated by microorganisms, plant roots, and soil animals. It is well known that all biochemical reactions are catalyzed by enzymes, which are proteins with catalytic properties owing to their power of specific activation. Soil enzyme activities are often measured as a potential indicator of microbial activity.

Doran (1980) evaluated seven soils from five states that had been in no-till or conventional tillage systems. He concluded that no-tillage results in higher total organic C and total kjeldahl N than does conventional tillage.

Beare and coworkers (1994) found that the formation of macroaggregates in no-till soils protected a significant amount of the increased C from decomposition.

The purpose of this study was to evaluate some chemical, biochemical and microbiological properties of erosion plots soils in long-term, no-till and conventional tillage systems.

## MATERIALS and METHODS

Five soil samples of each plot were collected from erosion plots at the Milan No-till Research Station in Milan, Tennessee. The depth was 0-5 cm. The moist soils were sieved to less than 2 mm and then stored at 4°C until analyzed.

### Enzyme activities:

**Phosphomonoesterases (Acid and Alkaline Phosphatases),** The assay of phosphomonoesterase activities are based on colorimetric estimation of the *p*-nitrophenol released by phosphatase activity when soil is incubated with buffered (pH 6.5 for acid phosphatase activity and pH 11 for alkaline phosphatase activity) sodium *p*-nitrophenyl phosphate solution and toluene (Tabatabai and Bremner, 1969; Eivazi and Tabatabai, 1977).

**Arylsulfatase**, The method is based on colorimetric determination of *p*-nitrophenol released by arylsulfatase activity when soil is incubated with buffered (pH 5.8) potassium *p*-nitrophenyl sulfate solution and toluene (Tabatabai and Bremner, 1970).

**Dehydrogenases**, The method based on extraction with methanol and colorimetric determination of the TPF produced from the reduction of TTC in soils (Casida et al., 1964).

**$\beta$ -Glucosidase**, The method is based on colorimetric determination of *p*-nitrophenol released by  $\beta$ -glucosidase activity when soil is incubated with buffered (pH 6.0) PNG solution and toluene (Eivazi and Tabatabai, 1988).

**pH**, was determined by a glass electrode (soil/water ratio, 1:5).

**Microbial biomass**, was determined using a chloroform-fumigation extraction procedure that was a modification (Vance et al., 1987; Sparling and West, 1988) of the fumigation-incubation technique developed by Jenkinson and Powlson (1976).

Soils were analyzed for **total carbon, nitrogen and sulfur** with a LECO CNS-2000 C, N and S analyzer (Matejovic, 1995).

**The inorganic N** was analyzed using the microplate method by Sims et al. (1995).

**Other nutrients (Ca, Cu, Fe, K, Mg, Mn, Na, P, Zn)** were analyzed by extraction with Mehlich and determined on the Inductively Coupled Plasma Spectrophotometer (ICP).

All data were analyzed using ANOVA and means were separated using the Least Significant Difference method at  $p=0.05$ .

## RESULTS and DISCUSSION

Soil enzymes are largely a function of microbial activities, and treatments that enhance microbial numbers or biomass in soils are likely to enhance measurable enzyme activities (Tabatabai, 1996). Arylsulfatase catalyzes the hydrolysis of organic sulfate esters, an important source of organic S in soils. Glycosidases catalyze the hydrolysis of glycosides resulting in the release of monomeric sugar molecules. These enzymes are thought to be important to microbial energy production in soil. The enzyme  $\beta$ -Glucosidase catalyzes the final step in the breakdown of cellulose to glucose, and would be important in soils with accumulation of plant materials, such as a no-till soil.

Long-term no-tillage results in many changes in soil properties. Among the most important of these changes are increases in total soil carbon. Increased soil C enhances many other soil properties and will often impact soil biological and biochemical properties. Table 1 gives data for some soil enzyme activities and Table 2 for total C, N, S, pH, Inorganic N, and Microbial Biomass C in the 0-5 cm layer of soil. Except Alkaline phosphatase, Acid phosphatase, Arylsulfatase,  $\beta$ -Glucosidase and Dehydrogenase activities were higher in N.T. than does C.T. (Table 1). Total C, N, and S; MBC;  $\text{NO}_3\text{-N}$  were higher in N.T. while pH is lower and  $\text{NH}_4\text{-N}$  is the same (Table 2). No-tillage, and other practices that increase the amount of crop residue on the soil surface, has been shown to increase total C in soil surface (e.g., Doran, 1980; Ismail et al., 1994). Other workers have observed an increase in total N with no-tillage and increased levels of residue cover (Havlin, 1990; Ismail et al., 1994).

Table 1. Some of Soil Enzymes Activities

Tillage practices	Phosphatases ( $\mu\text{g } p\text{-NP g}^{-1} \text{ soil}$ )		Arylsulfatase ( $\mu\text{g } p\text{-NP g}^{-1} \text{ soil}$ )	$\beta$ -Glucosidase ( $\mu\text{g } p\text{-NP g}^{-1} \text{ soil}$ )	Dehydrogenase ( $\mu\text{g TPF g}^{-1} \text{ soil}$ )
	Acid	Alkaline			
N.T.	930.15 a	105.17 a	81.14 a	118.84 a	39.07 a
C.T.	499.35 b	87.25 a	17.27 b	61.55 b	27.86 b

\* Means within a column for a given parameter followed by the same letter are not significantly different as determined by LSD at  $\alpha=0.05$ .

Mehlich extractable Ca, Cu, K, Na, and P were not significantly different between N.T. and C.T. Fe, Mn and Zn were higher in N.T. while Mg was higher in C.T. (Table 3). This is expected results that obtained at low soil pH.



**Table 2. Some properties of soil**

Tillage practices	pH	Total %			Inorganic N (ppm)		Microbial Biomass C (mg MBC kg <sup>-1</sup> soil)
		C	N	S	NO <sub>3</sub> -N	NH <sub>4</sub> -N	
N.T.	5.04 b	1.22 a	0.15 a	0.013 a	10.36 a	3.15 a	163.2 a
C.T.	5.40 a	0.65 b	0.08 b	0.008 b	4.70 b	2.31 a	97.2 b

\* Means within a column for a given parameter followed by the same letter are not significantly different as determined by LSD at  $\alpha=0.05$ .

**Table 3. ICAP Mehlich extractable elements (ppm)**

Tillage practices	Ca	Cu	Fe	K	Mg	Mn	Na	Zn	P
N.T.	1109.02 a	1.726 a	85.12 a	72.60 a	160.16 b	42.54 a	12.56 a	1.01 a	12.56 a
C.T.	1114.42 a	1.274 a	67.00 b	83.02 a	204.76 a	33.98 b	11.70 a	0.69 b	11.70 a

\* Means within a column for a given parameter followed by the same letter are not significantly different as determined by LSD at  $\alpha=0.05$ .

## REFERENCES

- ALLMARAS, R. R., UNGER, P. W., and WILKINS, D. E. (1985). Conservation tillage systems and soil productivity. In R. F. Follet and B. A. Stewart (editors) Soil Erosion and Crop Productivity. American Society of Agronomy, Madison, Wisconsin. pp. 357-413.
- BEARE, M. H., CABRERA, M. L., HENDRIX, P. F., and COLEMAN, D. C. (1994). Aggregate-protected and unprotected organic matter pools in conventional- and no-tillage soils. Soil Sci. Soc. Am. J. 58:787-795.
- CASIDA, L. E., KLEIN, D. A. ve SANTORO, T. (1964). Soil dehydrogenase activity. Soil Sci. 98:371-376.
- DORAN, J. W. 1980. Soil microbial and biochemical changes associated with reduced tillage. Soil Sci. Soc. Am. J. 44:765-771.
- EIVAZI, F. ve TABATABAI, M. A. (1977). Phosphatases in soils. Soil Biol. Biochem. 9: 167-172.
- Soil Enzymes. In: Methods of Soil Analysis. Part 2. Microbiological and Biochemical Properties. p 775-833. 1994. R. W. Weaver et al., editors. S.H.Mickelson, managing editor.
- EIVAZI, F. ve TABATABAI, M. A. (1988). Glucosidases and galactosidases in soils. Soil Biol. Biochem. 20:601-606.
- Soil Enzymes. In: Methods of Soil Analysis. Part 2. Microbiological and Biochemical Properties. p 775-833. 1994. R. W. Weaver et al., editors. S.H.Mickelson, managing editor.
- HAVLIN, J. L., KISSEL, D. E., MADDUX, L. D., CLAASSEN, M. M., and LONG, J. H. (1990). Crop rotation and tillage effects on soil organic carbon and nitrogen. Soil Sci. Am. J. 54:448-452.
- ISMAIL, I., BLEVINS, R. L., and FRYE, W.W. (1994). Long-term no-tillage effects on soil properties and continuous corn yields. Soil Sci. Am. J. 58:193-198.
- JENKINSON, D. S., and POWLSON, D. S. (1976). The effects of biocidal treatments on soil. V: A method for measuring soil biomass. Soil Biol. Biochem. 8:209-213.
- MANNERING, J. V. and FENSTER, C. R. (1983). What is conservation tillage? Journal of Soil and Water Conservation 38: 141-143.
- MATEJOVIC, I. (1995). Total nitrogen in plant material determined by means of dry combustion: a possible alternative to determination by Kjeldahl digestion. Commun. Soil Sci. Plant Anal. 26:2217-2229.
- MEYER, L. D., WISCHMEIER, W. H., AND DANIEL, W. H. (1971). Erosion, runoff, and revegetation of denuded construction sites. Trans. of the ASAE 14 (1): 138-141.
- SIMS, G. K., ELLSWORTH, T. R. and MULVANEY, R. L. (1995). Microscale determination of inorganic nitrogen in water and soil extracts. Commun. Soil Sci. Plant Anal. 26 (1&2):303-316.



- SPARLING, G. P., and WEST, A. W. (1988). Modifications to the fumigation-extraction technique to permit simultaneous extraction and estimation of soil microbial C and N. *Commun. Soil Sci. Plant Anal.* 19:327-344.
- TABATABAI, M. A. and BREMNER, J. M. (1969). Use of *p*-nitrophenyl phosphate for assay of soil phosphatase activity. *Soil Biol. Biochem.* 1:301-307. Soil Enzymes. In: *Methods of Soil Analysis. Part 2. Microbiological and Biochemical Properties.* p 775-833. 1994. R. W. Weaver et al., editors. S.H.Mickelson, managing editor.
- TABATABAI, M. A. and BREMNER, J. M. (1970). Arylsulfatase activity of soils. *Soil Sci.Soc. Am. Proc.* 34:225-229. Soil Enzymes. In: *Methods of Soil Analysis. Part 2. Microbiological and Biochemical Properties.* p 775-833. 1994. R. W. Weaver et al., editors. S.H.Mickelson, managing editor.
- TABATABAI, M. A. (1996). Soil Enzymes. p. 775-833. In D. L. Sparks (ed.) *Methods of Soil Analysis, Part 3. Chemical Methods.* SSSA Book Series no.5. Soil Science Society of America and American Society of Agronomy, Madison, WI.
- VAN DOREN, C. A., and STAUFFER, R. S. (1944). Effect of crop and surface mulches on runoff, soil losses, and soil aggregation. *Soil Sci. Soc. Amer. Proc.* 8: 980101.
- VANCE, E. D., BROOKES, P. C., and JENKINSON, D. S. (1987). An extraction method measuring soil microbial biomass C. *Soil Biol. Biochem.* 19:703-707.

# DETERMINING OF P FACTOR FOR CONTOUR TILLAGE USING RAINFALL SIMULATOR UNDER FIELD CONDITION IN AEGEAN REGION

Cevdet Köse<sup>1</sup> Alaettin Taysun<sup>2</sup>

<sup>1</sup>Köy Hizmetleri Araştırma Enstitüsü, Menemen-İZMİR  
<sup>2</sup>Ege Üniversitesi Fen Bilimleri Enstitüsü, Bornova-İZMİR

## ABSTRACT

This research was carried out to determine P factor of USLE under the contour tillage applications using rainfall simulators on Gediz Basin located in Aegean Region. 70 mm/h for total 90 minutes of rainfall was applied to each 7.30 m by 1.70 m sized total 10 parcels using computer controlled rainfall simulator, which has Veejet 80100 type nozzles. Simulated rainfall was applied 60-minute duration on dry soil (dry rain) first time and after 30 minutes 30-minute duration rainfall applied on wet soil (wet rain). According to the results, runoff beginning time in dry rainfall condition, has been higher than wet rainfall condition. Most of the loss of soil has been observed in winter and spring whereas the least lost has been observed in that summer rainfall. Increase of tillage depth and stone cover, decreases the soil loss. The factor the Universal soil loss equation for contour tillage has been determined. considering different soil properties as well as the seasonal affects. Factor values have changed at a range of 0.06 and 0.97.

## 1. INTRODUCTION

Effective control of soil erosion requires ability to quantitatively to predict the amount of soil loss, which would occur under alternate management strategies and practices.

The Soil- erodibility factor (K) and the conservation practice factor (P), which are the factors of Universal soil loss equation that is widely used in predicting soil loss, needs to be determined in different soil groups and climate conditions. But, since it is expensive and time consuming to measure the run off under the natural conditions, it is preferred to determine these factors through the rainfall simulator, which enables the scientist to carry out these studies at the many locations and within the short time period.

In this study, using rainfall simulator, it has been determined parameter P of USLE equation and relationships between soil loss and some physical features of soils in Gediz Basin conditions.

## 2.MATERIAL AND METHODS

### 2.1.Material

#### 2.1.1.Study Area

The research was conducted in Gediz basin, which is located at west part of the Turkey. The study areas from which experimental soil samples are taken are placed on almost middle part of the Basin. Stone cover and surface roughness values and some properties of the study areas are given in table 2.1 and 2.2, respectively

**Table 2.1 Stone cover and surface roughness for the experimental plots**

rial No	Stone cover (%)		Surface roughness (cm)			
	efore rainfall	fter rainfall	Furrow floor		Furrow ridge	
			Before rainfall	After rainfall	Before rainfall	After rainfall
1	17.30	25.4	6.5	2.8	8.7	7.0
2	2.50	4.4	4.0	2.0	7.5	6.5
3	2.20	7.6	7.0	4.0	10.5	6.0
4	2.00	3.5	14.0	4.0	18.0	18.0
5	1.50	3.9	17.0	5.0	23.5	15.5
6	16.00	22.7	-	-	19.0	15.0
7	12.80	18.3	-	-	17.0	17.0
8	15.40	15.6	13.0	3.0	7.5	8.0
9	0.25	1.0	-	-	13.0	9.0
10	1.23	3.5	8.3	2.2	3.0	0.7

**Table 2.2 Some properties of experimental soil**

Trial No	Skeleton %	Sand %	Silt %	Clay %	CaCO <sub>3</sub> %	Agregat Stab. %	Organic Mat. %
1	10.24	64.9	19.50	15.6	0.60	15.88	1.40
2	22.87	52.0	30.2	17.7	17.00	8.50	1.43
3	22.87	52.0	30.2	17.7	17.00	8.50	1.43
4	12.33	54.9	16.60	28.5	0.68	30.67	0.95
5	12.33	54.9	16.60	28.5	0.68	30.67	0.95
6	10.24	64.9	19.50	15.6	0.60	15.88	1.40
7	10.24	64.9	19.5	15.6	0.60	15.88	1.40
8	17.33	66.3	14.1	19.60	3.16	14.71	1.55
9	13.36	56.1	17.3	26.6	7.15	20.51	0.75
10	9.74	70.2	11.6	18.2	6.53	36.17	0.50

### 2.1.2 Some Features of Rainfall Simulator

In this study, the computer controlled rainfall simulator, with high kinetic energy, has six rainfall storm unit and V- jet 80100 type nozzles, was used (Taysun, 1985).

### 2.2. Method

The experimental plot sized 1.70-m. width, 7.30-m length on 7, 9,13 per cent slopes. The simulated rainfall applications were replicated two times for each trial. The rainfall at 69.75-mm h<sup>-1</sup> intensity was applied to dry soil condition during 60-minutes period, then 30 minutes period interval and 30- min rainfall was applied to wet soil, thus, totally 90- min rainfall was applied. Rainfall was applied to the plot number1, 2 and, 3 in winter, number 4 and 5 in spring, number 6, 7, 8, and 9 in summer and number10 in autumn. Simulation time was controlled and recorded by means of chronometer and computer. Run off samples were manually collected and soil loss were measured after each rainfall application. The soil conservation factor P was calculated as a ratio of soil losses from contour plots to losses from the plots that cultivated along with the land slope (Doğan and Güçer, 1976).

## 3. RESULTS AND DISCUSSION

The data obtained from the dry soil and wet soil trials were given in table 3.1 and 3.2 respectively

**Table 3.1 Time of concentration, total run off, total soil loss, average sediment concentration and factor-P values for the dry soil**

Rainfall to dry soil (60')								
Trial No	Rainfall dates	Time of (sec.)	Total (l/m <sup>2</sup> )	Total (kg/m <sup>2</sup> )	Av. (g/l)	Factor-	Soil (cm)	Land (%)
1	17.12.93	686	51.25	0.382	7.45	0.61	7-8	9
2	24.02.94	695	50.60	2.860	56.52	1.13	7-8	13
3	24.02.94	979	52.22	0.833	15.95	0.45	10-12	13
4	09.03.94	705	63.57	0.804	12.65	0.31	7-8	9
5	09.03.94	778	60.99	0.583	9.56	0.20	16-18	9
6	28.07.94	1787	8.42	0.150	17.81	0.53	7-8	9
7	28.07.94	1838	5.32	0.060	11.28	0.21	10-12	9
8	29.07.94	0	0.00	0.00	0.00	0.00	7-8	7
9	04.07.96	1059	0.48	0.002	4.17	0.01	7-8	9
10	17.09.96	1219	30.06	0.181	6.02	0.27	7-8	9



**Table 3. Time of concentration, total run off, total soil loss, average sediment concentration and factor-P values for the wet soil condition**

Rainfall to wet soil (30')								
Trial No	Rainfall Simulation dates	Time of concent. (sec.)	Total (l/m <sup>2</sup> )	Total soil loss (kg/m <sup>2</sup> )	Av. Sediment concent. (g/l)	Factor-P	Soil tillage depth (cm)	Land slope (%)
1	17.12.93	62	29.25	0.120	4.10	0.33	7-8	9
2	24.02.94	32	31.10	0.712	22.89	0.61	7-8	13
3	24.02.94	50	32.07	0.396	12.35	0.34	10-12	13
4	09.03.94	41	37.47	0.494	13.18	0.31	7-8	9
5	09.03.94	58	37.15	0.315	8.48	0.20	16-18	9
6	28.07.94	55	14.38	0.458	31.85	0.57	7-8	9
7	28.07.94	98	13.01	0.266	20.44	0.33	10-12	9
8	29.07.94	480	2.82	0.015	5.32	0.07	7-8	7
9	04.07.96	1017	3.54	0.062	17.50	0.13	7-8	9
10	17.09.96	94	25.95	0.149	5.74	0.20	7-8	9

Table 2 shows that factor P varied from 0.00 to 1.13 for dry soil conditions, while it ranged from 0.07 to 0.61 in wet soil conditions. P value was zero in trial 8, which was one of the plots with dry soil condition and no soil loss occurred in this trial. On the other hand, the soil loss from the plot that cultivated up and down slope was 0.655 t/ha. It can be seen that, the large amount of soil loss has occurred in the trial 2, as a result of this, factor P was found as 1.13, whereas normally it is expected not to be bigger than one. Because of this, some of the contour furrows was damaged after 16 minutes heavy rainfall. Factor P for the cumulative rainfall was determined between 0.06-0.97. The highest P value was obtained from trial 2, while the lowest one from trial 9.

The reason of obtaining high P value is that the amount of soil loss from P plot is very close to those of the plot that cultivated parallel to land slope. On contrast to that, low P factor value shows that the amount of soil loss from plot-P was smaller than those of the plot that cultivated up and down slope. The high P value of plot 1 and 6 is attributed to the high percentage of stone cover in these plots.

#### 4. CONCLUSIONS

The following conclusions can be stated from this study:

- After rainfall simulation to the plots, the time of concentration –Tc (Run off beginning time) was longer in the dry soil condition (60min) when compared to wet soil condition (30 min)
- Negative correlation was determined between the time of concentration (Tc) and soil loss for wet soil condition.
- It was determined that the time of concentration (Tc) in both conditions was longer in summer, compared to that in winter, spring and autumn.
- The highest run off rate was obtained in winter and spring, while the lowest run off rate was in summer after dry, wet and cumulative rainfall implementation. The run off in winter caused 253 % more soil loss at the plots (number 1 and 6), which has the same soil features, compared to those in summer.
- Under the dry soil condition, soil loss in summer were less than that in spring and winter, but under the wet soil condition, in contrast to that, soil loss in summer time was more than that in spring and winter time. As a result of experiment, cumulative rainfall caused 21 % more soil loss in summer than in winter.
- Increasing of 4-5 cm in the depth of ploughing at cross –slope farming decreased run off and soil loss.

- It was measured that soil loss at cumulative rainfall were less by 190 %, 45% and 87 % in February, March and July respectively.
- As the stone cover on the soil surface increased, because of mulch effect, soil loss decreased.
- The factor P, which is one of the important factors of Universal Equation, was determined according to different soil features and also seasonal differences. As it seen from the table 3.3, the P factor ranged between 0.06 and 0.97.
- As increasing stone cover on the soil surface, P value also increased. In this case, contour cultivation has less effect on soil loss.

## 5. REFERENCES

- Doğan, O. ve Güçer, C. 1976. Su erozyonunun nedenleri-oluşumu ve Üniversal denklem ile toprak kayıplarının saptanması. Merkez TOPRAKSU Araştırma Enstitüsü Müdürlüğü Yayınları, Genel Yayın No.41, Ankara.
- Taysun, A. 1977. Bornova ve civarındaki mevcut büyük toprak gruplarının, bazı fiziksel ve kimyasal özellikleri ile bunların erozyonla olan ilişkileri üzerinde araştırmalar (Doktora Tezi). E.Ü. Zir. Fak. Toprak Bölümü, Bornova.
- Taysun, A. 1982. Gediz Havzasının rendzina tarım topraklarında, yapay yağmurlayıcı yardımıyla, taşlar bitki artıkları ve polivinilalkol'ün (PVA) toprak özellikleri ile birlikte erozyona etkileri üzerinde araştırmalar (Doçentlik Tezi). E.Ü.Zir.Fak. Toprak Bölümü, Bornova.
- Taysun, A. 1985. Doğal ve yapma yağışın karşılaştırılması, yağış benzeticiler ve damla düşme hızı tayin aletleri. Köy Hizmetleri Genel Müdürlüğü Menemen Araştırma Enstitüsü Yayınları, Genel Yayın No. 119, Menemen.
- Taysun, A., Uysal, H., Köse, C., Mollenhauer, K. ve Frede, H.G. 1996. Ege Bölgesinde toprak aşınabilirlik faktörünün (K) yapay yağmurlayıcı (=Rainfall simulator) yardımıyla arazi koşullarında saptanması. Proje No. TOAG-859, Bornova
- TOPRAKSU. 1974. Gediz Havzası Toprakları. TOPRAKSU Genel Müdürlüğü Yayınları.No. 302, Ankara.
- U.S.Department of Agriculture. 1951. Soil survey manual. Agric. Handb.No. 18.

# SLOPE AND PHOSPHOGYPSUM'S EFFECTS ON SEAL AND CRUST FORMATION AND INFILTRATION RATE

Mücahit Karaoğlu Mustafa R. Çanga

Ankara Üniversitesi, Ziraat Fakültesi Toprak Bölümü 06110 ANKARA

## ABSTRACT

In this study, slope and phosphogypsum's (PG) effects on seal and crust formation and infiltration rate (IR) have been investigated. Clayey soil of Samsun (Typic Udorhent) and silty loam soil of Ankara (Typic Calciorthid) were used.

Using a rainfall simulator, control and PG (at a rate of 5 and 10 ton.ha<sup>-1</sup>) applied soils samples that have six different slopes angles (0, 2, 6, 15, 24 and 30 %) were subjected to two simulated rainfalls with an intensity of 45 mm for 60 minutes leaving seven days dry interval between two treatments.

As a result of this study, it was found that in the PG-treated soils samples seal and crust formation were thinner and later than the control samples, and the increases of the infiltration rate were significant as statistically at level  $P \leq 0.01$ .

## INTRODUCTION

Several studies have been conducted on the effect of rainfall on the structure and hydraulic properties of soil crusts (Agassi et al., 1981; Morin et al., 1981). McIntyre (1958) found the crust to consist of two distinct parts: (a) an upper skin seal attributed to compaction due to raindrop impact, and (b) a "washed in" region of decreased porosity, attributed to fine particles' movement and accumulation. He measured thickness of 0.1 and 2 mm for the skin seal and the "washed in" zone, respectively.

Formation of a crust at the soil surface, generally due to the beating action of raindrops but also as a result of sprinkler irrigation (Aarstad and Miller, 1973), is a common feature of many soils, particularly in the arid and semiarid regions. Surface crusts are thin (<2-3 mm) and are characterised by greater density, finer pores, and lower saturated conductivity than the underlying soil (Morin et al., 1981).

The rapid drop in the IR of soils during rainstorms is mainly due to seal formation on the soil surface. Breakdown of the soil structure and formation of a seal are enhanced by the impact energy of the raindrops and the low concentrations of electrolytes in rain water (Agassi et al., 1981; 1985).

PG powder present at the soil surface may effect the crust properties and the IR curves by two additional physical mechanisms: by interfering mechanically with the organisation of the skin crust and thus disturbing the formation of a continuous crust; and by a mulching effect of the PG powder which protects the soil surface from the beating action of the raindrops (Agassi et al., 1986).

It has been shown (Gal et al., 1984) that PG reduces surface sealing by raising the electrolyte concentration in the solution at the soil surface, thus reducing the dispersion of the soil aggregates and the soil clays and preventing the formation of the "washed in" layer. Thus, the crust forms more slowly on the surface of soil treated with PG, and is more permeable than the crust of untreated soil, reducing the rate of runoff.

## MATERIAL AND METHODS

A clayey soil material from Samsun, where the mean annual precipitation is 710.9 mm and a silty loamy soil material from Ankara, where the mean annual precipitation is 385.5 mm were used in this study. Each soil exposed to erosion. Soil samples were taken from the Ap horizon of each soil series (0-20 cm). Disturbed soil samples were collected, air dried, crushed to pass a 2-mm sieve for laboratory analysis and a 7-mm sieve for experiments.

Six slope angles were examined (0, 2, 6, 15, 24 and 30%) for both untreated soil samples and for soil samples treated with PG. After spread over of PG at a rate of 5 and 10 ton.ha<sup>-1</sup>, at the ground of the soil surface 2 and 4 mm thickness of PG were formed respectively. The PG, a by-product of phosphate fertiliser industry, has a dry composition of: CaSO<sub>4</sub>, 97%; MgSO<sub>4</sub>, 1%; P<sub>2</sub>O<sub>5</sub>, 0.6%; fluorapatite and SiO<sub>2</sub> 1.4% (Warrington et al., 1989).



The samples air-dried were subjected to two simulated rainfalls with an intensity of 45 mm.h<sup>-1</sup> for 60 minutes having 7 days intervals. Distilled water was used to simulate rainwater. Typical mechanical parameters of the applied rain were: median raindrop diameter, 5.09±0.03 mm; median drop velocity, 5.5 m.s<sup>-1</sup>; fall height, 2.75 m; and kinetic energy 15.07 J.mm<sup>-1</sup>.m<sup>-2</sup>.

As soon as soil samples were saturated, the volume of the effluent was measured at 5-min intervals, and the IR was calculated. The samples exposed to first simulated rainfall had been dried during seven days. At the same time seal and crust formation were observed on the level samples (0%) and then 2<sup>nd</sup> simulated rainfall was applied at 8<sup>th</sup> day.

In order to verify, the differences between the values of the infiltration rates values belong to control and PG treatments for each simulated rainfall whether significant or not, Analysis of Variance and Duncan tests were applied.

## RESULT AND DISCUSSION

Kurupelit series has a clay texture (48.4%) and Çiftlik series has a silty loam texture (55.1%) in the Ap horizon. According to soils analysis (Table 1), the Kurupelit series is slightly acid, and has moderately high permeability, lower CaCO<sub>3</sub> content, the moderate exchangeable sodium, high organic carbon and aggregate stability percentage. The Çiftlik series is slightly alkaline, and has high permeability, higher CaCO<sub>3</sub> content, lower exchangeable sodium, organic carbon and aggregate stability percentage.

Table 1. Physical and chemical properties of the soils used.

Soil series and site	International Classification	Mechanical composition (%)			Organic Matter (%)	Aggregate stability (%)	pH (1:5)	Exchangeable Na <sup>+</sup> (%)	Hydraulic conductivity (cm/h)	CaCO <sub>3</sub> (%)
		Sand	Silt	Clay						
Kurupelit Samsun	Typic Udorthent	23.2	28.4	48.4	4.09	90.40	6.58	1.97	6.25	0.10
Çiftlik Ankara	Typic Calcorthid	22.0	55.1	22.9	1.60	45.85	7.85	0.52	9.90	19.97

### PG's effects on seal and crust formation

Seal formation at the soil surfaces exposed to rainfall is due to two mechanisms: (a) breakdown of the soil aggregates caused by the impact of raindrops, and (b) a physiochemical dispersion of the clay, which can then migrate and clog pores immediately beneath the surface (Warrington et al., 1989).

An untreated soil will, at the beginning of a rainstorm, form pits as a result of the impact of the raindrops (Hardy et al., 1983). As storm proceeds, a crust is formed, and runoff and erosion take place (Warrington et al., 1989). Agassi et al. (1984) showed that crust formation processes on a given soil can be limited by preventing the impact of the raindrops (e.g. mulching) or by increasing the electrolyte concentration of the rainwater. It was proposed (Keren and Shainberg, 1981) that the release of electrolytes by PG dissolution reduced clay dispersion and crust formation. Gal et al. (1984) showed that PG reduced surface sealing by raising the electrolyte concentration in the solution at the soil surface, thus reducing the dispersion of the soil aggregates and the soil clays and preventing the formation of the 'washed-in' layer. Thus the crust forms more slowly on the surface of soil treated with PG, and is more permeable than the crust of untreated soil, reducing the rate of runoff.

In order to observe seal and crust formation on the level soil samples caused by the impact energy of raindrops, control and PG treatments were applied for each series. After the seal formation (Fig. 1) the soil permeability and IR reduced rapidly. Owing to absence of slope, rain water accumulated to soil surface, and a puddle occurred. After seven days, a crust structure (Fig. 2) was formed on the each level soil sample exposed to air dry. The PG application delayed the beginning of the seal formation, and reduced thickness of a seal and crust structure. The results of seal and crust formation are presented in Table 2.

Table 2. Results related to seal and crust formation.

Events	Simulated Rainfall	Kurupelit		Çiftlik	
		C	PG	C	PG
Puddle	1	50	55	40	45
Occurrence (mm)	2	45	50	40	40
Average seal	1	2,0	1,4	1,5	1,2
Thickness (mm)	2	1,8	1,5	1,5	1,2
Average crust	1	1,5	1,1	1,3	0,9
Thickness (cm)	2	1,8	1,5	1,5	1,2

### Slope and PG's effects on infiltration rates

The effects of slope angle (0 and 30%) and the PG treatment on the IR are illustrated in Fig. 3 for the Kurupelit series and in Fig. 4 for the Çiftlik series. There is a drop in the IR of the control soil for each soil series, however the drop in the IR of the Çiftlik series is more evident than IR of the Kurupelit series. The Çiftlik series is more susceptible to surface sealing but more permeable than the Kurupelit series. Thus the infiltration rate from the silty loam was higher than the infiltration rate from the clay for the first rainfall. Similar observations were made by Ben Hur et al. (1985) and Warrington et al. (1989) who found that soils with moderate (15-20%) clay percentage and low content of organic matter are most susceptible to crusting. The infiltration curves for the other slopes ranged between those of the 0 and 30% slopes.

The IRs of the soils samples treated with PG ( $10 \text{ t.ha}^{-1}$ ) dropped much less rapidly than those of the control soils samples. The drop began after a greater cumulative rainfall, and the final IRs were higher (Fig. 3 and 4).

Infiltration rates increase 1.4 (30%, 2<sup>nd</sup> rainfall, PG  $5 \text{ t.ha}^{-1}$ ); 1.7 (30%, 2<sup>nd</sup> rainfall, PG  $10 \text{ t.ha}^{-1}$ ) fold for the Kurupelit series and 2.0 (30%, 2<sup>nd</sup> rainfall, PG  $5 \text{ t.ha}^{-1}$ ); 2.2 (30%, 2<sup>nd</sup> rainfall, PG  $10 \text{ t.ha}^{-1}$ ) fold for the Çiftlik series in respect of control treatments at the different slopes.

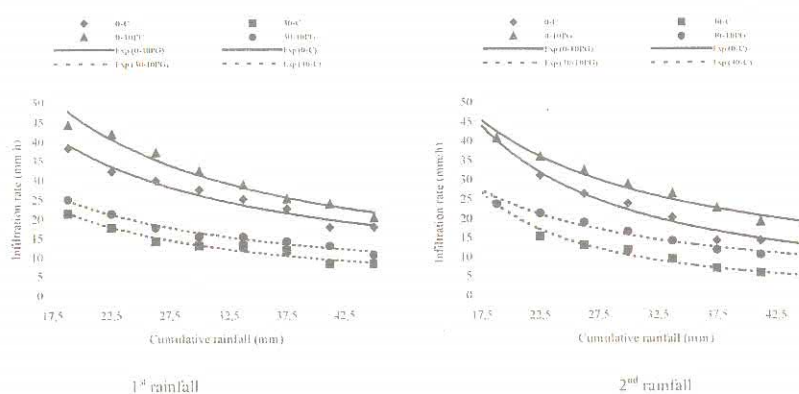


Figure 3. Infiltration rates for the Kurupelit series.

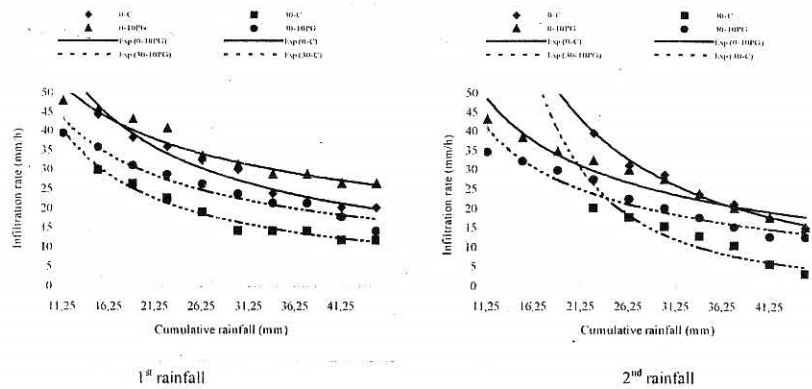


Figure 4. Infiltration rates for the Çiftlik series.

Table 3. Duncan test for infiltration rates.

Slope%	Mean	S.Dev.	PG	Mean	S.Dev.	Soil	Mean	S.Dev.	Rainfall	Mean	S.Dev.
0	28,621 <sup>a</sup>	0,858	C	17,484 <sup>b</sup>	0,607	K.pelit	19,146 <sup>b</sup>	0,496	1	24,246 <sup>a</sup>	0,231
24	18,096 <sup>b</sup>	0,858	10	25,106 <sup>a</sup>	0,607	Çiftlik	23,691 <sup>a</sup>	0,496	2	18,591 <sup>b</sup>	0,602
	0.01			0.01			0.01			0.01	

According to analysis of variance and Duncan test for infiltration rates (Table 3), differences between slopes, phosphogypsums, soils and rainfalls were significant as statistically at level  $P \leq 0.01$ .

The final IRs for the six slopes and each soil series are presented in Fig. 5 and 6. Differences between slopes  $\leq 15\%$  are significant. As slope angle increased to 24 and over, there was no decrease in the final IR, besides the evidently increase in the final IR of the PG-treated soils samples occurred in the 2<sup>nd</sup> rainfall for each soil series.

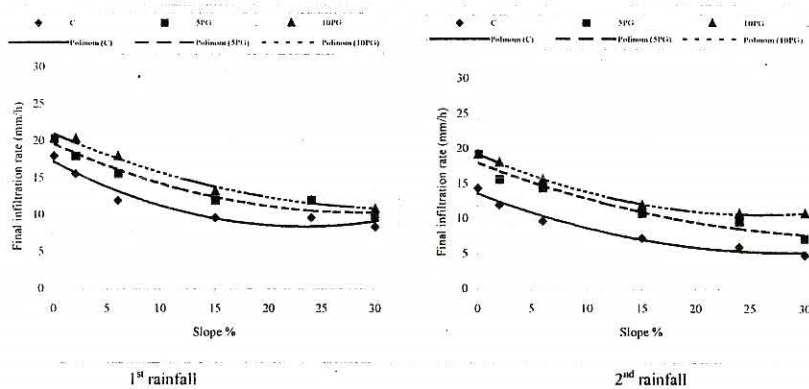


Figure 5. Final infiltration rates for the Kurupelit series.



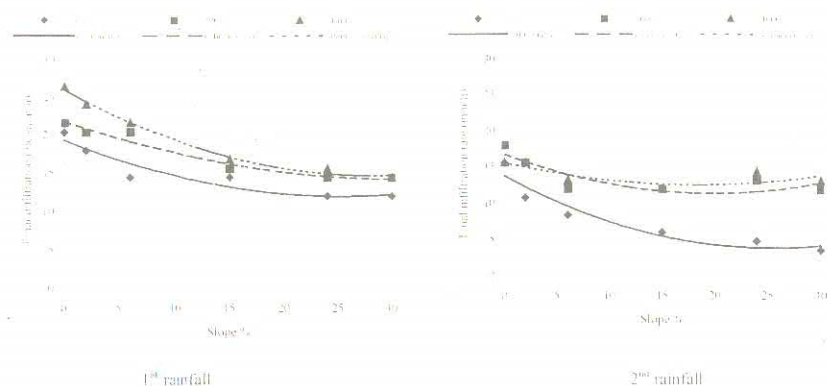


Figure 6. Final infiltration rates for the Çiftlik series.

The effect of slope angle on the properties of the seal, as determined by the final IR, was similar in both PG-treated and untreated soils samples, in spite of the fact that PG-treated soils are less susceptible to sealing and are less erodible than untreated soils.

Final infiltration rates increase 1.6 (24%, 2<sup>nd</sup> rainfall, PG 5 t.ha<sup>-1</sup>); 2.2 (30%, 2<sup>nd</sup> rainfall, PG 10 t.ha<sup>-1</sup>) fold for the Kurupelit series and 3.3 (30%, 2<sup>nd</sup> rainfall, PG 5 t.ha<sup>-1</sup>); 3.7 (30%, 2<sup>nd</sup> rainfall, PG 10 t.ha<sup>-1</sup>) fold for the Çiftlik series with respect to control treatments (Table 4).

According to analysis of variance and Duncan test for final infiltration rates, differences between slopes, PGs, soils ( $P \leq 0.01$ ) and rainfalls ( $P \leq 0.05$ ) were significant as statistically (Table 5).

## CONCLUSION

Breakdown of the soil aggregates caused by the impact of raindrops and a physiochemical dispersion of the clay cause seal and crust formation at the soil surface. After the seal formation IRs decrease sharply, and a puddle occurs. When PG was spread over the soil sample especially at a rate of 10 ton.ha<sup>-1</sup>, it dissolved and prevented clay dispersion; seal and crust formation were thinner and later than the control samples, approximately increased infiltration rates and final infiltration rates twofold and fourfold, respectively.

Table 4. Final infiltration and final infiltration rates (mm.h<sup>-1</sup>)

Slope	Kurupelit series						Çiftlik series					
	1 <sup>st</sup> Rainfall			2 <sup>nd</sup> Rainfall			1 <sup>st</sup> Rainfall			2 <sup>nd</sup> Rainfall		
	C	5PG	10PG	C	5PG	10PG	C	5PG	10PG	C	5PG	10PG
0	18.0	20.3	20.4	14.4	19.2	19.2	20.4	21.6	26.4	15.6	18.0	15.6
2	13.3	15	17	10	13	15	18	17	20	9.9	13	13
	13.6	18.0	20.4	12.0	15.6	18.0	18.0	20.4	24.0	10.8	15.6	18.6
6	10	13	15	9.8	12	13	12	17	18	9.7	16	13
	12.0	15.6	18.0	9.6	14.4	15.6	14.4	20.4	21.6	8.4	12.0	13.2
15	8	10	11	6.6	9.9	10	12	13	14	6.8	10	16
	9.6	12.0	13.2	7.2	10.8	12.0	14.4	15.6	16.8	6.0	12.0	12.0
24	9.8	10	10	8	9.9	9.9	10	12	13	9.4	11	12
	9.6	12.0	12.0	6.0	9.6	10.8	12.0	14.4	15.6	4.8	13.2	14.4
30	6.7	8	9.9	4	6.6	6.9	10	12	12	6.3	10	13
	8.4	9.6	10.8	4.8	7.2	10.8	12.0	14.4	14.4	3.6	12.0	13.2

Final infiltration rates were printed out as italics.

Table 5. Duncan test for final infiltration rates.

Slope%	Mean	S.Dev	PG	Mean	S.Dev	Soil	Mean	S.Dev	Rainfall	Mean	S.Dev
0	19.117a	0.364	C	11.383e	0.258	Kurupelit	13.164b	0.210	1	18.391a	0.141
2	17.942b	0.364	5	14.779b	0.258	Çiftlik	14.828a	0.210	2	12.061b	0.283
6	14.625c	0.364	10	16.025a	0.258						
15	11.842d	0.364									
24	11.233d	0.364									
30	10.117e	0.364									
	0.01			0.01			0.01			0.05	

## REFERENCES

- Aarstad J.S., Miller D.E. (1973). Soil management practices for reducing runoff under center-pivot sprinkler systems. *Journal of Soil Water Conservation* 28: 171-173.
- Agassi M., Shainberg I., Morin J. (1981). Effect of electrolyte concentration and soil sodicity on the infiltration rate and crust formation. *Soil Science Society of America Journal* 45: 848-851.
- Agassi M., Morin J., Shainberg I. (1984). The effect of water drop impact energy and water salinity on the infiltration rate of sodic soils. *Soil Science Society of America Journal* 49: 186.
- Agassi M., Morin J., Shainberg I. (1985). Effect of raindrop impact energy and water salinity on infiltration rate of sodic soils. *Soil Science Society of America Journal* 49: 186-190.
- Agassi M., Shainberg I., Morin J. (1986). Effect of powdered phosphogypsum on the infiltration rate of sodic soils. *Irrigation Science* 7: 53-61.
- Ben Hur M., Shainberg I., Keren R., Gal M. (1985). Effect of water quality and drying on soil crust properties. *Soil Science Society of America Journal* 49: 191-196.
- Gal M., Arcan L., Shainberg I., Keren R. (1984). Effect of exchangeable Na and phosphogypsum on crust structure SEM observations. *Soil Science Society of America Journal* 48: 872-878.
- Gabriels D., De Boodt M., Minjaux W. (1975). Description of a rainfall simulator for erosion studies in the laboratory. *Pedologie* 2: 80-86.
- Hardy N., Shainberg I., Gal M., Keren R. (1983). The effect of water quality and storm sequence upon infiltration rate and crust formation. *Soil Science Society of America Journal* 34: 665-676.
- Keren R., Shainberg I. (1981). Effect of dissolution rate on the efficiency of industrial and mined gypsum in improving infiltration of a sodic soil. *Soil Science Society of America Journal* 45: 103.
- Mc Intyre D.S. (1958). Permeability measurements of soil crusts formed by raindrop impact. *Soil Science* 85: 185.
- Morin J., Benyamini Y., Michaeli A. (1981). The dynamics of soil crusting by rainfall impact and the water movement in the soil profile. *Journal of Hydrology* 52: 321-335.
- Warrington D., Shainberg I., Agassi M., Morin J. (1989). Slope and phosphogypsum's effects on runoff and erosion. *Soil Science Society of America Journal* 53: 1201-1205.

# LAND DEGRADATION OF THE MOUNTAINOUS AREAS IN TURKEY

Ibrahim ATALAY

Department of Geography Buca Faculty of Education Dokuz Eylul University  
35150 Buca, Izmir-TURKEY

## ABSTRACT

Land degradation activities have been continued in the mountainous areas of Turkey, in general. Especially two main mountain ranges named the Northern Anatolian Mountains in the north and the Taurus Mountains in the south have been subject to the different types of degradational events.

Natural vegetation of mountains has been deteriorated as the result of misuse of land, heavy and early grazing and destruction of forests. For example, some parts of the slopy lands were converted into agricultural fields. Hard parent materials such as granite, quartzitic stones have been outcropped as a stony land in some places due to intense erosion. Some parts of *Fagus* and *Picea* forest areas are replaced by *Rhododendron* communities in the Northern Anatolian Mountains. Antropogenic steppe are widespread on the slopes facing north of the Northern Anatolian Mountains.

Nomadic animal husbandry being carried out in the mountainous areas has caused the degeneration of the natural vegetation and vanishing of the forests.

Dispersed rural settlements and traditional activities has also been led to land degradation especially in the mountainous areas. With continuous forest destruction, the upper limits of the forest shifted one or two hundred metres from the natural timber line and most parts of the oro-Mediterranean forests have been degraded. Some parts of the forest areas are occupied by juniper communities which can be termed as a regressive succession. These situations also have caused the decrease of herb production. So the upper part of the oro-Mediterranean forest areas have been converted into stony bare lands. These lands cover an area of 1 million hectares in the western part of Taurus Mountains.

In order to explain land degradation events two study areas are taken into consideration. One of them is Eastern part of the Northern Anatolian Mountains and other is Taurus Mountain ranges.

**Key words:** Land degradation, vegetation succession, erosion

## INTRODUCTION

The fate of people who are living in the mountainous areas is depended on animal husbandry. This subsistence manner must have began in the Neolithic period, in that era firstly animals were domesticated in the Near-East. In other words, geographical potential and the natural conditions of the mountainous areas is imposed the animal husbandry as the only industrial activities which used to be carried out. That is why, mountainous areas produced the life-style of nomadic and semi-nomadic activities. Thus the nomadism has special importance in terms of both Near-East and Anatolian human geography.

Actually, men lived in the Anatolia generally adapted themselves to the natural conditions. The men mostly coming to the Anatolia as the result of the migration from the Central Asia and Eastern part of the Anatolia engaged in animal husbandry in the mountainous areas in accordance with the physical conditions of mountainous areas. For example, after Mongol invasion to Anatolia, some Turkish tribes who lived in Anatolia had to continue to practise nomadism for time being of which varied largely from region to region. Thereafter, evolution of land utilisation was marked by a transition to settled life. Many place names like kışla, kışlak, yayla, oba, ağıl, kom etc. are historical vestiges of this evolution. Sedentary life was partly the result of natural setting of the country with attractive and mild coastal lowlands as winter quarters (kışlak) and high mountains suitable for transhumance (yayla) on one the hand, and the agricultural possibilities of the country which attracted the nomad to become settled agriculturists. As a result, peasant communities spread all over the central and western Anatolia, and nomads became a minority already in the 14th and 15th centuries. Transition to sedentary



life in Eastern Anatolia processed much slower. It is only at the turn of 16th and 17th centuries that the nomads of the Eastern Anatolia were officially forced to settled life because of financial and military reasons. Today, it is only region of Turkey where nomadism and semi-nomadic way of life still survives locally, while it is only vestigial in Taurus Mountains (Bazin 1988, 1990).

## **MATERIALS and METHODS**

In order to examine the land degradation, the ecological conditions of the mountainous areas are briefly summarized.

### **North-eastern Anatolian Mountains**

The Northeastern Anatolian Mountains belonging to Alpine mountain system and extending E-W direction, cover the northern part of the Anatolia. It commences at the Black Sea shore and abruptly rise as high as 3500 m especially in the eastern part of the Black Sea Subregion. This orogenic range deeply dissected by the rivers flowing into Black Sea. For this reason there is great altitudinal differences between the upper part of the mountains and river valleys. For example the relative altitude between Çoruh river valley and Eastern Black Sea mountains is more than 1500 m. Steep slopes are common along the valley (Fig 1).

Oceanic climate prevails on the northern part of this mountains, whereas semiarid and continental climatic conditions are dominant in the backward section, and within the deeply dissected valleys. For example semiarid climate is seen within the Çoruh river valley extending between Artvin and İspir. The mean slope inclination is more than 40 % along the valley (Atalay 1987).

As to geologic structure, as a whole the main orogenic belt is composed of mesozoic volcano-sedimentary strata. Asidic tuffs and ultrabasic rocks which erupted submarine are seen along the valley. Granitic rocks are common in the core section of the mountains. Metamorphic rock is outcropped in the vicinity of Artvin City.

The mountainous belt is divided into three sections in terms of ecological conditions. First level occurring between sea level and 600 m is under the oceanic climate. The mean annual temperature is about 12-10°C and water deficiency does not occur due to the fact that yearly precipitation is more than 1000 mm. The forest mainly composed of mainly *Fagus orientalis*, *Castanea sativa*, *Tilia* sp., *Alnus*, and *Quercus* sp (Atalay 1994). They grow under the wet habitats. Agricultural activities depend on field productions.

Second zone is found between 600/800-2000 m and the productive forest areas providing timber for the timber factories established along the coastal belt of Black Sea.

Third zone is placed mainly on the alpine meadows upon the natural timberline. The grasses began to grow at the end of the June in the alpine belt of the Eastern Black Sea mountains and the high plateaus of NE Anatolia; the blossoming of the sub-alpine grasses commence at the end of the May-beginning of the June.

Shrub vegetation is common along the valley due to lee of precipitation. One can see some Mediterranean plant species and communities containing *Juniperus oxycedrus*, *Palirus spina christi*, *Pistacia lentiscus*.

### **Main reason of the land degradation**

Very rugged topographical conditions, less-cohesive deposits, destruction of natural vegetation, misuse of land, and heavy grazing are the main reasons of the land degradation.

Erosion is actively being continued especially on the steep slopes in places where natural vegetation cleared. Indeed, intense erosion is common along the steep slopes of the Çoruh river valley, inner part of the Northeastern part of Anatolia. For this reason parent material composed of granitic rock is converted into rocky land due to soil completely eroded, in these places. The gully and rill erosion and debris flows are widespread on the volcanic tuffs and less cohesive sedimentary strata which are composed of sandstone and silt stone. Asidic tuff mostly prevents the spreading of vegetation due to the fact that cation exchange capacity is very low (8-10 m.e. 100 g soil) and active slope debris movements are common. These mass movements have deteriorated the natural equilibrium of slope stabilization. This situation is prevented the natural regeneration of the plants so that bare lands are widespread along the steep slopes of the Çoruh river valleys.

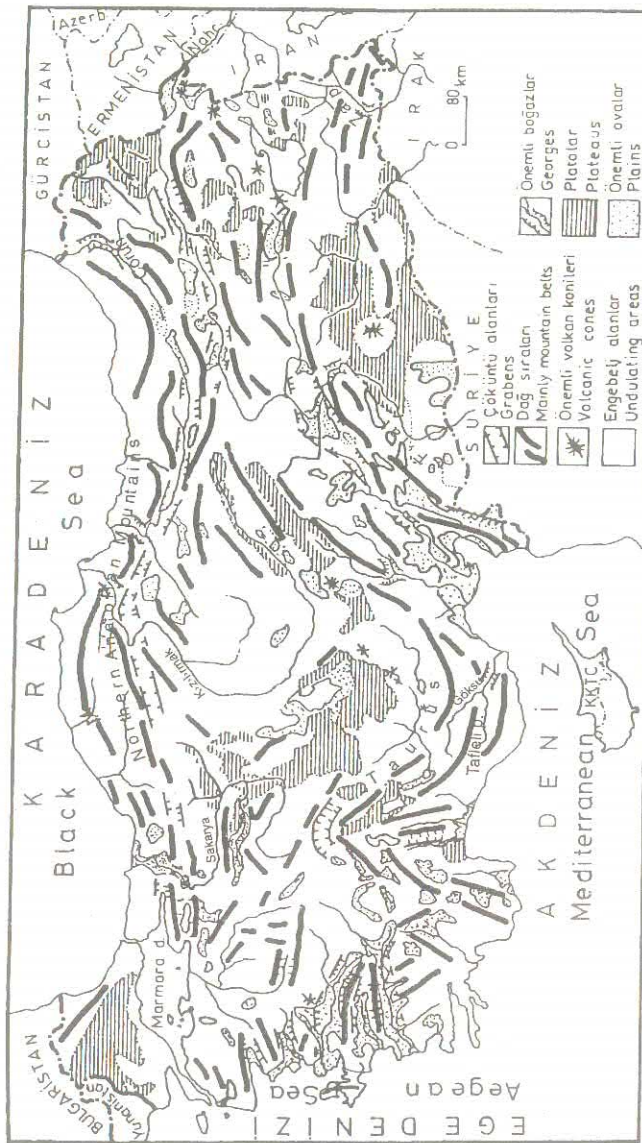


Fig. 1: General relief properties and degraded lands in Turkey



Dry forests which are associated with *Juniperus* and *Quercus* species along the valley have been destroyed for fuel requirements. Coniferous forest occurring on the upland areas have been degraded due to animal grazing and agricultural purpose.

Agricultural activities depending on the cereals (barley, corn, wheat) carry out on the slopy areas due to insufficient land for agricultural purpose. Most of the these fields correspond the intense soil erosion areas. In other words misuse of the land has led to encouragement of erosion.

The main livelihood of dispersed rural settlement mostly depend on animal husbandry. The economic activity is responsible for the degradation of the natural environment. Most part of the meadows are covered by the bitter and spiny cushion plant species as the result of heavy grazing. This has lead to degeneration of the natural herb and the encourament of the rain drop erosion.

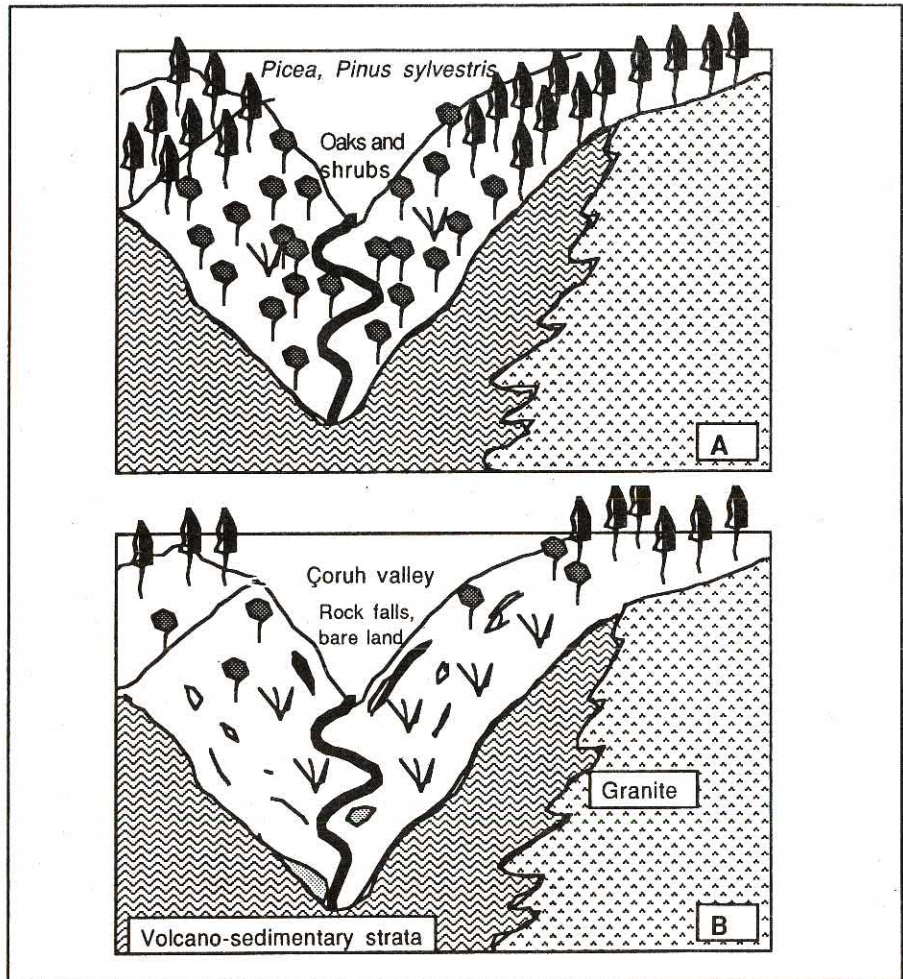


Fig. 2: Degradational events in Çoruh valley. A) Natural vegetation occurrence in Çoruh river valley, B) Present situation of this valley as the result of destruction of natural vegetation. Natural vegetation has been completely destroyed in the most parts of this valley.



These destructional events responsible for the land degradation especially on the slopy areas. Because most of the agricultural area are abandoned and dry forest areas existed in the vicinity of Çoruh valley are completely destroyed. Land degradation is one of the main reason the internal migration. Approximately half of the rural population have moved to the industrial region of Turkey since 1950's.

### Taurus Mountains

Taurus mountains beginning western part of the Mediterranean Region continue southeastern part of Turkey. As a general rule the western and central part of the mountains are composed of Mesozoic and Tertiary limestones. The eastern parts of the mountains are generally made up of flysch containing ultrabasic rocks metamorphic rocks such as marble, gneiss and other various schists belonging to Paleozoic.

Also Taurus ranges have been deeply dissected by the main river course flowing into Gulf of Iran and Mediterranean Sea. For example the high elevation of the western Taurus attains more than 3000 m, while central part of the area named Tageli plateau is about 2000 m and in the SE part of the mountains summits exceed 4000 m. The relative altitude between valley bottom and higher part of the mountains is more than 1000 m. Slope inclination exceeds 100 percent on the slopes of canyon valley in the karstic land and V shaped valley on the schists and sedimentary terrains.

The western part of the Taurus Mountains is under the Mediterranean climatic regime, while continental climate prevails on the southern section of this mountain.

This mountain range is also divided into three main ecological unites.

1- Eu and or Lower Mediterranean belt extends between 0-1000 m in which mediterranean climate prevails characterized rainy and mild winters, hot and dry summers. This belt coinciding with the Mediterranean Region of Turkey is most productive areas for agricultural products. Principal agricultural products are cotton, vegetables, citrus, banana and olive. On the other hand one can see greenhouse fields along the coastal belt of the Mediterranean sea. This belt also is the main growth area of the red pine (*Pinus brutia*) forests.

2- Second zone named Oro-Mediterranean belt is found between 1000 to 2000 m in which coniferous forests composed of *Cedrus libani*, *Pinus nigra* and *Abies cilicica*. Main agricultural area is seen within the poljes and karstic depressions containing marly material and reddish Mediterranean soils in the karstic terrains.

3- Subalpine belt is widespread above the natural timberline. This area is also main meadows areas both for Yörük society and permanent settlements areas especially villages. On the other hand, the belt is the resort areas during the summer season for the human who are living along the Mediterranean Sea.

Ecological properties of the eastern part of the Taurus mountains is different than that of the western sections. Namely oak forests constitute the climax forest vegetation in the east.

In the Taurus mountains there are two types activities: Nomadic and semi nomadic activities.

**Nomadic activities:** The subalpine grasses are also meadows of Yörük Nomadic Society. Indeed the real nomadic activities are carried out by the Yörük tribes (walking men tribes) in the Taurus mountains. Their livelihood is depended on the animal husbandry especially in the Taurus mountains and on the coastal belt of the Mediterranean region. The main pasture areas of Yörüks are the Baba Mountains, Çal Mountains in the west and Dümbelek düzü, the western parts of Bolkar mountains in the middle part of Taurus mountains (Fig.2).

They stay during the winter season under the mild climatic condition of the Mediterranean and graze their animals within the maquis formation which are composed of *Quercus coccifera*, *Mrytus communis*, *Arbutus unedo*, *A. andrahne*, *Phillyrea latifolia*, *Pistacia terebinthus*, *Laurus nobilis* etc. This maquis area is also considered as the natural meadows for the animals.

**Semi-Nomadic activities:** Semi-nomadism is an activity related to the animal husbandry on mountainous areas in Turkey and means the people of the rural areas graze the animals outside of the village especially on the higher parts of the mountains during the summer season. This event is related to insufficient meadows in the vicinity of the village or peasants have to look for the new or additional meadow areas in order to graze their animals.

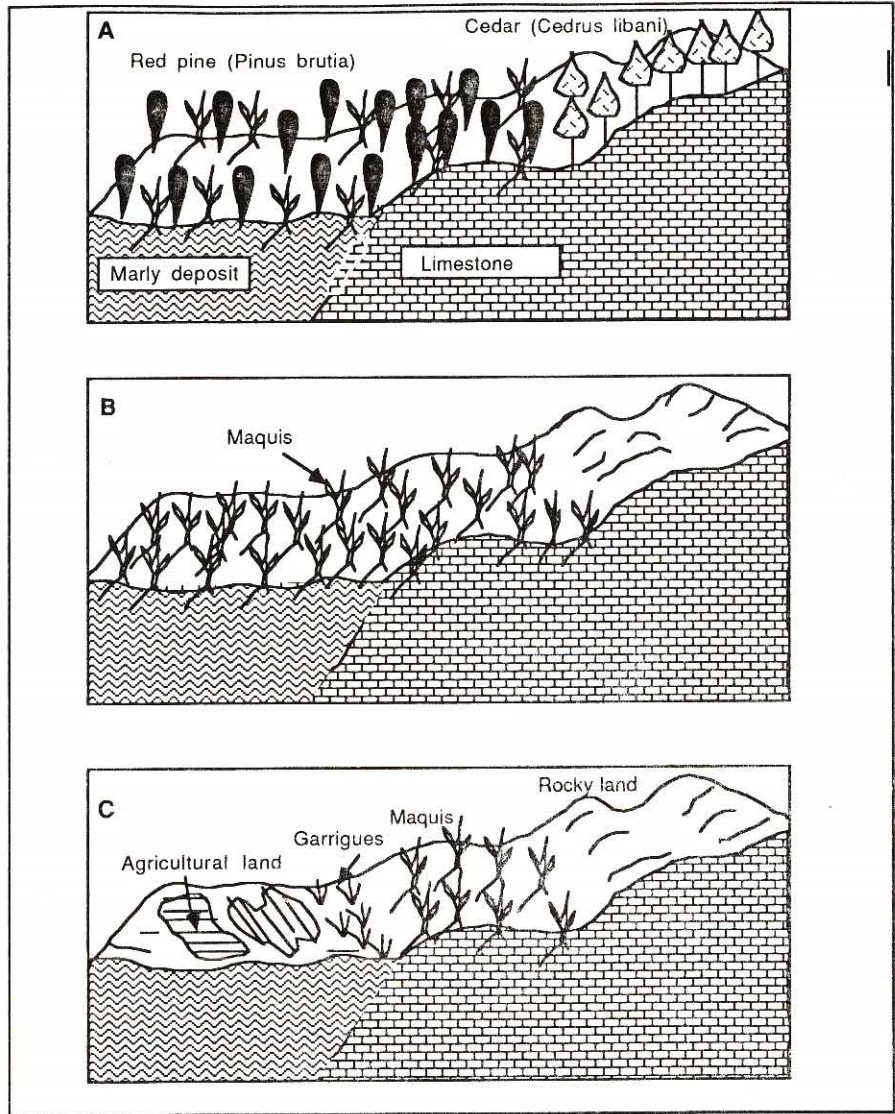


Fig. 3: A) Natural vegetation belts of the western part of Taurus Mountain, B) The spreading of maquis as the result of clearance of the natural vegetation in the red pine occurrence areas. C) Present situation of some part of Taurus mountain. Arable land is opened on the marly deposits, maquis communities are only found in the karstic land due to regeneration of maquis with root suckers in the karstic land and garrigue dominance on the abandoned farmland and rocky land in the upper part of Taurus Mountains.

The breeding of animals comes foremost among the subsistence activities of the rural population in Turkey. There are very close and unavoidable relations between yaylas and yayla activities and animal breeding.



### Main Reason of Land Degradation

Actually the deterioration of natural equilibrium in the mountainous areas are over grazing and early grazing in the meadow areas of alpine and subalpine areas, and in the forests.

**Over grazing:** There is no established the grazing capacity of the meadows by the government. The pascants is also not know how the grazing capacity is. For this reason, except for some alpine meadows of the Eastern Black Sea region, almost all parts of the meadows have been subject over grazing. Over grazing activities have been led to erosion and the deterioration of the climax herb species. Indeed the meadow areas have been converted into stony and bare lands as the result of rain drop and sheet erosion. These situation is being prevented the regeneration of the herb species.

Majority of the climax species have been vanished, while the spiny cusion and bitter species have widespread as the result of competition. One can see the dominance *Acontholimon*, *Astragalus*, *Alhagi*, *Verbascum*, *Euphorbia* and *Atriplex* etc. in the mountainous areas.

**Early grazing:** In the mountainous meadow are suffered the early grazing. Grazing activities being carried out both early spring and late fall have been led to the preventing of the regeneration and the optimum growing of herb vegetation. For this reason the natural equilibrium of the soil-water-plant relationships are deteriorated and so most the climax species have been vanished.

Grazing in the forest is also main responsible for the desertification in the mountainous areas. Indeed continued grazing activities in the forests have been caused the preventing of regeneration. The upper timberline has shifted a hundred and two hundred meters. Plateaus forest areas were converted into stony lands especially in the karstic terrains.

### The special importance of karstic lands in terms of degradation

Some coniferous trees such as *Pinus nigra*, *Pinus brutia*, *Cedrus*, *Abies* and broad-leaved trees such as *Castanea*, *Alnus* etc. also grows in the karstic lands. These trees regenerate by the natural seedlings. If the forest trees completely cleared, bare or rocky areas come into scene. In other words if forest communities had been completely cleared the natural regeneration of cedar and black pine could not take place. In these areas natural regeneration of the forest could happen only on the areas protected from grazing in the vicinity of the forest. Tree seeds fall in the cracks containing soil, germinate and after one and two years, the forest commences to spread slowly. Indeed the cedar forest which is found in the protected areas has begun to spread (Atalay 1987,1995 and 1999; Boydak and Ayhan 1990; Boydak 1996). One can see natural regeneration areas in the upper part of the Taurus Mountains. If there are no tree communities, karstic land remain as a bare land (Fig. 3). In this case the reforestation of the karstic lands is generally impossible because of the fact that there is no sufficient soil on the surface for the plantation of plants. Most parts of the karstic bare land of the Taurus Mountains have been arisen as the result of forest destruction.

Indeed the upper karstic part of the Taurus Mountains resembles the rock-stony desert areas due to the destruction of natural vegetation.

As to Mediterranean coastal belt, the degradation of climax forest has been led to regressive succession. Maquis which is understory of *Pinus brutia* forest has begun to spread in the places where *Pinus brutia* forest completely destroyed. The maquis vegetation occurring along the coastal belt of the Mediterranean geographical region can be considered as a regressive succession (Atalay 1994; Atalay and Semenderoğlu 1996). Garrigue vegetation also appears both abandoned agricultural area and destroyed forest areas. Maquis and garrigue communities can be taken into consideration as regressive succession for Turkey Mediterranean climate.

The eastern part of the Taurus mountains has been suffered intense erosion and land degradation especially in the Zap River basin (Fig 4). Special properties of the basin is different than that of the other region of Taurus Mountains. It can be stated that this basin has been subject heavy destruction and so that erosion and land degradation is being continued seriously. Indeed the steep slopes attaining 100 percent inclination are dominant in the vicinity of Hakkâri Town. These slopes are dissected by deep gullies leading to landslides and rock avalanches. Parent materials which are composed of limestone and schists converted into rock places. Some of the agricultural areas are abandoned due to intense erosion. On the other hand ultrabasic rock



is outcropped in the places where deep gully and eroded areas. These surfaces prevent the growth of the vegetation due to high alkaline reaction. Oak forest areas are replaced by the steppe herbs. The sediment load of the Zap river is higher than that of the other river. Main sediment resources are derived from the parent material erosion, slope debris because soils have been transported.

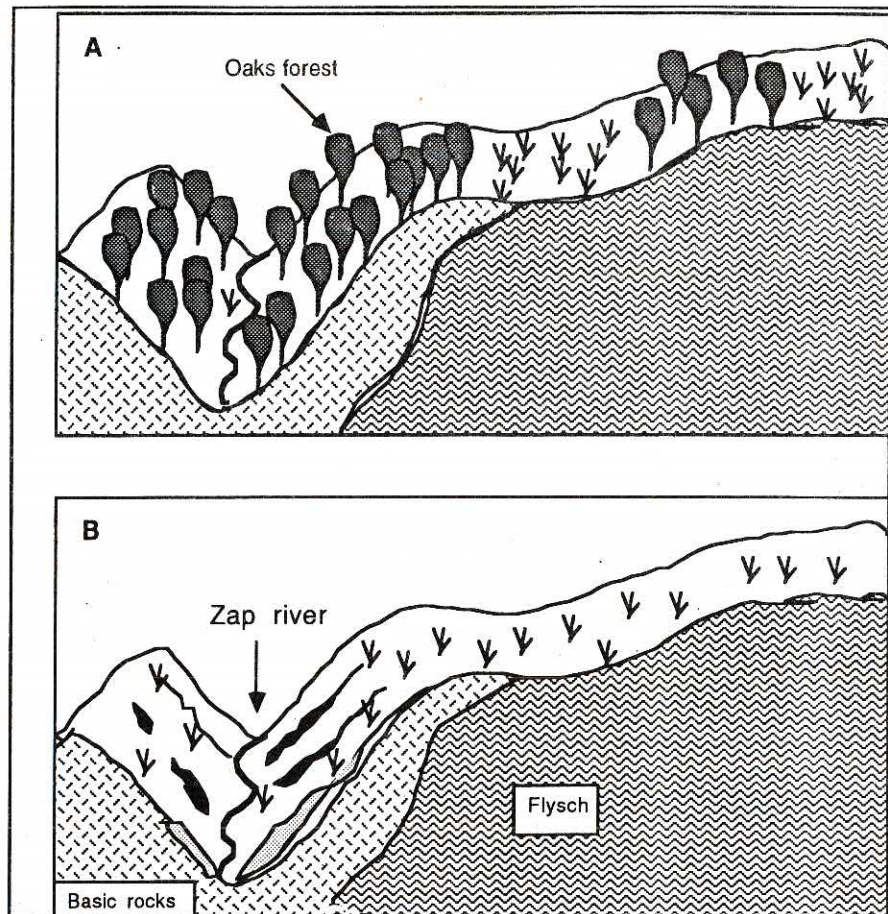


Fig. 4: A) Natural vegetation formation of the Zap river valley and its surroundings, B) Present situation occurring mass movements, soil erosion as the result of misuse of land and clearance of natural vegetation.

## RESULTS

Lard degradation is widespread on the mountainous areas. The main reasons of the land degradation are summarized below.

1. Misuse of the land is common on the rugged areas for obtain cereals requirements. Especially land capability classes of 6. and 7. are devoted for agricultural activities in the some part of the mountainous areas.
2. Scattered rural settlements are responsible for the degradational events.
3. Heavy and early grazing system has been caused degeneration of the meadow herbs and

most of the climax species have been vanished. The grazing capacity has been decreased.

4. Erosion, debris flow and landslides are common on the less-cohesive deposits existing on the slopy land.

It is necessary to protect from the over grazing and excessive forest exploitation in order to maintain natural equilibrium in the mountainous areas.

Leading measures would be taken are indicated as follows:

- To determine pasture and/or meadow areas according to land capability classification,
- To determine the grazing capacity of the meadows,
- To establish and construct some plants such as shelter, stable,
- To obtain low-interest bank deposits in order to set up modern plants such as dairy farms,
- To prepare rule, law in order to arrange the use of the meadows,
- To educate the peasants in order to learn how meadows should be used,
- To assess the animal products according to the modern methods and to establish cooperative system in order to sell the animal products.

Turkey's Government accepted in 1998 a series of laws in order to prevent the degeneration of the meadow and to establish actual grazing capacity.

## REFERENCES

- Atalay, I. (1987a), *Introduction to geomorphology of Turkey*, Aegean Univ Pres, 484 pp, Izmir.
- Atalay, I. (1987b). *The ecological conditions of natural occurrence areas of cedar (Cedrus libani A. Rich.) and regioning of seed transfer of cedar in Turkey*. General Directorate of Forest, Pub No. 661/63 Ankara, 167 pp.
- Atalay, I., (1987). Geography of the Lake Tortum and its immediate surroundings: *Ege Coğrafya Derg.-Aegean Geographical Journal*, 4:19-40.
- Atalay, I., (1988a). Vegetation levels of the Taurus Mountains of Mediterranean region in Turkey: *Ege Coğrafya Derg.-Aegean Geographical Journal*, 4:88-122.
- Atalay, I., (1988b). Akdeniz Bölgesi'nde vejetasyon tahribatının sonuçları. *Canlılar ve Çevre*, 69-78, Ege Üniv. Botanik Bölümü İzmir,
- Atalay, I., (1988c). Rural settlements and their effects on the land degradation in Turkey: *Sociologia Urbana e Rurale, Bologna, Italy*, ISBN: 0392-4939, p.184.
- Atalay, I., (1989), *Soil geography* (in Turkish), Aegean Univ. Press, Izmir, 444 pp.
- Atalay, I., (1989). Erosion problems in Turkey. *Plant and Pollutants in developed and developing countries*. Botany Dep. Science Fac. Ege Univ. p. 645-660.
- Atalay, I., (1994). *Vegetation geography of Turkey*, Aegean Univ. Press, Izmir, 336 pp.
- Atalay, I. (1966). Effects of the parent materials of soils on the land degradation in Turkey. *International Conference on land degradation*. 10-14 June, Adana, 1996, Programme, Abstracts and Excursion.
- Atalay, I. and Semenderoglu, A. (1996). Regressive and progressive succession of the Mediterranean vegetation. *27 th of Geographical Congress*, Hague, Abstracts, The Netherland.
- Atalay, I., (1997a). *Geography of Turkey*, Aegean Univ. Press, Izmir, 496 pp.,
- Atalay, I. (1997b). Red mediterranean soils in some karstic regions of Taurus Mountains, Turkey, *Catena*, 28: 247-260.
- Atalay, I., (1999). The ecology and importance of prevention of land degradation in the karstic lands. *Resource Management*, (Ed. A.L. Singh) Aligarh Muslim University, India, p. 227-237.
- Bazin, M., (1988), "Le nomadisme Yörük aujourd'hui: les Sankeçili du Taurus central": *Production pastorale et société*, 20: 11-29.
- Bazin, M., (1990), "Land-und Raumnutzungskonflikte in Kilikien (Türkei)": *Geographische Rundschau*: 11/1990: 584-590.
- Boydak, M. and Ayhan, Ş. (1990). Anamur yöresinde çıplak karstik alanların sedir ekimiyle ağaçlandırılması (The reforestation of the bare karstic lands with cedar plantation). *Ormançılık Araş. Enst. Derg.* 36 (1): 7-21.
- Boydak, M. (1996). *Toros sedirinin (Cedrus libani A. Rich.) ekolojisi, silvikültürü ve doğal ormanların korunması (Ecologic, silvicultural properties and protection of natural forest of Taurus cedar (Cedrus libani A. Rich.)*. Forest Ministry Pub. Nu. 012, Ankara, 78 pp.



# ASSESSMENT OF POTENTIALLY AVAILABLE SOIL NITROGEN BY INCUBATION METHODS AS RELATED TO STATUS OF SOME SOIL-N FORMS

Awad Elkarim, A. H. And Usta, S.

Department of Soil Science, Faculty of Agriculture Ankara University

## ABSTRACT

Laboratory experiments were conducted to evaluate two biological aerobic and anaerobic short-term incubation methods for assessing potentially available organic soil nitrogen and estimating the ability of soils under investigation to supply nitrogen. Status of some major known fractions of soil nitrogen such as amino acid-N and amino sugar-N which may considered to be the most predominant sources of mineralization were extracted under reflux by using 6N HCl. Soil organic matter, soil total-N and soil inorganic nitrogen which initially present in the soil were considered and correlated with the biological procedures. Surface soil samples (0-20 cm) were collected from Polatli State Farm soils to represent criteria of arid and semi-arid region, which is usually cultivated with cereals, and normally received high doses of nitrogen fertilizers. Results obtained from the study showed that highly significant correlations were found when the total hydrolyzable ammonia-nitrogen, total hydrolyzable nitrogen and soil total nitrogen were compared with the results of the two incubation methods. Whereas, soil organic matter showed less significant correlation. Amounts of amino acid-N and amino sugar-N in the soil hydrolysate showed that no significant correlation were found when compared with those two incubation methods.

## INTRODUCTION

During the last decades numerous biological and chemical methods attempting to provide a reliable and simple index of soil nitrogen availability were proposed. Most of biological procedures recently proposed involve determination of ammonium-N produced during short-term incubation periods (7-25 days) under controlled aerobic and anaerobic conditions (Bremner, 1965; Geist, 1977; Gianello and Bremner, 1986; Stanford, 1982; Jalil et. al. 1996).

These methods have a rational basis in that, the release of mineral N during the incubation periods involved microbially based processes as does the release of N during the growing season in the field (Smith and Shengxui, 1993).

Therefore, many of the literature cited elsewhere adopted the incubation procedures to be the best laboratory method currently available for the assessment of potentially available soil-N in soils (Gianello and Bremner, 1986).

Although these biological methods encountered with many limitations as they are not simple and rapid enough for use in soil testing laboratories when compared with chemical methods, the incubation techniques provide a fairly satisfactory index of organic soil nitrogen availability. Nevertheless, variability of soils and climate makes accurate prediction of soil nitrogen availability by using such methods difficult.

In soils of arid and semi-arid regions which usually cultivated with cereal crops and generally received appreciable amount of N fertilizers, predictions of soil ability to supply available N with reasonable accuracy during the growing season is very important. With such predictions of soil nitrogen availability it could be able to provide some recommendations to optimize the quantities of N fertilizers to be applied in such soils.

Evaluation of such techniques in assessing potentially available soil N and as a result of that to state a reliable index of soil N availability in arid and semi-arid soils have studied to a very limited extent. This may be due partially to the generally low levels of native soil nitrogen in these soils as well as to the apparent high losses of the applied nitrogen fertilizers by  $\text{NH}_3$  volatilization.

Status of some major known fractions of soil N such as total hydrolyzable N, total hydrolyzable  $\text{NH}_4$ , amino acid-N, polymer at amino sugar-N and acid insoluble-N and their relation to the potentially available soil N measured by biological incubation methods may help in obtaining a better understanding of such soils to provide available nitrogen to plant. The objective of this study was to evaluate two short-term incubation procedures in assessing of potentially available soil N in arid and semi-arid soils collected from Central Anatolia. A further goal was established to show the



relationship between the potentially available soil-N measured by incubation methods and status of some major known fractions of soil N extracted by 6 N HCl.

## MATERIALS & METHODS:

The soils used in the study were collected from 31 different sites in Polatlı State Farm (latitude: 32° 00' to 32° 30' N; longitude: 39° 30' to 39° 00' E ) mainly used for production of cereal crops. The soil samples (0—20 cm) were taken from uncultivated parcels and were air-dried and crashed to pass through 2-mm screen and stored at -5 °C . Analysis reported in Table 1 shows that some physical and chemical properties of the soils used in the study .

Table 1 Some physical and chemical properties of soils used in the study

Soil series	Clay %	Silt %	Sand %	PH 1:2.5	CaCO <sub>3</sub> %	Soil OM %	Total N%	NH <sub>4</sub> -N ppm	NO <sub>3</sub> -N ppm
Kap - A <sub>1</sub>	36	41	23	7.72	25.7	1.93	0.21	4.74	4.08
Kap - A <sub>2</sub>	35	38	27	7.52	32.1	1.53	0.13	3.56	9.82
Kap - A <sub>3</sub>	30	39	31	7.48	44.8	2.04	0.18	11.12	5.84
Beyazbayır- B <sub>1</sub>	35	31	34	7.63	25.7	1.13	0.14	3.08	2.68
Beyazbayır- B <sub>2</sub>	39	37	24	7.62	24.3	1.37	0.13	12.52	7.44
Beyazbayır- B <sub>3</sub>	38	37	25	7.55	35.7	1.53	0.15	11.08	18.25
Cirali - C <sub>1</sub>	29	37	34	7.56	36.4	2.78	0.24	16.97	5.49
Cirali -p- C <sub>2</sub>	34	31	35	7.64	30.8	1.76	0.13	3.78	7.37
Cirali - C <sub>3</sub>	35	38	27	7.58	32.1	2.06	0.16	8.71	10.18
Bezik - E <sub>1</sub>	36	37	27	7.54	22.8	2.1	0.18	11.82	14.17
Bezik - E <sub>2</sub>	33	36	31	7.52	27.2	2.06	0.17	6.52	4.65
Bezik - E <sub>3</sub>	38	37	25	7.58	18.5	1.44	0.17	5.62	5.24
Ciftagil - F <sub>1</sub>	34	37	29	7.53	22.1	1.82	0.16	8.18	11.98
Ciftagil - F <sub>2</sub>	22	38	40	7.44	2.3	1.86	0.16	6.52	6.45
Ciftagil - F <sub>3</sub>	35	38	27	7.68	17.2	1.9	0.19	11.22	17.71
Ciftagil - F <sub>4</sub>	36	37	27	7.52	35.7	2.41	0.25	9.54	15.97
Kepir - I <sub>1</sub>	40	43	17	7.58	21.4	2.69	0.2	3.45	20.63
Kepir - I <sub>2</sub>	39	42	19	7.55	14.3	1.16	0.14	5.93	19.5
Kepir - I <sub>3</sub>	41	40	21	7.39	10.7	1.64	0.15	8.65	61.2
Kiebeli - K <sub>1</sub>	46	41	13	7.57	13.5	1.35	0.14	10.85	7.3
Kiebeli - K <sub>2</sub>	47	40	13	7.38	8.2	2.14	0.18	8.25	8.5
Kiebeli - K <sub>3</sub>	44	37	19	7.46	9.9	2.35	0.17	4.95	32.4
Polatlı - P <sub>1</sub>	38	39	23	7.64	5.3	1.37	0.15	2.55	5.4
Polatlı - P <sub>2</sub>	36	37	27	7.54	17.1	1.06	0.15	5.95	16.5
Polatlı -P <sub>3</sub>	35	42	23	7.62	7.6	1.72	0.14	8.22	6.8
Yaylabel --Y <sub>1</sub>	32	34	34	7.56	16.2	1.29	0.14	5.12	6.2
Yaylabel --Y <sub>2</sub>	37	39	24	7.64	26.2	1.95	0.12	6.47	8.3
Yaylabel --Y <sub>3</sub>	42	37	21	7.62	12.8	1.98	0.15	5.87	7.2
Yuzukbasi --Z <sub>1</sub>	29	37	34	7.65	26.4	1.35	0.15	3.52	2.9
Yuzukbasi --Z <sub>2</sub>	40	41	19	7.59	7.2	2.62	0.19	7.15	4.1
Yuzukbasi --Z <sub>3</sub>	39	38	23	7.61	5.9	1.12	0.14	3.05	10.7

### *Aerobic Incubation Method*

This method was previously described by Kencey and Bremner (1967). It involves determination of (NH<sub>4</sub>+NO<sub>3</sub>+NO<sub>2</sub>)-N produced from a mixture of 10 g soil sample and 30 g 30- to 60-mesh quartz sand. Then the mixture was distributed evenly over the bottom of 250 ml bottles

specially designed for the experiment and the mixture moistened with 6ml of distilled water to bring the moisture content of soil to its field capacity. The necks of the bottles were fitted with a rubber stopper having a central hole (16mm) sealed tightly with an aeration device, and then placed in a constant temperature incubator at  $30 \pm 2^\circ\text{C}$ . After 14 days, the bottles were removed from the incubator and 100ml of 2M KCl were added. The bottles were shaken for one hour in mechanical shaker and allowed to stand for  $\frac{1}{2}$  hour. 20ml aliquot of the supernatant liquid were added to the distillation flask using dispenser. The amounts of  $(\text{NH}_4 + \text{NO}_3 + \text{NO}_2)\text{-N}$  mineralized during the incubation period were determined from the ammonium-N liberated by steam distilling this aliquot with 0.2 g MgO and 0.2 g Devarda alloy for 3.3 min. The mineralizable  $\text{NH}_4\text{-N}$  calculated as the difference between the amount of ammonium-N before and after incubation.

#### *Anaerobic incubation method:*

The anaerobic incubation procedure (waterlogged) used in the study was previously described by Waring and Bremner, (1964) and modified and developed by Keeney (1982) and strongly recommended for the assessment of the mineralizable-N during incubation period.

The method involves incubation the soil samples under waterlogged conditions in enclosed test tubes with as little head space as possible in the tubes.

The amounts of ammonium-N produced when 5 g of soil sample incubated under waterlogged conditions (12 ml of distilled water) at  $40 \pm 2^\circ\text{C}$  for 7 days were determined by using steam distillation apparatus. Also the amount of ammonium-N in the soil sample before incubation was determined by the same procedure, and mineralisable-N was calculated from the difference in the results of the two analysis.

#### *Analytical procedures*

The hydrolysis procedure used herein is based on the observation that maximal release of some major known fractions of soil organic-N (6N HCl acid-extractable forms) such as amino acid-N, amino sugar-N and nearly maximal release of total-N, was obtained by hydrolysis under reflux for about 6-12 hours using 3 ml of 6N HCl  $\text{g}^{-1}$  of soil (Stevenson 1982). Five g of finely ground ( $< 100$  mesh) soil were placed into round-bottom flask fitted with a standard-taper (24/40) groundglass joint, 2 drops of octyl alcohol and 20 ml of 6N HCl were added. The flask contents were mixed thoroughly by swirling and placed in electric heating mantle then connected to a Liebig condenser fitted with a (24/40) ground-glass joint and then heated under reflux for 12 hours. After completion of hydrolysis the flask allowed to cool and its content filtered. The filtrate was neutralized to pH 6.5 by cautious addition of NaOH using a pH meter to follow the course of the neutralization. Determinations of different forms of soil nitrogen were carried out in the neutralized hydrolysate as described by Bremner (1965). All forms of N were converted to  $\text{NH}_4$  which was distilled under alkaline conditions in  $\text{H}_3\text{BO}_3$ -mixed indicator solution and determined by titration with standard 0.005N  $\text{H}_2\text{SO}_4$ .

## RESULTS AND DISCUSSION

Results given in Table 2 shows the potentially available soil-N in  $\text{mg NII}_4\text{-N kg}^{-1}$  soil as measured by aerobic incubation method described by Keeney and Bremner (1967) and anaerobic incubation method as described by Waring & Bremner (1964) then modified by Keeney (1982) in the 31 soils of Central Anatolia.

As shown in Table 2, the quantities of mineralized N in aerobic incubation method ranged between 6.34 and 74.33 and averaged  $21.78 \text{ mg NH}_4\text{-N kg}^{-1}$  soil. As compared to aerobic incubation method greater amounts of mineralized N ranging between 26.01 and 111.32 and giving a mean value of  $63.87 \text{ mg NH}_4\text{-N kg}^{-1}$  soil was obtained with anaerobic incubation method. These findings were in agreement with that of Gianello and Bremner (1986) for Brazilian soils. The reasons of obtaining greater amounts of mineralized N in anaerobic methods that only  $\text{NH}_4\text{-N}$  was measured and the losses of ammonia gases were avoided in enclosed system during the anaerobic conditions. Significant correlation was found between the aerobic and anaerobic incubation methods used for the assessment of potentially available soil-N when applied in Central Anatolian soil. ( $r = 0.72$   $p < 0.001$ ). Soil-N parameters such as total N content and soil organic matter were evaluated to be used as indexes of soil nitrogen availability in test soils, because several workers have found that the results of many biological procedure assessing soil-N availability are closely related to total soil-N which in turn is closely related to organic matter content (Keeney 1982). According to the results given in Table 3.

total soil-N, as an index of N availability, was found to be significantly correlated with the potentially available soil-N measured by the two incubation methods ( $r = 0.70$  and  $0.66$  respectively). Whereas, the correlation coefficient between soil organic matter, as an index of N availability, and the two biological methods was found to be comparatively low ( $r = 0.44$  and  $0.47$  respectively).

Table 2. Nitrogen values obtained by the aerobic and anaerobic incubation methods in  $\text{mg NH}_4\text{-N kg}^{-1}$  soil

Soil series	Aerobic Method	Anaerobic Method
Kap - A <sub>1</sub>	28.87	67.02
Kap - A <sub>2</sub>	12.20	46.74
Kap - A <sub>3</sub>	20.85	78.13
Beyazbayır - B <sub>1</sub>	15.53	67.02
Beyazbayır - B <sub>2</sub>	6.34	36.75
Beyazbayır - B <sub>3</sub>	9.34	42.52
Cirali - C <sub>1</sub>	24.15	102.25
Cirali - C <sub>2</sub>	12.45	29.92
Cirali - C <sub>3</sub>	15.34	35.93
Bezik - E <sub>1</sub>	19.89	52.72
Bezik - E <sub>2</sub>	17.84	60.24
Bezik - E <sub>3</sub>	12.99	28.37
Ciftagil - F <sub>1</sub>	27.07	62.12
Ciftagil - F <sub>2</sub>	13.13	39.75
Ciftagil - F <sub>3</sub>	34.08	80.59
Ciftagil - F <sub>4</sub>	74.33	111.32
Kepir - I <sub>1</sub>	36.96	101.94
Kepir - I <sub>2</sub>	18.58	55.06
Kepir - I <sub>3</sub>	29.32	67.85
Kiebeli - K <sub>1</sub>	12.32	62.73
Kiebeli - K <sub>2</sub>	19.17	76.12
Kiebeli - K <sub>3</sub>	24.88	72.28
Polatlı - P <sub>1</sub>	18.47	66.41
Polatlı - P <sub>2</sub>	16.91	45.49
Polatlı - P <sub>3</sub>	19.74	53.46
Yaylabel - Y <sub>1</sub>	31.35	80.86
Yaylabel - Y <sub>2</sub>	15.85	26.01
Yaylabel - Y <sub>3</sub>	21.68	80.99
Yuzukbasi - Z <sub>1</sub>	18.64	69.20
Yuzukbasi - Z <sub>2</sub>	25.11	94.61
Yuzukbasi - Z <sub>3</sub>	21.76	85.52
Average	21.78	63.87

Correlation Coefficient ( $r$ ) = 0.72 ( $p < 0.001$ )



Table 3. Potentially available soil-N obtained by aerobic and anaerobic incubation methods in mg.  $\text{NH}_4\text{-N kg}^{-1}$  soil and some soil-N parameters

Soil series	Aerobic Method	Anaerobic Method	Soil O M %	Total N %	NH <sub>4</sub> +NO <sub>3</sub> mg/kg soil	C/N Ratio
Kap A <sub>1</sub>	28.87	67.02	1.93	0.20	8.82	5.51
Kap A <sub>2</sub>	12.20	46.74	1.53	0.13	13.38	6.92
Kap A <sub>3</sub>	20.85	78.13	2.04	0.18	16.96	6.42
Beyazbayır--B <sub>1</sub>	15.53	67.02	1.13	0.14	5.76	4.82
Beyazbayır--B <sub>2</sub>	6.34	36.75	1.37	0.13	19.96	5.87
Beyazbayır--B <sub>3</sub>	9.34	42.52	1.53	0.15	29.33	5.98
Cıralı --C <sub>1</sub>	24.15	102.25	2.78	0.24	22.46	6.73
Cıralı --C <sub>2</sub>	12.45	29.92	1.76	0.13	11.15	7.59
Cıralı --C <sub>3</sub>	15.34	35.93	2.06	0.16	18.85	7.30
Bezık --E <sub>1</sub>	19.89	52.72	2.11	0.18	25.99	6.92
Bezık --E <sub>2</sub>	17.84	60.24	2.06	0.17	11.17	7.11
Bezık --E <sub>3</sub>	12.99	28.37	1.44	0.17	10.86	4.82
Ciftağıl -F <sub>1</sub>	27.07	62.12	1.81	0.17	20.16	6.38
Ciftağıl -F <sub>2</sub>	13.13	39.75	1.86	0.16	12.97	6.82
Ciftağıl --F <sub>3</sub>	34.08	80.59	1.90	0.19	28.93	5.69
Ciftağıl -F <sub>4</sub>	74.33	111.32	2.41	0.25	25.51	5.57
Kepir -I <sub>1</sub>	36.96	101.94	2.79	0.20	24.08	7.92
Kepir -I <sub>2</sub>	18.58	55.06	1.16	0.14	25.49	4.81
Kepir -I <sub>3</sub>	29.32	67.85	1.64	0.15	69.85	6.52
Kiebeli--K <sub>1</sub>	12.32	62.73	1.35	0.14	18.15	5.78
Kiebeli--K <sub>2</sub>	19.17	76.12	2.14	0.18	16.75	6.83
Kiebeli--K <sub>3</sub>	24.88	72.28	2.35	0.17	37.35	7.94
Polatlı --P <sub>1</sub>	18.47	66.41	1.37	0.15	7.95	5.41
Polatlı--P <sub>2</sub>	16.91	45.49	1.06	0.15	22.45	4.11
Polatlı--P <sub>3</sub>	19.74	53.46	1.76	0.14	15.02	7.38
Yaylabel- Y <sub>1</sub>	31.35	80.86	1.29	0.14	11.32	5.56
Yaylabel- Y <sub>2</sub>	15.85	26.01	1.95	0.12	14.77	9.21
Yaylabel-- Y <sub>3</sub>	21.68	80.99	1.98	0.14	13.07	7.89
Yuzukbasi-- Z <sub>1</sub>	18.64	69.20	1.35	0.15	6.42	5.14
Yuzukbasi-- Z <sub>2</sub>	25.11	94.61	2.72	0.19	11.25	8.27
Yuzukbasi-- Z <sub>3</sub>	21.76	85.52	1.10	0.14	13.75	4.65
Correlation coefficient ( r ) between aerobic method and soil N parameters ( r ) =			r = 0.44	r = 0.70	r = 0.26	r = -0.03
Correlation coefficient( r )between anaerobic method and soil N parameters ( r ) =			r = 0.47	r = 0.66	r = 0.11	r = -0.03
r-values between 0.45 and 0.56 are significant at 1% level						
r-values above 0.56 are significant at 0.1% level.						

As presented in Table 4, highly significant correlation was established when we compared the amount of total hydrolysable  $\text{NH}_4\text{-N}$  extracted by reflux with 6N HCl and the aerobic and anaerobic incubation methods (  $r = 0.79$  and  $0.73$  respectively ). However, the correlation between the two incubation methods and total hydrolysable N determined in the same soil hydrolysate (  $r = 0.66$  and  $0.57$  respectively ) was not as good as for the total hydrolysable  $\text{NH}_4$ . Amounts of some major known fractions of soil N such as amino acid-N and amino sugar-N in the soil hydrolysate showed no significant correlation when compared with these two incubation methods. In conclusion, the total hydrolysable ammonium-N extracted under reflux with 6N HCl showed the highest correlation with the potentially available soil-N measured with the two incubation methods. As a result of that, the total hydrolysable ammonium-N could be suggested for the prediction of N availability in such soils.

Table 4. Potentially available soil-N obtained by aerobic and anaerobic incubation methods and some major known fractions of soil-N extracted under reflux with 6N HCl. All values in mg NH<sub>4</sub>-N kg<sup>-1</sup> soil

Soil series	Aerobic Method	Anaerobic Method	Total Hyd. N	Total Hyd. NH <sub>4</sub> -N	Amino Sugar-N	Amino Acid-N	Acid Insoluble-N
Kap- A <sub>1</sub>	28.87	67.02	1335	181.3	131.6	341.2	697
Kap - A <sub>2</sub>	12.2	46.74	946	127.1	100.4	442.4	342
Kap - A <sub>3</sub>	20.85	78.13	1198	198.2	83.2	476	638
Beyazbayir--B <sub>1</sub>	15.53	67.02	828	138.9	111.2	184.8	521
Beyazbayir--B <sub>2</sub>	6.34	36.75	722	128.8	95.9	358.4	622
Beyazbayir--B <sub>3</sub>	9.34	42.52	966	203.7	87.5	229.6	523
Cıralı - C <sub>1</sub>	24.15	102.25	1545	233.1	149.8	543.2	847
Cıralı - C <sub>2</sub>	12.45	29.92	887	125.6	112.4	495.6	457
Cıralı - C <sub>3</sub>	15.34	35.93	966	202.5	99.9	408.8	663
Bezik - E <sub>1</sub>	19.89	52.72	1050	176.1	112.3	369.6	714
Bezik - E <sub>2</sub>	17.84	60.24	1033	132.4	160.2	515.2	641
Bezik - E <sub>3</sub>	12.99	28.37	896	120.5	151.2	109.2	845
Ciftağıl - F <sub>1</sub>	27.07	62.12	1019	200.5	58.5	117.6	627
Ciftağıl - F <sub>2</sub>	13.13	39.75	1002	151.2	135.8	520.8	582
Ciftağıl - F <sub>3</sub>	34.08	80.59	1218	216.4	107.2	582.4	714
Ciftağıl - F <sub>4</sub>	74.33	111.32	1500	329.1	122.4	422.8	1032
Kepir - I <sub>1</sub>	36.96	101.94	1257	226.5	99.7	439.4	787
Kepir - I <sub>2</sub>	18.58	55.06	988	174	93.4	428.4	406
Kepir - I <sub>3</sub>	29.32	67.85	912	198.8	117.6	364.2	544
Kiebeli - K <sub>1</sub>	12.32	62.73	756	167.4	144.2	498.4	593
Kiebeli - K <sub>2</sub>	19.17	76.12	806	234	102.2	442.4	1008
Kiebeli - K <sub>3</sub>	24.88	72.28	1145	174.1	144.8	387.2	568
Polatlı - P <sub>1</sub>	18.47	66.41	896	169.1	67.5	302.4	565
Polatlı -P <sub>2</sub>	16.91	45.49	1086	206.5	132.3	120.4	398
Polatlı -P <sub>3</sub>	19.74	53.46	1008	173.6	102.2	347.2	375
Yaylabel - Y <sub>1</sub>	31.35	80.86	879	183.1	107.4	660.8	470
Yaylabel - Y <sub>2</sub>	15.85	26.01	949	138.5	137.3	352.8	277
Yaylabel - Y <sub>3</sub>	21.68	80.99	957	172.2	138.2	425.6	499
Yuzukbasi - Z <sub>1</sub>	18.64	69.2	929	186.2	88.2	408.8	588
Yuzukbasi - Z <sub>2</sub>	25.11	94.61	1226	212.1	148.3	417.2	683
Yuzukbasi -Z <sub>3</sub>	21.76	85.52	831	208.9	35.4	361.2	546
Correlation coefficients (r) between aerobic method & 6N HCl extractable N form (r) =			r=0.66	r=0.79	r=0.03	r=0.20	r=0.50
Correlation coefficients (r) between anaerobic method & 6N HCl extractable N form (r) =			r=0.57	r=0.73	r=-0.04	r=0.35	r=0.51
r-values between 0.45 and 0.56 are significant at 1% level							
r-values above 0.56 are significant at 0.1% level							

## REFERENCES

- Bremner, J. M. (1965). Nitrogen availability indexes. In C.A.Black et al.(ed.) Methods of soil analysis, Part 2. Agronomy 9:1324-1345. Am. Soc. of Agron. Madison, Wis.
- Geist, J. M. (1977). Nitrogen response relationships of some volcanic ash soils. Soil Sci. Soc. Am. J. 41 :996-1000.
- Gianello, C., Bremner, J. M. (1986). Comparison of chemical methods of assessing potentially available organic nitrogen in soil. Comm. Soil Sci. Plant Anal. 17:215-236.
- Jalil, A., Campbell, C.A., Shoenau, J, Henry, J.L., Jame, Y. M. and Lafon, G. P. (1996) Assessment of two chemical extraction methods as indices of available nitrogen. Soil Sci. Soc. Am. J. 60:1954-1960.
- Keeney, D.R. (1982). Nitrogen availability indexes .In Methods of Soil Analysis. Part 2<sup>nd</sup> edn Eds A.L. Page, R.H. Miller and D.R. Keeney, pp 711-733 Am Soc. Agron. Madison, Wisconsin.
- Smith, K.A. and Li. Shengxiu (1993). Estimation of potentially mineralizable N in soil by KCl extraction . 1. Comparison with pot experiments. Plant and Soil 157:167-174
- Stanford, G. (1982). Assessment of soil nitrogen availability . In Nitrogen in Agricultural soils. Ed. F.J. Stevenson. pp.651-688. Am. Soc. Agron. Madison Wisconsin.
- Stevenson, F. J. (1982). Nitrogen—Organic forms. In methods of Soil Analysis. Part 2<sup>nd</sup> edn Eds, pp 625—642 Am. Soc. Agron. Madison, Wisconsin.
- Waring, S.A. and J. M. Bremner (1964). Ammonium production in soil under water. logged condition as an index of nitrogen availability. Nature (London),

# N BALANCE OF N<sup>15</sup> APPLIED AS AMMONIUM SULPHATE TO IRRIGATED POTATOES IN SANDY-TEXTURED SOILS

Mahmut Basri Halitligil<sup>(1)</sup>, Ali Akin<sup>(1)</sup>, Adem Ibeyi<sup>(2)</sup>

<sup>(1)</sup> Ankara Nuclear Research and Training Center, Turkish Atomic Energy Authority, Ankara

<sup>(2)</sup> Rural Affairs Research Institute, General Directory of Rural Affairs, Ankara-Turkey

## ABSTRACT

In order to obtain information on potato yield, N uptake, N fertilizer residue in the soil and the portion of N fertilizer leached below 200 cm of soil depth, 9 field experiments were conducted at three different locations in 1992, 1993 and 1994. The N rates used in these experiments were 0, 200, 400, 600, 800 and 1000 kg N/ha with a completely randomized block design with 3 replications. Nitrogen fertilizer was applied in two equal portions; one at planting and one just before the first irrigation. Although all yield data were used to find out the marketable tuber yield - the N rate response curve and the fate of applied fertilizer N was determined only for the 400 and 1000 kg N/ha rates. Isotope microplots were established where <sup>15</sup>N-labelled ammonium sulphate was applied at % 5.0 and 2.5 atom excess enrichments for 400 and 1000 kg N/ha rates, respectively. At harvest, marketable and dry tuber yield was determined for all N rates. Dry tuber and leaf plus vine yields were determined for the isotope microplots and they were analyzed for the % N and % <sup>15</sup>N atom excess. The percent N<sub>d</sub> derived from fertilizer ( % Ndff ) and N use efficiency ( % NUE ) were calculated for the plant samples. The <sup>15</sup>N-labelled residue left in 0 - 200 cm soil was also determined. The amount of N fertilizer leached beyond 200 cm soil depth was also calculated. <sup>15</sup>N-labelled nitrate and total nitrate of the groundwaters from wells were determined at different dates.

Our results show that the optimum marketable tuber yield was obtained with 600 kg N/ha. Tuber N uptake was increased slightly, while leaf plus vine N uptakes increased considerably as the N rate was increased from 400 to 1000 kg N/ha. The percent NUE values decreased nearly by half and the amount of N fertilizer in the 0 - 200 cm soil layer increased more than 3 times when the N rate was increased from 400 to 1000 kg N/ha. Nearly half of the applied fertilizer N ( 45.6 % ) at 400 kg N/ha and more than half of the applied fertilizer N ( 60.8 % ) at 1000 kg N/ha was still in 0 - 200 cm soil depth after harvest. Four times more N fertilizer was leached beyond 200 cm soil depth when 1000 kg N/ha nitrogen was applied in stead of 400 kg N/ha rate. Our results also indicate that the potential of contamination of the groundwaters do exist due to leaching of the applied N fertilizer.

## INTRODUCTION

Due to their light textured soils, farmed lands of the Derinkuyu, Suvermez and Kuyulutatlar region of the Nevşehir province of Central Anatolia, Turkey, are mainly used for potato cultivation. Nearly forty thousand hectares are under ( Anonymous, 1987 and 1989 ).

Recently, farmers began to use new high yielding varieties and as a result of this they began to apply very high amounts of N fertilizers (sometimes more than 900 kg N/ha) and very frequent and high irrigation rates in order to get much higher yields. Some researchers conducted fertilizer N experiments with potatoes in this area. However, the aim of those investigations was only to find out the plant response to several N rates. Consequently, no direct data are available about the fate of fertilizer N, the amount taken up by the potato crop and especially the unrecovered N residue in the soil profile or the leached portion of fertilizer N to the groundwater. Therefore, the main objectives of this study were : a.) to find out the marketable potato tuber yield, the N rate relationship under sandy textured soils and b.) to find out the fate of <sup>15</sup>N labelled ammonium sulphate fertilizer ( fertilizer N in the potato plant, in the soil, and the portion lost or leached ) applied at rate of 400 and 1000 kg N/ha .

## MATERIAL AND METHODS

Nine field experiments were conducted at different locations in the Nevşehir province. (at Merkez Suvermez and Kuyulutatlar in 1992; at Kuyulutatlar 1, Suvermez, and Kuyulutatlar 2 in 1993 and at Merkez, Kuyulutatlar 1 and Kuyulutatlar 2 in 1994 ). This province is located in the Cappadocia region of the Central Anatolia Plateau. Mean annual rainfall is about 410 mm of which most falls in winter and spring. All experiments were carried out on typically sandy textured soils belonging to the Regosol great soil group. The soils have a low organic matter content and water retention properties.



They are low in  $P_2O_5$  content, high in  $K_2O$  content, neutral in pH and have no salinity and drainage problems ( Table 1 ).

The experimental design used in all experiments was a completely randomized block with three replications. The N rates were 0, 200, 400, 600, 800 and 1000 kg N/ha applied as  $(NH_4)_2SO_4$ . N fertilizer was applied in furrows in two equal portions : one at planting and one just before the first irrigation. 100 kg  $P_2O_5$ /ha, as triple superphosphate was applied to all plots at seed bed preparation. Each plot measured 4.2 m x 5.1 m = 21.42 m<sup>2</sup> with 70 and 50 cm between and within row spacing, respectively. The high cost of  $^{15}N$ -labelled fertilizer and the differences in recommendations of the N rate to the potato crop, as well as the N rate local farmers generally apply, dictated the use of isotope microplots ( 0.9 m x 1.4 m = 1.26 m<sup>2</sup> ) only for the rates 400 and 1000 kg N/ha, for which % 5.0 and 2.5  $^{15}N$  atom excess ( %  $^{15}N$  a.e. ) enrichments were used, respectively. Each isotope microplot contained 6 plants.  $^{15}N$ -labelled fertilizer, in granular form, were also applied in furrows, half at planting and the other half just before the first irrigation.

About 11 to 17 irrigations were applied ( Table 2 ) during the growing season with sprinklers being the only irrigation method used in the region. At the end of September or at the beginning of October plants from each plot ( 2.8 m x 3.6 m = 10.08 m<sup>2</sup> ) were harvested and separated into tuber and leaf plus vine. Marketable tuber yields were determined from all N treatments in order to find the N fertilizer response curve of the potato crop. Afterwards, they were dried at 70° C, ground and screened through a 2 mm screen for the % N analysis.

For the  $^{15}N$  balance study, tuber and leaf plus vine of two out of six plants from each 400 and 1000 kg N/ha treatment were dried and the total dry matter yield was determined. After drying they were ground and passed through a 2 mm screen to be analysed the % N and %  $^{15}N$  a.e. which was done with the micro Kjeldahl method (Kjeltech) and the Dumas dry combustion method and emission spectrophotometer (Jasco 150), respectively, according to Axmann et al.(1990).

The nitrogen yield ( kg N/ha ), % N derived from fertilizer ( % Ndff ), N fertilizer yield ( kg N/ha ) and % Nitrogen use efficiencies ( % NUE ) values were calculated.

Soil samples from 0 - 200 cm depth, with 20 cm increments, were taken from each experimental site just before planting, and the total N content was determined. Also, after the potato harvest soil samples were taken again from the same depths of the 0, 400 and 1000 kg N/ha rate plots. Total N,  $NO_3$  and  $^{15}N$ -labelled  $NO_3$  determinations carried out. Fertilizer N residues in the 0-200 cm soil layer were determined. Also, by subtracting the amount of plant N uptake plus fertilizer N residue in 200 cm soil depth from the amount of  $^{15}N$  applied, the amount of N fertilizer leached below 200 cm soil depth ( which is the unaccounted or lost portion ) was calculated at both 400 and 1000 kg N/ha rates.

Analysis of variance the marketable tuber yields for each experiment and the regression analysis including all the data obtained in three years were done according to Steel and Torrie, (1960). Also, for the  $^{15}N$  data the standard deviations for dry matter, N yield, fertilizer N in the 200 cm soil layer, for each treatment at each location and year were calculated. For the averages over locations and years, standard deviations were also calculated.

## RESULTS AND DISCUSSION

### *a.) Marketable potato tuber yield - N rate relationship data :*

In all experiments, the marketable tuber yields were significantly increased (  $P < 0.01$  ) by N fertilization in comparison to the unfertilized treatments. The N rates which produced the highest marketable yields varied for each experiment. From the 9 experiments, the highest tuber yields was obtained with three 400 kg N/ha rate, four 600 kg N/ha rate and one 200 kg N/ha rates. In only one experiment there was no significant difference in tuber yield among the N rates.

The necessary amount of N fertilizer that should be applied for the optimum potato tuber yields under our experimental conditions was found to be around 600 kg N/ha. In other words, around 2857 kg ammonium sulphate fertilizer ( 21 % ) per hectare must be applied to get maximum tuber yield. This is a very high amount of N fertilizer which can only be explained with the frequently (almost every 5 to 7 days) applied high rates (1000 mm ) of sprinkler irrigation. Other investigations on potato tuber yield - N rate relationship under sandy textured soils showed varying results. Lauer (1985) conducted N rate experiments with potato on sandy to loamy sandy soils and reported that for

the optimum tuber yields and economic return 340 kg N/ha fertilizer should be applied. However, the researcher who had conducted N rate experiments in Nevşehir, ( Turkey ) found N rate - yield responses similar to ours. Karaca and Demir (1994), conducted N-rate experiments under sandy loamy soils and they reported that optimum marketable tuber yields were obtained with 600 kg N/ha, although the economical rate that should be applied was found to be 500 kg N/ha. In conclusion, all these results clearly indicate that N rates above 600 kg N/ha would be a waste of money in respect to the optimum marketable tuber yields.

b.)  $^{15}\text{N}$  balance data:

Tuber and total dry matter yields showed slight decreases, whereas leaf plus vine dry matter yields showed slight increases with the increasing N rate from 400 to 1000 kg N/ha when the averages over locations and years are considered ( Table 3 ). Also, tuber N uptake was increased slightly, leaf plus vine N uptakes increased considerably as the N rate was increased. These results do coincide with the findings of Lauer (1985). They indicate that excess N to potatoes crop will show up as increased N, especially in the vines.

Percent Ndff increased from 60 to 67, while the Ndff increased ( kg N/ha ) from 174 to 211, when N rate was increased from 400 to 1000 kg N/ha, respectively, when averaged over year and location . Also N uptake from the soil N pool, increased with fertilization (110.0 and 116.4 kg N/ha for 0 and 400 kg N/ha rate ,respectively). However, with increasing N rate, less N uptake from the soil was observed ( 116.4 and 102.8 kg N/ha for 400 and 1000 kg N/ha rate, respectively ).

Averaged NUE values decreased from 42 to 20.8 , and the N fertilizer residue in the 0-200 cm soil depth increased from 182.2 to 608 kg N/ha, respectively, with increasing N rate. We obtained low % NUE values, which could be expected under irrigated sandy soils ( Korte and Sotirion, 1980; Rawitz et al.1980; Westermann and Kleinkopt, 1985; Saffigna et al., 1977; Lauer, 1985) Under such soil and management conditions ways of increasing the efficiency of N use must be investigated. Efficiency of N use can be improved by more frequent application of N fertilizer during the growing period ( Lauer,1985 ).

Our data show that nearly half of the applied N fertilizer ( 45.6 % ) at 400 kg N/ha and more than half of the applied N fertilizer ( 60.8 % ) at 1000 kg N/ha was still in the 0 - 200 cm soil depth after harvest. Also, the amount of  $^{15}\text{N}$ -labelled  $\text{NO}_3^-$  found was two fold higher at 1000 than at 400 kg N/ha at each 20 cm increment of the 0 - 200 cm soil depth ( Fig. 2 ). This trend was true at each location and year as it can be seen clearly from the figure.

Due to rapid nitrification occurring in well aerated sandy soils, there is a potential for leaching of nitrate. In our study, the amount of fertilizer N leached below 200 cm was not actually measured. It was calculated and therefore standard deviation values were not calculated for them. As can be clearly seen from Table 6, under our experimental conditions, much more fertilizer N ( more than 4 fold ) was leached beyond 200 cm soil depth when 1000 kg N/ha nitrogen was applied in comparison to 400 kg N/ha (44 and 181 kg N/ha,respectively).

## CONCLUSIONS

From our results, it is confirmed that N application by farmers of very high rates ( more than 900 kg N/ha ) to the potato crop in the Nevşehir province is unnecessary. There are two basic reasons for this : a.) the optimum marketable tuber yield can be obtained at maximum 600 kg N/ha in the region. So, there is no need for higher N fertilizer rates; and b.) in fact, with the very high N rate, farmers are potentially polluting the groundwaters. This is very important because they are using the water from wells for irrigation and drinking which can cause serious health problems in the region in the future.

Nitrogen fertilization research in this potato growing area should continue extensively in order to find ways to increase the % NUE. This can be accomplished by applying fertilizer N much more frequently, especially with irrigation water. In other words, fertigation practices, which can increase the % NUE and limit the nitrate movement in the soil, while decreasing the nitrate contamination of groundwaters, would be more intensively investigated.

## REFERENCES

- Anonymous. 1989. Agricultural structure and production. State Statistics Institute. Publication No. 1055, Ankara
- Axmann, H., Sebastianelli, A. and Arrillaga, J.L. (1990). Sample preparation techniques of biological material for isotope analysis. In Use of Nuclear Techniques in Studies on Soil-Plant Relationships. ( Edited by G. Hardarson) IAEA, Vienna, p. 41-54
- Karaca, M. and Demir, Z. 1994. N rate and application time influences to potato tuber yields and inorganic N residue in the soil. Final report. Field Crops Research Institute. Publication No. 3434, Ankara.
- Lauer, D.A. 1985. Nitrogen uptake patterns of potatoes with high-frequent sprinkler - applied N fertilizer. Agronomy Journal 77: 193 - 197.
- Rawitz, E., Burns, S., Etkin, H., Hardiman, R. and Hillel, D. 1980. Fate of fertilizer nitrogen in irrigated fields under semi-arid conditions. In ' Soil Nitrogen as Fertilizer or Pollutant ' proceedings of a research coordination meeting held at Piracicaba, Brasil, during 3 - 7 July 1978 supported by IAEA. Published by IAEA, in Austria, page 195 - 236.
- Steel, R.G.D. and Torrie, J.H. 1960 Principle and procedures in statistics. McGraw Hill, New York, 481 p
- Westermann, D.T. and Kleinkopf, G.E. 1985. Nitrogen requirements of potatoes. Agronomy Journal 77: 616 - 621.

Table 3. Fertilizer N effects on dry matter yield, N uptake, Ndf ( as % and kg N/ha ), total N in the 0-200 cm ( before planting and after harvest) and fertilizer N residue in the 0-200 cm , fertilizer N leached below the 200 cm soil depth at different N rates averaged over years and locations.

	Nitrogen Fertilizer Rate ( kg N/ha )		
	0	400	1000
Dry matter ( kg /ha )			
Tuber	5184 ( 789 )	10423 (1586)	9024 (1308)
Leaf+Vine	2447 ( 411 )	4511 ( 758 )	4642 (733)
Total	7631 (1147)	14934 (2245)	13666 (2023)
N uptake ( kg N/ha )			
Tuber	70.5 (11.2)	201.3 (17.4)	207.0 (16.2)
Leaf+Vine	40.0 ( 6.0 )	89.0 (10.7)	106.4 (11.3)
Total	110.0 (15.2)	290.3 (24.6)	313.4 (25.8)
Ndf			
%		59.9 (2.7)	67.2 (3.0)
kg N/ha		173.9 (8.6)	210.6 (9.8)
% Ndf		42.0 (14.0)	20.8 (7.4)
Total N ( NH <sub>4</sub> + NO <sub>3</sub> )			
in soil at harvest			
( kg N/ha )		381 (19.3)	870 (25.5)
Fertilizer N residue in			
0 - 200 cm soil			
depth ( kg N/ha )		182 (16.8)	608 (21.2)
Fertilizer N leached			
below 200 cm soil			
depth ( kg N/ha )		44	181

Each value is average of three replications and the values in parenthesis are the standard deviations.



Table 1. Some properties of the soils at different experimental sites.

Year and Location	Soil Depth (cm)	Texture	pH	Total Salt(%)	CaCO <sub>3</sub> (%)	O.M. (%)	P <sub>2</sub> O <sub>5</sub> (kg/ha)	K <sub>2</sub> O (kg/ha)
1992 Merkez	0-20	Sandy	6.5	0	0	0.46	101.9	690.3
Suvermez	0-20	Loamy sand	6.9	0.01	0	0.92	202.7	1825.2
Kuyulutlar	0-20	Loamy sand	6.2	0	0	0.92	249.3	1216.8
1993 Kuyulutlar 1	0-20	Loamy sand	6.6	0.01	0	0.29	60.9	845.1
Suvermez	0-20	Silty loam	6.9	0.05	0	0.34	141.8	1591.2
Kuyulutlar 2	0-20	Silty loam	6.8	0.07	0	0.29	129.9	1556.1
1994 Merkez	0-20	Silty loam	6.9	0.03	0	0.46	44.3	795.6
Kuyulutlar 1	0-20	Loamy sand	7.2	0.03	0	0.29	19.9	450.3
Kuyulutlar 2	0-20	Silty loam	6.9	0.04	0.03	0.34	64.2	936.0

Table 2. Dates of the agricultural practices done at different locations and years.

Agricultural Practices	1992			1993			1994		
	Merkez	Suvermez	Kuyul.	Kuyul. 1	Suvermez	Kuyul. 2	Merkez	Kuyul. 1	Kuyul. 2
Potato Variety	Granola	Marfona	Marfona	Granol	Granola	Granola	Granola	Granola	Granola
Planting	23.04.92	28.04.92	29.04.92	30.05.93	30.05.93	30.05.93	11.05.94	11.05.94	11.05.94
First N appli.	23.04.92	28.04.92	29.04.92	01.06.93	01.06.93	01.06.93	11.05.94	11.05.94	11.05.94
Second N appli.	18.06.92	18.06.92	18.06.92	06.07.93	06.07.93	06.07.93	14.06.94	15.06.94	15.06.94
First irrigation	19.06.92	19.06.92	19.07.92	07.07.93	07.07.93	07.07.93	15.07.94	16.07.94	16.07.94
Irrigation Times *	17	11	13	14	14	13	13	16	13
Hoeing	27.06.92	27.06.92	22.06.92	09.07.93	09.07.93	09.07.93	24.07.94	18.07.94	18.07.94
Pesticide appli. **	03.06.92	07.07.92	07.07.92	02.07.93	02.07.93	02.07.93	20.07.94	20.07.94	20.07.94
Harvest	24.09.92	23.09.92	24.09.92	14.10.93	13.10.93	13.10.93	29.09.94	28.09.94	28.09.94

\* • Each irrigation is about 100 mm of water application with sprinkler

\*\* for potato bug and also for weeds

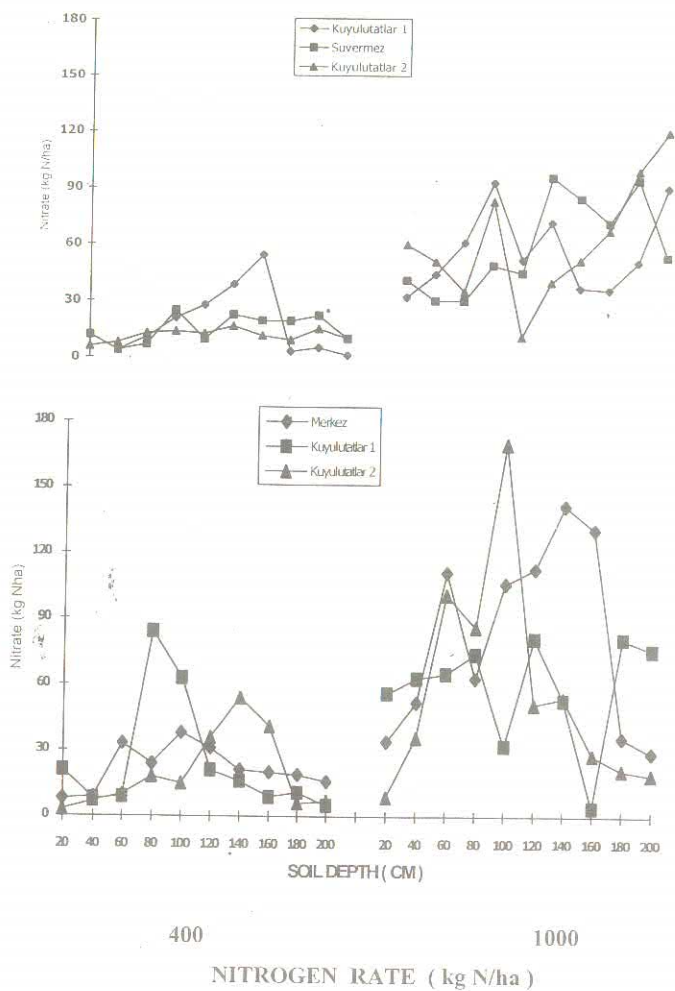


Figure 2: Amount of  $^{15}\text{N}$ -labelled  $\text{NO}_3^-$  determined at two N rates at 0-200 cm soil depth with 20 cm increments at three locations in

## EFFECT OF FARMYARD AND GREEN MANURING ON ORGANIC CHEERY GROWING: II KEMALPAŞA REGION (TURKEY)

B. Okur<sup>(1)</sup>, N. Eryüce<sup>(1)</sup>, B. Çokuysal<sup>(1)</sup>, H. Çakıcı<sup>(1)</sup>, D. Anaç<sup>(1)</sup>, S. Tézcan<sup>(2)</sup>, M. A. Ul<sup>(3)</sup>, A. Ünal<sup>(4)</sup>

<sup>(1)</sup> Ege University Faculty of Agriculture, Soil Science Dept. 35100 Bornova-İzmir/Turkey

<sup>(2)</sup> Ege University Faculty of Agriculture, Plant Protection Dept. 35100 Bornova-İzmir/Turkey

<sup>(3)</sup> Ege University Faculty of Agriculture, Irrigation and Drainage Dept. 35100 Bornova-İzmir/Turkey

<sup>(4)</sup> Ege University Faculty of Agriculture, Horticulture Dept. 35100 Bornova-İzmir/Turkey

### ABSTRACT

Cherry which is one of the unique cash crops in Turkey has a very high local consumption and an export potential with over 8.5 million bearing trees and 215.000 tons production. Due to its high economic value, growers often over fertilize and use agricultural chemicals. To avoid such misuses, environmentally friendly techniques are undertaken in order to grow organic or ecological cherry. An experiment was established where three cherry varieties cv. Sapıkisa, Napolyon and Salihli, as early, mid and late season were studied respectively. Irrigation was practiced at full ( $I_{1.00}$ ) and half ( $I_{0.50}$ ) levels and fertilization was realised by farmyard and green manuring. Sticky yellow traps were placed on each of the experimental trees for *Rhagoletis cerasi* L. (Diptera: Tephritidae) and evaluations were fulfilled. Soils and leaves were sampled at the start and at the end of the experimental period. Results given below belong to the second sampling time. The significant effect of manuring on all of the leaf minerals was found high. On the other hand irrigation treatments had impacts only on leaf-N and Ca contents. As for the varieties, leaf mineral composition showed significant differences with respect to P, K, Ca, Fe, Mn, Zn.

### INTRODUCTION

Changes in human population are closely associated with the improvements in plant production which results in tremendous pressures in the environment by the increasing use of agricultural chemicals. Recently, there is an increasing global awareness for environmental protection and the concern is finding its place in agricultural activities. In Turkey, 67 crops on 27.000 ha of land is organically grown. Cherry, *Prunus avium* L., is one of these crops which finds a very convenient climate in Ege Region of western Turkey by possessing 20% of the tree bearing and 25% of the total production (Anonymous, 1998).

Kemalpaşa province in this region is significant by its well established plantations and the diversity of productive varieties.

Within the scope of this project which aimed to introduce environmentally friendly techniques in cherry growing, different manuring programmes were applied to different varieties under different irrigation conditions to examine the yield and the nutrient status of the trees leaf samples.

### MATERIAL AND METHODS

The experiment was performed in 1998 in an organic cherry farm possessing 160 trees of early (Sapıkisa), mid (Napolyon) and late season crops (Salihli). At the orchard, cultural, physical and biological protection are practised as recommended.

Farmyard manure (FYM) and green manure (GM) formed the manuring programme as 150 kg/tree and 500 g vetch seed /tree respectively. To fulfill the green manuring, vetch was mixed into soil at the stage of abundant flowering and irrigation was practised at two levels as the recommended full irrigation ( $I_{1.00}$ ) and ( $I_{0.50}$ ) half of the recommend dose.

The experiment was designed in randomised blocks with the 5 replications, as 3 manuring programme (FYM + GM + Control), 2 irrigation practices ( $I_{1.00}$  +  $I_{0.50}$ ) and 3 varieties.

Soil samples were taken from the distinct horizons of the profiles to evaluate the fertility status of the orchards before the application of treatments. To examine the effect of treatments, leaf samples were collected as recommended (Kacar, 1972). Soils and leaves were analysed for their physical and chemical properties. Sticky yellow traps were placed on each of the experimental trees for *Rhagoletis cerasi* L. and evaluations were fulfilled.



## DISCUSSION

Some of properties related to the experimental orchard soil is given in Table 1. The experimental soil was neutral in reaction, sandy-loam in texture, poor in  $\text{CaCO}_3$  and organic matter and had no salinity problem. The major and minor elements of the leaf samples are given in Table 2.

Table 1. Properties of the experimental soil

Depth	pH	Total Soluble Salts %	$\text{CaCO}_3$ %	Texture	Organic Matter %
0-30 cm	7,05	<0,030	1,19	Sandy-loam	0,20
30-60 cm	6,70	<0,030	0,80	Sandy-loam	--
60-90 cm	6,92	<0,030	0,90	Sandy-loam	--
90-120 cm	6,70	<0,030	0,95	Sandy-loam	--

Table 2. Major and minor leaf nutrients

Treatments	Napolyon									
	%						$\text{mg kg}^{-1}$			
	N	P	K	Ca	Mg	Na	Fe	Cu	Mn	Zn
I <sub>1,00</sub> + GM	2,55	0,22	1,79	1,58	0,55	0,023	116,0	21,4	61,5	29,9
I <sub>0,50</sub> + GM	2,89	0,26	1,95	1,71	0,53	0,021	111,9	19,9	61,6	30,4
I <sub>1,00</sub> + FYM	2,79	0,24	1,91	1,67	0,55	0,024	111,7	22,6	60,5	28,3
I <sub>0,50</sub> + FYM	2,93	0,29	1,93	1,68	0,57	0,020	123,8	25,2	65,7	34,0
I <sub>1,00</sub> + Control	2,45	0,18	1,71	1,46	0,45	0,020	95,6	15,4	56,2	23,3
I <sub>0,50</sub> + Control	2,55	0,19	1,74	1,48	1,47	0,023	98,4	16,4	57,9	25,2
Salihli										
I <sub>1,00</sub> + GM	2,86	0,31	2,02	1,76	0,48	0,027	109,6	23,5	69,6	33,9
I <sub>0,50</sub> + GM	2,75	0,27	1,94	1,66	0,43	0,020	101,3	21,7	63,4	29,7
I <sub>1,00</sub> + FYM	2,80	2,29	2,03	1,75	0,46	0,024	107,2	24,9	65,9	31,7
I <sub>0,50</sub> + FYM	2,71	0,25	1,91	1,65	0,40	0,020	99,7	23,43	65,2	32,0
I <sub>1,00</sub> + Control	2,47	0,21	1,78	1,51	0,35	0,020	90,3	18,9	59,4	24,0
I <sub>0,50</sub> + Control	2,42	0,20	1,77	1,48	0,33	0,020	89,6	17,4	56,3	20,1
Sapıkısa										
I <sub>1,00</sub> + GM	2,78	0,28	1,95	1,85	0,43	0,021	106,8	21,2	64,3	26,9
I <sub>0,50</sub> + GM	2,91	0,31	1,95	1,84	0,47	0,024	106,1	22,6	64,5	31,1
I <sub>1,00</sub> + FYM	2,80	0,29	1,96	1,83	0,46	0,024	106,0	21,3	63,5	29,8
I <sub>0,50</sub> + FYM	2,80	0,33	1,99	1,84	0,49	0,020	110,9	23,5	65,6	31,3
I <sub>1,00</sub> + Control	2,74	0,29	1,88	1,79	0,44	0,020	97,6	19,8	60,4	27,2
I <sub>0,50</sub> + Control	2,67	0,28	1,92	1,74	0,41	0,020	98,1	19,1	62,1	22,7

Results of laboratory analyses with respect to the reference values given by Bergmann (1986) and Leece (1975) showed that leaf N, K, Ca, Mg, Mn and Zn contents were at optimum levels. On the other hand leaf P and Fe changed from low to optimum while Cu being above.

Statistical analyses (Table-3) related to the effect of treatments on leaf nutrients revealed that manuring has significantly (%1) influenced the nutrient concentration. As for the irrigation treatments, the effect was significant at 1% level on leaf N, P, K, Ca and 5% on leaf Mg, Mn only.

No significant statistical interaction was found between the two considered treatments. It can be concluded that the effect of manuring and irrigation on leaf nutrients is independent. In the case of varieties are their relation with respect to leaf nutrients, a statistically significant difference is seen. Variety effects were significant at 1% level for P, K, Ca, Mg and Fe while being 5% for Mn. The interaction between the manuring and the varieties showed that the effect of these factors are not independent which consequently notifies a definite change in case the other changes excluding the case of leaf K and Ca. This interaction was found significant at 1% level for K and Ca.

The interaction between the irrigation and the varieties showed that the effect of these two factors are not independent except for N and Ca. This interaction effect was significant at %5 level.

The effect of the interaction of three considered factors(manuring, interaction and varieties) was not found statistically significant.

Table 3.Results of variance of analysis

Variants	%					mg kg <sup>-1</sup>			
	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
Replication	0,655ns	2,315ns	0,026ns	1,411ns	6,499*	1,347ns	3,397ns	0,985ns	0,317ns
Manuring (A)	19,164**	12,952**	66,098**	59,500**	19,602**	22,708**	17,048**	13,662**	13,130**
Irrigation (B)	11,635**	7,926**	23,189**	9,997**	4,415*	3,029ns	1,798ns	0,017ns	5,198*
A X B	1,388ns	1,590ns	2,271ns	3,027ns	1,012ns	1,433ns	0,399ns	0,924ns	0,027ns
Variety (C)	3,194ns	15,900**	28,296**	97,767**	27,440**	8,484**	1,220ns	0,803ns	3,261*
A x C	1,408ns	1,969ns	5,962**	4,891**	1,013ns	0,988ns	1,149ns	4,197**	1,042ns
B x C	3,845*	0,092ns	1,556ns	5,067*	0,741ns	0,310ns	0,111ns	1,869ns	0,318ns
A x B x C	0,646ns	0,055ns	3,024*	0,573ns	1,243ns	0,631ns	0,369ns	0,833ns	0,804ns

ns : none significant

\* : (p< 0.05) Means followed by the same letter are not significantly different

\*\* : (p< 0.01) Means followed by the same letter are not significantly different

LSD tests of the treatments and the statistically related leaf nutrients are given in Table-4. From the table, it can be concluded that compared to that of control, FYM and GM significantly increased the concentration of entire leaf nutrients. However no significant difference was found between the two manuring programme.

The LSD tests related to the varieties and leaf nutrients revealed that "Sapıkısa" with a higher leaf P and Ca concentration was different from Napolyon and Salihli. Salihli and Sapıkısa had higher leaf K and Mn concentrations than that of Napolyon varieties. For leaf Mg concentration, Napolyon variety formed the first, Sapıkısa the second and Salihli the third group of LSD tests. Napolyon also had a higher leaf Fe concentration than Sapıkısa and Salihli. No definite similarities were found between the leaf nutrients concentration of different varieties.

In the case of irrigation and leaf nutrient relations, LSD tests proved that full irrigation enhanced leaf N, P, K, Ca, Mg and Mn concentration.

The environmentally friendly plant protection technique-sticky yellow trap results showed that there is a significant decrease in the population of *Rhagoletis cerasi* L.

Table 4.LSD tests of the treatments

Treatments	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
GM	a**	a**	a**	A**	a**	a**	a**	a**	a**
FYM	a	a	A	A	a	a	a	a	a
Control	b	b	B	b	b	b	b	b	b

Varieties	P	K	Ca	Mg	Fe	Mn
Napolyon	b**	b*	b**	A**	a**	b*
Salihli	b	a	B	C	ab	a
Sapıkısa	a	a	A	b	b	a

Irrigation	N	P	K	Ca	Mg	Mn
I <sub>1,00</sub>	a**	a**	a**	A**	a*	a*
I <sub>0,50</sub>	b	b	B	b	B	b

ns : none significant

\* : (p&lt; 0.05) Means followed by the same letter are not significantly different

\*\* : (p&lt; 0.01) Means followed by the same letter are not significantly different

## CONCLUSION

This research was carried out in Kemalpaşa province of Ege region. According to the results of analyses, manuring and irrigation applications enhanced leaf nutrient contents than that of the control. Also variety changes were effective in this point of view.

Increased the leaf nutrients of the studied cherry varieties. Decreases in *Rhagoletis cerasi* L. population by sticky yellow traps proved its efficiency in cherry growing.

## REFERENCES

- Anonim (1998) Türkiye İstatistik Yıllığı DİE No: 2110.733s. Ankara
- Bergmann, W. (1986): Farbatlas, Ernährungsstörungen bei kulturpflanzen. Gustav Fischer Verlag. Jena, Stuttgart 306 s.
- Kacar, B. (1972) Toprak Analizleri. Bitki ve toprağın kimyasal analizleri II., A.Ü. Z.F. Yayın No. 453. Ankara.
- Leece, R. (1975) Diagnostic leaf analysis for stone-fruits, 5 Sweet Cherry. Jour. Exp. Agric. Anim. Husb., 118-122 pp.



# THE EFFECT OF GREEN MANURING ON NITRATE LEACHING UNDER FIELD CONDITIONS

Emine Erman Kara

Niğde University, Engineering Faculty, Environmental Engineering Department, Niğde-Türkiye

## ABSTRACT

The aim of this experiment was to determine the effect of the decomposition of green manure on available N and nitrate leaching in soil profile under field conditions. The experiment consisted of 5 treatments, Grass, Clover, Bean, Vetch and controls replicated in 4 blocks. The green manure as plant biomass incorporated in the top 20cm soil layer at the beginning of flowering. Soil samples were taken once a week from the 20 experimental plots, for a period of 9 weeks. The 1<sup>st</sup> and 9<sup>th</sup> samplings were to a depth of 120cm, in 20cm increments, and the rest to 60cm. The soil was tested for  $\text{NH}_4^+$ -N and  $\text{NO}_3^-$ -N in all soil samples..

Ammonium concentrations did not indicate any clear trend with treatment or time, but they were almost negligible compared with nitrate concentrations. The latter were generally very high even in the control, and were greatly affected by incorporation of Vetch and Clover, wheares grass seemed to have immobilized N shortly after its incorporation. Changes with time indicated nitrate leaching to deeper soil layers.

## INTRODUCTION:

Degradation of soil organic matter (OM) under continuous cropping is a major reason for decreasing soil productivity. Decomposition of OM is a sequence of microbial processes that is enhanced by increasing temperature, aeration, and optimal moisture content. Such conditions prevail particularly in warm climates under intensive cropping and irrigation. Incorporation of plant residues into the soil is an important means to sustaining soil OM and releated soil properties, such as biological activity, available nutrients reservoir, and soil structure. The source of plant residues can be residues of the previous crop, such as wheat or cotton, green manures, mostly legumes, or wastes from plant industries. The impact of organic matter management on soil has been studied extensively from various points of view, e.g. sustainable agriculture management and soil productivity, no tillsvs. Conventional tillage systems, farm residues and green manure in relation to nutrients availability and biological activity in soil (Doran and Smith, 1987; Frazer et al., 1988; Ladd et al., 1985).

The aim of this study is that the decomposition rate constants of green manures depend, apart from environmental conditions, on their composition. Microbial buildup, enzyme activity, and creation of temporal and local anaerobic microsites in soil are affected by the rate of decomposition, and together with residues C/N ratio, determine available N immobilization, net mineralization and denitrification losses. Quantification of these processes is necessary to predict changes in available N in soil following incorporation of plant residues. These changes must be considered under aspects of N fertilization management, in order to assure sufficient available N for the following crop and prevent accumulation of excess nitrate, and the consequent ecological hazards of ground water pollution .

## MATERIALS AND METHODS

A field experiment was carried out in the Bafra Experimental station between September 1994 and July 1995. The aim of the experiment was to determine the effect of decomposition of different green manures on available nitrogen concantrations at different soil layer. The experiment consisted of 5 treatments, control, Vetch, Bean, Clover and Grass, replicated in 4 blocks (Block design) The green manure (plant biomass) was incorporated in the top 20cm soil layer. Soil samples were taken once a week from the 20 experimental plots 9 times. The 1st and 9th samplings were to a depth of 120cm, in 20cm increments, and the rest to 60cm.  $\text{NH}_4^+$ -N and  $\text{NO}_3^-$ -N were determined in all soil samples. The experimental site, previously used for studying different cropping systems, is

located in the Bafra plain about 15-20cm above sea level and between the 41<sup>st</sup> and 31<sup>st</sup> degree of north length and 35<sup>th</sup> degree of east latitude. The mean temperature of the subtropic climate between 1994 and 1995 was 13.3<sup>0</sup>C. The highest temperature with 22.6<sup>0</sup>C could be observed in August, 1994, and the lowest one with 4.7<sup>0</sup>C in March, 1995. The mean monthly precipitation during the above period was 63mm. The mean monthly temperatures and precipitations from April 1994 to March 1995 are shown in Table 1.

Table 1. Mean Monthly Temperatures and Precipitations During 1994-1995

	Average Temperature (°C)	Precipitation (mm)
April 1994	10.1	129.5
May 1994	15.9	22.3
June 1994	21.2	21.7
July 1994	22.5	25.9
August 1994	22.6	22.8
September 1994	19.3	84.3
October 1994	13.5	70.6
November 1994	9.8	93.4
December 1994	7.2	49.8
January 1995	5.3	61.0
February 1995	6.7	56.5
March 1995	4.7	119.1

Some soil properties of the experimental field are shown in Table 2.

Table 2. Some Physical and Chemical Properties of Experiment Soil (Bafra Experiment Station)

Soil Depth (cm)	Clay (%)	Silt (%)	Sand (%)	Soil Texture	Organic Matter (%)	CaCO <sub>3</sub> (%)	Total Salt (%)	pH	NH <sub>4</sub> <sup>+</sup> -N (ppm)	NO <sub>3</sub> -N (ppm)
0-20	38.7	34.8	26.5	CL	3.0	5.9	0.07	7.7	8.2	75.2
20-40	39.8	37.9	22.4	CL	2.5	7.6	0.19	7.8	1.5	37.0
40-60	44.3	35.3	20.3	C	1.4	9.9	0.11	7.9	8.9	12.5
60-80	44.0	31.5	24.5	C	1.0	11.4	0.10	7.9	3.9	18.0
80-100	41.8	31.7	26.5	CL	0.8	9.9	0.083	8.0	2.8	30.2
100-	39.8	35.8	24.5	C	0.7	10.6	0.09	7.9	1.9	37.4

#### Experimental site amended with green manure

The experimental field is set up as a block design (4 replicates) and 20 subplots. One block consists of 5 differently treated subplots. After a 6 month growth (15 March 1995) the complete biomass was incorporated by a cultivar. Table 3 shows the carbon and nitrogen contents (%) of the plant material added as green manure to the experimental field.

Table 3. Carbon and Nitrogen Contents in As Well As the C:N Ratio of the Plant Materials Used As Green Manure. Amounts (kg/ha) of Green Manures Incorporated in the Soil.

	N (%)	C (%)	C/N	Amounts of green manures incorporated in the soil (kg/ha)
Vetch	1,5	48,9	17,5	7844
Bean	2,3	51,4	22,3	6274
Clover	2,3	48,9	21,3	4893
Grass	1,5	50,1	33,4	9267

The experimental field is set up as a block design (4 replicates) and 20 subplots (2,8x6m). One block consists of 5 differently treated subplots. Between the blocks there are 2m broad paths and between the plots 1m broad strips for separating and handling the differently treated plots.

After a 6 month growth (15 March 1995) the complete biomass was incorporated by a cultivar. Table 3 shows the carbon and nitrogen contents (%) of the plant material added as green manure to the experimental field. Just before the green manures were sown on 4 November 1994 all plots received 5kgN/da ((NH<sub>4</sub>)<sub>2</sub> SO<sub>4</sub>) and 10kgP/da (Triple super phosphatase) The harvest of the

green manuring plants occurred on. 15<sup>th</sup> of March 1995 the upgrown plants were cutted, chopped to 10cm pieces and completely incorporated into the soil by using a cultivator. Soil sampling (two per plot, six or eight per treatment) was carried out with an Pirkhaver auger. The drawn samples were divided and combined in subsamples of 0-20cm, 20-40cm, 40-60cm, 60-80cm, 80-100cm and 100-120cm, freed from roots and organic remains and stored at 4<sup>0</sup>C. In the soil samples the following chemical parameters were determined. NO<sub>3</sub><sup>-</sup> and NH<sub>4</sub><sup>+</sup> were determined according to Fabig (1980). Plant analysis were carried out according to Schaller, 1988. Carbon was quantified after oxidation potassium dichromate and nitrogen by the Kjeldahl method. To determine the effect of green manuring statistically variance analysis and Duncan's test were carried out.

## RESULTS AND DISCUSSION

### NO<sub>3</sub><sup>-</sup>-N formation

The effect of green manuring to the soil NO<sub>3</sub><sup>-</sup>-N was seen as Vetch>Clover>Bean>Grass respectively. Soil NO<sub>3</sub><sup>-</sup>-N content which was high on the top layer decreased gradually as the depth of the soil increased. The leaching of NO<sub>3</sub>-N content was determined high according to the control plot on which Clover was applied. (Figure 1).

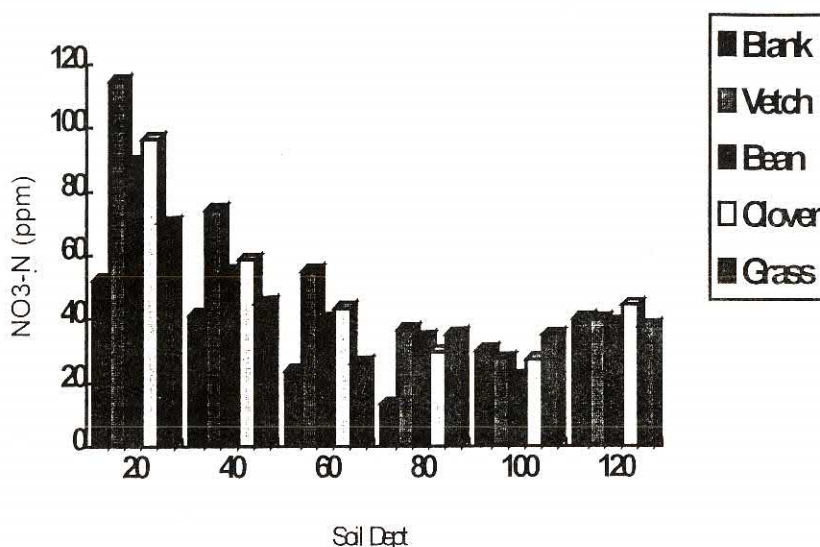


Figure.1. The Effect Of Different Green Manure Applications on NO<sub>3</sub><sup>-</sup>-N Content (ppm) At Different Soil Depth (cm)

### NH<sub>4</sub><sup>+</sup>-N formation

The effect of green manuring on soil NH<sub>4</sub><sup>+</sup>-N content was determined high according to the control plot on which clover was applied. According to the sampling period, the soil NH<sub>4</sub><sup>+</sup>-N content did not clearly change. Soil NH<sub>4</sub><sup>+</sup>-N content which was high on the top layer decreased gradually as the depth of the soil increased. The effect of green manuring to the soil NH<sub>4</sub><sup>+</sup>-N was seen Clover > Bean > Vetch > Grass respectively. The leaching of NH<sub>4</sub><sup>+</sup>-N content was determined high according to the control plot on which Vetch and Bean was applied. (Figure 2).



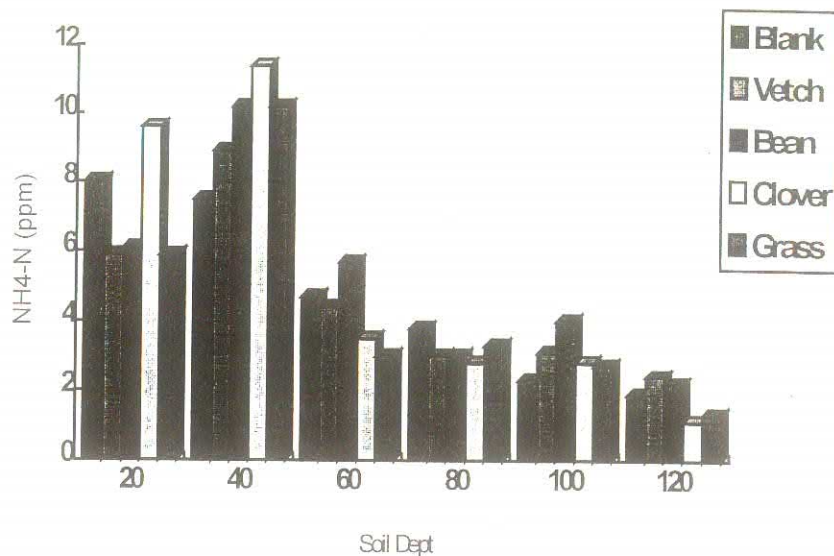


Figure 2. The Effect Of Different Green Manure Applications on NH<sub>4</sub>-N Content (ppm) At Different Soil Depth (cm) .

#### Mineral nitrogen formation (N-NH<sub>4</sub>+N-NO<sub>3</sub>)

The effect of green manuring on soil mineral nitrogen content was determined high according to the control plot on which clover was applied. The effect of green manuring to the soil mineral nitrogen content was seen as Vetch>Clover>Bean>Grass respectively. Soil mineral nitrogen content which was high on the top layer decreased gradually as the depth of the soil increased (Figure 3).

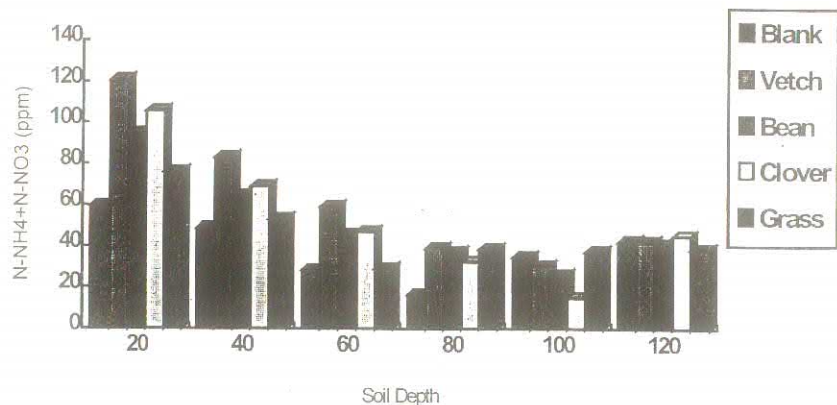


Figure 3. The Effect of Different Green Manure Applications on Soil Mineral Nitrogen(N-NH<sub>4</sub>+N-NO<sub>3</sub>) Content (ppm) At Different Soil Depth (cm)

#### REFERENCES:

- Fabig.(1980). Einfluss des Sauerstoffpartialdruckes auf die eigung von einfachenaromatischen wasserstoff-donatoren (Benzonat, p-Hydroxybenzoat) für die anaerobe Atmung (denitrifikation). Dissertation Universität Hohenheim. Hochschulsammlung Biologie, Freiburg, 8.
- Ladd J.N.,Amato M.,Oades J.M.(1985). Decomposition of plant material in Australian soils. III.Residual and microbial biomass C and N from isotope-labelled legume material and soil organic matter decomposition under field conditions. Aust. J. Soil Res. 23: 603-611.
- Doran J.W.,Smith M.S.(1987). Organic matter management and utilization of soils and fertilizer nutrients. P.53-72. In: J.F.
- Frazer D.G.,Doran J.W.,Sahs W.W.,Lesoin G.W. (1988). Soil microbial populations and activity under conventional and organic management. J.Environ. Qual. 17: 585-590.
- Schaller K. (1988). Praktikum zur Bodenkunde und Pflanzenernährung. Geisenheim. P.277.

## DYNAMICS OF NITROGEN COMBINATION AND THEIR BALANCE IN THE ROTATION SYSTEM

Z.R. Movsumov

Institute of Soil Science and Agrochemistry, Baku, Azerbaijan

### ABSTRACT

In this work the questions of dynamics of connections of nitrogen and its balance are considered depending on entering fertilizers to soil. The norm of losses of gaseous nitrogen from carbonate soils is established. It is shown, that at local entering the efficiency nitric is increased and the unproductive losses are reduced. This way of entering reduces application of nitric fertilizers to 25 %.

The method of the investigations: It was applied laboratorial, lizimetical, small-allotment field methods.

Dynamics of nitrogen combinations and their balance were studied in different Azerbaijan soils depending on bringing nitrogen fertilizer form, on the depth of their doing up, on soil salted degree, and on the predecessors in rotation links.

Carbamide sulfate ammonium and water ammonia were tested form nitrogen fertilizer forms. The investigations were carried out in irrigated meadow-serozem soil.

It was revealed that nitrogen ammoniac form bringing in the firm if sulfate ammonium and water ammonia is nitrified for a short time its great part turns into nitrate form, in 26 days after bringing if sulfate ammonium in soil more than 60% of common quantity of nitrogen is discovered in nitrate form, but in bringing of water ammonia in doze of 90 kg/ha, nitrogen about 40%, Comparatively urea is slowly nitrified. For the indicating period in bringing of amid nitrogen (urea) in doze of 60 kg/ha, nitrate nitrogen formed 28,3%, but in doze of 90 kg/ha 24,5 % from general quantity and ammoniac nitrogen.

After watering nitrification of urea is strengthened.

In bringing of water ammonia, nitrogen main part is preserved in ammoniac form.

By the end of plant vegetation (cotton) least quantity of nitrogen remains last occasion, as compared with other forms, watt is explained by most loss of gaseous ammonia in this form.

In surface bringing of nitrogen fertilizers in carbonate soil, significant nitrogen loss happens in gaseous form. Our investigations determined that in ammoniac saltpeter, sulfate ammonium and urea brining in carbonate soil, most loss of gaseous nitrogen happens in care of bringing urea, which reach, 26,0 % from bringing.

Nitrogen gaseous loss mainly happens in fertilizer surface bringing (0-5 sm.).

In doing up of fertilizers in the depth of 10-15 sm. loss of nitrogen decreased to 50%.

The investigations on nitrogen form dynamics turning in dependence on salted degree and soil carbonate indicated that gaseous ammonia most loss happens in high carbonate soil. To these soils belong mountain - forestry, where loss formed 16,5% and serozem - meadow from which loss in gaseous form formed 7,5-9,5%. In significant loss discovering in swampy weak- carbonate soil. In some cases straight dependence between carbonate soil gaseous ammonia loss degree is not preserved.

Soil salted degree also influences on nitrogen loss from bringing fertilizers. In bringing of urea in meadow-serozem soils, where dense residuum forms more than 1/0%, nitrification processes is depressed, great part of nitrogen remains in ammoniac form and loss in this case reaches 26% from bringing quantity.

Dynamics of nitrogen combinations is studied and conditions of lizimetric experiment. Lizimeters were pouring type with size of 100 x 100 sm., the depth 60 sm. The first series of lizimeters is under cotton, the second remained without plants, nitrogen fertilizers were brought in the form of ammoniac saltpetre, and sulfate ammonium.

It was revealed that nitrate nitrogen most quantity is discovered in upper layers of soil. Nitrate washing in lower layer of soil are compensated by their lifting up with ascending steam, in evaporation.



Many investigators consider that in strong rains almost all nitrate nitrogen is leached from root of inhabited layer of soil, from here- the recommendation on nitrification process weakening. The results of our investigations only indicated that not only rain and frequent watering in high irrigation norm don't leach all nitrate nitrogen from soil.

For the determination of effective norms in nitrogen fertilizers, the studying of nitrogen balance has a great importance. Balance of nitrogen fertilizers under winter wheat was studied in long ago irrigated bright-chestnut in conditions of bogar brown leached soils, in dependence of predecessors.

In nitrogen balance determination under wheat in receipt part of balance was included: entering soil nitrogen with fertilizers, seed plant residuum, formed at expense of accessory crop, at expense nitrogen fixed bacterium, and nitrate entering with atmosphere precipitation. The expense part: nitrogen estranged by main and accessory crop, the loss which in gaseous form are significant.

The carried out balance calculations indicated that in control version, where nitrogen fertilizers weren't independently brought from predecessors, nitrogen balance is negative. In monoculture balance intensity formed 56%, after maize 35 and fallow 34%.

In bringing fertilizers in minimum doze ( $N_{60}P_{45}K_{30}$ ) expense part of nitrogen excelled in receipt. So it was in deficit that is balance negative.

However balance intensity was higher than in control and formed in monoculture 93% after maize 88.4, after fallow 80 %.

In double ( $N_{120}P_{90}K_{60}$ ) and threefold ( $N_{180}P_{135}K_{90}$ ) norm, nitrogen balance was positive.

In industrial conditions on the whole on Azerbaijan republic balance of nitrogen and potassium is negative, but phosphorus balance is positive.

Nitrogen negative balance is mainly connected with increase of its carrying-out as with main as accessory crop. Potassium is in negative balance in connection with potassium fertilizer shortage and its entering soil with low norm.

Including bean cultures in rotation decreases nitrogen deficit. However its loss in result of washing and volatilizing in the form of gaseous ammonia, decreases bringing nitrogen fertilizers affectivity.

In the purpose of increase nitrogen assimilation coefficient by plants and the increase of return form bringing fertilizer unity.

For coefficient increase of nutrition elements assimilation from bringing fertilizers and decrease of their residual negative influence on environment, it is necessary improve fertilizer bringing method. In this connection last time, local method of fertilizer application attracts scientists attention.

The investigations on local-band bringing of fertilizers, under winter- bar key are carried out in greyish-brown irrigated Apsheron soil.

Fertilizers were brought in the form of nitrofosck, on the depth of 8-10 and 12-14 sm. and for comparison in scattering. Fertilizers (NPK) were brought from the calculation - 100,500 and 25% from annual norm, unreaching part of nourishment elements ( $N_{90}P_{90}K_{20}$ ) were brought in the from of simple fertilizers.

It was determined hat the bringing of compound fertilizers (nitrofosk) local-band method promotes forming higher crop of grain. The most crop of barley grain was got, in the full norm (100%) local bringing in fertilizer in the depth of 12-41 sm. (43,0 c/ha). Barley grain crop in local bringing of mineral fertilizers in non-full norm (75 and 50%) , was almost equal to full norm (100%) scattered (continuos bringing). One of the important indices economical efficiency of mineral fertilizers brought under cereals ear cultures, is albumen collection increase with unit of sown area.

That's why coefficient of nitrogen assimilation by plants in local method increases and albumen maintenance in barley.

If in scattered (continuos) method fertilizer bringing albumen size forms 10,1%, in local method, reaches 12,8% albumen collection, in the first case forms 373,5 kg/ha, but in the second 46.3 kg/ha.

In Apsheron conditions, ecological and economical efficiency of local method fertilizer application, was also studied under tomatoes. Fertilizers in the form of ammoniac salt petre, super phosphate and potassium salt in the forms  $N_{90}P_{120}K_{60}$  and  $N_{120}P_{150}K_{90}$  was brought in continuos (in 100% norm) and local in quantity of 100%, and also on 75 and 50% from annual norm. It was determined that local method has not only economical (tomato fruit crop increases 89,9 and 97,1 c/ha) but great ecological significance.

In localization of fertilizers, increasing of nourishment elements assimilation coefficient results in significance decrease of nitrate in soil, but favorable conditions creation for the growth and plant development promotes synthesis nitrogen containing combinations and decrease of nitrate accumulation in tomato fruit, that important for industry of ecological pure nourishment products.

Thus the studying of nitrogen combinations dynamics in soils of Azerbaijan and their balance in the rotation system gives chance to work out rational norms and methods of nitrogen bringing of nitrogen fertilizers, under different predecessor with calculation of preservation and soil fertility increase.

## REFERENCES

- Agayev V.A., and Movsumov Z.R. (1987). Nitrati v rastitel'noy produkcii i agroekologicheskie usloviya ih nakopleniya. In: "Izvestiya AN Azerb.SSR", seriya Biol.Nauk, 3.  
Mineev V.G. (1990). Chimizatsiya zemledeliya i prirodnyaya sreda. Moscow.  
Movsumov Z.R. (1978). Azot v zemledelii Azerbajdzhana. Baku, "Elm".

# FOR SOWING TREATMENT CELERAS SEED WITH OZONE

N.A. Mamedov

Institute of Soil Science and Agrochemistry, Baku, Azerbaijan

## ABSTRACT

The technique of previous ozonization of grain cultures and irrigative water is offered. The optimum ratio between the ozone and air mix for utter annihilation of microbe on a surface grain and in certain volume of irrigative water are established. Is experimentally proved, that germination of seed is normalized, the duration of vegetative period decreases, but the grain productivity is increased approximately by 30 %.

## CONCLUSION

The group of Azerbaijan scientists patented method for sowing treatment celeras seed with corona charge (Qezalov et al. ???). In the modern understanding influence of corona charge to celeras seed could be realized expenses of ozone is formed in corona charge (Sultanli et al. 1999). Last years studying and investigation of ozone in laboratory and wide application in different spheres of science, technology, medicine, agriculture and new technology open the new possibilities of its applications. In the all generators electrosynte of ozone realize in the camera of active elements, at atmospheric pressure, or in the air currents or as in pure oxygen so in the mixtures of oxygen-air currents.

The distinguish ozone generators by power of there types: The ozone generators low (till 1 gr/h), middle (from 1 till 100 gr/h), high (from 100 gr/h) producing possibilities. For treatment of seed we offer ozone generators by middle powerful. It is known that admit limit of cosentration ozone in working zone is 100 mkgg/m<sup>3</sup>. The ozoning of air surrounding with concentration of ozone 40 mkgr/ m<sup>3</sup> improve condition of work creating comfortable atmosphere, increasing ability, working, decreasing general microbe soiling to few times, reduce conditional-patogential microflora to 15-20 times, microscopic 10 times, increasing share of saprophytes till 50%, normalized ion consist of air expenses of decreasing high and increasing light negative ions.

The offer mounting (Qezalov et al. ???) is biggest, need expense, and have essential leak. There is localization in the corona charge with sharp end of electrodes, which lead to gleam charge, where concentration of ozone in the charge gap essential decrease.

Undoubtedly, it is profit to apply ozone generators of middle powerfully for treatment cereals, that have been carrying out by us.

Speed of moving of seed on the netly elevators blowing ozone-air mixture with concentration ozone 2 mg/ m<sup>3</sup>, it is chosen from consideration, that when the normal condition the time to is 15 minute, with in creasing temperature of atmospheric and moisture, it is necessary to increase time interaction or concentration of ozone.

The investigation show, that quantity microbes on the surround of the seed humiliation to 90%. Productivity increase to 30%. The time ripening decrease, sprout is normalized. Characteristics of our ozonize generators is known (B.Y. Sultanli, et al. 1999).

Also by us was carried out treatment spilling water with ozone water.

The time interaction of ozonize with waters defining degree soiling and composition 5-15 minute when concentration 0.2-1.2 mg/l.

Possibility of our ozonizer the investigation photocolometric methods.

## REFERENCES

- X.B. Qezalov, S.V. Karayev, Y.Q. Tarverdiyev. "Mounting for sowing treatment seed" SU15847882A1  
B.Y. Sultanli, I.B. Davudov, N.A. Mamedov, B.B. Davudov. (1999). "Ozone: its electrosynte and application as ". Azer. Xim. Jour. .



# OPTICAL PROPERTIES OF SOILS AND THEIR AGRICULTURAL APPLICATION

Geraizade A.P.

Institute of Soil Science and Agrochemistry, Baku, Azerbaijan

## ABSTRACT

Today with the help of the space shooting the huge quantity of the information about a soil cover is received. The utilization all this information for the purposes of soil science frequently it happens difficultly. The difficulties are connected mainly that the dependences of reflective properties of soil from its various characteristics are insufficiently investigated. The results of the given work are directed on excluding these lacks at deciphering of remote materials. The simultaneously received results can add a databank about the soil characteristics.

## CONCLUSION

For investigated soils the models of change of optical parameters on a structure are made. Is established, that each ground has the spectral curve of distribution of optical parameters. All dependences are expressed by analytical expressions. The received result is offered for use in soil science and agriculture etc.

Methods of ground measurement of plant environment parameters in account on the vast territory frequently is given by doubtful results and are connected to significant quantity of casual deviations from their real status. It concerns as the characteristic of ground and plant cover.

Therefore today are solved set of various tasks on reception of the information by a remote way containing the total data on many characteristics of environment. Such information is rational for a rating of ground resources, rating of soil degradation degree, of ground salinity degree, of agricultural crops status, and also at mapping of grounds and vegetative cover.

The analysis of set of the published works shows, that most of informative parameters at remote sensing of environment investigations are the spectral factors of reflection and its physical essence displaying result of interaction of coming light flows with researched ground objects. Though a significant material on study of spectral factors of soil reflection now is saved, however many questions still are not solved, concerning techniques of spectrometer researches of soil and other natural objects. It is connected that the influencing factors depend on set of interdependent parameters of ground. All this in turn creates difficulties at the formal description of properties and status of soil.

The spectrometer researches include as a direct task - reception and data processing about the spectral reflective characteristics of ground, and return task - recognition and definition of various parameters of research object.

For a present stage of application of remote methods characteristic the accumulation of significant quantity of the primary information and rather insignificant quantity of the interpreted material is.

In this connection on the foreground the problem of the decision of return tasks, and also problem of automation of interpretation of the data of remote sounding enters. Thus the difficulties consist in an establishment of a correct ratio between the taken information and attributes of the object of the image.

Soil submitting the general laws of interaction of light and substance has the specificity. The formation of soil optical properties depends first of all on chemical components, from humidity, mechanical components, and also at supervision in a natural status and from height of the Sun above horizon. From chemical components the reflective ability investigated soils basically was influenced of humus substance, by soluble oxides of iron, salts, silicon acid, carbonate, sulphites and etc. In the given work the results of researches of optical properties of various types are resulted soils, formed on various parent breed.

The distinctions of the optical characteristics both on a profile of soil and depending on their types are established. Within the limits of each type of soil the dependences of the optical characteristics of soil from the influencing factors are revealed. The surface of a soil cover concerns to casual and non-uniform surfaces and represents set of elements with the certain geometry and distinguished optical properties of each element. The models of the optical characteristics of a soil-plant system are depending on the physical-chemical properties of soil and biometric parameters of plants. At drawing up of such models should be taken into account both casual deviations of separate elements, and characteristic features of these elements. It can be reached on the basis of realization of field and laboratory researches of the optical characteristics of objects. In the first case the casual deviations of separate elements of research object, in second - only characteristic features of these elements should be taken into account.

The laboratory research of the spectrometric characteristics allows to create bank of spectral factors of reflection including all basic variety of physico-chemical properties of soil. The offered material can be used as at interpretation of the data received by remote methods, and at realization of classification researches of soil.

**Table 1. Integrated factors of reflection on a profile of soils, R, %**

<b>1. Vertic Chernozems Cultivated</b>		<b>4. Yermic Combisols Meadow irrigated</b>	
<i>Horizons, cm</i>	<i>R</i>	<i>Horizons, cm</i>	<i>R</i>
0 - 18	22.1	0 - 28	27
18 - 37	27.1	28 - 50	32.8
37 - 67	31.4	50 - 70	33.5
67 - 96	36.8	70 - 100	36.7
<b>2. Yermic Combisols Irrigated</b>		<b>5. Meadow Irrigated</b>	
<i>Horizons, cm</i>	<i>R</i>	<i>Horizons, cm</i>	<i>R</i>
0 - 20	26.6	0 - 24	40.6
20 - 38	27	24 - 52	44.5
38 - 67	33.5	52 - 76	45.9
67 - 86	36.7	76 - 100	47.6
<b>3. Yermic Combisols</b>		<b>6. Eutric Calcisols Irrigated</b>	
<i>Horizons, cm</i>	<i>R</i>	<i>Horizons, cm</i>	<i>R</i>
0 - 27	25.7	0 - 26	33.7
27 - 43	32.2	26 - 52	38
43 - 64	34.9	52 - 96	41.1
64 - 87	40.1	96 - 112	43.5

Soils used in agricultural manufacture, differ by significant diversity of physico-chemical parameters and also are exposed also to seasonal change.

All this should be taken into account at selection of soil samples for laboratory researches of the optical characteristics of soil, that it was possible to take into account all variety of the influencing factors. Samples are necessary for taking up to presowing cultivation, after postharvest processing after realization of various agrotechnics processing, after harvest a crop etc.



All these factors have the raised variability and result in significant variations of reflective properties of researched objects.

Therefore the spectrophotometric information should be taken in view of all influencing factors. Only by such way it is possible to raise stability of the spectrophotometric information on object and, hence, to raise reliability of the received items of information about its properties and status. To minimize mistakes brought in by the influencing factors it is necessary to investigate action of each of them on reflective properties of objects.

The spectral factors of reflection of natural objects characterize as well distribution of coming on a surface soil solar radiation, thermal balance of a surface, and also speed and direction of various processes proceeding in ground.

The characteristics of separate investigated soils are resulted below. To them concern the Chernozems irrigated. These soils characterizes by an originality of distribution of spectral reflection curve on a profile. As a whole change on size of integrated factor of reflection in limits from 22.1 up to 36.8 % (Table 1). These soils contain in the top horizon about 6.4 % of organic substance, factor of which reflection very low. Same horizon contains 4.73 % carbonate ( $\text{CaCO}_3$ ). With depth the quantity карбонатов is increased up to 28 %, and the quantity of organic substance, accordingly, decreases. The contents of physical clay changes in small limits and, naturally, can not appreciably participate in formation of factor of reflection on a profile these soil. In this case major factors determining spectral factors of reflection are the contents of organic substances and carbonates. Characteristic feature these soil is the sharp increase of a curve of reflection in red area of a spectrum of light.

Three versions of Yermic Cambisols further were investigated. First are Yermic Cambisols irrigated, the second version was chosen in mountain region, third version is the meadow Yermic Cambisols.

The change of spectral curve reflection of irrigated Yermic Cambisols on a profile a little bit more complex, than at Vertic Chernozems Cultivated. The top horizon has these soils has the smooth course of spectral factors of reflection, which size varies in limits from 20 up to 34 %. The following two horizons are characterized by several extreme points on a spectral curve of reflection. Extremums meet at lengths of electromagnetic waves about 500 - 600 nm and 610 - 680 nm. The spectral curve reflections of horizons 67 - 86 cm and 86 - 120 cm differ among themselves only in the field of 400 - 470 nm. In the whole value of factors of reflection varies within the limits of 20 - 45 %. The integrated factors on a soil profile change within the limits of 26.0-36.7 %. The contents of organic substance on a soil profile changes within the limits of 2.63-0.6 %.

The spectral factors of reflection of Yermic Cambisols on a profile change in an interval 19-42 %. With depth the difference between sizes of factors of reflection of nearby horizons smooths out. The curve reflections on a profile of soil settle down with the certain law. The contents of humus on a profile gradually decreases from 4.17 %, the contents of carbonate were increased on a profile up to size 29.4 %. Integrated factor of reflection changes in limits from 25.7 up to 40.1 % on a profile of soil (Table 1).

The character of change of spectral curves in case of Yermic Cambisols Irrigated is even more complex. In this case curves received for different genetic horizons are crossed among themselves. It concerns first of all to horizons 28-50 cm and 50-70 cm, which spectral curves are crossed in the field of 520 nm. The humus horizon these soils stretches. The contents of humus in the top horizon makes 4.23 %, and on depth 1 m makes size 1.04 %. On spectral curve reflection in dark blue area of a spectrum the minimal values of brightness are appreciable. At transition from dark blue area to green, the brightness of soil grows a little. The greatest size of brightness meets in the field of red waves. The spectral curve of reflection these soils in an average part of a profile of soil sharply grow. It is connected that in an average part of a structure the contents of carbonate ( $\text{CaCO}_3$ ) high (more than 13 %). In other horizons the contents of carbonate is distributed in regular intervals within the limits of 8.20 - 8.90 %.

The spectral curve reflections of Eutric Calsisols Irrigated have wavy character on all profile. Though factor of reflection these soils on a profile changes over a wide range of 27- 60 %, however integrated factors these soils on a profile change rather in a narrow interval 33.7 - 43.5 %.



Irrigated meadow soil in comparison with above given soils have the low contents of humus. These soils have high reflective ability. One of the reasons of such high reflective ability these soils is the high content of carbonates ( $\text{CaCO}_3$ ) and low contents of humus. The quantity of carbonates on a profiles of soil is increased with depth from 7.96 % to 33.19 %.

Thus we see, that all considered here of soils differ as on character of change of spectral curve reflection, and on size of integrated factor of reflection (Table 1). All these differences require realization of the comparative analysis of spectral curve reflection and classical characteristics of soils. Only by such way it is possible to receive the answer to a question: what parameter of ground is the reason of occurrence on a curve concrete extreme point?, also it becomes natural by a key at decipher of remote sending materials.

## REFERENCES

- Geraizade A.P. (1999). The dependence of reflection coefficient of soil horizons. In: Proceeding of the Fifth Baku International Congress "Energy, Ecology, Economy". Baku. 553 - 556.
- Geraizade A.P. (1990). Microphotometric analyse of moisture measuring on remote materials. In: Aerokosmic methods in Soil Science and its agricultural application. Moscow, "Nauka", 183-189.
- P. Kronberg. (1985). Fenderkundung der Erde. Ferdinand Enke Verlag Stuttgart, 350 p.

# AN INVESTIGATION ON DETERMINATION OF ZINC FRACTIONS OF SOILS IN BAFRA PLAIN AND THEIR AVAILABILITY FOR PLANTS

Songül Rakıcıoğlu, Ahmet Korkmaz

Ondokuz Mayıs University, Agricultural Faculty, Department of Soils Science,  
Samsun/TURKEY

## ABSTRACT

This research was conducted to determine the zinc fractions of soils in Bafra Plain and their availability for barley. For this purpose, DTPA extractable zinc, other zinc fractions and their availability for plants were determined on 46 soils sampled from 0 to 20 cm depth. The total zinc in the 46 soil samples varied from 26.84 to 184.31 ppm with an average of 60.25 ppm. A sequential fraction showed that 0.39-3.66 % of total zinc was exchangeable (EX-Zn), 0.01-0.19 % was associated with organic matter (OM-Zn), 0.26-7.39 % was associated Mn oxides (MnOX-Zn), 0.86-49.46 % was associated with crystalline Fe oxides (FeOX-Zn), 7.62-53.82 % was associated with amorph Fe oxides (AFeOX-Zn) and 12.32-83.80 % was present in residual form (R-Zn). It was determined that the amount of DTPA extractable Zn in soil samples varied from 0.50 to 4.60 ppm. The extractable Zn content with DTPA showed positive correlations with R-Zn and AFeOX-Zn ( $p < 0.01$ ). Zn uptake by barley varied from 12.81 to 35.92  $\mu\text{g Zn} / 100\text{g soil}$ . Zn uptake showed a positive correlation with CFeOX-Zn and negative correlations with T-Zn and R-Zn ( $p < 0.01$ ). There was not any significant relation between the other Zn fractions and Zn uptake by barley. The extractable Zn content with DTPA showed a positive correlation with barley Zn uptake ( $p < 0.05$ ).

According to the statistical analysis results, direct effects of Zn fractions on barley Zn uptake were ordered as R-Zn > CFeOX- Zn > MnOX- Zn > AFeOX-Zn > EX-Zn. The most important soil property affected on Zinc uptake from Zn fractions was the soil pH.

## INTRODUCTION

The total amount of Zn shows variety from soil to soil depending upon soil characteristics. Zinc in soils is usually present in Sphalerit [ $\text{ZnCO}_3$ ] and hemimorfit ( $\text{Zn}_4(\text{OH})_2 \text{Si}_2\text{O}_7 \cdot \text{H}_2\text{O}$ ] mineral form. (Barber, 1995). It is accepted that the total zinc content in soil is generally between 10-300 ppm (Aydemir and İnce, 1998). Zn contents are between 3.5-57 ppm in West Germany's podzol and sandy soils (Schliching and Elgala, 1975), Zn contents are between 15-20 ppm in Canada's loamy and Clay soils (Presant, 1971). Holmgren et al. (1993) studied on the Zn contents of the 3045 soils sampled from 307 different soil series in USA. In their study, average Zn content of the soils was 42.9 ppm, average Zn content in mineral soils was 41.4 ppm and average Zn content in organic soils was 64.9 ppm. Lee et al. (1997) found 37-63 ppm Zn in Oklahoma Benchmark surface soil and 135-203 ppm Zn in clay fraction. Haktanır (1984) reported that the most important part of the total Zinc in soils was associated with organic and inorganic soil colloidal fractions. Therefore, total Zn fraction in soils can not be evaluated as a criteria for determination of available Zn fraction in soils for plants. Liang et al (1990) indicated that available Zn in soils for plants is not directly associated with total Zn in soils.

The main factors in the Zn fractions in soil are Fe and Mn oxides (Jenne, 1968). After all the extractable Zn fractions, the residual Zn fraction in soil is mostly present in crystalline structures of primer and seconder minerals (Shuman, 1985). According to Shuman (1979) and Neilsen et al. (1986), Zn in soils is water soluble, exchangeable forms, associated with Fe, Al, Manganeseoxides, organic bound Zn and present in residual form. In the study by Chandrashektar and Kedlaya (1988), the amounts of available Zn fractions within the total Zn fractions were ordered as; soluble < exchangeable < organic bound Zn < complex < absorbed < residual Zn. They found that soluble, exchangeable and complex Zn fractions should be increased to decrease the yield losses. Iyenger et al (1981), studied on the 19 soil samples. They found that total Zn (T- Zn) was fractionated in water - soluble and exchangeable Zn (Ca-Zn) specifically adsorbed (AC - Zn), organic bound Zn (HAH-Zn), Al and Fe-oxide bound Zn (AMOX-Zn), and residual Zn (R-Zn) forms. Most of the T-Zn, was present in the amorph Al and Fe oxides bound Zn (%25) and residual Zn (%6) fractions. The averages of CA - Zn, AC-Zn, PYRO-Zn and HAH-Zn fractions are 0.4, 3.3, 2.5 and 2.0 % of the T-Zn, respectively.

The CA-Zn in the 19 soils increased with a decrease in soil pH, whereas the AC-Zn increased with an decrease in soil pH, the PYRO-Zn in the soils varied directly with organic C and soil pH.

In this study, total Zn and distribution of Zn fractions in soils of Bafra Plain and relationships of these fractions, with Zn contents and Zn uptake by plant were investigated .

## MATERIALS & METHODS

In this study, soil samples taken from Samsun-Bafra plain were used. Soils were selected to represent Bafra Plain and taken from 0-30cm depth in December 1997.

Textures of soil were determined according to Bouyoucus (1951), pH, salinity, organic matter, EC and exchangeable cations to Richards (1954)  $\text{CaCO}_3$  to Çağlar (1958); available P to Olsen et al. (1954) and extractable Fe, Cu, Zn and Mn with DTPA to Lindsay and Norvell (1978).

Table 1. Methods to determine Zinc fractions in soil.

Fractions	Solvents	Soil : Solutions	Shaking Time	Boiling Time	References
Total-Zn	1:3 , HCl : $\text{HNO}_3$	1:10	-	1.5 hours	Kick ve ark., 1980
EX-Zn	1 M $\text{Mg}(\text{NO}_3)_2$	1:4	2 hours	-	Shuman,1983
OM-Zn	NaOCl (5.3 %)	1:2	-	100 °C, 30 min.	Chao ve Zhou,1983
MNOX-Zn	0.1 M $\text{NH}_4\text{OH}$ .HCl pH=2	1:10	30 min.	-	Shuman,1983
AFexOx-Zn	0.25 M $\text{NH}_4\text{OH}$ .HCl + 0.25 M HCl	1:10	-	50 °C, 30 min. (with shake)	Chao ve Zhou,1983
CFexOx-Zn	0.2 M $(\text{NH}_4)_2\text{C}_2\text{O}_4$ + 0.2 M $\text{H}_2\text{C}_2\text{O}_4$ ,pH=3	1:10	-	100 °C,30 min. (with shake)	Shuman,1983
					Chao ve Zhou,1983

Residual Zn was calculated subtracting sum of the Zinc fractions from total Zn content. To determine the Zinc uptake by plants in the soils, modified Neubauer method was used as a biological method (Cottenie and Gabriels, 1966). The plant Zn contents, were determined with AAS according to Kacar (1972)

The statistical analysis of data obtained from laboratory analysis results was done by TARİST computer package program and evaluated according to Düzgüneş (1963).

## DISCUSSION

The physical and chemical properties of the soils are given in Table 2 .

Table2. The physical and chemical properties of research soils

Soils properties (n = 46)	Minimum	Maximum	Mean <sup>1</sup>	Mean <sup>2</sup>	S <sub>d</sub>
Sand, %	9.54	38.83	25.39	24.67	5.78
Silt, %	12.57	48.56	35.33	34.43	7.30
Clay, %	11.09	77.89	39.20	37.69	10.90
PH	6.60	8.20	7.54	7.53	0.33
Total salt, %	0.006	0.052	0.02	0.02	0.01
$\text{CaCO}_3$ , %	0.20	12.39	5.48	3.25	4.08
Organic matter, %	0.88	2.86	1.65	1.60	0.43
Total N, %	0.044	0.143	0.08	0.08	0.02
Available P, ppm	3.99	24.82	10.56	9.06	6.28
CEC, me/100g	15.30	65.66	34.97	33.02	12.22
Exchangeable Na, me/100g	0.25	1.66	0.93	0.85	0.37
Exchangeable K, me/100g	0.32	3.04	1.03	0.87	0.63
Exchangeable Ca+Mg, me/100g	13.08	62.46	32.93	31.00	11.79
DTPA-extractable Fe, ppm	5.79	27.28	15.05	13.83	6.02
DTPA-extractable Cu, ppm	0.91	8.18	3.27	2.81	1.81
DTPA-extractable Mn, ppm	0.51	12.77	6.10	5.26	3.00

Mean<sup>1</sup>; Arithmetic, Mean<sup>2</sup>; Geometric, S<sub>d</sub>; Standard deviation



It was determined that sand 9.54-38.83 %, silt 12.57-48.56 %, clay 11.09-77.89 % ; pH 6.60-8.20; Salt 0.006-0.052 %; CaCO<sub>3</sub> 0.20-12.39 %; Organic matter 0.88-2.86 %; available P 3.99-24.82 ppm; exchangeable Ca+Mg 13.08-62.46 meq/100gr and DTPA extractable Fe 5.97-27.28 ppm, Cu 0.91-8.18 ppm and Mn 0.51-12.77 ppm varied in the soils.

The total zinc and the distribution of the zinc fractions and as a percent of total zinc are given in Table 3.

Table 3. The total zinc and the distribution of zinc fractions and as a percent of total Zn.

Zinc fractions	Minimum	Maximum	Mean <sup>1</sup>	Mean <sup>2</sup>	S <sub>d</sub>
T-Zn	26.84	184.31	69.25	62.93	32.66
EX - Zn, ppm	0.478	1.637	0.88	0.86	0.22
EX - Zn ( % in T-Zn)	0.39	3.66	1.56	1.36	0.82
OM-Zn, ppm	0.01	0.11	0.04	0.03	0.02
OM-Zn ( % in T-Zn)	0.01	0.19	0.06	0.05	0.05
MnOX-Zn, ppm	0.157	2.981	1.21	1.02	0.70
MnOX-Zn ( % in T-Zn)	0.26	7.39	2.06	1.62	1.47
CfeOX-Zn, ppm	0.739	21.557	10.43	9.38	4.03
CfeOX-Zn ( % in T-Zn)	0.86	49.46	18.63	14.75	11.90
AfeOX-Zn, ppm	1.761	23.097	14.51	13.72	3.96
AfeOX-Zn ( % in T-Zn)	7.62	53.82	24.66	22.75	9.95
R-Zn, ppm	3.90	140.30	42.14	29.91	32.09
R-Zn ( % in T-Zn)	12.32	83.80	53.23	47.53	21.32

Mean<sup>1</sup>; Arithmetic, Mean<sup>2</sup>; Geometric, S<sub>d</sub>; Standard deviation

The zinc fractions as a percent of total Zn were R-Zn>AfeOX- Zn>CfeOX-Zn>MnOX-Zn>EX-Zn>OM-Zn. Chandreshkter and Kedlaya (1988) determined that the available zinc fractions in total zinc are water soluble Zn<exchangeable Zn<organic bound<complexed zinc<adsorbed Zinc<residual Zinc. The contents of extractable Zinc with DTPA and the plant zinc uptake in these soils are given in Table 4.

Table 4. The content of extractable zinc with DTPA and the plant zinc uptake in these soils .

n = 46	Minimum	Maximum	Mean <sup>1</sup>	Mean <sup>2</sup>	S <sub>d</sub>
DTPA extractable Zn, ppm	0.50	4.60	1.19	1.03	0.80
Zn uptake by barley, µg Zn/100g soil	12.81	35.92	20.99	19.71	8.054

It was determined that the contents of extractable Zn with DTPA changed between 0.50-4.60 ppm. They were generally sufficient, but the Zn levels in 3 soils were critical (0.05ppm). The plant zinc uptake in research soils changed between 12.81-35.92 µgZn/100gr soil. The statistical relationships between total zinc, DTPA extractable zinc and the other zinc fractions with plant zinc uptake are given in Table 5 .

Table 5. The statistical relationships total zinc, DTPA extractable zinc, zinc fractions and zinc uptake.

Zinc fractions	The Zinc uptake by barley	
	Correlation Coefficient	Regression Equation
Total-Zn	- 0.377 **	y = -0.1112x + 28.695
DTPA extractable Zn	0.203 *	y = 0.5255x + 20.367
OM-Zn	0.011 ns	a
EX-Zn	-0.038 ns	a
MnOX-Zn	-0.151 ns	a
CfeOX-Zn	0.222 **	y = 0.6044x + 14.803
AfeOX-Zn	-0.090 ns	a
R-Zn	-0.474 **	y = -0.1232x + 26.185

ns No significant, \* significant at p<0.05, \*\* significant at p<0.01

a Regression equations of no significant relationships weren't presented

A negative correlation ( $p < 0.01$ ) was found between plant zinc uptake and total zinc residual zinc (R-Zn) in soils. Also, Martens and Chesters (1967) determined significant negative correlations ( $p < 0.01$ ) between plant zinc uptake with total zinc contents of soil and clay contents. Plant zinc uptake showed positive significant correlations with DTPA extractable Zn and CFeOX-Zn. The positive correlation between plant Zn uptake and CFeOX-Zn can be explained with that non available Zn form in soils can be become available Zn form by deoksimugineik acid products by barley roots in soil (Römheld and Marschner, 1990; Çakmak et al., 1995). Also it was determined that there were significant correlations between DTPA extractable Zn with R-Zn ( $r = 0.288^{**}$ ) and AFeOX-Zn ( $r = 0.606^{**}$ ).

In order to determine the direct and indirect effects of Zn fractions and some soil properties on Zn uptake by barley, path analysis results are given in Table 6.

Table 6 . The results of path analysis for direct and indirect effects of zinc fractions and some soil properties on barley Zn uptake.

Zinc Fractions	Zn uptake, $\mu\text{g Zn}/100\text{g}$		Zinc Fractions	Zn uptake, $\mu\text{g Zn}/100\text{g}$	
	Path Coef.	%		Path Coef.	%
OM-Zn			CFeOX-Zn		
Direct Effect	-0.0498	41.99	Direct Effect	0.2473	67.69
Indirect Effects			Indirect Effect		
EX-Zn	-0.0003	0.22	OM-Zn	-0.0092	2.53
MnOX-Zn	-0.0008	0.64	EX-Zn	0.0002	0.05
CFeOX-Zn	0.0459	38.72	MnOX-Zn	-0.0534	14.61
AFeOX-Zn	-0.0005	0.41	AFeOX-Zn	-0.0011	0.31
R-Zn	0.0084	7.06	R-Zn	0.0073	1.99
PH	0.0060	5.06	PH	0.0226	6.18
Organic matter	0.0030	2.51	Organic matter	0.0068	1.86
Lime Content	-0.0024	2.05	Lime Content	-0.0080	2.19
P	0.0010	0.80	P	0.0008	0.20
Clay	0.0006	0.53	Clay	0.0086	2.35
EX-Zn			AFeOX-Zn		
Direct Effect	-0.087	10.76	Direct effect	-0.0170	11.95
Indirect Effect			Indirect Effect		
OM-Zn	-0.0015	1.83	OM-Z	-0.0014	0.99
MnOX-Zn	-0.0060	7.48	EX-Zn	0.0003	0.20
CFeOX-Zn	-0.0058	7.19	MnOX-Zn	-0.0044	3.05
AfeOX-Zn	0.0006	0.71	AFeOX-Zn	0.0165	11.55
R-Zn	-0.0157	19.38	R-Zn	-0.0425	29.81
PH	0.0168	20.76	PH	-0.0273	19.14
OM	-0.0098	12.12	Organic matter	-0.0237	16.65
Lime Content	-0.0027	3.33	Lime Content	0.0015	1.05
P	0.0040	4.91	P	0.0009	0.60
Clay	-0.0093	11.49	Clay	0.0071	4.98
MnOX-Zn			R-Zn		
Direct Effect	-0.1761	50.40	Direct Effect	-0.3301	68.64
Indirect Effect			Indirect Effect		
OM-Zn	-0.0002	0.06	OM-Zn	0.0013	0.26
EX-Zn	-0.003	0.08	EX-Zn	-0.0004	0.09
CFeOX-Zn	0.0750	21.46	MnOX-Zn	-0.0217	4.52
AFeOX-Zn	-0.004	0.12	AfeOX-Zn	-0.0054	1.13
R-Zn	-0.0408	11.66	R-Zn	-0.0022	0.46
pH	0.0240	6.87	PH	-0.0077	1.60
OM	-0.0057	1.64	Organic matter	-0.0533	11.08
Lime Content	-0.0114	3.24	Lime Content	0.0006	0.13
P	-0.0031	0.88	P	0.0013	0.23
Clay	-0.0124	3.54	Clay	-0.0569	11.82

The direct effects of Zn fractions on the barley zinc uptake are shown as below;

$R\text{-Zn} > C\text{FeOX-Zn} > MnOX\text{-Zn} > OM\text{-Zn} > A\text{FeOX-Zn} > EX\text{-Zn}$

Except R-Zn, in the indirect effects of all the zinc fractions through soil properties on plant Zn uptake, pH was the most effective soil property. This situation indicates that pH is the most important property for plant zinc uptake from the different zinc fractions in soil. Other than pH, some other soil properties such as: organic matter,  $\text{CaCO}_3$  available P and clay content are also important properties for plant zinc uptake.

## REFERENCES

- Aydemir, O ve İnce, F. (1988). Bitki Besleme. Dicle Üniv. Eğitim Fak. Yayınları No:2 Diyarbakır.
- Barber, S. A., (1995). Soil Nutrient Bioavailability 2<sup>nd</sup> ed. P. 1-414 John Wiley and Sons, Inc. New York.
- Bouyoucos, G., (1951). A Recalibration of The hydrometer method for making mechanical analysis of soils. *Agron.* 43: 434-438.
- Chandrashekar, P. and N. Kedlaya, (1988). Soil zinc fractions and their availability in an Oxisol. *Journal of The Indian Society of Soil Science*, 36:3, 487-491.
- Cottenie, A. and R. Gabriels, (1966). The Neubauer Methods as an aid for trace element. *Investigation in Soils Abst Natur Wissenschften* 53:199.
- Chao, T.T., and I. Zhou, (1983). Extraction techniques for selective the solution of amorphous iron oxides soils and sediments. *Soil Sci. S and Am J.* 47:225-232.
- Çağlar, K.Ö., (1958). Toprak İlmî. Ankara Üniversitesi Yayınları No:10, Ankara.
- Çakmak, İ., Torun, A., Erenoglu, B., (1995). Türkiye'de toprak ve bitkilerde Zn eksikliği ve Zn eksikliğine dayanıklılık mekanizmaları. *Tr. J. of Agriculture and Forestry* 20:13-23 (Özel Sayı).
- Düzgüneş, O., (1963). Bilimsel Araştırmalarda İstatistik Prensipleri ve Metodları. E.Ü. Matbaası, İzmir.
- Haktanır, F., (1984). Trakya Bölgesi topraklarının Zn durumu ve bu toprakların yararışlı Zn kapsamının belirlenmesine kullanılacak yöntemler. T.A.E.K., Ankara Nükleer Araştırma ve Eğitim Merkezi Nük. Tar. Böl. 6-84.
- Holmgren, G. G.S., Meyer, M., Chaney, R.L. and Daniels, R.B., (1993). Cadmium, Lead, Zinc, Copper, Nickel in agricultural soils of the United States of America. *J. Environ. Qual.* 22:335-348.
- Iyengar, S. S., D. C. Martens and W. P. Miller, (1981). Distribution and plant availability of soil Zinc fractions. *Soil Sci. Soc. Am.* 45:735-789.
- Jenne, E. (1968). Controls on Mn, Fe, Cu, Ni, Cu and Zn concentrations in soil and waters. The significant role of hydrous Mn and Fe oxides. P. 337-387. In *Trace Inorganics in Water Hdv. Chim. Ser.* 73.
- Kacar, B. (1972). Bitki ve Toprağın Kimyasal Analizleri: III Toprak Analizleri. Ank. Üniv. Ziraat Fak. Bitki Besleme Kürsüsü, Ankara.
- Kick, H., H. Burger and K. Sommer, (1980). Gesamthalte an Pb, Zn, Sn, As, Cd, Hg, Cu, Ni, Cr and Co in Landwirtschaftlich und Gaertnerisch Genutzten Böden Nordrhein-Westfalens. *Landwirtsch Forschung* 33(1):12-22.
- Lee, B.D., Carter, B.J., Basta, N.T. and Weaver, B., (1997). Factors influencing heavy metal distribution in six Oklahoma Benchmark Soils. *Soil Sci. Soc. Am. J.* 61:218-223.
- Lindsay, W. L. and W. A. Norwell, (1978). Development of a DTPA soil test for Zinc, Iron, Manganese and Copper. *Soil Sci. Soc. Am. J.* 42:421-428.
- Liang, J., J. W. B. Stewart and R. E. Karamanos, (1990). Distribution of Zinc fractions in Preiric Soils. *Can J. Soil Sci.* 70:335-342.
- Martens D. C., and Chesters, G., (1967). Comparison of chemical tests for estimation of the availability of soil zinc. *J. Sci. Ed. Agric. Vol.* 18, 187-193.
- Neilsen, D., P.B. Hayt and A. F. Mackenzie, (1986). Distribution of soil Zinc fractions in British Columbia Interior Orchard Soil. *Can J. Soil. Sci.* 66:445-454.
- Olsen, S. R., Cole, C. V., Watanabe, D., D. S., and Dean, L.A., (1954). Estimation of available phosphorus in soils by extraction with Sodium Bicarbonate. U.S. Dept of Agr. Cir. 939 Washington D.C.
- Presant, E. W., (1971). Geochemistry of Iron, Manganese, Lead, Copper, Zinc, Antimony, Silver, Tin and Cadmium in the Soils of the Bathurst Area, New Brunswick. *Geol Surv. Can. Bull.* 174:1-14.
- Richards, L. A., (1954). Diagnosis and Improvement of Saline and Alkali Soils U.S. Dept. Agr. Handbook. No. 60, 110-118.



- Römheld v, Marschner, H.,(1990). Genotypical differences among Graminaceous Species in release of Phytosiderophores and uptake of Iron Phytosiderophores. *Plant and Soil*. 123:147-153.
- Schlichting, E. und Elgala, Am.,(1975). Schwermetall-Verteilung und Tongehalten Böden, *Z.P. Pflanzenernähr Boden Kultur* 6, 563.
- Shuman, L. M.(1979). Zinc, Manganese and Copper in soil fractions. *Soil Sci*. 127:10-17.
- Shuman, L.M.(1983). Sodium Hypochlorite Methods for extracting micro elements associated with soil organic matter *Soil Sci. Soc Am. J.* 47; 656-660.
- Shuman, L. M.(1985). Fractionation method for soil microelements. *Soil Sci*. 14:11-12.

# DEGRADATION OF THE HARRAN PLAIN SOILS DUE TO IRRIGATION

<sup>1</sup>Mehmet Ali Cullu, <sup>2</sup>İsmail Çelik and <sup>1</sup>Ahmet Almaca

<sup>1</sup>University of Harran, Faculty of Agriculture, Dept. of Soil Science, Şanlıurfa-TURKEY

<sup>2</sup>University of Çukurova, Faculty of Agriculture, Dept. of Soil Science, Adana-TURKEY

## ABSTRACT

In the research, hydraulic conductivity, structural properties, salinization and clay mineralogy of widely distributed 4 soil in the Harran Plain were investigated following irrigation.

At the study, structure stability index values were 30.37-70.67 %, aggregation index values between 0.03-0.28 mm and hydraulic conductivity values were changing from 0.07 to 1.51 cm/h. ESP values were determined between 1,03-45,10 %.

Smectite is the dominant clay mineral in the soils of the Harran Plain followed by palygorskite and kaolinite respectively.

Results revealed that a slight decrease was observed in structure stability and aggregation indexes after irrigation, however decrease in hydraulic conductivity was significant. Moreover, soil salinity were significantly increased in soils, and there were no change in clay mineral contents.

## INTRODUCTION

Misuse of soils caused degradation of their productivity in relatively short periods. The degradation of physical, chemical and mineralogical characteristics of soils reflects this event to product as much as degradation rate.

Özcan and Çetin (1996) stated that, soil is an essential support of human life, not only in relation to our food supply but also for production of fiber and shelter. The rapid increase in the rate of land use as a result of pressures from population, technology and industrial development have caused the acceleration of land degradation.

According to Bilgehan (1998), irrigated agriculture enables intensive agriculture while increasing yield. Although, irrigated agriculture provides some benefits such as yield increases, it brings about some problems. The most important of the problems are variations in the infiltration and drainage rates, salinization-alkalinization and degradation of soil structure.

When the water is applied, particles of soil with high smectite clay content swell considerably due to hydration of expandable layers (Rolstan et al., 1984). Such swelling reduces the cross-sectional area of soil pores. The process of swelling is more pronounced in the presence of the high sodium or low salt concentration, or both in the soil water. Dispersion of fine soil particles is controlled by a similar mechanism. Dispersion is directly influenced by ions adsorbed on particle surfaces, particularly clay minerals. The presence of high sodium, especially at the low salt concentration in the soil water causes dispersion and movement of the fine particles within the pores. The particles may then become lodged in smaller pore, blocking waters and airs.

The impact of salinity is manifested by the degradation of the soil structure (Richards, 1954; Rhoades, 1990). The application of irrigation water to areas with abundant halite (common in arid and semiarid areas) and more than 15 % exchangeable sodium lead to the alkaline hydrolysis. If the soil is low in chloride and calcium, and irrigation water applied rich in exchangeable sodium bicarbonate or sodium carbonate, the clay particles in the soil absorb the sodium and magnesium salt by losing their permeability, water infiltration and oxygen for plant roots.

The aim of this study is to investigate the degradation of selected, widely distributed, soil series with high water tables due to irrigation.

## MATERIALS AND METHODS

In the study, 4 disturbed and undisturbed soil samples which were threaten by salinization were taken from widely distributed soils series of the Harran Plain. In each series, soil samples were sampled from the upper 3 horizons belonging to the root zone.

The soil moisture regime for the area is Xeric-Aridic and the temperature regime is Thermic (USDA Soil Conservation Service, 1993), the mean annual evaporation is 1945 mm and the average annual rainfall is 390.1 mm (Köy Hizmetleri Şanlı Urfa Araştırma Enstitüsü, 1997).

Soil samples were separated according to sample sizes, which would be needed for different laboratory analyses.

The analyses conducted were: Texture (Bouyoucos, 1951),  $\text{CaCO}_3$  (Allison and Moode, 1965); pH, EC, CEC and exchangeable sodium (Richard, 1954), structural stability index (Leo, 1963), aggregation index (Yeşilsoy and Berkman, 1974). The saturated hydraulic conductivity values were measured according to (Klute and Dirksen, 1986) using undisturbed soil samples of 100  $\text{cm}^3$  volume. The dry bulk density was determined using the core method of (Blake and Hartge, 1986). The clay mineral analyses were conducted according to Jackson (1979).

## RESULTS AND DISCUSSION

In this study, 4 soil series of the Harran Plain, which are affected by groundwater, were investigated for determining physical and chemical degradation. Disturbed and undisturbed soil samples were collected from 4 soil series. The results were compared with previous data obtained taken before irrigation. Irrigation of the Harran Plain has started in 1995 and after irrigation, the water table increased and inhibited plant growth due to degradation of the chemical and physical characteristics of the soils.

Table 1. Some Physical Properties of the Studied Soils.

Soil Series	Depth (cm)	Particle Size Distribution (%)			Texture Class	Bulk Density ( $\text{g/cm}^3$ )	Aggregation Index (mm)	Structural Stability Index	Hydraulic Conduc. (cm/h)
		Sand	Silt	Clay					
Akçakale	0-20	1,20	34,42	64,38	C	1,18	0,08	64,00	0,22
	20-45	0,63	52,30	47,07	SiC	1,33	0,06	63,91	0,43
	45-60	0,81	28,82	70,37	C	1,40	0,04	70,67	0,18
Ekinyazı	0-22	19,86	28,43	51,71	C	1,52	0,28	51,83	0,60
	22-45	19,78	32,22	48,00	C	1,60	0,14	47,30	0,11
	45-60	18,60	31,90	49,50	C	1,46	0,13	50,68	0,07
Gürgelen	0-19	13,08	43,95	42,97	SiC	1,23	0,08	30,37	0,51
	19-42	6,79	32,91	60,30	C	1,47	0,09	49,13	0,67
	42-55	3,91	33,88	62,21	C	1,52	0,06	60,93	0,22
Harran	0-15	0,90	32,89	66,21	C	1,18	0,04	61,38	0,71
	15-30	3,21	30,79	66,00	C	1,25	0,05	63,84	0,47
	30-55	0,70	28,72	70,58	C	1,31	0,03	65,37	0,57

The hydraulic conductivity of the soils were significantly decreased, also a slight decrease were observed in the structure stability and aggregation indexes.

Bilgehan, (1998) stated that, structural characteristics of soils and aggregate stability in water must be determined in soils of rainfed areas before irrigation in order to monitor of changes degradation following irrigation.

Chemical analyses showed an increase in ESP and EC with depth (Fig. 1 and Table 2), depending on annual rainfall, evaporation and land use.

Çullu et al. (1999), indicated salinity fluctuations during the year because of different agricultural applications to gather with shallow water tables and high evaporations.



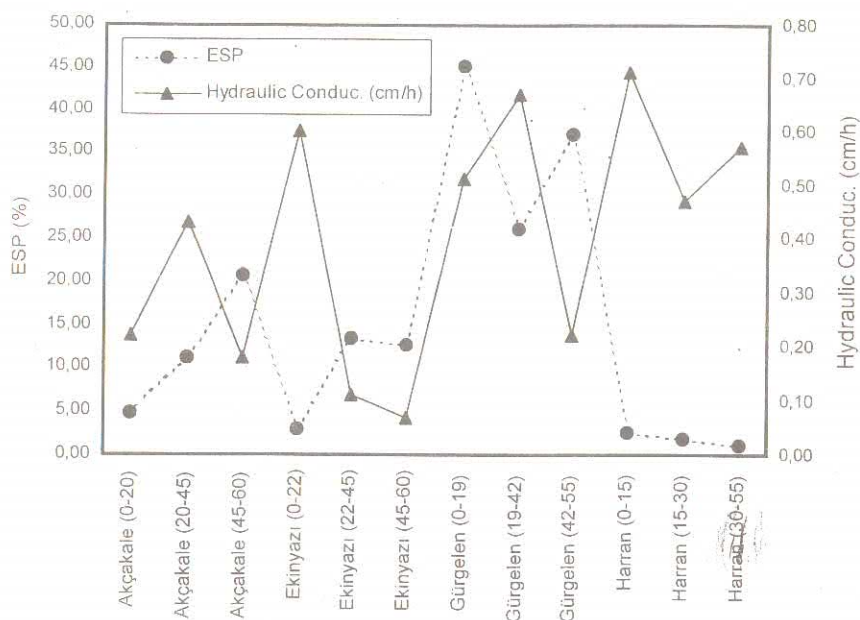


Figure 1. Relation between hydraulic conductivity and ESP values of the selected soils.

Table 2. Some Chemical Analyses of Selected Soils.

Soil Series	Depth (cm)	pH (ex.)	EC dS/m	CEC me/100 g	Exc. Na me/100 g	CaCO <sub>3</sub> (%)	ESP (%)
Akçakale	0-20	8,16	4,394	33,70	1,63	18,67	4,84
	20-45	8,19	3,600	38,59	4,35	19,25	11,27
	45-60	8,16	5,530	32,61	6,74	21,12	20,66
Ekinyazı	0-19	8,30	3,312	21,20	0,65	17,53	3,06
	19-42	7,86	9,088	20,11	2,72	19,10	13,52
	42-55	7,83	8,703	25,54	3,26	22,64	12,76
Gürgelen	0-22	7,82	24,00	23,37	10,54	21,22	45,10
	22-45	7,95	9,050	22,83	5,98	22,14	26,19
	45-60	8,11	8,558	29,35	10,87	21,12	37,04
Harran	0-15	8,38	0,768	42,39	1,09	32,74	2,57
	15-30	8,32	0,719	42,39	0,76	35,40	1,79
	30-55	8,39	0,962	41,85	0,43	37,61	1,03

There is a negative relation between ESP and hydraulic conductivity (Fig. 1). However the evaporation and leaching depth as well as intensity of salt accumulation has affected this relation. The high value of ESP causes degradation of soil structure, decreases hydraulic conductivity creating variations during the year with soil depth.

Yeşilsoy et al. (1992) suggested that, in order to extrapolate the possible changes taking place in soils after irrigation, to develop a map indicating the present infiltration rates and alkalization tendencies. The examination of these maps reveals that there is an inverse relationship between infiltration rates and alkalization tendencies. These results suggest that improper management

practices, which promote alkalization, might cause further decreases in infiltration rates and increase the dimensions of the problems.

Table 3 is indicated the clay mineralogy of salt affected widely soil series of the Harran Plain. Results revealed that no more important changes, which is a pleasure for irrigation. However, high exchangeable sodium is threatening the productivity of the soil.

Diñç et al. (1988) stated that, with the beginning of irrigation, palygorskite may weather to smectite and this will decrease hydraulic conductivity of the soil.

Table 3. Clay Minerals of the Studied Soil.

Soil Series	Depth (cm)	Smectite (%)	Paligorskite (%)	Illite (%)	Kaolonite (%)
Akçakale	0-20	40,20 ++	31,70 +	0,00	28,00 ++
	20-45	35,00 +	30,00 +	0,00	35,00 +
	45-60	25,00 ++	27,20 ++	23,90 ++	23,90 ++
Ekinyazı	0-22	44,10 +	35,30 +	0,00	20,60 +
	22-45	39,20 +	29,40 +	0,00	31,40 +++
	45-60	40,50 ++	30,60 +	0,00	28,90 ++
Gürgelen	0-19	27,20 +	25,20 +	24,50 +	23,10 ++
	19-42	27,20 ++	27,20 ++	25,00 +	20,60 ++
	42-55	33,80 +	36,90 +	0,00	29,20 ++
Harran	0-15	36,40 +	37,90 +	0,00	25,80 +
	15-30	28,60 +	23,40 +	22,10 +	26,00 +++
	30-55	28,00 ++	28,00 ++	21,30 +	22,70 +++

**Relative Abundance:** +++: many, ++: common, +: few

However dominant smectite may probably cause dispersion and swelling of the topsoil together with high exchangeable sodium (Table 3).

The swelling and dispersion of soil clays affect water transmission properties by altering the geometry or continuity of soil pores (Rolston et al., 1984). The hydraulic properties of soil, such as hydraulic conductivity, are highly dependent on both exchangeable sodium percentage and the salt concentration of the percolating soil solution.

As a result, the GAP irrigation caused on increase on the height of the water table of Southern part of the Harran Plain, causing salinization. This is affected the physical and chemical properties of some soil series and decreased plant production, gradually.

## REFERENCES

- Allison, L. E. and Moode, C. D. (1965). Carbonate (C. A. Black Editör) Methots of soil analysis. Part 2. Agronomy series. No 9. Am. Soc. of Agronomy. Wisconsin Series. P:1379-1396.
- Bilgehan, G., (1998). Structure characteristics of soils in Harran Plain before irrigation. pp.208-214. M. Şefik Yeşilsoy Int. Sym. On Arid Region. Menemen, İzmir.
- Blake, G. R. and Hatge K. H. (1986). Bulk density. In: Methods of soil analysis. Part 1, Physical and mineralogical methods (E. A. Klute). Agr. Monogr. 9. ASA and SSSA, Madison, pp:363-375.
- Bouyoucus, G. J., (1951). A recalibration of the hydrometer method for making mechanical analyses of soils. Aronomy J. 43:434-438.
- Çullu, M. A., Almaca A., Öztürkmen A. R., İnce F., Seyrek A., Alkan A., Kızılgöz İ. (1999). Harran Ovası Toprakları'nda tuzluluğun mevsimsel değişimi. GAP 1. Tarım Kongresi. 26-28 Mayıs 1999. S:901-908.
- Diñç, U., Şenol S., Sayın M., Kapur S., Güzel N., Derici M. R., Yeşilsoy M. Ş., Yeğingil İ., Sarı M., Kaya Z., Aydın M., Kettaş F., Berkman A., Çolak A. K., Yılmaz K., Tunçgöğüs B., Çavuşgil V.,

- Özbek H., Gülüt K. Y., Karaman C., Dinç O., Öztürk N., Kara E. E. (1988). Güneydoğu Anadolu Bölgesi Toprakları. I. Harran Ovası Toprakları. TÜBİTAK TOAG:534.
- Jackson, M. L. (1979). Soil chemical analysis-Advanced course. 2<sup>nd</sup> ed. University of Wisconsin, Madison.
- Klute, A. and Dirksen C. (1986) Hydraulic conductivity and diffusivity: Laboratory methods. (E. A. Klute). Agr. Monogr. 9. ASA and SSSA, Madison, pp:687-734.
- Köy Hizmetleri Şanlıurfa Araştırma Enstitüsü (1997). 1997 Yılı Şanlıurfa Harran Ovası hidrometeorolojik rasat verileri, Şanlıurfa.
- Leo, M. W.M. (1963). A rapid method for estimating structural stability of soils. Soil Sci. 96:342-346.
- Özcan, H. and Çetin M., (1996). Land degradation induced by high groundwater level and soil salinity in the fourth stage project area of Yüreğir Plain: A case study. 1<sup>st</sup> Int. Conference on Land Degradation. S: 93-99.
- Rhoades, J. D., (1990). "Overview" Diagnosis of salinity problems and selection of central practices in K. K. Tanji (Editor). Agricultural salinity assessment and management. American Soc. of Civil Engineers. PP. 18-41, New York, U. S. A.
- Richards, L. A., (1954). Diagnosis and improvement of saline and alkaline soils. U.S.D.A. Agriculture handbook, no.60, Washington, U:S:A.
- Rolston, D. E., Bigger J. W. and Nielson D. N. (1984). California Agriculture, October.
- USDA Soil Conservation Service. (1993). World Soil Resources, Washington, DC.
- Yeşilsoy, M. Ş. ve Berkman A. (1974). Islak eleme yöntemi ile topraklarda agregasyon indeksinin saptanması. Ç. Ü. Ziraat Fak. Yılığ. 1-2, S:95-110.
- Yeşilsoy, M. Ş., Aydın M., Bilgehan, G. Kamber R., Taysun A., Derici M.R., Ağca N., Erşahin S., Tuli A. Dağdeviren İ., (1992). Harran Ovası'nda önemli ve yaygın toprak scirilerinin sulama başlamadan önce strüktür ve infiltrasyon özellikleri ile alkalileşme olasılıkları (proje bileşeni No:5.5.2).



## KARAPINAR: A CASE STUDY OF REHABILITATION OF A WIND ERODED AREA IN TURKEY

Erhan Akça<sup>1</sup>, Selim Kapur<sup>1</sup>, Memduh Serin<sup>2</sup>, Bahri Çevik<sup>3</sup>, and Hari Eswaran<sup>4</sup>

<sup>1</sup>University of Çukurova, Department of Archaeometry, Adana, Turkey

<sup>2</sup>Istanbul University, Department of Biology, Istanbul, Turkey

<sup>3</sup>University of Çukurova, Department of Engineering, Adana, Turkey

<sup>4</sup>USDA Natural Resources Conservation Service, Washington DC, USA

### ABSTRACT

The Karapinar area occupies a desert fringe position in the Great Konya Basin of Central Anatolia. Grazing has been a way of life for centuries and the population gathered wood from the shrubs for fuel. The village has served crusades and hordes moving east west over Anatolia. In the middle of this century, due to rapid increases in animal population, the scanty vegetation was denuded and the land further exposed to the vagaries of climate. By the fifties, wind erosion had noticeably increased and active dune formation could be observed. The General Directorate of Rural Services responded by establishing an Erosion Control Camp\*. A soil survey was conducted in the early sixties and other management studies were initiated. The initial successes were encouraging and in the seventies an area of 14,000 ha was fenced off and the land set-aside as a wind erosion rehabilitation area. Today, about 30 years later, the site is known as "Köy Hizmetleri Toprak Tali İstasyonu or Soil Conservation Sub-station of the General Directorate of Rural Services" and has become a teaching and demonstration center for managing land prone to wind erosion. It is also fondly referred to as a monument to visionary thinking and good land management science.

The purpose of the present study is to observe the major changes in the quality of the land resource. Aerial photographs, other documentation, the soil map of 1965, and historic climatic data were used to evaluate the conditions prior to application of mitigation technology. A new soil survey was commenced, samples were taken close to the points of the original sampling, recent aerial photographs were interpreted, and discussions were held with farmers and villagers in the area.

The changes in the three decades are an example of the resilience of the ecosystem. The experiment is also an illustration of how processes of desertification can be thwarted through a managed ecosystem that ensures a balanced mixture of agricultural land use of ecosystem integrity. Land allocation for biodiversity, stabilization of moving sands, protection of the more fragile lands, and technically sound management of better lands, have cumulatively resulted in a truly sustainable land system in this desert margin. The study is quantifying the changes so that the ecosystem management principles can be duplicated elsewhere.

### INTRODUCTION

The Anatolian Plateau is a vast undulating landform occupying the interior of Turkey. In the Southern part it is bounded by the Taurus mountain range as a result of which there is no drainage outlet. The Great Konya Basin, a closed basin with an area of about one million hectares, occupies the central part of the plateau and the study area, Karapinar Plain, is located on the southeastern part of the Konya Basin. Historically and traditionally, the region is used for grazing and in the last few decades, irrigation facilities have been introduced for cultivation of wheat and other cereal crops.

Major constraints for land use are wind and water erosion and salinization. Being a closed basin, irrigation results in secondary salinization and though measures have been taken to reduce the intensity of this process, it remains a continuing struggle. The soils are generally sandy and silty and with the land being bare for extended periods during summer, it is extremely susceptible to wind erosion. The problem is compounded by low-input agriculture. Modern land management technology, such as minimum or zero tillage has yet to be introduced. During the dry summer months, average wind velocity is 18 to 25 m/sec, with a wind direction of north-northeast. Enterprising farmers have constructed windbreaks of poplar and other trees.

Wind erosion and shifting sands reduce the quality of the land and an experimental station was established at Karapinar in 1962 to address the issue. Over-grazing by the increasing sheep flocks has denuded and prevented reestablishment of vegetation. Subsequent to a soil survey of the area

---

\* with the third author assigned as the soil conservationist

(Groneman, 1968), a 14,000 ha of land was fenced-off. A hydro-geological survey provided information on ground-water resources. To prevent local farmers from gathering wood or graze their herds, a barbed wire fence was installed. Thirty-two wells, 60 to 70 m depth were dug to provide water. In designing the area, four sections were established to implement different kinds of conservation practices. Small tracts of land were set aside to serve as comparative study areas or control plots.

Over the years, rehabilitation was commenced on the remaining areas. A first priority was stabilizing the dunes. These were vegetated using innovative technique to supply water for the young shrubs. Based on the soil map, the remaining undulating lakebed soils were selected for reforestation or to be used for irrigated agriculture. In the next decade, irrigating conduits were constructed and irrigation systems put in place. Early station records show that a prime challenge was to enhance the organic matter content of the soils while simultaneously ensuring that salinity levels were not being adversely affected.

The purpose of the study was to evaluate the changes that have taken place in the last 30 years. The major focus is on soil properties and conditions because of the availability of the 1968 soil map and documentation. Discussions with other scientists who have worked in the area during the last two decades have provided additional information on productivity, changes in faunal activity, biodiversity, and the general ambiance of the area. These are summarized to emphasize the improvement in land quality and the related consequences.

## METHODS

The soil map of Groneman (1968) was digitized and all other maps produced for the study were developed at the same scale and used as overlays. Aerial photographs taken at periods prior to the beginning of the station and recent ones (1989) were also interpreted and digitized to serve as overlays. The 15 sites sampled for characterization in the original study were located and re-sampled in 1998. Satellite samples were taken to monitor the depth of the sand, particularly at points close to dunes. Studies of other disciplines, particularly those related to vegetation, biodiversity, and productivity, were used to infer on aspects of land quality and resilience of the ecosystem.

### Physiographic Setting

The study area (Fig. 1) comprises a paleo-lake, which is one of the many lakes that formed in the Great Konya Basin of Central Anatolia, and adjoining beach deposits. On the west is an "old sand plain" of pre-Wurm age, located at an elevation of 1035 to 1050 m above sea level and about 35 m above the paleo-lake. The north of the paleolake is the basaltic lava flows of the Ketir-Mekeler system and which forms an obstacle for the northern transgression of the mobile sands. The dune field of Karapinar was mobile until the start of the rehabilitation program in 1960. The field is made of sand barchans grouped in-moving chain. They reach 240 m in length, 150 m in width, and about 40 m in height with a windward slope of about 5-20% and leeward slopes of about 30-60% (Erinc, 1962). The sand contains large amounts of shell fragments pointing to its lacustrine origin and some volcanoclastic fragments as inclusions. Roberts (1983) estimates the deposits to date to 13-11,000 BP. Geologists working in the area have recognized at least two generations of younger dunes. The older of the two are relatively stabilized by vegetation and it is the younger, present on the dried lake-floor bed that is mobile.

Mean annual rainfall of the area is about 277 mm with an evapotranspiration of about 780 mm. The rain commences about January and ends in mid-June. Winter soil temperature only exceeds 5°C in mid-March and so the available rainfall during the growing season is only about 80 mm. The soil moisture regime is weak aridic and the soil temperature regime is mesic (Soil Survey Staff, 1998). The period during which the land is bare and thus vulnerable to wind erosion is about 200 days.



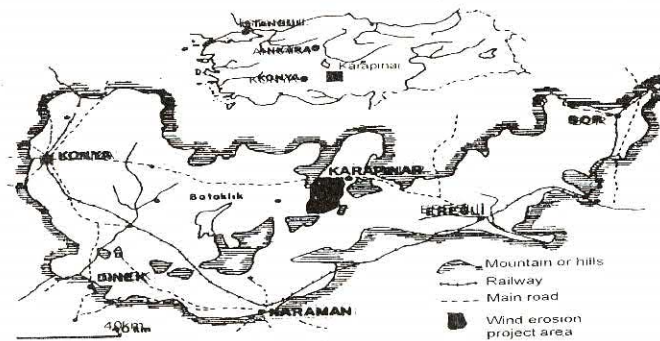


Figure 1. Location of the study area

## DISCUSSION AND CONCLUSION

With intensified land use in the Great Konya Basin, soils are becoming degraded through erosion and salinity build up. A survey conducted in 1976 (Cangir, 1998) showed small area subject to degradational processes but this has increased in a repeat study in 1996 (Table 1). The best quality lands are most severely affected. About 1% of the Basin is now currently affected and most of the damage is irreversible.

LAND QUALITY CLASS	TOTAL AREA (ha)	AREA (ha) DEGRADED IN 1976	% OF CLASS	AREA (ha) DEGRADED IN 1996	% OF CLASS
I	663,515	-		14,049	2.11
II	476,799	-		3,267	0.69
III	610,308	-		1,608	0.26
IV	498,298	-		2,929	0.59
Total (class I-IV)	2,248,920			21,853	0.97
V	15,300				
VI	518,864				
VII	1,529,579				
VIII	459,596				
TOTAL	4,772,059				

Table 1. Land quality classes in the Great Konya Basin and area subject to human induced degradation. (Degradation is estimated only for the arable lands (Classes I-IV).

The Karapınar Conservation area has now validated technology to contain wind erosion and minimize salinity build-up. One of the challenges is to transfer some of these technologies to the Konya Basin farmers. There are still other continuing constraints to sustainable land use in Karapınar, which requires yet other technologies. This deals largely with the areas under irrigation. Though the period during which the land is bare has been significantly reduced through cropping, crop residue removal and burning of straw both reduce carbon sequestration and make the land surface vulnerable to wind erosion. Minimum tillage and some straw incorporation into the soil needs to be done to build-up the organic matter status of the soils.

Biodiversity enhancement has yet to be adequately addressed. Experience is lacking and knowledge must be transferred from other parts of the world. Establishment of shallow farm ponds at strategic places would provide a water source to attract birds and other fauna. As human presence is very low at the site, it becomes an attractive refuge for wildlife.



## REFERENCES

- Cangir, C., Kapur, S., Boyraz, D. and Akça, E., 1998. The Problems of Agricultural Soils and the Strategies of Optimum Land Use in Turkey. M. Sefik Yesilsoy International Symp. on Arid Region Soils. 21-24 September 1998, Izmir, Turkey pp 464-472.
- Erine, S. 1962. On the relief features of blown sand at the Karapinar surroundings in the Interior Anatolia. Review Geographical Institute, Univ. Istanbul, 8:113-130.
- Groneman, A.F. 1968. The soils of the wind erosion control camp area, Karapinar, Turkey. Ph D. Thesis, Agric Univ, Wageningen, Netherlands, 160 pp.
- Roberts, N. 1983. Age, paleo-environmental and climatic significance of Late Pleistocene Konya Lake, Turkey. Quaternary Research. 19:154-171.

## LAND DEGRADATION AND DESERTIFICATION IN DESERT MARGINS

Paul Reich<sup>1</sup>, Hari Eswaran<sup>1</sup>, Selim Kapur<sup>2</sup>, and Erhan Akca<sup>2</sup>

<sup>1</sup>USDA Natural Resources Conservation Service, Washington DC

<sup>2</sup>Cukurova University, Adana, Turkey

### SUMMARY

The term 'desert margin' as used here is the transition zone between the typical deserts and regions where there is an adequate supply of moisture for plant growth during the warm season. Low rainfall, high evapotranspiration, and high variability of rainfall characterize the desert margins. The global area of desert margins is 15.1 million km<sup>2</sup> or 11.5% of the global ice-free land surface. In a previous study, 'desertification tension zones' where the probability of desertification is maximum were determined and a comparison with the current study, shows that desert margins are most prone to desertification. High human and animal population densities, poor or lack of land management and the low and highly erratic rainfall pattern in combination accentuate the land degradation processes.

The paper considers processes and causes of desertification in the desert margins. The country of Turkey is used as a case study. There is sufficient information to demonstrate that this is the ecosystem within the zone of susceptible dry lands that is most prone to desertification. As such it needs priority attention both from national and international institutions to develop and implement mitigating technologies. In addition, many developing countries would need financial assistance to alleviate the situation, and from a global environmental and socioeconomic point of view, this is a wise investment. Assessment and monitoring of such systems, understanding of the socioeconomic and environmental context of land management and development of national to local policies to facilitate their use are the ingredients for reducing desertification.

### INTRODUCTION

The United Nations Convention to Combat Desertification (CCD) defines desertification as "land degradation in arid, semi-arid and dry subhumid areas resulting from various factors, including climatic variations and human activities" (Middleton and Thomas, 1997). The true deserts described as being 'hyper-arid' are excluded in the definition and further, CCD also refers to the arid, semi-arid and subhumid zones collectively as 'susceptible drylands'. An Aridity Index (ratio of precipitation to evapotranspiration) is employed and drylands have a ratio between 0.05-0.65. Despite these politically correct definitions, there is still much divergence in the use of the terms. Mainguet (1999), for example, includes the true deserts in her concept of drylands.

If climate is considered as a major control of desertification processes, such processes intensify in the drier portions of the zone of susceptible drylands. In this paper, the 'desert margins' form the transition between the typical deserts and the climatically better endowed drylands. Low precipitation and high variability of precipitation characterize the desert margins in the zone of susceptible drylands. The risk of drought is probably the highest and communities in such regions are most vulnerable.

Thomas and Middleton (1994) made three observations on desertification, which are still valid. First is that available databases are still inadequate to reliably provide information on extent, severity, and changes. Second, drylands are one of the most fragile ecosystems and thus highly susceptible to land degradation and desertification. Third that desertification is a major, if not the primary cause of human suffering and misery in drylands. Some basic questions need further studies and elaboration. These (when the susceptible drylands are considered as a whole) include:

1. How does fragility of the ecosystem vary?
2. What are the desertification processes operating in different parts of the zone?
3. Is land degradation in terms of reduction in land quality a significant process at the drier ends of the zone or is desertification essentially determined by vegetation degradation?

4. What are the relative intensities and roles of climatic variability and land use pressures in desertification in the desert margins?

The purpose of this paper is to make a global assessment of desert margins, showing their geographic distribution and evaluating some of the land degradation processes operating in this sub-ecosystem of susceptible drylands. Vulnerability to desertification is considered from the point of view of population pressures and their impact on land resource stresses.

## METHODS

Reliable global databases are currently inadequate to unequivocally address this issue, however, some preliminary assessments on global and Mediterranean biophysical resources (Eswaran and Reich, 1998, 1999) enables an assessment of vulnerability of the land resource base to land degradation. The actual intensity of the desertification process is then a function of socioeconomic and other factors. A global soil and climate GIS database of Africa developed by Eswaran et al. (1999) was used to provide the biophysical resource characteristics of the desert margins of this continent. For the assessment of vulnerability to desertification, soil units were empirically assigned to vulnerability classes after excluding regions that are cold, dry, or humid as per UNEP's definition of desertification. The procedure of Eswaran and Reich (1998) employing the following considerations are used in this assessment:

- Coefficient of variability of rainfall – vulnerability increases with increasing coefficient;
- Depth of soil including presence of impermeable layers;
- Extreme levels of chemical and physical conditions, such as very high or very low pH (Lal, 1994);
- Resilience of soil – ability to recover from mismanagement (Brinkman, 1990);
- Information incorporated in soil classification term (Eswaran, 1992).

Employing the procedures indicated earlier, thematic maps (at scale 1:30 million) depicting land quality, land degradation, and desertification assessments are made of the desert margin zones of the world. Published reports of degradation (Oldeman et al., 1992) were used to validate specific locations on the map. To evaluate the number of people affected, the map of vulnerability to desertification was superimposed on an interpolated population density map developed by Deichmann (1994). Other overlays such as land cover or land use could be used to further characterize the desert margins.

## Mechanisms in desert margins

Land degradation, being the loss in land quality or the reduced ability of the land for biomass production, results from a number of processes. The processes are generally self-feeding with one being the consequence of another or accentuating a related process.

1. Anthropogenic pressures result from overgrazing, over-cultivation of marginal land, removal of biomass for fuel, and mismanagement of irrigated land. Collectively these processes strip the land of the protective vegetative cover that protects the land from wind and water erosion and crusting. A major characteristic of the desert margin is its inability to recover from such shocks in a short time frame; its resilience or the ability to restore the original biomass when conditions revert to the normal is low. Once the land cover is removed, the land is at the mercy of degradation processes. Local conditions of landform and climate determine the kind and intensity of these processes.
2. Loss of vegetation, which results in reduced evapotranspiration and an increase in albedo or the amount of radiation reflected back to the atmosphere, accelerates land surface-atmosphere feedback. Absence of cloud formation and thus rain causes a positive feedback further



reducing the ability to regenerate vegetation. Progressive decline in land cover -- banded, patchy, stippled patterns -- is an indicator of desertification.

3. Hydrological feedback occurs when the reduced ground cover results in greater runoff and decreased soil storage of moisture. Rainfall efficiency in terms of fostering vegetation production, which is typically low in these areas, is further hampered. In early stages of desertification when the shrubs are present as bands, the individual clumps may have a high biomass (Valentin and d'Herbes, 1999) but a definite decline on an area basis may be measured.
4. Climate variations, caused by large scale deforestation at distant sites or by surface temperature anomalies, also affect the above processes. A characteristic feature of rain in desert margins is that it comes in a few storms of high intensity and regional climatic variations accentuate storm intensities. In the absence of adequate ground cover, high storm intensities are very erosive.

Monitoring the extent, severity, and expansion of desertification is the most urgent and most difficult area of degradation research. This requires large investments that would be rewarded by our ability to predict and control desertification processes.

Both the vegetation and land use in the countries bordering the Mediterranean Sea clearly indicate the continuous influence of human activity for several thousand years. Some believe that deforestation and improper land use since the Classical times have led to extensive erosion and land degradation. Modern pressures on land and influx of urban migration required political action in the latter half of the last Century and the European Union responded with several projects, the most important of which is the MEDALUS or the Mediterranean Desertification and Land Use project (Brandt and Thorne, 1996). The principal goals include the understanding, prediction, and mitigation of desertification. The emphasis is on providing a methodology for addressing the desertification problem in Europe.

In the lands bordering actual deserts, such as the Sahel or the periphery of the Central Asian Deserts, the fluctuation of the climate is from arid to less arid conditions. The flux appears to have no predictable periodicity. Conditions of aridity are determined by global climate patterns. In such situations, land degradation results from humans attempting to utilize the small amounts of biomass available and from a point of view of intensity of land degradation processes, rates are low. This is in contrast with the Mediterranean or more humid semi-arid regions, where the iterative processes of land degradation contribute to aridity. In the lands bordering actual deserts, when more favorable moisture conditions prevail, vegetation re-establishes quickly or the resilience is high. In contrast, the land degradation induced conditions in the semi-arid parts of the world are different. The resilience of both the soils and vegetation is low and thus recovery is poor.

### **Global distribution**

The term 'desert margin' as used here is the transition zone between the typical deserts and regions where there is an adequate supply of moisture for plant growth during the warm season. At the periphery of deserts, there is a flux in the climatic conditions; at the borders of the Sahara, the desert conditions vary annually. In some years there may be adequate soil moisture for biomass production while in other years, drought conditions prevail. In these desert rims, there is a probability of 60% or more that strong moisture stress prevails in most years. Away from this zone, the amount of soil moisture increases permitting one grain crop cultivation in most years. In addition to the desert rim, there are three other types of transitions. First, where the desert merges with areas with winter rainfall areas or a Mediterranean type of climate and these are termed Dry Xeric soil moisture regimes (SMR) in this paper. Second, where the merger is with semi-arid regions in tropical areas (Aridic Tropustic SMR) and thirdly, to temperate areas (Xeric Tempustic) with semi-arid climates.

Within the zone of susceptible drylands the desert margins occupy the 'arid areas' and part of the 'semiarid areas' as defined by Middleton and Thomas (1997). These areas are defined on the ratio of precipitation to evapotranspiration: the arid areas have a ratio of 0.05 to 0.20 and the semi-arid, 0.20 to 0.50. The desert margins as defined in this paper occupy the arid areas and part of the semi-arid areas and table 1 provides the ratio and soil moisture regime term for some selected stations. The ratio is a simplified manner of expressing the susceptible drylands and will not equate to the soil moisture regimes employed here.

A combination of soil moisture and temperature regimes of Soil Taxonomy (Soil Survey Staff, 1999) characterizes the soil climate and table 2 provides the area occupied by the susceptible drylands combinations. The desert margins at the periphery of the true deserts or the soils with weak aridic SMR (Table 2, Fig. 1) is about 7.93 million km<sup>2</sup> or 20.6% of the desert areas. The Mediterranean region (or soils with xeric SMR) occupies 4.42 million km<sup>2</sup> and the desert margin of this ecological area where it abuts soils with aridic SMR occupies 1.98 million km<sup>2</sup> or 44.5%. The semi-arid areas of the tropics (Tropustic) occupy 20.35 million km<sup>2</sup> and the desert margins in this zone (table 2) occupy 6.30 million km<sup>2</sup> or 31% of the zone. The temperate and boreal semi-arid zones (Tempustic) occupy 10.91 million km<sup>2</sup> and the desert margin component of this is about 0.31 million km<sup>2</sup> or 5.0%. In total, the global area of desert margins is 15.1 million km<sup>2</sup> or 11.5% of the global ice-free land surface.

Country	Station	SMR	Prec. (mm)	Evap. (mm)	Prec./Evap ratio
Turkmenistan	Baram Ali	Aridic (Weak)	124	948	0.13
Chad	Massakory	Aridic (Weak)	472	1880	0.25
Niger	Tera	Aridic (Weak)	495	1752	0.28
Mali	Nara	Aridic (Weak)	483	1640	0.29
Sudan	Renk	Aridic (Weak)	520	1705	0.30
Brazil	Parau	Aridic (Weak)	572	1713	0.33
Turkey	Karapinar	Aridic (Weak)	277	679	0.41
Afghanistan	Kabul	Aridic (Weak)	303	721	0.42
Australia	Donors Hill	Aridic (Weak)	625	1483	0.42
Turkey	Konya	Aridic (Weak)	316	694	0.46
Canada	Newgate	Aridic (Weak)	265	578	0.46
Russia	Volgograd	Aridic (Weak)	364	678	0.54
Somalia	Erigaro	Aridic (Weak)	429	798	0.54
USA Oregon	Fossil	Aridic (Weak)	363	660	0.61
Iran	Bebbehban	Tropustic (Xeric)	337	1313	0.26
Senegal	Bakel	Tropustic (Aridic)	494	1785	0.28
Upper Volta	Tougan	Tropustic (Aridic)	602	1842	0.33
Mali	Kogoni	Tropustic (Aridic)	542	1638	0.33
India	Kurnool	Tropustic (Aridic)	669	1705	0.39
Sudan	Drilling	Tropustic (Aridic)	680	1496	0.45
India	Landur	Tropustic (Aridic)	757	1590	0.48
Kenya	Marmanti	Tropustic (Aridic)	847	1533	0.55
Nigeria	Yelwa	Tropustic (Aridic)	970	1700	0.57
Chad	Moissala	Tropustic (Aridic)	1116	1607	0.69
Algeria	Baghar	Xeric (Dry)	408	811	0.50
Turkey	Beypazari	Xeric (Dry)	390	759	0.51
USA California	Beaumont	Xeric (Dry)	432	825	0.52
Morocco	Tissa	Xeric (Dry)	546	1009	0.54
Turkey	Adana	Xeric (Dry)	639	992	0.64
Turkey	Menemen	Xeric (Dry)	627	890	0.70
Turkey	Eimahi	Xeric (Dry)	543	741	0.73

Table 1. Soil moisture regime and some climatic variables for representative stations of desert margins.

SUSCEPTIBLE DRY LANDS:	TROPICAL	TEMPERATE	BOREAL	TOTAL
ARID	1,122	5,820	983	7,925
MEDITERRANEAN		3,625	790	4,415
SEMI-ARID	20,348	7,352	3,555	31,255
Sub-humid	4,799	1,778	1,189	7,766
TOTAL	2,269	18,575	6,517	51,361

Table 2. Susceptible drylands in soil climate classes ('000 km<sup>2</sup>)

The differences in the causes, intensities, and consequences of land degradation processes in the different desert margins of the world must be understood to better manage them. In addition to soil moisture conditions, soil temperature also influences land degradation through its influence on land use and land cover. Desert margins (DM) can be differentiated through their soil climate attributes as shown in table 3.

Desert margins of:	TROPICAL	TEMPERATE	BOREAL	TOTAL
ARID	1,122	5,820	983	7,925
MEDITERRANEAN		1,976		1,976
SEMI-ARID	4,838	315	1	5,154
TOTAL	5,960	8,112	985	15,058

Table 3. Soil climate classes of desert margins ('000 km<sup>2</sup>)

The arid DM borders the true deserts. The Mediterranean DMs have winter rains while the semi-arid DMs have rains during the warm periods when temperature is conducive to plant growth. In the tropical DMs, the difference in the soil temperature between winter and summer equivalent months is <5°C; the temperate regions have a mean annual soil temperature >8°C while in the boreal regions, the mean annual soil temperature is less than the biological zero of 5°C. By this approach, the DMs occupy about 15 million km<sup>2</sup> or 11.5% of the earth's ice-free land surface.

The region around the Mediterranean Sea has extensive areas of desert margins. Despite the exploitation of these lands for several centuries, their fragility has become of concern only recently. Table 4 shows the extent of DMs in the countries of the Mediterranean region. Iraq, Lebanon, and Syria have large areas of DMs. The North African countries have much smaller extents due to the large areas of true deserts. About half the land mass of Turkey qualifies as desert margins and the advent of desertification is very prominent there.

### Dominant processes

There are many processes that initiate or are responsible for land degradation and these can operate individually, simultaneously, successively, or in varying combinations. One set of processes or conditions, unless checked, frequently triggers others. To implement mitigating actions, it is important to evaluate the processes and address each, or a combination, in an organized manner. A clear understanding of processes, interactions and consequences is necessary to have meaningful results.



COUNTRY	DESERT MARGIN LAND AREAS (km <sup>2</sup> )				TOTAL LAND AREA	% DM
	ARID	MEDIT.	SEMI-ARID	TOTAL DM		
FRANCE		52		52	543,829	0.0
GREECE		35,276	3,141	38,417	105,198	36.5
IRAQ	209,394	38,084	100,265	347,743	440,929	78.9
ITALY		10,522	97	10,619	296,659	3.6
JORDAN	17,528	20,187		37,715	89,403	42.2
LEBANON	2,049	6,202	564	8,815	10,203	86.4
LYBIA	42,821	28,901	13,812	85,534	1,615,929	5.3
MOROCCO	38,903	107,911	1,655	148,469	411,864	36.0
PORTUGAL		23,656		23,656	93,253	25.4
SPAIN	8,242	152,129		160,371	486,111	33.0
SYRIA	59,463	95,257	3,422	158,142	193,918	81.6
TUNISIA	13,310	27,394		40,704	155,325	26.2
TURKEY	117,781	312,352	254	430,387	790,964	54.4
TOTAL	509,491	857,933	123,210	1,490,634	5,233,585	28.5

Table 4. Desert margin areas in countries of the Mediterranean region.

Table 5 is an outline of dominant causes and their relative consequences in the three kinds of desert margins. The desert margins of the Sahel, the Mediterranean region, and the Asian (particularly Central Asia) are distinct entities in the context of their socioeconomic status, land use systems, and land degradation pressures. For example, land resource impacts of tourism is a major determinant of the quality of land and water resources in most of the Mediterranean countries. Overgrazing perhaps is an immediate problem to reckon with in the Sahel while, subsistence farming hurts much of Asia.

Even if the land users recognize that their land is being degraded, poverty prevents them from addressing the conditions in most of the countries and particularly in the Sahel and in Asia. It is perhaps true to suggest that unless poverty is addressed land degradation would remain the character of subsistence farming. In the poorer countries, demands on the constrained national budgets reduce the political will to initiate or participate in any programs. This is also a poverty-related issue. Feeding and clothing the population and ensuring minimal civil strife is the challenge in developing countries, which prevents them from mounting conservation programs.

In low-income countries, poverty feeds on population growth. Eswaran et al., (1999, 2000) and Beinroth et al., (2000) have demonstrated the population supporting capacity globally and for some countries of Asia. Many of the countries require large investments with modern technologies to produce the food for their populations. A combination of the small farm size and the resource poor conditions of the farmers, are the basic ingredients for land degradation. Further, as much of the land of reasonable quality is already used, sloping lands and swamps are under onslaught with predictable consequences.

### Desert margins of Turkey

Desert margins occupy about 54.4% of the land area of Turkey (Table 4). Figure 2 shows the distribution of the desert margins in Turkey. According to the definitions, the desert margins occupy much of the Anatolian Plateau, the Mediterranean coast and the GAP area extending into Iran on the east and Syria in the south. The Konya Basin, being aridic, is excluded. The Black Sea coastal zone has high rainfall and is also excluded from the region considered as desert margins. Dogan (1998) estimates that about 83% of the whole country suffer from wind or water erosion problems. In addition, there are other soil-related constraints, such as salinity/alkalinity and hydromorphism that reduce the agricultural producing capacity. Most of these constraints are in the desert margin zones. Productivity is further hampered by the fact that the rural poor do not have the means or the technology to appropriately manage such systems in a sustainable manner.

The low-input agricultural systems in the desert margins promote land degradation and desertification. The issue is land management or the lack of appropriate management systems.

Where irrigation facilities have been developed, productivity is significantly enhanced during an initial phase. With time, there is a slow but systematic build-up of salinity due to inadequate drainage systems. Productivity decline then sets in. When irrigation is not available, grazing with small ruminants is the traditional land use. In good years, when rainfall is adequate, one crop of low-yielding grain is obtained. Managed pastures are few. Thus, over-grazing leads to erosion and a general change in vegetation with hardy weeds replacing edible shrubs.

All the causes of desertification (Table 5) operate in the desert margins of Turkey and good examples of each can be documented. As this eco-zone occupies more than half the country, policies based on detailed assessments are urgently needed to reduce land degradation pressures and bring some semblance of sustainability.

Although soil surveys exist in many of the areas of the desert margins in Turkey, the information in combination with information of other resources is not widely used for resource assessment. The condition of land resources is not monitored, as in most countries of the world, and consequently there is no appreciation of both the state and the degradation of the resource base. The norm is to try to respond when there are desperate calls for help from land users. Preliminary studies (Cangir, et. Al., 2000) clearly demonstrate the intensity of land degradation processes in the country.

## CONCLUSION

Desert margins, from a biophysical and a socioeconomic point of view, form an unique ecosystem which has not been the subject of detailed studies largely because they occur in the developing countries of the world. However, due to population increases and demands for agricultural land, this last frontier of land is invaded and currently being stressed. This is the ecosystem within the zone of susceptible dry lands that is most prone to desertification. Eswaran et al. (2000) identified 'tension zones', which are ecosystems that are most prone to desertification largely due to high population density. Most of the tension zones occur in the desert margins.

Identification and location of desert margins in countries, if followed-up with appropriate policy decisions and action plans, will help to:

1. Enable the judicious use of land resources through protection and preservation of fragile systems, sustainable production on the better endowed areas, and targeting of research and development; ensure a balanced land use through appropriate land allocation for forestry, wild-life, agriculture, and urban use; and promote a more rational use of the scarce water resources;
  2. Buffer the socioeconomic stresses and reduce economic instability and political unrest in a country as a whole; reduce pressures on affected areas and promote sustainable development outside the affected areas;
  3. Alleviate pressures on biodiversity and promote environmental integrity;
  4. Help reduce the iterative processes leading to global climate change through increased land cover and as a result, enhance carbon sequestration; and
- Assure food security and a better quality of life for most of the people.

DOMINANT CAUSES	MANIFESTATION OF PROCESSES OF LAND DEGRADATION		
	SOUTH OF SAHARA	MEDITERRANEAN	ASIAN
Tourism	Not significant	High economic returns from tourism are placing pressures directly and indirectly. Coastal ecosystems are increasingly polluted and resort areas are threatened.	Not significant
Urbanization	Not significant	Urban sprawl not only consumes high quality lands but pose problems with waste management.	In the developing countries, resource consumption results in use of agricultural lands for dwellings; urban sprawl is also a problem.
Increasing animal population	Increasing population of large and small ruminants, in most cases beyond the carrying capacity of the land, is a major degrader of the land. Substitution of small for large ruminants is an indicator of decline in land quality manifested by the inability of the land to produce biomass of necessary quality and quantity. Removal of land cover and hoof-prints become locations for accelerated erosion by wind and water. Demand for meat by urban centers, absence of grazing lands and resource consumption of arable lands are linked processes.		
Increased human population	DM zones have high population density with high population growth rates. In many countries, population has exceeded the carrying capacity of the land. As much of the land of good quality is also used, grazing and agriculture has moved to the more fragile ecosystems, locations where the land is rapidly desertified. Populations in the DMs further have high rates of illiteracy, lack appropriate infrastructure and support services to implement programs of land management, and are frequently ignored in national development strategic programs.		
Heritage and cultural values	Though different in the countries, the resource poor land users rely on cultural values and social traditions to appease themselves of poverty due to an absence of any viable recourse. National programs frequently interpret this as a resistance to change and thus explain their inability to institute sustainable land management.		
Poverty	Caught in the cycle of subsistence agriculture, land users have no purchasing power to invest in options and no support services to assist them.	Not a dominant factor or of the same magnitude in the other regions, except in a few North African countries.	As in the arid areas, farmers are caught in the poverty spiral. They lack capital to invest in technologies. Social programs generally designed to appeal to moral issues rather than entrepreneurial skills.
Political will	Economic status of countries prevents any concerted effort. In general only few countries demonstrate political commitment.	Political will and desires are resulting in good programs; however, desertification is generally not considered as immediate threat.	Population pressures and economic priorities of countries permit only casual attention. In general only few countries demonstrate political commitment.

Table 5. Socioeconomic factors as causes of desertification



## REFERENCES

- Beinroth, F.H., H. Eswaran and P. F. Reich. 2000. Land quality and food security in Asia. In Press. Proc. Of 2<sup>nd</sup> Intl. Workshop on Land Degradation, Thailand.
- Brandt, J.C. and Thornes, J.B. (Eds.) 1996. Mediterranean Desertification and Land Use. John Wiley and Sons, New York. 554 pp.
- Brinkman, R. 1990. Resilience against climate change. In, "Soils on a Warmer Earth", (Eds. Scharpenseel, H.W., M. Shoemaker, and A. Ayoub). Elsevier, Amsterdam. 51-60.
- Cangir, C., S. Kapur, D. Boyraz, E. Akça, and H. Eswaran 2000. An assessment of land resource consumption in relation to land degradation in Turkey. In Press.
- Deichmann, U. 1994. A medium resolution population density database for Africa. Unpublished document of author. Dept. of Geography, Univ. California, Santa Barbara, Ca.
- Dogan, Orhan. 1998. Sustainable policies for soil resource management in Turkey. Publ. Directorate of Rural Services. Publ. No. 212. 24pp.
- Eswaran, H. 1992. Role of soil information in meeting the challenges of sustainable land management (18th Dr.R.V. Tamhane memorial lecture). J. Indian Soc. Soil Sci. 40:6-24.
- Eswaran, H. and P. Reich. 1998. Desertification: a global assessment and risks to sustainability. In: Proc. of 16<sup>th</sup> Intl. Congr Soil Science, Montpellier, France. CD ROM
- Eswaran, H. and P. Reich. 1999. Impacts of land degradation in the Mediterranean region. Bulgarian J. of Agric. Sci. 5:14-23.
- Eswaran, H., F. Beinroth, and P. Reich. 1999. Global land resources and population supporting capacity. Am. J. Alternative Agric. 14:129-136.
- Eswaran, H., P. Reich, and F.H. Beinroth. 2000. Global desertification tension zones. In press. International Soil Conservation Organization Conference, Purdue Univ. Indiana.
- Lal, R. 1994. Tillage effects on soil degradation, soil resilience, soil quality, and sustainability. Soil Tillage Res. 27:1-8.
- Mainguet, M. 1999. Aridity, Droughts and Human Development. Springer-Verlag, Berlin, 301 pp.
- Middleton, N.J. and D.S.G. Thomas. (Eds.) 1997. World Atlas of Desertification. 2<sup>nd</sup>. Edition. Publ. By UNEP. Arnold, London. 182 pp.
- Oldeman, L.R., R.T.A. Hakkeling, and W.G. Sombroek. 1992. World map of the status of human-induced soil degradation: an explanatory note. Wageningen, Netherlands: International Soil Reference Center. 34 pp.
- Soil Survey Staff. 1999. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. 2<sup>nd</sup> edition. U.S. Dept. Agric. Handbook 436. Govt. Printing Office.
- Thomas, D.S.G. and N.J. Middleton. 1994. Desertification: Exploding the Myth. Wiley, Chichester.
- Valentin, C., and J.M. d'Herbes. 1999. Niger tiger bush as a natural water harvesting system. Catena, 37:231-256.

# THE EFFECTS OF DIFFERENT STALK TILLAGE AND SEEDBED PREPARATION METHODS IN COTTON FARMING UPON SOME PHYSICAL CHARACTERISTICS AND AGGREGATE STABILITY OF THE SOIL

Tuna Doğan<sup>1</sup>, Gönül Aydın Bilgehan<sup>2</sup>, İbrahim Yalçın<sup>1</sup>

<sup>1</sup> Department of Agr.Machinery, Faculty of Agriculture, Univ. of Adnan Menderes, Aydın/TURKEY.

<sup>2</sup> Department of Soil Science, Faculty of Agriculture, Univ. of Adnan Menderes, Aydın/TURKEY.

## ABSTRACT

Aydın is one of the cities where cotton farming is applied commonly. In Aydın, to practice the traditional tillage method in seedbed preparation and to obtain the optimum soil condition, the soil is over cultivated and crushed.

Due to direct physical effects such as ploughing, seedbed preparation and cultivation, the structure of noncultivated soil display a great tendency to decay. Therefore, the effects of two tillage and seedbed preparation methods, (namely the traditional and the reduced tillage methods) have been examined in terms of their effects upon the soil structure when the cotton stalks are mixed and not mixed with the soil.

The results of the research have shown that the aggregate strength and size, which indicate the soil structure, are badly affected when the traditional method is applied.

## INTRODUCTION

Soil structure can be evaluated by determining the extend of aggregation and stability of the aggregates. These characteristics change with tillage practices a cropping system, they play a significant role in affecting soil-plant relationship.

Problems, which are related to the soil structure, increase in natural soils when they are cultivated. Three causes of this are;

1-In soils, which are cultivated for vegetal purposes, destructive effects, increase and accumulate year by year due to the use of tractors and over dispersing tillage equipment. The destruction in the condition of the natural vegetation causes the soil to become weak against the destruction of the rain.

2-The mechanization process involving in soil loosing increases the air circulation within the soil and this increases the oxidation of the polymer complex which help the soil structure resistance.

3-Vegetal production applications at present decrease the production rate of products, which help to improve the soil structure. Breakdown of organic matters getting rapidly result in decrease of soil structure stability. (Brafield and Miller, 1954).

The frequent tillage operations in the traditional method affect the soil negatively. Over tillage operations, not only increase the cost of the product but also disaggregate the organic matters in the soil. Production of some crops, which require over tillage, such as cotton, the soil aggregates are easily decomposed. Such decompositions cause soil erosion (Kayışoğlu et al., 1996).

The changes occurring in the soil structure due to tillage mainly depend on the quantity of the soil moisture. Because of the soil contraction caused by over moisture in the soil. The soil structure is badly effected. In the case of soil compaction with minimum water content, crumbled structure with small pore forms. Then, this results in a reduction in the quantity of large pores, in total quantity of pores, in permeability and, at the and, in crop quantity (Utkayeva et al., 1986).

In this study, it was tried to determine the effect of two different seedbed preparations on soil structure in a plot where cotton stalks are mixed or not mixed with soil.

## MATERIALS AND METHODS

### MATERIALS

Soils on which the research was carried out are one of the parts belonging to the Great Meander Seri which is stretched out in the valley (Bilgehan Aydın, 1998).

Table 1. Result of the physical and chemical analysis of soil series subject to the study (Bilgehan Aydın, 1998).

Depth (cm)	Sand %	Clay %	Silt %	Texture	Horizon	pH (H <sub>2</sub> O)	S.S.C. (%)	C.C. (%)	Organ. Matter (%)	CEC (me/100 gr.)	KDK (me/100 gr.)
0-27	58.4	13.6	28	Sandy- loam	Ap	7.60	0.060	12.5	0.94	0.48	15.29
27-50	56.4	13.6	30	Sandy- loam	2C1	7.84	0.040	13.4	0.54	0.52	16.07
50-80	38.4	17.6	44	Loam	3Ab	7.83	0.040	12.4	1.07	0.74	17.31
80-100	34.4	23.6	42	Loam	3C1	8.04	0.045	12.3	0.67	1.04	18.21
100-150	38.4	21.6	40	Loam	3C2	8.12	0.035	13.3	0.67	0.78	16.90

S.S.C.: Soluble salt content C.C.: %Calcium carbonate

Some characteristics of the machines and equipments applied in various tillage methods are shown in Table 2.

Table 2. Some characteristics of machines and equipments.

Tractor and Machines	Working Width (m)	Working Depth (cm)	Working Speed (km/h)
Stalk cutting machine	1.40	-	3.68
Plough (4 body-only share)	0.90	25	3.08
Disc harrow (Tandem, Mounted)	2.20	10	7.59
Moulboard Plough	0.98	25	7.08
Chisel	2.80	30	3.91
Disc harrow (Tandem, Trailed)	2.20	10	7.36
Broadcaster (twin discs)	8.80	-	7.19
Field sprayer	7.10	-	2.01
Field scrubber	2.40	-	6.72

## METHODS

In this research, the cotton stalks were cut in 10 cm depth by moulboard without plough, and it was thought that those stalks could be picked by a straw baler (Yumak and Eveim, 1992; Anonim, 1995). In addition to this, the stalks were cut into pieces by stalk cutting machine and disc harrow.

Because of different tillage methods were applied on the plots with stalks and without stalks, the field on which the research was carried out had been designed split-plot pattern (Açıkgöz, 1993). Plot lengths were taken 25 meters and 8 rows of cotton seeds were planted on each variant. Between the variants 5 meters of vacant land was left and similarly 10 meters of land was left without cultivating between the repetitions so that the tractor could return easily.

Two different tillage and seedbed preparation methods applied in the research;

### Traditional Tillage Method:

Moulboard plough(autumn)+Moulboard plough+Trailed Disc harrow(x6)+Broadcaster+Field sprayer+Trailed Disc harrow+Scrubber

### Reduced Tillage Method:

Moulboard plough(autumn)+Chisel+Mounted disc harrow+Broadcaster+Field sprayer+ Mounted disc harrow +Scrubber

Evaluations are made according to 6 different methods consisted of various procedures (Table3).



Table 3. Procedure continuation of the methods.

PROCEDURE 1	PROCEDURE 2	METHODS
Stalk Cutting Machine (Stalk cutting)	Traditional Tillage Method	Method 1
	Reduced Tillage Method	Method 2
Disc harrow (Stalk cutting)	Traditional Tillage Method	Method 3
	Reduced Tillage Method	Method 4
Plough+Straw baler (Cutting and picking)	Traditional Tillage Method	Method 5
	Reduced Tillage Method	Method 6

The analytic method was used in obtaining the results containing time etudes. Throughout the tractor's operation united with the equipments, the time measurements for each procedure were done and values of effective work time requirements were found out. The results of this research were evaluated on the basis of the standard plot which has 150 m length, 66,67 m width and 1 ha size and was used in researches by Uçucu (1981) and Yalçın and Uçucu (1999). While calculating the values effective work time requirements in the fifth and sixth methods, the values related to the straw baler which could be referred in the application of the method were obtained from the literature (Evcim, 1990).

56 disturbed and undisturbed soil samples were taken from 6 different soil tillage practiced and non-tillage plots in research field at 4 different soil strata, namely 0-10, 10-20, 20-30 and 30-40 cm depths (2 repetition). Then, following analyses were carried out;

Aggregation index: to determine the resistance of aggregates to water for soil samples sieved with 8 mm sieve (Yeşilsoy and Berkman, 1974).

Total porosity (Vomocil, 1965) and volume weight (G.R.Blake, 1965).

By sieving; using Retsch brand sieve, which is capable of sieving the materials of 19 mm, 4,5 mm, 2,36 mm, 2 mm, 1 mm and less than 1 mm diameter. During analysis, it was run for 4 minutes.

Throughout the evaluation of all data obtained out of laboratory and plot tests the Turkish Statistical Software "TARİST" was used (Açıkgöz vd., 1994).

## DISCUSSIONS

Structural and some structure related physical soil analysis were carried out for soil samples that were taken from research field. The results are given Appendix 1.

Aggregation index refers to the resistance of aggregates to water. When these values are examined, it can be seen that 3 practices, where reduced tillage were applied, at first 0-10 cm stratum have greater aggregation index values than other 3 practices where traditional tillage were applied at first 0-10 cm stratum. This shows that surface soils are more crumbled by traditional tillage methods. Since the data at hand are the results of just 1-year trial, the differences seem too little in magnitude. But, as the research continues, the differences are expected to be clearer.

If total porosity values and volume weights are examined, one can see that volume weight values of traditional tillage applied practices at 0-10 cm stratum are less than that of reduced tillage applied practices. Volume weight values generally increase from surface to deeper strata. The plot of non-tillage has greater volume weight values than others. At the strata with higher volume weight values, total porosity values decrease as expected. Due to intense soil tillage, higher volume weight values below surface are generally encountered throughout Meander Valley.

In regards of dry sieving results, before tillage and methods used make no significant differences (Table 4). On the other hand, at 0-10 cm strata, sum of weight percentages of soil aggregates of 2 mm or below is more than 50 % for all methods. But, as a result of variance analysis between dry sieving values of different methods, F values at 5 % and 1 % levels are statistically in significant.

Table 4. Dry sieving results at different depths before and after soil tillage (%).

Methods	Depth (cm)	19> (mm)	9-4.5 (mm)	4.5-2.36 (mm)	2.36-2 (mm)	2-1 (mm)	1< (mm)
Before tillage	0-10	2.22	19.34	18.31	4.50	13.07	42.51
	10-20	6.54	41.60	15.41	2.91	9.44	24.32
	20-30	5.49	43.84	14.49	3.32	8.23	24.58
	30-40	2.72	40.78	15.86	3.14	9.48	27.98
1	0-10	2.40	21.80	14.84	3.09	13.33	44.50
	10-20	4.71	33.18	16.65	3.40	12.56	29.46
	20-30	5.09	35.42	15.69	3.05	11.52	29.20
	30-40	4.63	36.65	19.29	3.63	12.03	23.72
2	0-10	4.59	20.58	14.28	3.44	11.91	45.17
	10-20	1.32	30.38	16.03	3.11	12.40	36.69
	20-30	5.56	28.68	16.47	3.48	12.11	33.61
	30-40	8.36	39.48	16.01	3.57	10.25	22.28
3	0-10	1.09	26.07	18.21	3.77	15.78	35.04
	10-20	6.83	27.09	16.58	3.41	11.96	34.04
	20-30	9.12	37.57	17.88	3.42	11.59	20.38
	30-40	13.91	41.21	15.90	2.69	9.04	15.64
4	0-10	4.27	24.51	14.26	3.03	11.18	42.70
	10-20	4.03	31.48	17.07	3.41	12.71	31.26
	20-30	1.53	27.19	20.72	4.03	13.93	32.56
	30-40	10.26	35.89	16.06	2.98	9.57	25.20
5	0-10	2.78	24.85	15.11	3.34	12.69	41.19
	10-20	7.06	34.67	16.38	3.25	11.42	27.17
	20-30	2.00	35.07	19.42	3.75	12.95	26.76
	30-40	5.33	41.58	19.38	3.28	10.53	20.87
6	0-10	3.11	22.66	14.17	3.04	11.73	45.49
	10-20	2.06	32.28	17.03	3.28	12.31	32.26
	20-30	7.60	32.04	18.37	3.31	11.60	18.04
	30-40	5.17	40.97	19.34	3.33	10.25	20.89

Intense soil tillage practices for seedbed preparation for, especially, cotton and second crop are a major problem in the Valley, because they result in crumbling of aggregates and decrease in their resistances. Moreover, that the valley soils contain less amounts of clay, organic matter and lime, which supports aggregate formation, and high amounts of sodium in some places is another major problem which decreases aggregate formation and resistance. Therefore, since maintaining physical productivity is of great importance, lessening the intense soil tillage in the Valley is indispensable in terms of both economy and soil conservation.

Effective work time requirements for methods and their statistical groups are given in Table 5.

Table 5. Effective work time requirements of methods.

Methods	Effective work time		Statistical Groups
	TPTh/ha*	MPTh/ha**	
1	12.62	12.62	B
2	8.51	8.51	C
3	10.76	10.76	C
4	6.65	6.65	D
5	15.47	15.47	A
6	11.36	11.36	B
	LSD(%5)=1.377	LSD(%5)=1.377	

\*TPTh/ha: Tractorpower time h/ha

\*\*MPTh/ha: Manpower time h/ha

As the Table 5 implies, in terms of effective work time requirements by methods depending on machinery, the most suitable method is the Method-4. Generally, effective work time requirements of reduced tillage methods are less than that of the traditional tillage methods.

Considering that different methods have no significant effect on soil characteristics and structure in respect of the results at hand, one can say that reduced tillage methods, which are more profitable in terms of effective work time requirement, can be employed without any hesitation.

## REFERENCES

- Bradfield, R., Miller, R.D. (1954) Soil Structure. Transaction of the V. International Congress of Soil Sci. 1, 131-145.
- Blake, G.R., (1965) Methods of Soil Analysis. Part I. 371-373.
- Vomocil, J.A. (1965) Methods of Soil Analysis. Part I. 299-314.
- Yeşilsoy, M.Ş., Berkman, A. (1974) Islak Eleme Yöntemi İle Topraklarda Agregasyon İndeksinin Saptanması. Çukurova Üniversitesi, Ziraat Fakültesi Yıllığı. 1-2, 95-110.
- Uçucu, R. (1981) Buğday ve Arpa Hasat-Harmanında Uygulanan Değişik Sistemlerin Ege Bölgesi Koşullarında İş Başarıları, İşgücü Gereksinimleri ve Maliyetleri. Doçentlik Tezi, E.Ü.Ziraat Fakültesi, İZMİR.
- Utkayeva, V.F., Sponzhinkov, P.M., Shchepot'yev, V.N. (1986) The Compacting Effect of Agricultural Equipment on Soil Structure. Translated From Pochvovedeniye, 2:54-62.
- Evcim, Ü. (1990) Tarımsal Mekanizasyon İşletmeciliği ve Planlaması Veri Tabanı. Ege Üniversitesi Ziraat Fakültesi Yayınları, 495, İZMİR.
- Yumak, H., Evcim, Ü. (1992) Pamuk Saplarının Balyalanması Olanakları. Tarımsal Mekanizasyon 14.Ulusal Kongresi Bildiri Kitabı, S:223-231, SAMSUN.
- Açıkgöz, N. (1993) Tarımda Araştırma ve Deneme Metodları (III.Basım). Ege Üniversitesi Ziraat Fakültesi, 478, İZMİR.
- Açıkgöz, N., Akkaş, M.E., Moghaddam, A. ve Özcan, K. (1994) PC'ler için veritabanı Esaslı Türkçe İstatistik Paketi:TARİST. E.Ü.Ziraat Fakültesi, İZMİR.
- Anonim. (1995) Ziraî Mücadele Teknik Talimatları. T.C. Tarım ve Köyişleri Bakanlığı Koruma ve Kontrol Genel Müdürlüğü, Cilt-2, ANKARA.
- Kayıoğlu, B., Taşeri, L., Bayhan, Y. (1996) İkinci Sınıf Toprak İşleme Aletlerinin Toprağın Bazı Fiziksel Özellikleri ve Agregat Stabilitésine Etkisi. 6.Uluslararası Tarımsal Mekanizasyon ve Enerji Kongresi Bildiri Kitabı, 594-603, ANKARA.
- Bilgehan Aydın, G. (1998) ADÜ Ziraat Fakültesi Araştırma ve Uygulama Çifliğı Topraklarının Bazı Strüktür Özellikleri. Ege Bölgesi 1.Tarım Kongresi, 2.Cilt, 478-485, AYDIN.
- Yalçın, İ., Uçucu, R. (1999) Comparison of Different Tillage and Sowing Techniques Applied in Cotton Farming in Terms of Time Requirements and Energy Consumptions. 7<sup>th</sup> International Congress on Mechanization and Energy in Agriculture, ICAME'99, p.332-337, ADANA.



Appendix 1. Structure and some physical analysis results for soil samples.

Methods	0-10cm						10-20cm						20-30cm						30-40cm					
	HA	P	OAC			AI	HA	P	OAC			AI	HA	P	OAC			AI	HA	P	OAC			AI
			Pr.+Ag	Pr	AI				Pr.+Ag	Pr	AI				Pr.+Ag	Pr	AI				Pr.+Ag	Pr	AI	
1	1.45	49.11	0.202	0.121	2.24	1.56	47.86	0.198	0.113	1.63	1.43	53.16	0.248	0.117	2.93	1.53	48.38	0.152	0.1099	1.03				
2	1.48	50.23	0.213	0.110	1.74	1.50	50.49	0.169	0.116	1.26	1.44	50.85	0.156	0.108	1.47	1.54	46.48	0.176	0.1102	1.66				
3	1.44	50.77	0.247	0.115	2.31	1.48	54.42	0.376	0.135	3.31	1.56	52.34	0.264	0.117	2.46	1.51	52.53	0.199	0.1082	2.20				
4	1.44	47.69	0.202	0.109	1.29	1.48	48.12	0.176	0.107	1.73	1.49	49.35	0.193	0.127	1.50	1.56	48.18	0.195	0.1098	1.34				
5	1.40	53.73	0.148	0.116	1.15	1.49	50.94	0.184	0.107	1.21	1.58	47.65	0.171	0.109	2.19	1.50	51.91	0.222	0.1099	1.55				
6	1.55	48.58	0.186	0.131	1.90	1.53	50.76	0.216	0.126	1.41	1.56	50.26	0.159	0.119	0.91	1.62	49.29	0.174	0.1111	1.09				
Before Tillage	1.55	50.63	0.243	0.109	2.79	1.63	50.18	0.181	0.104	1.31	1.66	46.84	0.339	0.117	3.58	1.62	49.44	0.212	0.1268	1.87				
HA: Bulk density			P: Porosity			OAC: Mean weigh diameter																		

# THE IMPACT OF LAND USE CHANGES ON NATURAL VEGETATION ALONG THE COASTAL ZONE BETWEEN EDREMIT AND KÜÇÜKKUYU (NW TURKEY)

Recep EFE

Department of Geography, Fatih University, İstanbul-Turkey  
Tel: 212 889 11 85, Fax: 889 08 32, e-mail: [recepta@fatih.edu.tr](mailto:recepta@fatih.edu.tr)

## ABSTRACT

The coastal zone between Küçükkuyu and Edremit has special value from the viewpoint of biodiversity due to the variety of plant assemblages demonstrated. Anthropogenic factors play an important role in the degradation of natural vegetation (i.e., land use practices have changed in the last two decades along the coastal zone in the Edremit area). In particular, these changes have accelerated over the last five years (between 1995-2000). New settlements were and are being established on land that was once used for agriculture. Natural vegetation has been cleared to make room for the construction of second homes and vegetative cover is under heavy urbanization and touristic pressure throughout the northern part of the Gulf of Edremit. Locally dominant species such as *Olea oleaster* and *Pinus brutia* are the major plants that have been affected by on-going human interventions in the area.

## INTRODUCTION

Turkey is one of the richest countries in the world regarding the biodiversity of its flora. The number of plant species exceeds 10,000 (including subspecies and varieties). The number of taxa of Turkish flora (all of the steps in the plant hierarchy such as family, genus, species, subspecies and variety) is closer to the number of taxa found represented in all of Europe (Gemici *et al.*, 1992). The Gulf of Edremit has been populated for thousands of years (Ramsay 1890, Balcıoğlu 1937, Derin 1968, Stewig 1968). Issues of contemporary environmental change in the Mediterranean ecosystem and their association with desertification remain controversial in many respects due to their multifaceted social and environmental dimensions. Desertification is described by the UN Convention to Combat Desertification (CCD) as "land degradation in arid, semiarid, and dry subhumid areas resulting from various factors, including climatic variations and human activities." In this context, land includes the soil and water resources, as well as natural vegetative cover upon which rural agricultural livelihoods are dependent. Degradation implies a reduction of the resource potential by one or a number of processes operating on the land (Middleton and Thomas 1997). One study has defined desertification in this context as "an effectively permanent decline in the rate at which land yields agricultural products under a given management system" (Abel and Blaikie 1989: 113). This study has characterised the loss of biodiversity plus soil erosion associated with the intensification of land use change over the last thirty years in the Gulf of Edremit and its environs.

## Geography and physical characteristics

The study area is situated on Turkey's western coast. It extends from Küçükkuyu eastward to Altınoluk, Güre, Akçay and Edremit. It is located in the Aegean region geographically and the Mediterranean region phytogeographically. The Gulf area has a Mediterranean climate with a mean annual precipitation rate of 660 mm, the majority of which falls between October and March. The area experiences two seasons: wet mild winters, and dry hot summers, which are the main characteristics of the Mediterranean climate. Winter, the low sun period between October and April, is wet; and the summer period between May and October is dry. Only 3.5 percent of total annual precipitation occurs during the summer period. The average annual temperature is 15.7 °C and summer temperatures rise to 30 °C in July and decrease to 6 °C in January. This temperature regime is found only along the narrow coastal zone. The slopes and higher parts of the Kaz Mountains are cooler in summer and colder in winter.

Tropical air masses, which come from the south, are influential concerning local climate. The Kaz (İda) Mountains on the north of the Bay of Edremit lie in an east-west direction, and serve to block the cooler air masses coming from north. Prevailing winds from the southwest bring wet air

from the Mediterranean and Aegean seas. Soil types include the Inceptisols and Entisols (whose horizons are not well developed).

Relatively short rivers rise from the Kaz Mountains, drain the area, and flow to the Aegean Sea. The Mihli, Koca, Manastır, Kuru, and Çehiz rivers are the main water courses and flow down the steep slopes of the Kaz mountains. These rivers transport run-off and soil materials, and deposit them in the lowlands forming alluvial fans and small deltas. The coastal plain to the east of Ilıca is joined to the Edremit plain. The rolling hills on the north of Küçükkuyu developed on sedimentary rocks belonging to the Upper Miocene. There are igneous rocks on the east that form the small hills. Metamorphic rocks are represented by marble and schist on the slopes of the Kaz Mountains.

## MATERIAL & METHODS

This paper examines the interactions across scales and across time between changes to vegetative cover and increasing human intervention. A variety of information and analytical methods are employed, including analysis of air photos and field surveys of vegetation change. Topographical, vegetation, and forest management maps were used to characterise the distribution of natural vegetation in the past. The present situation in the field was studied through direct observation. Plant samples were collected from the study area in different seasons between 1998-2000. Photographs were taken in the summer and winter seasons in order to observe the difference in terms of deciduous and evergreen plants. Vegetation studies were carried out along 5-km transects starting from the sea. Sampling was based on 20x20 study sites located between the Aegean Sea and the Kaz Mountains. Plants were collected from the area during summer of 1999 and the winter of 2000. Climatological data was taken from the General Directorate of Meteorology.

## DISCUSSION

Three types of vegetative formations were observed in the study area. Forest formations are widespread on the slopes, and maquis and garrigue cover the lowlands and gentle slopes. Red pine (*Pinus brutia*) and oak (*Quercus infectoria*) are the dominant species in the forest formations. Maquis is another form of native vegetation in the area and is a cover of drought-resistant shrubs, including sclerophyllous and spiny-leaved species. Forest, maquis and garrigue vegetation are interspersed together throughout the study area.

**Dry forest:** Dry forest begins at the margins of agricultural land and it extends to the Kaz mountains. This formation is spread extensively throughout the southern slopes of the Kaz Mountains between the altitudes of 200 to 700 meters. Red pine (*Pinus brutia*), Gall oak (*Quercus infectoria*), Valonia oak (*Quercus ithaburensis ssp. macrolepis*) and Turkish oak (*Quercus cerris*) are the most common species in the dry forest formation.

Undergrowth does not demonstrate much variety and downy cistus (*Cistus creticus*) is the most common species under the tree layer. Compared to *Pinus brutia*, *Quercus infectoria* and *Q. cerris* show a restricted distribution on the slopes between Akçay and Altınoluk. Characteristic and differential species of this forest include the following: *Pirus elaeagnifolia*, *Prunus spinosa*, *Crataegus monogyna*, and *Carpinus orientalis*.

**Maquis vegetation:** This formation usually occurs on the slopes between 100 to 500 meters and includes the following: *Olea europaea*, *Arbutus andrachne*, *Arbutus unedo*, jasmine box (*Phillyrea latifolia*), terebinth tree (*Pistacia terebinthus*), and storax (*Styrax officinalis*). Maquis formation consists of the following: kermez oak (*Quercus coccifera*), prickly cedar (*Juniperus oxycedrus*), broom (*Spartium junceum*); (*Phillyrea latifolia*), laurel (*Laurus nobilis*), wild olive tree (*Olea europaea var. oleaster*), (*Pistacia terebinthus*), strawberry tree (*Arbutus unedo*), and oleander (*Nerium oleander*). The maquis vegetation is adapted for survival through long summer droughts. These sclerophyllous plants are typically equipped with small, hard or thick leaves that resist water loss through transpiration. Maquis vegetation of the coastal zone and lower slopes is replaced by red pine forests at about 500 meters. The coastal area was originally covered with vegetation consisting of maquis elements, oak and red pine. However, previous stands of this vegetation have been replaced by human practices (e.g., agriculture) and development.



**Garrigue formation:** The garrigue covers the degraded areas. The garrigue elements are hardy, and therefore more resistant to the stress caused by human activities and the local climate. The coastal zone between 0-400 meters was originally forested, but much of the land was cleared for human uses. Consequently, the assemblages of the plant cover have changed with extensive clearing and soil erosion has accelerated on the slopes. Degraded and abandoned lands have been invaded by garrigue elements.

### Soil types and vegetation

Inceptisols and entisols are weakly developed soils occurring in the study area. The most developed zone is the A horizon. The pH of these soils varies from 6 to 7.5 and they lack clay. Entisols, which lack distinct horizons, occur on steep slopes and lowlands. Soil characteristics are not a factor for explaining changes in the vegetation community structure.

Soil fertility in lowland areas of the region is high since nutrients that are essential to plant life have not been washed out of the soil. Conversely, soil erosion induced by human activities have lead to extensive land degradation at higher altitudes. Many slopes have been denuded of their soils and are barren. Sediment, representing the displaced soil, has formed thick layers of sand and silt in adjacent valley floors and the coastal zone.

The coastal zone alongside the Aegean Sea is rich in terms of Halophytic and Psammophytic species. Representative Halophytic plants consist of *Arthrocnemum fruticosum*, *Halocnemum strobilaceum*, *Juncus acutatus*, *J. maritimus*, *Tamarix parviflora* and are common on salty soils on the lowlands close to the sea. *Ammophila arenaria*, *Cakile maritima*, *Centaurea spinosa*, *Euphorbia paralias* are the species widespread on sandy areas (Güvensen *et al.*, 1996). The construction of touristic facilities like hotels, motels and pansions is inducing the displacement and local extinction of some of these plants.

### Human impact on vegetation

The area is predominantly covered with Mediterranean vegetation consisting of Red pine (*Pinus brutia*) and maquis (*Olea eorepea*, *Pistacia terebinthus*, *Phillyria latifolia*, *Quercus coccifera* etc.) elements. The past thirty years have witnessed accelerated changes in natural vegetation because of increasing human pressure. Vegetation community changes are clearly associated with human activities (e.g., emerging agricultural patterns and tourism). The driving forces behind this conversion include changes to agricultural market demand, tourism, road construction and settlement growth into forested and agricultural areas. Privately-owned parcels are being used for building second homes and touristic facilities. Ecological integrity and biodiversity remains high within healthy sites. It is the maintenance of this biodiversity, in terms of both bush and grass cover, that can explain the observation that, as yet, ecological changes have not significantly reduced agricultural production. Vegetation changes are often reversible, such that even systems classified as severely degraded demonstrate rapid recovery characteristics, especially following the return of good rainfall after dry summers.

Nevertheless, degraded land is losing soil faster than it can be formed. The agricultural community is trying to compensate by employing fertilizer and by increasing irrigation. However, the potential yield from prime agricultural land has dropped by as much as 20% in the last 20 years. Much of the land along the coastal zone is being harnessed for agricultural activities, touristic development and residential development pressure. There is an on-going threat that second home development on existing agricultural land will cause a marked decline in the local productivity of olive and tangerine orchards.

Land use change is basically a process of land degradation driven by socio-economic forces, often working synergetically with vegetation change. This process is occurring continually in the Edremit Gulf area. The purpose of this study is to explore the dynamics of changes in the area, paying particular attention to the confrontation between sustainable development and attempts to increase the amount of land under cultivation and the land facing development. It is clear that anthropogenic factors play a key role in degradation of natural vegetation, since human structures have been built on the areas that were once strictly occupied by forest (*Pinus brutia*) and shrub (maquis) vegetation cover.

starting in the 1950s when the olive (*Olea europea*) areas started shifting from the coastal zone to inland. The olive cultivation areas were replaced with second homes and available land for new homes is being gained on the slopes by clearing the red pines. Simultaneously, further disturbances resulting from human activity include cutting and clearing the red pine forests to use the land for olive cultivation and thereby removing the climax vegetation on the higher slopes. The maquis vegetation occupying the slopes between 100 to 500 meters has been replaced by olive trees.

These factors, in combination, explain the rapid and intense degradation of Mediterranean vegetation cover. Findings show a common pattern of change in natural vegetation and ecological degradation consistent with altitudinal stratification and increases in the intensity of land use. Four indicators related to land use change are developed: land resource availability, land use productivity, loss of biodiversity, and ecosystem stability.

The higher slopes in the study area are being used for olive cultivation, which is not a suitable location for this activity. The shift from maquis and red pine to olive trees and clearing the *Pinus brutia* on the slopes increases erosion and induces land degradation. The other important factor in changing the area is increasing demand for second homes. The Mediterranean climate is extremely attractive for human habitation. This attraction lies in the thermal cycle of year-round pleasant temperatures, especially where moderated by coastal influences. In summer, the regional population increases by over 100 thousand people. As Table 1 demonstrates, this represents a substantial influx of temporary local residents over and above permanent residents.

Year	Edremit	Küçükkuyu	Altınoluk	Villages	Total	Increase %
1965	25.003	1050	1365	18.223	45.641	-
1970	24.115	1628	2500	19.642	47.885	4.9
1975	26.110	1768	2039	19.017	48.934	2.2
1980	27.145	2159	1829	20.506	51.639	5.5
1985	30.159	1809	2572	22.558	57.098	10.6
1990	35.486	3807	5219	24.846	69.358	17.6
1997	52.337	-	-	41.833	93.587	34.9

Table 1: The population of the major settlements in the study area (Source: State Statistical Institute).

In the Edremit Gulf area, land degradation is driven by the socio-economic forces that cause land use to evolve, and works synergistically with vegetative change. Successional change in the ecosystem starting from 1970s and continuing has been demonstrated. The *Olea europea* cultivation areas shifted from the coastal zone to inland. The resilience of the ecosystem's ability to recover from disturbance is very low in the Mediterranean climatic zone, in part, due to the low precipitation levels and high temperatures experienced in summer.

It is clear that anthropogenic factors play a key role in the clearing and degradation of natural vegetation, since human structures have been built on the area that once were strictly natural habitat. Olive and tangerine cultivation areas have been replaced with both urban and rural development. Available land for the construction of new homes is being gained on the slopes by clearing red pines. Consequently, the clearing of natural vegetative cover and other land use practices has accelerated ecosystem change.

## CONCLUSIONS

Over the last few decades, housing demand has added pressure to the ecosystem as forests have been cleared for building second homes and for olive cultivation.

Natural vegetation areas consisting of Mediterranean elements such as *Pinus brutia*, *Olea europaea*, *Pistacia terebinthus*, *Phillyria latifolia*, and *Quercus coccifera* have been extensively cleared.

Natural vegetation areas consisting of Mediterranean elements such as *Pinus brutia*, *Olea europaea*, *Pistacia terebinthus*, *Phillyria latifolia*, and *Quercus coccifera* have been extensively cleared.

The slopes at higher altitudes are being used for olive cultivation, which is not suitable for this land use. The shift from maquis and red pine to olive trees and clearing the red pine (*Pinus brutia*) on the slopes increases erosion and induces land degradation.

Human activities (e.g., monoculture) have simplified plant communities by eliminating biodiversity and causing land degradation.

The ability of the ecosystem to recover from disturbance (resilience) is low because of the characteristics of the Mediterranean climate (i.e., hot, dry summers).

## REFERENCES

- Abel, N.O.J., and Blaikie, p.M. (1989) Land degradation, stocking rates and conservation policies in the communal Rangelands of Botswana and Zimbabwe. Land degradation and rehabilitation 1:101-123.
- Atalay, İ. (1990) Vegetasyon Coğrafyasının Esasları, Dokuz Eylül Üniversitesi yayını. Yayın No: 901. İZMİR.
- Atalay, İ. (1989) Toprak Coğrafyası. Ege Üniversitesi Edebiyat Fakültesi Yayını. Yayın No:8. İZMİR.
- Balcioglu, T.H. (1937) Tarihte Edremit Şehri, BALIKESİR.
- Bilgin, T. (1969) Biga Yarımadası Güneybatı Kısımının Jeomorfolojisi. İstanbul Üniversitesi yayın no: 1433, Coğrafya Enstitüsü yayın no. 55. İSTANBUL.
- Davis, P. H. (1965). Flora of Turkey and the East Aegean Islands. Edinburg University Press. Volulme 1-10. EDINBURGH.
- Derin, N. (1968) Yaşadığımız Çevre Edremit. İZMİR.
- Efe, R. (1996) Yunt dağ ve çevresinde doğal bitki örtüsünün ekolojik şartları. Türk Coğrafya Dergisi, Sayı 31, 77-114. İSTANBUL.
- Gemici, Y., Seçmen, Ö., Ekim, T., Leblebici, E. (1992) Türkiye’de Endemizm ve İzmir yöresinin bazı endemikleri. Ege Coğrafya Dergisi, Volume 6, 61-84. İZMİR.
- Güvensen, A., Uysal, İ., Çelik, A., Öztürk, M. (1996) Karabiga ve Burhaniye arasındaki kıyı bitki örtüsüne olan çevresel baskıların irdelenmesi. Yerleşim ve çevre sorunları: Çanakkale ili, 9-13 Eylül. ÇANAKKALE.
- Middleton, N.J., and Thomas, D.S.G. eds. (1997) World Atlas of Desertification, 2<sup>nd</sup> ed. Edward Arnold. LONDON.
- Ramsay, W. (1890) The Historical Geography of Asia Minor. LONDON.
- Stewig, R. (1968) Batı Anadolu’nun kültürel gelişmesi. Kartografik Bilgiler. Çeviren: Ruhi Turan. İSTANBUL.
- Yaltırık, F. (1984). Türkiye Meşeleri, Tarım Orman ve Köyşleri Bakanlığı. Orman Genel Müdürlüğü Yayını. ANKARA.
- Walter, H. (1962) Anadolu’nun Vegetasyon Yapısı. İstanbul Üniversitesi, Orman Fakültesi Yayını. Yayın No: 80. İSTANBUL.



# LAND USE PLANNING IN EARTHQUAKE-PRONE AREAS

Nicholas Novakowski and Recep Efe  
Department of Geography Fatih University  
Büyükdere-İstanbul, Turkey 34900

## ABSTRACT

The catastrophic August 17<sup>th</sup>, 1999, earthquake in the Gölcük-İzmit area provides a living laboratory for investigating the implications of settlement patterns and land use in regions prone to seismic activity. A preliminary case study approach to *lessons learned* from the August 17<sup>th</sup> earthquake is provided. A proposed range of planning strategies for earthquake-prone areas is described, explained and prescribed. The land use planning role in guiding settlement patterns, in conjunction with building codes, is argued to represent one of the most important and enduring contributions concerning the mitigation of the human consequences of earthquakes.

## INTRODUCTION

The Gölcük-İzmit area (Figure 1) lies at the eastern edge of the Sea of Marmara and straddles the North Anatolian fault running east-west in northwestern Turkey. The Gölcük-İzmit area lies within the Marmara Region of Turkey and is part of the nation's industrial heartland. Of the seven regions of Turkey, the Marmara Region has the highest population density and the highest levels of GDP (Oxford Business Group, 1998). The local economies are dominated by primary (e.g., agricultural) and secondary (e.g., industrial) activities.

Figure 1. Location of the Gölcük-İzmit Earthquake: August 17, 1999.  
Source: MAGELLAN Geographix.



On August 17, 1999, a catastrophic earthquake occurred in the Gölcük-İzmit area. The primary earthquake measured 7.4 on the Richter scale. The United States Geological Survey or USGS (1999) reports that at least 17,118 people were killed and that over 50,000 were injured by the earthquake. Thousands of people remain missing and unaccounted for, and over 600,000 people were left homeless. Extensive human and property impacts related to the earthquake were experienced

throughout Kocaeli, Sakarya and Istanbul provinces. Damage is estimated by government sources to be approximately \$12 billion US (Gorvett, 1999).

The earthquake involved a right-lateral, strike-slip motion of the nearly vertical North Anatolian fault between Karamürsel and Gölyaka. The duration of the strong ground-shaking was 37 seconds (USGS, 1999). Site visits to the Gölcük-İzmit area conducted in September and October, 1999, demonstrated an extensive range of earthquake-related devastation: fault rupture, tectonic displacement, plus evidence of soil liquefaction, landslides, flooding and fire.

## EARTHQUAKES AND LAND USE PLANNING

"An earthquake is the vibration of the Earth produced by the rapid release of energy...the energy released radiates in all directions from its source, **the focus**, in the form of waves" (Tarbuck and Lutgens, 1997: 155). Earthquakes are associated with a variety of primary and secondary effects and impacts. Primary effects include ground-shaking, fault rupture and tectonic deformation. Secondary effects include soil liquefaction; rock, mud or land slides; submarine, snow or ice avalanches; fire; and flooding due to tsunamis, seiches, and alterations to the water table or to stream and river courses (Smith, 1996). These primary and secondary effects can induce a range of impacts: human destabilization, injury or death; damage to private and public property (e.g., homes, businesses, infrastructure); and the potential destruction of social or economic cohesion within an affected community.

The extensive damage associated with the Gölcük-İzmit earthquake demonstrates the need for comprehensive land use planning in areas facing seismic risk. Land use planning is "the process of protecting and improving the living, production and recreation environments in a city through the proper use and development of land" (Leung, 1989: 1). The primary concerns of land use planning include public welfare and security, circulation, environmental protection, beauty, comprehensiveness, conservation of resources, efficiency and equity. The potential contribution of a variety of land use strategies pertaining to both the primary and secondary effects of earthquakes was considered during the site visits.

### Ground-shaking

The main hazard created by seismic activity is ground-shaking, which can be explained on the basis of four types of elastic waves: the primary or P wave, the secondary or S wave, and the L or long waves — either Love or Raleigh waves (Abbott, 1996). "The severity of ground-shaking at any point depends on a complex combination of the magnitude of the earthquake, the distance from the rupture and the local geological conditions, which may either amplify or reduce the earthquake waves" (Smith, 1996: 126). With strong ground-shaking, the earth moves, buildings shift or collapse, plaster cracks, chimneys and architectural ornamentation fail, and underground pipes can be bent or sheared.

Perhaps the most important tool that planners have for anticipating the potential impacts of ground-shaking is *zoning*, the planning instrument that deals with the land uses and the physical form of development on individual parcels of land (both private and public). In other words, zoning can be used to designate the sorts of activities and the types of buildings permitted on specific land parcels. An earthquake-sensitive planning process begins with a comprehensive inventory of seismic hazard that identifies the land parcels along fault lines plus those areas subject to the danger of soil liquefaction, landslides, flooding, fire and any other secondary effects that make ground-shaking even more destructive. Considerations that are central to zoning in earthquake-prone areas include the following:

- Prohibit high-density development along active fault lines, in fault or fracture zones, and in potential liquefaction areas.
- Permit the following land uses in fault zones: agricultural land uses (e.g., crops, livestock, orchards, etc.), recreational land uses (e.g., parkland, cycling paths, golf courses) and light industrial uses with low staff levels or those using robotics (e.g., advanced technology firms). In some circumstances, low-density residential may be acceptable, but it must be recognized that there is always a risk trade-off that must be countered with earthquake-sensitive architecture.
- Zone high-priority infrastructure like hospitals, airports, subways, power stations, telecommunication spines, and bridges in areas of lower potential seismic activity.



- In site planning, encourage a variety of escape routes from individual sites at risk. Superior access for emergency vehicles is also a consideration.
- Zone the production locations and storage of hazardous and toxic materials at safer sites.
- Identify parcels that were once landfill sites or were reclaimed from the sea and minimize development potential on them. And,
- Use set-backs to minimize pounding between adjacent buildings.

*Infrastructure investment* is another planning tool that can be effectively used to guide settlement patterns away from areas of high seismic risk. Investment in highways, roads, bridges, public transportation, sewers and water supply represent tangible expressions of how an urban government desires future development to be expressed across the urban landscape. Government ownership of land in the urbanized areas of Turkey is extensive and can conceivably be used to effectively phase long-term infrastructure investment.

Another important implementing tool of an urban plan is the *building code*. The building code establishes structural and utility standards for the construction of homes, and commercial, industrial and institutional facilities (ASCE, 1986). Building codes in earthquake-prone areas need to address the functionality of buildings over time, rather than just at one point before occupation (Eisner *et al.*, 1993). More specifically, building codes can be used to specify construction details that are particularly relevant to earthquake-based hazard. As Zebrowski (1997: 55) observes, "the death toll from an earthquake has more to do with the type of building construction than with the intensity of the earthquake. Earthquakes seldom kill people; for the most part, it is our buildings that kill people." The following elements of construction detail represent rudimentary content for local building codes:

- The five primary considerations for building codes in areas of seismic risk include building height, consolidation of weight on the lower floors, the shape of buildings, the type of building materials, and the degree of attachment of the building to its foundation (Abbott, 1996).
- Height and density restrictions are essential unless earthquake-resistant technology is used (e.g., steel frames, shear walls). Building weight must be concentrated in the lower stories.
- Building shapes are an important consideration. While cantilevering and complex building massing should be avoided, stepped building profiles appear to work well (Smith, 1996).
- Building materials are critical and need to be both high-quality and fire-resistant. "Strong, flexible and ductile materials are preferred to those which are weak, stiff and brittle" (Smith, 1996: 139). Zebrowski (1997) argues for the use of prestressed concrete columns or walls in areas subject to seismic stress when better but more expensive alternatives are not feasible. Since property developers can save money by compromising the quality of the concrete used in construction, this possibility needs to be carefully monitored in the application of the building code across time (rather than in a single inspection).
- The type and reinforcement of building frames can also be critical (e.g., wood frames for buildings up to four stories, the prohibition of brick in a load-bearing function, prevention of *soft* stories on the ground level, the anchoring of frames to the foundation). The use of building reinforcements like trussing, shear walls, braced frames and moment-resisting frames needs to be stressed (Abbott, 1996). In the Gölcük-İzmit area, many buildings where brick was used in a load-bearing function had pancaked. And,
- Design restrictions also play a role in the safety of both the building's residents and people in the building's proximity during an earthquake (e.g., all architectural detail or ornamentation like pediments or statuary should be reinforced, and the use of large glass exterior walls should be minimized). "Architectural style can contribute to disaster if features like chimneys, parapets, balconies and decorative stonework are inadequately secured" (Smith, 1996: 141).

Despite the wide array of concerns that can be addressed through the building code, it is also important to recognize that the code can be circumvented by either corruption or sanctioned political pressure. There are a number of mechanisms that optimize the implementation of the building code. First, close observation of the inspection process by local politicians is mandatory. Second, federal watch-dog organizations with the power to enforce local codes can do spot checks to monitor code implementation as well as the performance of local councils. Third, there are also economic mechanisms that can be employed. Building inspectors in earthquake-prone areas should be extremely



well-trained and rewarded for their jobs. As well, property developers with good construction records can be rewarded with density bonuses for future projects.

The building code priorities identified above need to be addressed before a building can be considered habitable. For buildings that are already built, already inhabited, and are suspect, the urban planner still has a few instruments that can operate retroactively. Local governments can act through *land acquisition* or *land swaps* in order to deal with developed areas that are at particular risk. In an arena of last resort, a local government can use its power of *eminent domain* (i.e., *expropriation*). Expropriation involves a municipality obtaining privately-owned land for community purposes and paying for it at market value as assessed by an independent land appraiser (Hodge, 1991). In other words, if certain properties and the structures on them are at particular risk, the municipality can intervene in the private property market and purchase those properties that need to be relegated to a less-intensive land use.

### **Liquefaction**

Smith (1996: 129) states that liquefaction is "the process by which water-saturated sediments can temporarily lose strength, because of strong shaking, and behave as a fluid." During liquefaction, soil material transforms into a fluid mass and buildings can face subsidence and possible collapse. Planning strategies specifically targeted to liquefaction potential include the following:

- Prohibit high-density development (residential or otherwise) in areas of clay or alluvial sediment unless the building foundations are embedded into the bedrock (Eisner *et al.*, 1993). Previous landfill sites and lands reclaimed from the sea represent particular hazard. Various levels of building subsidence were observed during the Gölcük-İzmit site visits.
- If liquefaction areas are already developed, encourage agricultural land uses requiring irrigation in adjacent areas so that the local water table can be lowered. Simultaneously, the use of the underlying aquifers as drinking and industrial water sources can also bring the water table down. Ultimately, these strategies represent a trade-off where the urban planner has to weigh costs against benefits. If the urban area is adjacent to a saltwater body, then caution must be exercised in manipulating the water table since this may permit the infiltration of freshwater with saltwater.

### **Landslides**

"The severe shaking in an earthquake can cause natural slopes to weaken and fail" (Smith, 1996: 130). Since landslides are more of a threat when the topography is hilly, the following strategies are important:

- Minimize hillside development, unless the unstable slope issue is dealt with (e.g., the building code mandates that foundations must be anchored to the bedrock).
- Preserve all natural drainage courses and maintain them in their original state. The use of engineering solutions to hide or redirect watercourses puts hilly topography at risk.
- In all cases, there must be an attempt to recognize the importance of topography "Significant [wave] amplifications occur in steep topography, especially on ridge crests" (Smith, 1996: 129). Although grading should be minimized, if sloped areas are to be developed, then blend *cut and fill* slopes with the existing topography by using contour grading (Eisner *et al.*, 1993).

### **Flooding**

The flooding implications of earthquakes can result from a variety of secondary effects, including tsunamis, seiches, the courses of rivers and streams being altered, groundwater being discharged out of its reservoirs, shorelines falling due to fracturing, and the failure of dams during seismic stress. Anecdotal observations in the Gölcük-İzmit area include those of a seiche at least seven meters in height being experienced immediately after the earthquake (McGrory, 1999). The Gölcük shoreline demonstrated extensive displacement and flooding. In fact, during October, 1999, the city's waterfront continued to remain submerged under meters of water. Planning strategies for flooding include the following:

- Urban run-off systems need to be designed for the hundred-year storm or flood (e.g., design curbs, gutters and culverts to carry elevated levels of run-off). Debris basins can be constructed in valley floors and along water courses (Eisner *et al.*, 1993).
- If underwater or marine faults are an issue (e.g., in the Sea of Marmara), then development in low-lying coastal areas needs to be either prohibited or minimized. Even though waterfront development can represent highest and best use, low-lying coastal areas need to be developed according to flood plain management and the reach of the 100-year flood.

## Fire

Fire is an on-going threat during the aftermath of an earthquake. Following the Gölcük-İzmit earthquake, the largest petroleum refinery in Turkey (owned by Tüpraş) ignited. At the site level, gas lines can rupture and burn. Fire safety has a number of planning-related protocols:

- Open space and open space system planning is a priority for minimizing fire-related hazard. Many cities throughout Turkey, including the Gölcük-İzmit area, have been developed at high density and with minimal dedicated parkland. Provision for open space serves a number of functions. First, open space provides a place for retreat both during and after the ground-shaking. Second, open space can slow the progress of emerging fires. Third, open space functions best when it is part of a system or network because the open space can then be used as an escape route if evasive movement across terrain is necessitated. Fourth, visual access to open space is psychologically important during the anxiety of ground-shaking. Finally, open space systems are optimized when they are networked to water bodies (e.g., streams, rivers, lakes or seas) since this improves their effectiveness in offering escape from aggressive fires and has the added benefit of increasing their contribution to urban biodiversity.
- Accessibility for emergency fire-fighting vehicles and equipment is also a major concern at the site-level. As well, toxic flammables need to be stored in low-risk areas.

## CONCLUDING REMARKS

For other urban areas in Turkey that face similar levels of seismic risk, the Gölcük-İzmit earthquake represents a window into the sort of catastrophic damage that may occur again unless settlement patterns become planned, and existing and improved building codes are rigidly applied. Many opportunities for improving the performance of Turkish buildings during and after an earthquake exist and need to be optimized. During periods of low seismic activity, stringent planning and building code requirements may appear to be excessive and are infrequently palatable in political terms. Consequently, the challenge is to maintain the political motivation to ensure best practices in land use planning and in building construction consistently across time. For governments to remain credible in earthquake-prone areas, tenable settlement patterns plus building code evolution and implementation must recognize seismic hazard.

## REFERENCES

- Abbott, Patrick. (1996) *Natural Disasters*. Dubuque, Iowa: Times Mirror Higher Education Group, Inc.
- ASCE (American Society of Civil Engineers). (1986) *Urban Planning Guide*. Revised Edition. New York: American Society of Civil Engineers.
- Eisner, Simon *et al.* (1993) *The Urban Pattern*. 6<sup>th</sup> Edition. New York: Van Nostrand Reinhold.
- Gorvett, Jon. (1999) "Turkey's Earthquake Nightmare" in *Insight Turkey*. 1/4: 133-143.
- Hodge, Gerald. (1991) *Planning Canadian Communities: An Introduction to the Principles, Practice and Participants*. 2<sup>nd</sup> Edition. Scarborough: Nelson Canada.
- Leung, Hok Lin. (1989) *Land Use Planning Made Plain*. Kingston: Ronald Frye and Company.
- MAGELLAN Geographix. (1992) *Simplified Location Map*. Santa Barbara, California: MAGELLAN Geographix. Downloaded from <http://quake.wr.usgs.gov/study/turkey/images/turkey.izmit.bursa.quake.jpg>
- McGrory, Daniel. (1999) "Families Wait for Mementos from 'Atlantis.'" *Ottawa Citizen*, August 25, 1999. A6.
- Oxford Business Group. (1998) "Turkey Can't Be Pigeon-holed" in *Emerging Turkey: 1999*. London: The Oxford Business Group. 10-11.

- Smith, Kevin. (1996) *Environmental Hazards: Assessing Risk and Reducing Disaster*. New York: Routledge.
- Tarbuck, Edward and Frederick Lutgens. (1997) *Earth Science*. 8<sup>th</sup> Edition. Upper Saddle River, New Jersey: Prentice-Hall.
- USGS (United States Geological Survey). (1999) [http:// earthquake.usgs.gov/ncis/eqlists/sig\\_1999 .html](http://earthquake.usgs.gov/ncis/eqlists/sig_1999.html)
- Zebrowski, Ernest. (1997) *Perils of a Restless Planet: Scientific Perspectives on Natural Disasters*. Cambridge: Cambridge University Press.



# EFFECTS OF LANDSCAPE POSITION AND PARENT MATERIAL ON THE SOIL PROPERTIES IN KAHRAMANMARAS PROVINCE, TURKEY

Recep Gündoğan, Kadir Yılmaz

Kahramanmaraş Sutcu Imam University, Faculty of Agriculture, Department of Soil Science,  
Kahramanmaraş, Turkey. E-mail [rgundogan@ede.ksu.edu.tr](mailto:rgundogan@ede.ksu.edu.tr)

## ABSTRACT

Morphological, and selected physical and chemical properties of five pedons on four landscape positions (summit, shoulder, backslope, and toeslope) were examined to evaluate the effect of landscape position and parent material on soil properties. Parent material of soils on summit and shoulder was Upper Miocene formation consist of marl, sandy and conglomeratic layers rich in carbonate. Soils on the backslope and toeslope developed on non-calcareous Pliocene mixed deposits. The soil on the marl layer had 10 YR hue and loamy clay texture, massive structure and vertic features. Soils on sandy and conglomeratic layers had 7.5YR hue, weak-to-moderate granular or subangular structure. The soil on the backslope had clayey-skeletal, 5 YR hue and medium-to-coarse subangular structure. The soils on the toeslope had 7.5 YR hue, clay texture and vertic features. pH values ranged 6.8-7.86 and the soil on the backslope had the lowest pH value. Soil properties such as soil color and texture were influenced parent material and landscape positions

## INTRODUCTION

Hillslopes are classified into summit, shoulder, backslope, footslope and toeslope (Ruhe,1975).These landscape positions can greatly influence hydrological, and pedological processes (Hall,1983). The effects of topography on pedogenesis have been known for a long time and soil-landscape relationships have been widely used to study soil genesis (Jenny,1941; Birkeland,1984; Fanning and Fanning,1989; Hall and Olson,1991). Walker et al.(1968) reported that backslope soils were most affected by erosion and footslope soils showed higher clay and organic matter content. Malo et al. (1974), and Ovalles and Collins (1986) stated that there was significant relations between landscape positions and soil properties

Soil-landscape relationships could often be hidden by parent material (Stolt et al.,1993). The knowledge of the degree of parent material uniformity is essential in pedogenesis studies. Parent material unconformities were attributed to the stratification in parent rocks resulting in variability in particle size or mineralogy, or to litologic discontinuities resulting from colluvial, alluvial or eolian additions (Brewer,1976).

The objective of this study was to determine the effects of topography and parent material on soil properties. This approach was successfully used in determining uniform mapping units for soil survey (Briggs and Shishira,1975) and for soil management and soil productivity determinations (Chartres,1982; Stone et al, 1985).

## MATERIALS AND METHODS

### Site Description

The study site (Figure 1) is located in Kahramanmaraş Province, Turkey, approximately 15 km west of Kahramanmaraş city. Five representative pedons were selected to study from four different landscape positions: i) summit, ii) shoulder iii) backslope, and iv) toeslope. Morphological characteristics of soil profiles were identified using the Soil Survey Staff (1993).

Geology of the study area consists of Upper Miocene-age clay, sand and conglomerate layers covered with various depths of non-calcareous Pliocene-age mantle. Upper Miocene layers exposed at the faults edge because they were uplifted and inclined with 12-14° angle by tectonic (Önalın,1986, Gül,1987). Therefore, tectonic plays a significant role in current morphology of the study area.

Climate in the study area is characterized by dry and hot summers and warm and wet winters. The annual average precipitation is 710 mm. Monthly mean temperature ranges from -2 °C in

January to 17 °C in July, with mean annual value of 8 °C (Kaya,1996). Soil moisture regime is xeric and soil temperature regime is thermic (Tigem,1991). Soils were classified as Inceptisol and Vertisol (Gündogan et al., 1998).

### Laboratory Methods

Soil samples were air dried and passed through a 2-mm sieve. Particle size distribution was determined by Bouyoucos hydrometer method (Bouyoucos,1962). Soil pH was measured in saturated samples (Richards,1954). Organic C was determined by Walkley-Black wet oxidation method (Allison,1965). Carbonate content was determined by using Shiebler calcimeter method (Allison and Moodie,1965).

## RESULTS AND DISCUSSIONS

### Morphological properties

The soils (P1, P2) on the summit, and P3 on the shoulder developed from Upper Miocene deposits rich in carbonate. These deposits consist of marl, sandy and conglomeratic layers. P4 and P5 pedons are described on the backslope and toeslope respectively, and developed from non-calcareous Pliocene mixed deposits. Stratigraphic relations and relative landscape position of each pedon are shown in the cross section diagram of figure 1.

A summary of morphological properties of soils is listed in table 1. Soil depth varies from 45 cm to 110 cm. P2, P3 and P4 pedons have weak-to-moderate granular or subangular structure. Structure of P4 pedon is much stronger than that of the other pedons. The effect of parent material on structure and solum depth is more than the effect of landscape position. Structure has not developed in P1 and P5 pedons. The soil have cracks. While P1 pedon have 10 YR hue, P2 and P3 pedons 7.5 YR hue, oxidizing and well drained condition prevail in these pedons du to their coarse texture. P4 and P5 pedons on the backslope and toeslope have 5YR or 7.5 YR respectively, and lower value (<4) and chroma (>3). Similar colour pattern observed in a Entisol-Alfisol-Vertisol catena by weitekamp et al.(1996). They conclude that the movement Fe is restricted its low solubility and remained in profile, the greater solubility of Mn leads to its removal from upper slope sites and its subsequent transport to lower slope soils.

There are common pebbles and cobbles on the surface and within profile in the P3 and P4 pedons which is due to the movement of fine particles from upslope to downslope by erosion. Many researchers reported that upper slopes were affected from erosion (Walker et al., 1968; Birkeland,1984;Deniel et al. 1985).

### Physical and Chemical Properties

Physical and chemical properties of soils are given in table 2. Soil textures vary from sandy loam to clay. Clay increase in P1 pedon located on the summit is related to the marl layer of Upper Miocene formation. P4 pedon has less clay content than P5 pedon due to transportation of fine particles from backslope to toeslope.

Soil pH values range from 6.87 to 7.86 and P4 pedon has the lowest pH value probably due to the parent material that derived from quartzite. Organic matter content ranges from 2.12 % to 0.06 % and decreases with depth in all pedons.

The increase in carbonate content with depth in P1, P2 and P3 pedons is associated with the carbonate leaching. Lesser amount of carbonate in P4 and P5 pedons could be related to capillary rise and movement by runoff from upslope to downslope. Harper (1957) and Glinka (1963) had explained carbonate accumulation by capillary rise as well in their study.

## CONCLUSIONS

The soils formed on the Upper Miocene deposits are rich in carbonate and the soils formed on Pliocene deposits are non-calcareous.

The soils on the summit and shoulder formed on the Upper Miocene deposits are rich in carbonate and have 10 YR or 7.5 YR hue. Soils formed on the marl layer had lower value and finer

texture than that of the other soils formed sandy and conglomeratic layer. Soils on the backslope and toeslope formed on non-calcareous deposits have 5 YR or 7.5 YR hue. Fine particles translocated by water from upslope to downslope, therefore, backslope soils had less clay content and coarser particles compared to toeslope soils.

The findings of this study proved that the distribution of soil properties varies as a function of parent material and landscape position. However, parent material was dominant on the soil properties compared to landscape position.

Table 1. Morphological properties of studied soils

Horizon	Depth (cm)	Color (Dry;Wet)	Texture	Structure	Consistences (D, M,W)	Special features	
						Rock fragments	Others
Summit (P1), 0-2% slope, Typic Haploxerert							
Ap	0-22	10YR 3/3; 10YR3/3	CL	2mgr	h;fr;s,p	f. pb. (2-10 cm)	c.ba
Ad	22-40	10YR 4/3; 10YR4/3	CL	m	vh;fr;s,p	f.pb (2-5 cm)	cr
AC	40-60	10YR 5/3; 10YR5/3	CL	m	vh;fr;s,p	f.pb (2-5 cm);	cr
C	60-150	10YR 6/2; 10YR6/2	C	m	vh;fr;s,p	m. pb (2-5 cm)	c.cm.;cr
Summit (P2), 2-3% slope Calcic Haploxerept							
Ap	0-27	7.5YR 4/3; 7.5YR 4/4	CL	2msbk	h;fr;vs,vp	c.pb (0-5 cm);	f. ba
Bw1	27-40	7.5YR 5/4; 7.5YR 4/6	SL	1fsbk	h;fr;s,p	f.pb(3-5 cm)	
Bw2	40-63	7.5YR 6/3; 7.5YR5/4	L	1fsbk	h;fr;s,p	f.pb.(3-5 cm)	
C1	63-105	10YR 6/4; 10YR 7/3	L	m	h;fr;s,p		
C2	105-150	10YR 8/3; 10YR 7/3	L	m	h;fr;s,p		m.cm
Shoulder (P3), 3-5% slope, Typic Calcixerept							
Ap	0-25	7.5YR 4/3; 7.5YR 4/3	CL	2mgr	sh;fr;s,p	c. co. (2-10);	c.ba
Bw	25-45	7.5YR 6/4; 7.5YR 5/4	SL	1mgr	sh;fr;s,p	c. co. (2-10);	f.ba
1C	45-107	7.5YR 8/2; 10 YR6/4	SL	m	sh;fr;s,p	m.co (2-15 cm)	
2Ck1	107-150	7.5YR 8/2; 7.5YR 7/4	SiL	m	sh;fr;s,p		c.cm.
2Ck2	+150	7.5YR 8/2; 10 YR7/4	L	m	sh;fr;s,p		oy.cm
Backslope (P4), 12-15% slope, Typic Haploxerept							
Ap	0-35	7.5YR 3/4; 7.5YR 3/3	C	1fsbk	vh;fr;vs,vp	c.co. (2-15 cm)	f. ba.
Bw1	35-69	5YR 2/2; 7.5YR 2/2	C	2m-csbk	vh;fr;vs,vp	f.co.(2-15).	f.ba
Bw2	69-110	5YR 2/2; 7.5YR 2/2	C	2m-csbk	vh;fr;vs,vp	c.co. (2-15 cm.	f.ba
C2	110-160	5YR 2/2; 7.5YR 3/3	C	m		c.co (c2-15)	
2C	+160	10YR 6/4; 10YR 5/4	conlomerate				
Toeslope(P5), 0-2% slope, Typic Haploxerert							
Ap	0-21	7.5YR 3/4; 7.5YR 3/3	CL	1fgr	vh;fr;vs,vp	c.pb. (1-5 cm);	c. ba;cr
Ad	21-36	7.5YR 4/3; 7.5YR 4/3	CL	m	vh;fr;vs,vp	vf. pb. (1-3 cm).	f. ba;cr
AC	36-64	7.5YR 4/4; 7.5YR 4/3	CL	m	vh;fr;vs,vp	vf. pb (1-3 cm)	c. ba
C1	64-110	7.5YR 3/3; 7.5YR 3/3	C	m	vh;vf;vs,vp	vf. pb (1-3 cm)	f. ba
C2	110-140	7.5YR 3/3; 7.5 YR 3/2	C	m	vh;fr;vs,vp	vf. pb (1-3 cm)	
2C	+140	10YR 6/4; 10YR 5/4	conglomerate				

Structure: (shape) , sbk-subangular blocky, bk-angular blok, gr-granuler, m-masive, s-saperate; (size) f-fine, m-medium, c-coars; (grade) 1-weak, 2-moderate , 3-strong.

Consistence: so-soft, sh- slightly hard, h-hard, vh-very hard; fr-frible, fi-firm, vfi- very firm; ns-non-stick, ss-slightly stick, ms-moderately sticky, vs- very sticky; np-non-plastic, sp-slightly plastic, mp-moderately plastic, vp-very plastic

Spacial features: (Type) cm-carbonate masses; ba-biologic aktivty; pb-pebbles, co-cobbles; cr-cracks (Amount) vf-very few, f-few, c-common, m-many.



Table 2. Selected physical and chemical properties of studied soils

Horizon	Depth (cm)	pH	CCO <sub>3</sub> (%)	Organic Matter, (%)	Particle Size Distribution (%)		
					Sand	Silt	Clay
Summit (P1), 0-2% slope, Typic Haploxereert							
Ap	0-22	7.39	9.0	2.05	27.2	43.8	29.0
Ad	22-40	7.86	15.7	1.13	39.1	29.7	31.2
AC	40-60	7.42	22.9	0.46	25.8	37.3	36.9
C	60-150	7.74	31.2	0.46	15.2	28.0	56.8
Summit (P2), 2-3% slope Calcic Haploxerept							
Ap	0-27	7.91	8.5	1.22	39.9	25.0	35.1
Bw1	27-40	7.67	28.2	0.90	54.9	28.6	16.5
Bw2	40-63	7.48	42.1	0.43	44.9	34.8	20.3
C1	63-105	7.56	46.9	0.41	34.2	42.0	23.8
C2	105-150	7.57	43.2	0.09	33.5	40.3	26.2
Shoulder (P3), 3-5% slope, Typic Calcixerept							
Ap	0-25	7.57	8.26	1.72	36.3	31.1	32.6
Bw	25-45	7.44	24.4	1.03	59.0	28.0	13.0
C	45-107	7.84	28.5	0.38	72.3	19.7	8.0
2Ck1	107-150	7.55	66.1	0.26	15.3	58.3	26.4
2Ck2	+150	7.35	45.4	0.06	27.5	45.9	26.6
Backslope (P4), 12-15% slope, Typic Haploxerept							
Ap	0-35	7.25	-	2.12	31.3	25.4	43.3
Bw1	35-69	6.87	-	1.02	35.7	17.8	46.5
C1	69-110	6.90	0.5	0.84	46.1	21.2	32.7
C2	110-160	7.49	1.8	0.64	57.4	17.6	25.0
Toeslope (P5), 0-2% slope, Typic Haploxereert							
Ap	0-21	7.57	0.2	1.34	23.5	27.2	49.3
Ad	21-36	7.47	0.6	0.76	23.6	25.0	51.4
AC	36-64	7.62	0.4	0.55	30.8	26.1	43.1
C1	64-110	7.69	0.9	0.26	23.8	32.3	43.9
C2	110-140	7.58	22.2	0.26	38.4	33.5	28.1

## REFERENCES

- Allison L.E., Moodie C.D. (1965). Carbonate: Volumetric Calcimeter Method. In C. A. Black (ed), Methods of Analysis. Agronomy Monographs No: 9, Part 2. American Society Agronomy, Madison, Wisconsin, USA., p 1389-1392.
- Allison L.E. (1965). Organic Carbon: Walkley-Black Method. In C. A. Black (ed), Methods of Analysis. Agronomy Monographs No: 9, Part 2. American Society Agronomy, Madison, Wisconsin, USA., p 1367-1378.
- Birkeland P.W. (1984). Soils and Geomorphology. Oxford University Press, New York, p. 372.
- Bouyoucos G.J., (1962). Hydrometer Method Improved For Making Particle Size Analyses of Soils. Agron. Jour., 54, 464-465.
- Brewer R. (1976). Fabric and mineral analysis. Chapter 4: calculation soil formation. Krieger Publ., New York.
- Briggs D.J., Shishira E.K. (1975). Soil Variability in geomorphologically defined survey units in the Albudeite of Murcia Province, Spain. Catena suppl. 6: 69-84.
- Chartres C.J. (1982). The use of landform-soil associations in irrigation soil surveys in Northern Nigeria. J. Soil Sci. 33:317-328.

- Deniels R.B., Giliam J.W., Cassel D.K. and Nelson L.A. (1985). Soil erosion class and landscape position in the North Caroline Piedmont. *Soil Sci. Soc. Am. J.* 49: 1991-995.
- Glinka K.D. (1963). *Treatise on soil science* (translated from the Russian). Israel Program for Scientific Translations, Jerusalem.
- Gül M.A. (1987) Kahramanmaraş Yöresinin Jeolojisi ve Petrol Olanakları, TPAO Rapor No:2359, Ankara.
- Gündoğan R., Yılmaz K., Gürel N., Bodur M. N., Demirkıran A. R., Köksal İ., Şerbetçi H. (1998). KSÜ. Afşar Kampusu Topraklarının Etüd ve Haritalaması, KSÜ Araştırma Fonu Projesi (Yayınlanmamış), Kahramanmaraş.
- Hall G.F.(1983). *Pedology and Geomorphology*. In : L.P. Wilding, N.E. Smeck, and G.F. Hall (Eds.), *Pedogenesis and Soil Taxonomy. I. Concepts and Interactions*. Elsevier, Amsterdam.
- Hall G. F., Olson C.G. (1991). Predicting Variability of soils from landscape models. (In *Spatial variabilities of soils and landforms*, ed. Mauhaach, M.J., and Wilding, L. P.), SSSA Special Publication Number :28, p. 9-24.
- Harper W.G. (1957). Morphology and genesis of Calsisols. *Soil Sci. Soc. Am. Proc.* 21: 40-424.
- Janny H.(1941). *Factors of soil formation*, McGraw-Hill, New York, 281 p.
- Kaya, F. (1996). Kahramanmaraş İlinin İklim Özellikleri, Yüksek Lisans Tezi (Basılmamış), K.S.U. Sosyal Bilimler Enstitüsü, Kahramanmaraş, 144 s.
- Malo D.D., Worcester B.K., Cassel D.K., Matzdorf K.D. (1974). Soil-landscape relationships in a closed drainage system., *Soil Sci.Soc. A m. Proc.* 38:813-817.
- Ovalles F.A., Collins M.E. (1986). Soil-landscape relationships and soil variability in north central Florida. *Soil Sci. Soc. Am. J.* 50: 401-408.
- Önalın M. (1986).Kahramanmaraş Tersiyer istifinin sedimenter özellikleri ve çökme ortamları, I.Ü. Müh. Fak. Yerbilimleri Dergisi. 5 (1-2): 39-78.
- Richards L. A. (1954). *Diagnosis and improvement of saline and alkaline soils*. USDA Agriculture handbook, USA.
- Ruhe R.V. (1975). *Geomorphology*. Houghton Mifflin, Boston, Maryland.
- TİGEM (1991). Kahramanmaraş Tarım İşletmesi Topraklarının Etüd ve Haritalaması, Tarım İşletmeleri Genel Müdürlüğü Yayınları, No:11, 54 s., Ankara.
- Soil Survey Staff (1993). *Soil Survey Manual*, USDA, Handbook No: 18, Washington D.C., 437 p.
- Stolt M.H., Baker J.C., Simpson T.W. (1993). Soil-landscape relationships in Virginia: I. Soil variability and parent material Uniformity. *Soil Sci. Soc. Am. J.* 57: 414-421.
- Stone J.R., Gilliam J. W., Cassel D.K., Deniels R.B., Nielson A.L., Kleiss, H.K. (1985). Effect of erosion and landscape position on the productivity of Piedmont soil. *Soil Sci. Soc. Am. J.* 49: 987-991.
- Walker P. H., Hall G.F., Protz R. (1968). Soil trends and variability across selected landscapes in Iowa. *Soil Sci. Soc. Am. Proc.* 32: 987-991.
- Weitkamp W.A, Graham R.C, Anderson M.A., Amrhein C. (1996). Pedogenesis of a vernal pool Entisol-Alfisol-Vertisol catena in southern California. *Soil Sci. Soc. Am. J.* 60: 316-323.

# ASSESSMENT OF LAND SUITABILITY FOR OLIVE TREES GROWING IN CENTRAL PORTION OF THE NEGEV DESERT

Michael Shapiro, Vladimir Kurepin  
Soil Conservation And Drainage Division,  
Ministry Of Agriculture And Rural Development, Israel

## ABSTRACT

Present intensive development of the Negev desert region (southern Israel) makes it necessary to utilise agricultural plants previous planted in another climatic conditions. One of such plant is the olive tree, traditionally grown in north and central semi-humid portions of the country. For proper assessment of land suitability to the growth of olive trees, both physical and chemical soil properties as well as properties of soil cover heterogeneity should be taken into consideration. On the basis of such properties a number of soil morphological, analytical, and spatial land criteria are proposed. This work is based upon a detailed soil survey, at a scale of 1:2,500, carried out in the central Negev.

## INTRODUCTION

Olives (*Olea Europaea*) are traditional fruit trees for the majority of subtropical Mediterranean countries, especially Greece, the Mahgreb, and Spain. They also grow in other regions having a Mediterranean climate, such as California, Chile, South Australia and South Africa. In Israel olives have been grown since ancient times and are commercially produced in north and central parts of the country. The main Israeli regions of olive cultivation are the mountains and hills of the Galil, Samaria and Judea. In these mountains and hills olive tree plantations are situated on terra-rossa, rendzina and brown Mediterranean soils. The mountain soils consist of an upper stoneless layer grading into a layer of consolidated parent rock. The layer of parent rock involves a lot of deep vertical and subvertical cracks and wedges (pockets) filled by fine-textured material. Because of this, even shallow mountain soils have a sufficient volume of loose material necessary for tree development. On piedmont plains and river terraces olive trees are grown on different kinds of accumulated soils derived from loose material with significant amount of fine-textured particles. As a rule, all these soils are leached of soluble salts or are saline to an insignificant degree. Olive trees plantations situated in regions of traditional cultivation are characterized by stable surface or surface artificially fixed by means of soil conservation measures carried out over long periods of time.

Completely different properties characterize the soils of the central Negev. First of all, the climate of the central Negev is far drier (Table 1) and far hotter than in the northern and central portions of Israel. The central Negev aridity is inordinate even for such highly drought resistant species as *Olea Europaea*. Secondly, the only suitable soils for growing of olive trees are loessial serozems formed on alluvial fans of small piedmont plains between mountain ridges. The thickness of fine-textured upper layers of these serozems differs from point to point. Within the first 30-80 cm of the soil surface it usually grades into stony alluvial deposits with a high content of carbonates and sometimes gypsum and almost without any fine-textured material. Thirdly, the upper fine-textured serozem's layer is saline, sometimes contains a lot of exchangeable sodium and a large amount of boron. Finally, present-day aeolian-deflation and fluvial processes significantly influence soil cover of alluvial fans. This leads to a considerable spatial soil heterogeneity of agriculture plots and to a high degree of their surface instability. These peculiar landscape conditions determine necessitate detailed soil cover analysis of the plots intended for the growing of olive trees.

Table 1: Aridity of some Israeli regions.

Region	Rainfall, mm/year	K-1	K-2	K-3
Northern Israel, Galil	820	0.54	1.48	0.18
Central Israel, Jerusalem	650	0.40	1.95	0.18
Southern Israel, Revivim	85	0.04	0.16	0.01

K is a ratio of rainfalls to evaporation. K-1: for year, K-2: for November-February period, K-3: for March - October period.



## MATERIALS and METHODS

In order to study the suitability of the central Negev for olive cultivation a sample area was selected in the Revivim region. This is located 120 km south of Tel Aviv and 60 km to the east of the Mediterranean coast, near Kibutz Revivim, in the basin of Wadi Beer-Hajl (Fig.1, 2). The sample area is representative of the Negev Highlands, and is composed of two geomorphologic segments. The first is rocky. It is represented by low mountain ridges, whose highest points are about 600-650

Fig.1: The Revivim sample area location.

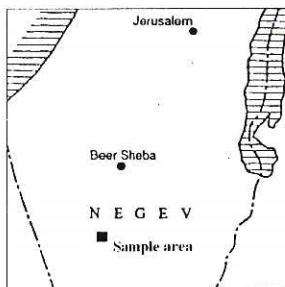
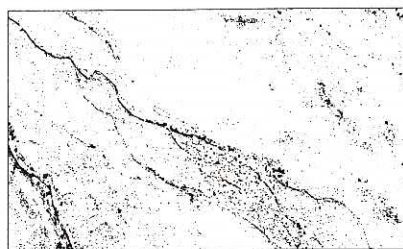


Fig.2: Aerial view of the Revivim sample area.  
Scale app. 1: 10,000.



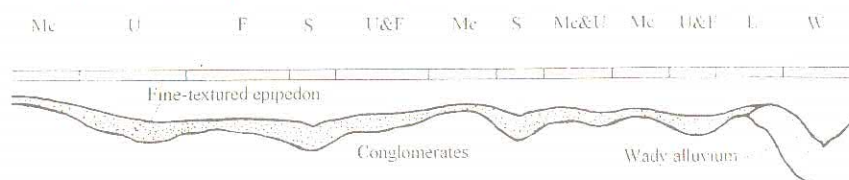
m a.s.l. They consist of consolidated limestones and dolomites of Cenomanian and Turonian age, chalks of Santonian and Campanian age, and flints and chalks of Eocene age. The mountain soils are shallow lithosols: stony brown or rendzinic. All are unsuitable for planting.

The second geomorphologic segment, having some potential for olive trees planting, is represented by intermontane well-drained piedmont alluvial plains. The groundwater level is deep and does not influence soil-forming processes. This segment is formed by coalescing gravel cones, the average altitude of which is about 300-350 m a.s.l. The cones consist of Neogene age conglomerates and are dissected by a network of intermittent streams (wadies). The wadi valleys are about 3-5 m or more in depth. The watersheds (drainage divides) separate these wadies over a distance of about several hundreds of m. On topographical maps at a scale of 1:10,000 these watersheds areas appear as rather homogeneous glacises.

Quite another picture is revealed after field inspection of watershed areas and analysis of detailed topographical maps and aerial photographs (scale 1:2,500-1:5,000). The watershed areas are composed of systematically repeating microrelief patterns. These patterns are composed of forms of microrelief which change over small distances (Fig. 3,4). These forms are:

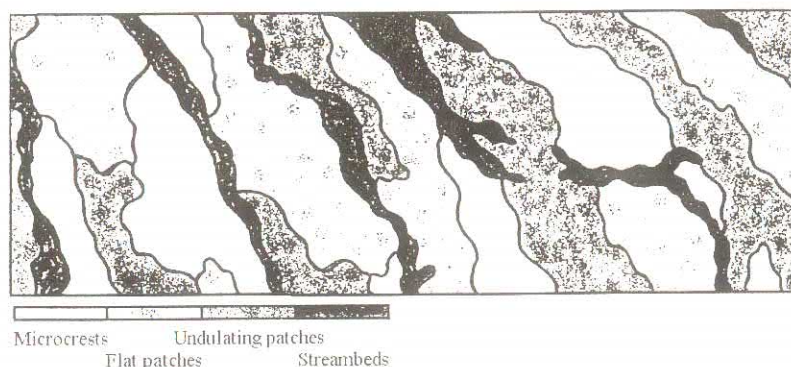
1. Narrow parallel or sub-parallel microcrests between wadies, rising 30-40 cm above the basic surface. Microcrests occupy about 25% of watershed areas. Their surface is bare, sometimes covered by a thin (3-4 mm) vesicular crust composed of carbonate and silicate material often found in other hot desert regions (Souirji&Marcoen 1998).
2. Flat patches between microcrests and microchannels. In most cases their surface is free of vegetation. Sometimes these patches are sporadically covered by shrubs. Barren patches are topped by thin vesicular crust. Patches surface nearby shrubs is covered by a very thin sand veil.
3. Gently undulating patches of diffuse vegetation. Near shrubs there are very small sand hummocks. Patches of flat and gently undulating plains interpenetrate each other and occupy about 50% of watershed areas.
4. Shallow microchannels of weak seasonal (ephemeral) streams, 20-30 cm in depth, part of which are blind creeks. These dry streambeds occupy about 15% of watershed areas. Microchannels have rather dense shrub cover (*Hammada scoparia* plant associations), favouring accumulation of sandy aeolian deposits.
5. Levees spreading along wadi slopes at watershed edges (10% of watershed areas). Levee height above the watershed surface is about 60-70 cm. As a rule, levee surfaces abound in loose gravelly and cobbly pavement.

Fig. 3: Simplified watershed cross section in the Revivim sample area.  
Horizontal scale app. 1:5,000. Vertical scale app. 1:250.



Geomorphologic locations: Me – microcrests, F – flat patches, U – gently undulating patches, S – streambeds, L – levees, W – wadies.

Fig. 4: Spatial distribution of microrelief forms in the Revivim sample area. Scale app. 1:5,000.



The width of the above-mentioned forms of microrelief (except for microchannels) ranges between 25-30 and 50-70 m, the length ranging between 200 and 300 m. All forms are orientated parallel or sub-parallel to lines of the major wadies from S-E to N-W.

The sample area's parent material is composed of three main layers. The surface layer consists of Holocene-Upper Pleistocene aeolian loamy sand. The sandy layer is underlain by Upper-Middle Pleistocene aeolian- and fluvial calcareous loesses. These two fine-textured layers compose an upper fine-textured epipedon, which abruptly grades into Neogene calcareous conglomerates. The main kinds of conglomerate fragments are rounded and subrounded gravels and cobbles. In most cases conglomerates are non- or slightly cemented by carbonates concentrations. Sometimes the degree of cementation rises to moderate. Thickness of the upper fine-textured stratum is one of the most critical soil properties in the course of assessing land suitability for olive tree cultivation. Depending upon microrelief, epipedon thickness ranges from 20-30 cm within microcrests to 70-100 cm or more within microchannels.

A detailed (at a scale of 1:2,500) soil survey of 200 ha revealed a high spatial variability of soil cover. A large difference in soil features between adjacent soil areas is connected with the influence of a number of soil- and relief forming processes, and peculiarities of spatial distribution of runoff within watersheds.

The main processes governing spatial variability of soil cover are: high level of wind erosion of areas unprotected by vegetation or vesicular crust and accumulation of aeolian dust material within locations covered by desert shrubs; redistribution of eroded particles by local runoff from microcrests to adjoining flat and undulating patches. Local fluvial activity favours transportation and accumulation of fine-textured material within streambeds during winter rainfalls. Intensive winter rainfalls lead to growth of a wadi network and accumulation of gravels and cobbles along watershed edges on levee surfaces. It is worth emphasising the significant degree of input of local runoff water upon the spatial differentiation of soil salt, carbonate and moisture content (Yair 1990). Among landscape features influencing the present status of soil cover, relief of pre-existing conglomerate surface and intensity of Pleistocene denudation should be mentioned.



Soils of the Revivim sample area are typical of hot deserts (Singer 1995, Soutirji&Marcoen 1998). According to the Israeli classification most of them are related to serozems (Dan 1981). Similar soils in the American soil taxonomy are Calcorthids, Camborthids, Haplargids (Keys... 1998). Table 2 illustrates major soils and geomorphologic locations of their areas.

From the applied point of view, main field-inspected soil properties are the thickness of the fine-textured epipedon, the degree of profile differentiation, the degree of internal drainage, and the degree of conglomerate cementation.

According to these criteria, the soils are divided to two groups. The first consists of stony soils in which the fine-textured epipedon thickness is less than 30 cm. Ordinary stony soils are formed on microcrests of watersheds, whilst alluvial stony soils are formed on levees along watershed edges. These soils are unsuitable for olive trees planting owing to the extremely high water infiltration rate, very low water-holding capacity, and lack of fine-textured material necessary for tree roots development.

All other soils are divided into weakly developed ones and serozems. Weakly developed soils are formed from present-day aeolian or alluvial material. They involve a little pedogenic alteration of parent material: an upper ochric horizon diffusely grades into a lower salic horizon. The soils have loamy sandy and sandy loamy texture. Shallow soils are underlain by conglomerate at a depth of 40-50 cm, whilst moderately deep soils are underlain by conglomerate at a depth of 60-100 cm. Physical properties of these soils don't restrict the growing of olive trees. Ultimate suitability for olive planting depends upon the degree of salt content and alkalinity.

In comparison with weakly developed soils serozems have a rather distinct profile. Typical ordinary serozems are composed of ochric, calcic and salic horizons underlain by conglomerates. In the profile of typical argilly serozems, the calcic horizon is replaced by an argillic horizon or by a calcic-argillic intergrade. Some serozems are covered by a thin vesicular crust. Thickness of shallow serozems is about 50-60 cm; thickness of moderately deep ones is about 80-110 cm. There is a sufficient difference in suitability of such soils for the growing of olive trees. Ordinary serozems are much more suitable than argilly ones due to their higher permeability, and lower salinity and alkalinity. The main negative feature of argilly serozems is connected with an argillic horizon enriched in clay content and secondary carbonates. As a rule, the upper ochric horizon of argilly serozems abruptly grades into the argillic horizon without a transitional horizon or with only a very thin transitional horizon.

So called in this study denuded (wind eroded) serozems have been found most unsuitable for growing olive trees. The profile of denuded serozems lacks an upper ochric horizon. Instead, there is a thin ochric-calcic intergrade, grading with depth into a calcic, or calcic-argillic, or argillic horizon. As a rule, denuded serozems have a thin vesicular crust at their surface.

There is no any distinct trend in the differentiation of conglomerate cementation. Generally, conglomerates are not cemented at all. Occasionally, the degree cementation rises to slight or moderate.

Salt, SAR, and boron levels of the soils vary within a wide range. Less salty soils are weakly developed ones and shallow typical ordinary serozems. With additional fine-textured epipedon thickness and additional soil profile differentiation, salt content also increases. For instance, typical ordinary serozems are characterised by an EC of 5-15 dS/m, SAR of 10-15, and 2-3 ppm of B content. The most saline soils are argilly serozems, especially denuded argilly serozems (the EC of argillic horizons being about 20-25 dS/m, SAR of 25-35, and B content of around 5-10 ppm).

## DISCUSSION

In order to define land suitability for the growth of olive trees a number of criteria concerning soil properties must be delineated. These are: physical and chemical properties, and properties of spatial soil distribution.

Physical properties deal with the thickness of the upper fine-textured layer, soil horizon texture, penetration and resistance classes, distinctness of horizons (the distance over which one horizon grades into another), and the degree of cementation of conglomerates. These properties are all evaluated with respect to the fact that the major portion of olive tree roots is concentrated in upper layer of 40-50 cm thickness and that olive trees don't tolerate waterlogged soils or soils with a low degree of percolation. Open, perfectly aerated, well-drained loamy soils without slow-permeability



horizons within their upper 80-100 cm are ideal. The high sensitivity of olive trees to the degree of soil drainage is a critical restriction in arid regions where trees plantations are irrigated with significant amounts of water. (The amount of irrigation water necessary for commercial olives production is about 450-500 mm. Taking into account the fact that at least a portion of irrigated water is obtained from local wells and has high levels of electroconductivity -EC- approx. 4-5 dS/m, exchangeable sodium -SAR- approx. 8, and approx. 1-2 ppm of boron content, the amount of irrigation water might be increased up to 700-800 mm).

A moderate and moderately rapid infiltration rate of arid soils is also an obligatory initial condition for successfully reducing soluble salts and boron from upper horizons by leaching. On the other hand, soils with either very rapid and slow infiltration rates are unsuitable for growing olive trees. The best combination of physical properties for olive trees cultivation in the Revivim sample area are found in loamy sandy to sandy loamy, rather loose, slightly carbonated soils. They consist of two or three horizons very gradually grading one into another, with a stoneless epipedon thickness of 60-80 cm, underlain by loose non-cemented conglomerates. Such properties characterize some weakly developed soils and ordinary typical serozems. The worst combination of the above-mentioned properties for growing olive trees involves both stony soils whose fine-textured epipedon's thickness is less than 30 cm, and fine-textured soils with carbonated upper horizons abruptly grading into highly carbonated, rather hard horizons enriched in clay (denuded argilly serozems), as well as ordinary serozems with thin clay loamy laminae (2-3 cm of thickness).

Table 2: Soils of the Revivim sample area, their geomorphologic locations, suitability to the growing of olive trees and predictability by means of map and aerial photograph interpretation.

	Soils													
	Stony		Fine-textured											
	Ordinary	Alluvial	Weakly developed				Serozems							
			Ordinary		Alluvial		Typical				Denuded			
							Ordinary		Argilly		Ordinary		Argilly	
	S*	S	S	M*	S	M	S	M	S	M	S	M	S	M
Location	Mc	L	F&U	F&U	S	S	F&U	U	F&U	F&U	Mc&F	F	Mc&F	F
Suitability	No	No	M	H	M	H	H	M	M	L	L	L	No	L
Predictability	H	H	M	M	H	H	L	L	L	L	M	L	M	L

\* Thickness classes: S - shallow, M - moderate.

Geomorphologic locations: Mc - microcrests, F - flat patches, U - gently undulating patches, S - streambeds, L - levees.

Classes of suitability and predictability: L-low, M-moderate, H-high.

Chemical properties defining soil suitability for olive trees cultivation are pH, EC, exchangeable sodium, and the amount of boron. Lime content in central Negev soils doesn't play restrictive role in growing olive trees. pH level shouldn't exceed 8-8.5. Taking into consideration the fact that olive trees are considered moderately tolerant to salinity (Maas 1986, Zinger 1985) and that all plots would undergo initial leaching and then be regularly irrigated, rather high levels of EC, SAR, and B content were recognised as permissible for virgin soils.

These levels are: EC 8-12 dS/m, SAR 10-15, B 2-4 ppm. These criteria are less strict than those acceptable in Israel for other kinds of fruit trees (Criteria... 1995). Practical Israeli experience indicate that while saline soils are leached, their SAR level is also reduced. As for boron, it should be noted that high levels of boron in soils can also be reduced by leaching but in lower proportions than other soluble salts. As a rule, soils having favourable physical properties for planting generally also have proper chemical properties (weakly developed soils and typical ordinary serozems). The worst soils are argilly denuded serozems.

Extremely high spatial variability, or heterogeneity, is one of the most important properties of studied soil cover. This variability is expressed by different kinds of elementary soil areas (in the meaning of

V.Fridland 1972) adjoining one to another and altering one another over a distance of tens of metres. This soil cover mosaic forms due to the local influence of soil formation factors mentioned above.

The main consequence of high soil cover variability is varying predictability of the soils by means of some landscape indicators, both at the initial stage of map and aerial photograph interpretation and during field investigation without pit digging. In the Revivim sample area, the degree of soil predictability varied from high to low (Table 2). The most predictable soils are ones formed on distinct forms of microrelief: microcrests, levees, and microchannels of seasonal streambeds. Soils of microcrests and levees are unsuitable for olive trees planting. Streambeds soils are suitable for this purpose but don't play substantial role from a spatial point of view. Gently undulating and flat patches have much lower predictability. These involve geomorphological locations within which all kinds of serozems may be found. According to predictability variations, the density of soil pits is planned. It is rather low on microforms with highly predictable soils (about 1 pit to 2-3 ha) and rather high (1-2 pits to 1 ha) on microforms with low predictability soils. It is worth mentioning that soils eliminated due to their negative physical properties don't require a chemical analysis. On the other hand, all soils which seem suitable for planting according to their physical properties are strongly recommended to be investigated in a chemical laboratory.

A practical consequence of high spatial variability in soil cover is the necessity to unite soil areas having different arable values while splitting territories into individual agricultural blocks. This splitting is performed on the base of detailed soil maps (1:2,500-1:3,000). The minimal size of such a block is about 1 ha. All blocks should be planted using drip irrigation, and each block might be irrigated in its own way with regards to soils chemical features. It is desirable that physical and chemical differences between soils of adjacent areas within the same block don't prevent use of the same cultivation measures. In spite of inclusion into recommended planting blocks soils with a wide range of physical and chemical properties, the main portion of the studied sample area is not considered as suitable for growing of olive trees. The relation between blocks recommended for future planting blocks and eliminated soils areas is about 3:7.

An obligatory condition of splitting territory into blocks is a requirement for soil cover protection. The main desirable soil cover protection measures include: remoteness from watershed edges at the distance of 50 m and more, preservation of vegetative cover on wadi valley slopes, use of non-inverting plowing in order to minimize disturbance of upper soil horizons, avoidance of heavy agricultural vehicles, regulation of runoff water flow from adjacent mountain slopes, etc.

## REFERENCES

- Criteria of land selecting for fruit trees planting. (1995). Min. of Agriculture: 1-4. Bet Dagan, Israel. [In Hebrew].
- Dan J. The northwestern part of the Negev hills and mountains. (1981). In: Aridic soils of Israel. The Volcani Center:223-238. Bet Dagan, Israel.
- Fridland V.M. (1972). Structure of soil cover. Moscow. [In Russian].
- Keys to soil taxonomy. Eighth edition. (1998). USDA. Washington.
- Maas E.V. (1986). Salt tolerance of plants. Applied Agr. Res. 1:12-26.
- Singer A. The mineral composition of hot and cold desert soils. (1995). In: Arid ecosystems. Advances in Geoecology, 28:13-28.
- Souirji A.&Marcoen J.M. Using topsoil characteristics to classify desert soils. (1998). 16th World Congress of Soil Science. Montpellier.
- Yair A. The role of topography and surface cover upon soil formation along hillslopes in arid climates. (1990). In: Soils and Landscape Evolution. Geomorphology, 3: 287-299.
- Zinger A. Olive trees plantation. (1985). Bet Dagan, Israel. [In Hebrew].

## ACKNOWLEDGEMENT

We would like to thank Mr.R.Zaidenberg (Ministry of Agriculture and Rural Development, Israel) for friendly assistance with the work at all its stages. We are also grateful to Dr. M.L.Collin (Ministry of National Infrastructures, Israel), who edited this paper.

# DELTOMETRIC METHODS AND HIS APPLICATION IN SOIL HYDROPHYSICAL INVESTIGATIONS

Gulaliyev Chingiz Gulali oglu  
Institute of Geografi, Baku, Azerbaijan

## ABSTRACT

By experimental way is shown, that the dependence dielectric of permeability of ground from its humidity has exponential character. The comparison of settlement results with the experimental data which have been carried out on an example soil of various types, gives a good enough coordination.

## CONCLUSION

To the basic electrophysical characteristics soil dependent concern as well her dielectric permeability ( $\epsilon$ ), from change of such factors as importance, frequency of an electrical field, temperature, volumetric weight and so on. These dependences have the rather large practical meaning(importance), as are connected with moisture resistant of ground.

The technique of spent researches allowed to remove humidity the characteristic dielectric permeability at known meanings of the basic soil properties. The range moisture from maximal hygroscopic up to bound field humidity ratio. Frequency of an electrical field was used varied within the limits of 0,4 - 10,0 МГц.

The dependences of a kind  $\epsilon(w)$  have independently, both practical, and theoretical meaning (importance) requiring(demanding) an explanation of a physical nature of the phenomena, observed in soil at passage of a variable electrical current, and revealing of behaviour of electrophysical parameters

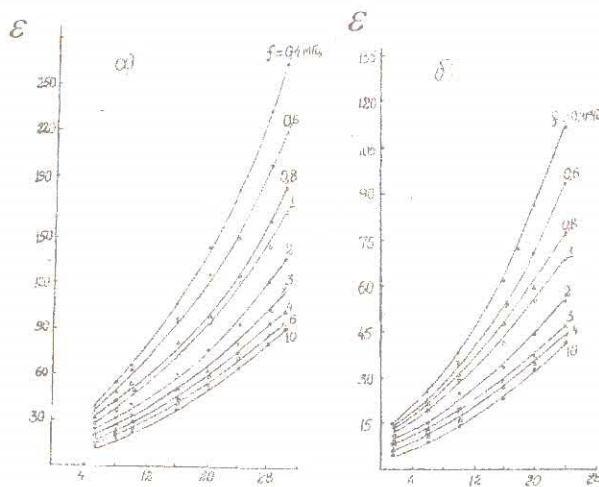


Fig. 1. Dependence dielectric permeability from humidity soil at  $\rho=1,4 \text{ г/см}^3$ ,  $T=20^\circ\text{C}$   
a) serous-meadow, b) meadow-serous.

depending on change of water properties soil.



In given clause the attempt of analytical expression of dependence dielectric of permeability from humidity of ground is undertaken.

As an example of figure 1 the meanings dielectric of permeability investigated by us soil are submitted depending on given moisture at fixed density and temperature. As appears from the diagrams, the increase of importance of ground promotes substantial growth her(it)  $\varepsilon$ .

In a airily-dry condition  $\varepsilon$  soil poorly depend on an electrical field. Accordingly distinction hygroscopic of humidity  $\varepsilon$  have different meanings. Further with increase of the contents of water  $\varepsilon$  is naturally increased, as depending on a type of ground, and its genetic horizon. Thus, the ground which is not containing, water on dielectric parameters represents isolator. The reason of equal sizes  $\varepsilon$  for a firm phase of various samples soil, consists that though the ground has different mineral structure, dielectric of the characteristic of these minerals is rather close among themselves. Further increase of humidity causes changes forces communication of a moisture with soil particles, and it clearly has an effect for a course moisture of dependence  $\varepsilon$ . From the diagram it is visible, that dielectric the permeability researched soil with growth moisture, down to a level maximal hygroscopic of a moisture considerably grows. Thus within the limits of each sample of ground of the greater humidity corresponds also large dielectric permeability. The mathematical processing of experimental data results in expression.

$$\varepsilon = (\varepsilon_0 - 1)e^{\frac{2}{3}W} + 1, \quad (1)$$

Where -  $\varepsilon$  - dielectric permeability at  $W=0$ .

From here follows, that the communication dielectric of permeability of ground with humidity has exponential character.

At a conclusion of a parity (1) the certain simplifications are admitted. So, is not taken into account, that with change of the form of communication of a moisture in process of a thickening of a water layer environmental a particles, the size dielectric of a susceptibility varies, that, however, does not break exponential of character of dependence  $\varepsilon(W)$ , but only has an effect for size of factors. The mathematical processing of experimental data results in expression

$$\varepsilon = ae^{bW} + c \quad (2)$$

To not contradicting parity (1). The meanings of factors and, b, c depend on a type of ground, frequency of a variable electrical field, temperature.

It is obvious, the formula (2) can be simplified at the expense of selection of factors and and b without essential change of accuracy and is given in a kind

$$\varepsilon = ae^{bW} \quad (3)$$

Deviation of settlement sizes dielectric of permeability of ground from experimental meanings for various moisture and frequencies of a variable electrical field.

The table on an example some soil of Ukraine (chernozem highly clayey, dark - chestnut highly clayey), Azerbaijan (grey - brown, meadow-serous, serous -meadow, by name - meadow and others) is given, illustrates results of approximation by the formula (3) experimental dependences  $\varepsilon(w)$ . As follows from the table, settlement meanings dielectric of permeability ( $\varepsilon$ ) and its experimental meanings ( $\varepsilon$ ) will well be coordinated with each other, despite of heterogeneity of properties of researched objects.

It is possible to explain available deviations from function (3) to that the meanings of factors and and b, strictly speaking, should depend on the form of communication of a moisture varied with increase humidity W. The mathematical processing of experimental data gives their average meanings. In accepted the models of a soil particle are not taken into account features a narrow capillary, which filling has at early stages of humidifying

In this case electrostatic component adsorption of potential owing to neutralize of action of opposite walls a capillary Reduces Decreases. In these conditions doublet of a molecule of water can

freely enough be guided in an electrical field, that causes of polarization of water in the condensed condition. At filling larger capillary the reduction adsorption of potential is insignificant. The fixation by walls capillary and surface of particles doublet of molecules of water results in reduction of rate of growth dielectric of permeability with increase of humidity.

The results of researches are offered use delcometric methods y at the control for humidity soil.

W	f = 0.4 МГц			f = 10 МГц		
	$\epsilon$	$\epsilon$	$\Delta\epsilon$	$\epsilon$	$\epsilon$	$\Delta\epsilon$
chmozem light clayey, Nikolaev area of the Ukrainian Republics						
8,08	21,9	25,7	3,8	10,2	11,7	1,5
11,75	33,0	32,3	-0,7	14,3	14,3	0,0
12,00	35,0	32,8	-2,2	15,2	14,5	-0,7
15,87	43,5	41,6	-1,9	18,8	17,9	-0,9
17,70	48,1	46,6	-1,5	21,3	19,8	-1,5
18,90	51,0	50,2	-0,8	21,5	21,2	-0,3
19,33	55,1	51,5	-3,6	22,4	21,7	-0,7
21,10	62,0	61,1	-0,9	25,5	25,3	-0,2
25,00	72,5	73,2	0,7	30,0	29,6	-0,4
26,66	78,5	81,1	2,6	31,5	32,5	1,0
30,33	98,6	101,7	6,1	37,1	39,7	2,6
light clayey dark - chestnut ground, Kherson area of the Ukrainian Republics						
8,0	42,9	42,1	-0,8	17,3	18,0	0,7
14,0	56,9	59,5	2,6	24,2	23,5	-0,7
18,0	75,2	75,0	-0,2	28,9	28,1	-0,8
20,0	87,5	84,2	-3,3	32,0	30,7	-1,3
24,0	103,0	106,2	3,2	36,2	36,7	0,5
26,0	121,0	119,2	-1,8	38,6	40,1	1,5
serous -meadow soil, north Mugan of the Azerbaijan Republics						
8,0	48,9	50,7	1,8	21,0	21,7	0,7
10,0	67,7	59,1	-8,6	25,7	24,9	-0,8
16,0	97,3	93,4	-3,9	37,0	36,7	0,6
20,0	126,7	126,7	0,1	50,9	49,5	-1,4
24,0	182,4	172,1	-10,3	66,0	65,5	-0,7
26,0	235,0	233,6	-1,4	84,0	85,9	1,9

## REFERENCES:

1. Gulaliev Ch.G., Geraizade A.P., Troitsky N.B. (1998). Functional estimation of electro-heat-physical parameters of the soil in aspect of multi-parametrical moisture measuring. Proceedings of 16 th World Congress of Soil Science. Montpellier, France, p.28.
2. Troitsky N.B., Gulaliev Ch.G., Geraizade A.P. (1986). Dependence of dielectric permeability of ground from moisture measuring. In "Reports of Agricultural Academy". Moscow, 7: 39-41.



# THE EFFECTS OF INOCULATION OF SOIL WITH DIFFERENT NUMBERS OF BACTERIA ON AGGREGATION

Tayfun Aşkın, Coşkun Gülser, Rıdvan Kızılkaya, Nutullah Özdemir  
Ondokuz Mayıs University, Faculty of Agriculture, Department of Soil Science, Samsun/TURKEY

## ABSTRACT

In this study, the effects of different numbers of bacterial population on aggregate stability were investigated during the different incubation periods. Same amount of glucose as a substrate was added into each sterilized soil sample. Sterilized soil samples were inoculated with 0, 2, 4, 6 and 8 ml doses of Nutrient Glucose media which included  $2 \times 10^9$  bacteria per ml. At the end of 1, 2, 3, 4 and 5 weeks incubation periods, aggregate stability percentages of soil samples were determined using wet sieving method and then used soil samples were placed aside. Generally, 4 and 6 ml inoculation doses of bacteria significantly increased aggregation between soil particles at  $p < 0.01$ . Aggregation slowed down after the first three weeks incubation. At the end of the fifth week incubation, probably increase in substrate requirements of bacteria and bacterial attack on products which bind soil particles together resulted in disaggregation in the soil samples inoculated with 6 and 8 ml doses.

## INTRODUCTION

In soils, the primary particles tend to themselves into structural units known as secondary particles or aggregates. Stability of soils against erosion and improvement of the soil physical conditions for plant growth are closely related with aggregation. Aggregation is an important part of soil formation because of influencing the soil behaviors in infiltration, aeration, root penetration, and reducing runoff and erosion. Decreases in soil structures occurs when soil is managed with intensive tillage (Havlin et al., 1990). Soil aggregation and water infiltration increase when cover crops are added to crop rotations (Dormaar and Lindwall, 1989; Meek et al., 1990). Some inorganic materials such as: clay particles, Fe and Al oxides and calcium carbonate can serve as cementing agents within macroaggregates (Hillel, 1982).

Biological factors also have a major effect on the development of stable aggregates. The many microbial products such as: polysaccharides, hemiceluloses or uronides, as well as numerous other natural polymers, are attached to clay surfaces by means of cation bridges, hydrogen binding, van der Waals forces and anion adsorption mechanisms. Organic polymers hardly penetrate between the individual clay particles but form a protective capsule around soil aggregates. This, organic products may further promote aggregate stability by reducing wettability and swelling (Hillel, 1982).

Stability of microaggregates depends on persistent organic binding agents, whereas macroaggregates are stabilized by plant roots and fungal hyphae. Soil organic matter is metabolized by a variety of microorganisms to produce polysaccharides that act to bind soil particles into microaggregates (Oades, 1993; Tisdall and Oades, 1982).

The objective of this study was to determine the effects of different numbers of bacterial population isolated from the same soil on aggregation at the end of the different incubation periods.

## MATERIALS & METHODS

Soil sample used in this study was taken from 0 to 20 cm soil depth in Merzifon, Turkey. Air dry soil sample was passed through a sieve with 2 mm size opening. Some physical and chemical properties of the soil sample were determined as follows; soil particle size distribution by the hydrometer method (Demiralay, 1993), lime content by Scheibler Calsimeter (Soil Survey Staff., 1993), pH in 1:2.5 (w/v) soil water suspension by pH meter, EC in the same soil suspension by EC meter (Black, 1965); and cation exchange capacity (CEC) according to Bower method (US Salinity Lab. Staff., 1954). Soil organic matter was measured by Walkley-Black method (Kacar, 1994).

After the soil sample was added on Nutrient Glucose Agar, grown bacterial colonies were isolated and transferred on Nutrient Glucose Liquid Media which was prepared as including  $2 \times 10^9$  total bacteria per ml (Temiz, 1994). 20 g soil sample was transferred into each flask and the flasks



were taped with cotton and aluminum foil. The flasks including 20 g soil samples in each were autoclaved at 121 °C for 30 minutes. After 100 mg glucose as a substrate was added to soil sample in each flask, the sterilized soil samples in flasks were inoculated with different numbers of bacteria adding 0, 2, 4, 6 and 8 ml doses of Nutrient Glucose Liquid Media with three replicates. Inoculated soil samples were incubated for 1, 2, 3, 4 and 5 weeks at  $25 \pm 2$  °C. During the incubation periods, soil samples were kept under near the field capacity.

At the end of the each incubation period, aggregate stability percentage of the samples were determined using wet sieving method (Kemper, 1965) and placed aside. Soil samples were wet sieved using a sieve with 0,250 mm size opening.

An analysis of LSD multiple comparisons test was used to determine the significance of the differences recorded among the total bacterial doses and different incubation periods on aggregate stability percentage (Steel and Torrie, 1980).

## RESULTS & DISCUSSIONS

### Soil Properties

Descriptive statistical results for some physical and chemical properties of the soil used in this study are given in Table 1.

Table 1. Some physical and chemical properties of soil.

Sand (S), %	30.06
Silt (Si), %	29.03
Clay (C), %	40.90
PH (1:2,5 in water)	8.20
EC <sub>25</sub> °C, mmhos.cm <sup>-1</sup>	1.80
Organic matter (OM), %	1.42
CaCO <sub>3</sub> , %	16.40
CEC, me.100 g <sup>-1</sup>	38.20

Soil analyses results can be summarized as; textural class of soil is clay, soil is moderately alkaline in pH, low in organic matter, very high in lime content and non saline according to EC value.

### Bacterial Effects on Aggregation

The effects of different inoculation numbers of bacteria on aggregate stability at the end of the incubation periods are given in Table 2. Percent changes in aggregate stability according to average percent aggregation of control (34.74 %) were calculated for every inoculation dose and incubation period and are also given in Table 2.

Aggregation in control applications did not show any significant change statistically during the each incubation period at  $p < 0.01$ . Effect of inoculation doses of total bacteria on aggregation varied for each incubation period. During the five different incubation periods, percent changes in aggregation according to control due to different numbers of bacterial inoculation are given in Figure 1. Aggregation of the samples inoculated with different numbers of bacteria increased during the first three weeks. The higher aggregation for each inoculation dose were obtained significantly at the end of three weeks incubation at  $p < 0.01$ . The highest aggregation was determined for 6 ml dose (53.91 %) at three weeks incubation. Also, 4 and 6 ml doses showed higher aggregation at the first (42.29 %) and the second (42.46 %) week incubation respectively.

After the first three weeks, these increases in aggregation slowed down during four and five weeks incubation. Aggregate stabilities of all the inoculation doses decreased at the end of five weeks incubation period. Disaggregation or negative percent changes in aggregation according to control were obtained for 6 ml (-2.85 %) and 8 ml (-9.67 %) of inoculation doses at the fifth week incubation.

Table 2. Mean aggregate stability (AS) percentages at the end of five different incubation periods and percent changes (PC) in aggregation according to aggregation in control.

Inoculation Doses, ml	Incubation periods, weeks											
	I		II		III		IV		V		Mean	
	AS %	PC %	AS %	PC %	AS %	PC %	AS %	PC %	AS %	PC %	AS %	PC %
Control	34.46 A <sup>a</sup> **	-	36.37 Aa	-	34.33 Aa	-	34.09 Aa	-	34.45 Ba	-	34.74	-
2	39.19 Bb	12.81	37.23 ABab	7.16	42.72 Bc	22.97	39.83 Bb	14.65	35.21 Ba	1.35	38.84	11.79
4	42.29 Cc	21.73	39.19 Bb	12.81	50.05 Cd	44.07	34.87 Aa	0.37	36.03 Ba	3.71	40.49	16.54
6	38.15 Bb	9.81	42.46 Cc	22.22	53.91 Dd	55.18	34.64 Aa	-0.29	33.75 Aba	-2.85	40.58	16.82
8	39.21 Bb	12.86	39.16 Bb	12.72	42.71 Bc	22.94	40.24 Bbc	15.83	31.38 Aa	-9.67	38.54	10.94
Mean	39.71	14.31	39.51	13.73	47.35	36.29	37.39	7.64	34.09	-1.86		

Each ml dose includes  $2.10^9$  total bacteria.

\*Numbers within a column followed by different capital letter(s) are significantly different at  $p < 0.01$ .

\*\*Numbers within a row followed by different letter(s) are significantly different at  $p < 0.01$ .

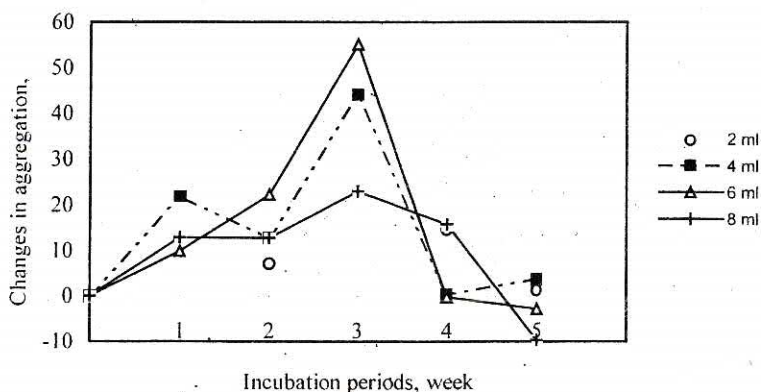


Figure 1. During the different incubation periods, percent changes in aggregation according to control.

In order to see the effects of inoculation of soil with total bacteria on aggregation, percent change in mean aggregate stability of each inoculation dose was calculated according to aggregation in control, regardless of the incubation period differences (Table 2). Percent changes in mean aggregation were plotted versus inoculation doses in Figure 2a. The effect of inoculation doses on aggregation was found significantly higher for 4 and 6 ml doses than for 2 and 8 ml doses at  $p < 0.01$ . Bacterial activity for aggregation was not enough in inoculation of 2 ml dose due to less binding products by bacterial activity. On the other hand, substance materials in soil were enough to bacterial activity of 4 and 6 ml doses to produce aggregation products between aggregates. However, 8 ml inoculation dose showed a decrease in aggregation. Increasing the number of total bacteria in soil probably decreased aggregation.

due to more substrate requirements of the bacteria. Because bacteria in soil did not produce enough binding agents between aggregates and probably attacked on some other previous produced products between soil particles.

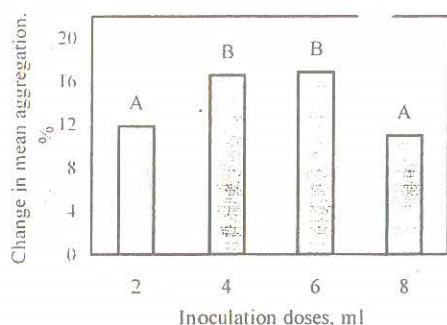


Figure 2a. For different inoculation doses percent changes in aggregation according to control

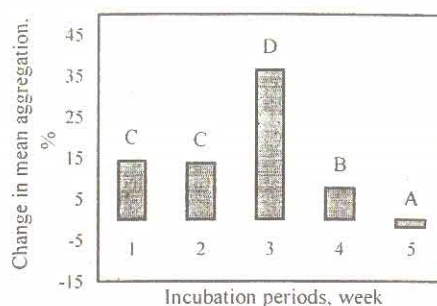


Figure 2b. For different incubation periods percent changes in aggregation according to control

The addition of energy material results in an increase in the number of microorganisms and their numerous activities (McCalla, 1950). Roberson et al. (1995) found that aggregation was highly correlated with organic C and N. Microbial extracellular polysaccharides due to high C content can be important factors affecting soil aggregation in cultivated soils.

Regardless of difference in inoculation doses, percent change in mean aggregate stability for each incubation period was estimated according to aggregation in control (Table 2). Percent changes in mean aggregation were plotted versus incubation periods in Figure 2b. The highest aggregation was obtained at three weeks incubation period. After three weeks incubation, aggregation in soil particles slowed down. Aggregation due to bacterial activity at the fourth week was found less than aggregation of the first three weeks. At the end of five weeks incubation, disaggregation occurred in soil when compared with aggregation of control samples. It may be explained with that consumption of natural binding agents by total bacteria increased with increasing the number of total bacteria after four weeks incubation.

The similar results were obtained in the study about the effects of microorganisms on soil aggregation by Aksoy (1973). He also found that increase in aggregation by microorganisms slowed down during the second four weeks of incubation. Incubation effect on aggregation also varied for different soils due to differences in organic matter content. Allison (1947) determined that higher permeability was related with improved aggregation by microorganisms. The lower permeability was due in part to disintegration of soil aggregates. The dispersion was occurred due to attack of microorganisms on the organic materials which bind soil into aggregates.

As a results, 4 and 6 ml inoculation doses generally increased aggregation in soil probably due to some bacterial products which bind soil particles together. Aggregation in soil slowed down after the first three weeks incubation. At the end of the fifth week incubation, disaggregation occurred most probably due to increase in substrate requirements of bacterial population. Many of the soil aggregating substances and the some products by microorganisms are later destroyed by other microorganisms (Waksman, 1952). In conclusion, the inoculation of soil with total bacteria to improve soil structure may be recommended. These inoculation may be effective, if energy materials for bacterial requirements are added to the soil.



## REFERENCES

- Aksoy, N. (1973). Mikroorganizmalarla aşılama ve fumigasyonun, muhtelif rutubet seviyelerinde inkubasyona tabi tutulan, bazı Doğu Karadeniz, Doğu Anadolu ve Güneydoğu Anadolu topraklarının agregatlaşmalarına olan etkileri. Atatürk Üniv. Yayınları. No 184. Ziraat Fak. Yayınları No 93. Araştırma No 56. Erzurum.
- Allison, L.E. (1947). Effect of microorganisms on permeability of soil under prolonged submergence. *Soil Sci.* 63:439-450.
- Black, C.A. (1965). *Methods of Soil Analysis. Part 1*, American Soc. of Agron., No 9.
- Demiralay, İ. (1993). *Toprak Fiziksel Analizleri*. Atatürk Üniversitesi Ziraat Fakültesi Yayınları, No:143, Erzurum.
- Dormaer, J.F., Lindwall, C.W. 1989. Chemical differences in dark brown chernozemic Ap horizons under various conservation tillage systems. *Can. J. Soil Sci.* 69:481-488.
- Havlin, J.L., Kissel, D.E., Maddux, L.D., Claassen, M.M., Long, J.H. 1990. Crop rotations and tillage effects on soil organic C and N. *Soil Sci. Soc. Am. J.* 54:448-452.
- Hillel, D. (1982). *Introduction to Soil Physics*. Academic Press Limited, 24-28 Oval Road, London.
- Kacar, B. (1994). Bitki ve Toprağın Kimyasal Analizleri:III, *Toprak Analizleri*, s:149-165, Ankara Üniversitesi Ziraat Fakültesi Eğitim, Araştırma ve Geliştirme Vakfı Yayınları No:3, Ankara.
- Kemper, W.D. (1965). *Methods of Soil Analysis. Part 1*, American Soc. of Agron., No 9. 511-519.
- McCalla, T.M., (1950). Studies on the effect of microorganisms on rate of percolation of water through soils. *Soil Sci. Soc. Proc.* 15:182-186.
- Meek, B.D., DeTar, W.R., Rolph, D., Rechel, E.R., Carter, L.M. (1990). Infiltration rate as affected by an alfalfa and no-till cotton cropping system. *Soil Sci. Soc. Am. J.* 54:505-508.
- Oades, J.M. (1993). The role of biology in the formation, stabilization and degradation of soil structure. *Geoderma* 56:377-400.
- Roberson, E.B., Sarig, S., Shennan, C. Firestone, M.K. 1995. Nutritional management of microbial polysaccharide production and aggregation in an agricultural soil. *Soil Sci. Soc. Am. J.* 59:1587-1594.
- Soil Survey Staff (1993). *Soil Survey Manual*. USDA Handbook No:18, Washington, USA.
- Steel, R.G.D., Torrie, J.H. (1980). *Principles and procedures of statistics.-A biometrical approach*. 2nd ed. McGraw-Hill, New York.
- Temiz, A. (1994). Genel mikrobiyoloji uygulama teknikleri. I. Baskı. Şafak Matbacılık Ltd. Şti. Ankara.
- Tisdall, J.M., Oades, J.M. (1982). Organic matter and water-stable aggregates in soils. *J. Soil Sci.* 33:141-163.
- U.S. Salinity Laboratory Staff (1954). *Diagnosis and Improvement of Saline and Alkali Soils*. Agricultural Handbook No:60, 1954.
- Waksman, S.A. (1952). *Soil Microbiology*. John Wiley & Sons. Inc., New York.

# EFFECTS OF VEGETATION WATER OF OIL MILLS ON SOME PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOILS

Saime Seferoğlu, Gönül (Bilgehan) Aydın, Mehmet Aydın  
AD.Ü. Agricultural Faculty Soil Science Dept. Cakmar Aydın

## ABSTRACT

Being one of the waste materials of oil mills, vegetation water (VW) causes some environmental pollution. However, some of the characteristics of this material are favorable for agriculture since organic matter, N,P,K and Mg content of this material are very rich.

In this research, VW was used as fertilizers in form of liquid and solid. It was let to dry in the factory reservoir and then used in the experiment as solid form.

This trial was carried out under alluvial soils of Agricultural faculty farm in Aydın. Completely randomised design with seven treatments and four replications were used.

Effects of VW of oil mills on some physical and chemical characteristics of soils were determined.

## INTRODUCTION

Environmental pollution problem resulting from wastes of factories has been one of the most controversial problems for the public in recent years. Since VW, one of the waste materials of oil mills, also causes environmental pollution, it has directed the sector in olive oil producer countries to find a solution to this problem.

Olive and olive oil production are one of the most important incomes in Aydın regions and some other parts of Turkey. Turkey is the fourth among the olive oil producer countries in the world (Anonymous, 1997). But, apart from its benefits, if the necessary measures are not taken or if other possibilities to use it in different ways are not provided, it could cause severe environmental problems and even pollution.

VW is produced from olive after removing oil in mills. This secondary product has a dark red colour and high total solid matter content, acidity, organic matter, P, K and Mg (Püskülcü et al. 1995). Turkey has 750 000-800 000 ton olive and 100 000-120 000 ton oil production per annum (Anonymous, 1995). According to some researches, 120 m<sup>3</sup> VW is produced from each 100 ton olive in mills that use continuous extraction system of oil (Işıklı, 1992). Depending on this calculation, 650 000 ton of 750 000-800 000 ton olive per annum in productive years is used for oil in mills. It is supposed that it leads to 650 000-700 000 m<sup>3</sup> VW per annum which is equal to the amount of environmental pollution caused by 7500 000 people.

To avoid some unfavourable circumstances which VW causes the developed countries use VW in different ways.

In those countries where olive production has improved;

-VW is filtered in soil and the mud obtained is directly used as a fertiliser or as a raw material in fertiliser factories.

- It is mixed with irrigation water in certain amounts used as irrigation water
- It is used as a fodder mixed with olive pulp.
- It is used as a raw material in fodder industry.
- As a fuel when mixed with olive solid wastes and forest wastes, in making briquette.
- It's used to produce biogas obtained through anaerobic process.

Because of its high organic matter, P, K and Mg content, using it as fertiliser is one of there ways. It was determined that there is an average 6 kg organic matter per 1 m<sup>3</sup> VW (Manuel Hermoso, 1984). Turkey looses about 4550 ton K<sub>2</sub>O, 845 ton P<sub>2</sub>O<sub>5</sub> and 211 MgO Per annum with about 650 000 ton VW (Püskülcü et al, 1995). It was determined that 1 m<sup>3</sup> VW has 3.5-11 kg K<sub>2</sub>O, 0.6-2.0 kg P<sub>2</sub>O<sub>5</sub>, 0.15-0.5 kg Mg (Acunaz, 1987). Urinos, 1981 claimed that VW has 0.005 K and 0.0015 P content so it could be used as fertilizers in the form of liquid and solid on the soil with the rate of 50 m<sup>3</sup> ha<sup>-1</sup> (Hermoso, 1983)

VW is used for different purposes in olive oil producer countries like Spain, Italy and Greece. But, the important one for us is the VW as fertiliser. However, When the related literature reviewed, it could be seen that there are not many researches done about the effects of VW when used as fertilizers on chemical and physical properties of soil. Therefore, this project will contribute to obtain some basic knowledge on the related subject (Llomas, 1978; Alvarez, 1979; Potenz, 1980; Morisot, 1981, Levi- Minzi et all. 1992 ). The purpose of this study is to contribute on some basics knowledge on decreasing environmental pollution and increasing VW use as agricultural input.

## MATERIAL AND METHODS

Research materials is VW which the running oil mills in the region pay no attention to. First, VW was used as liquid. Second, VW evaporated in a barges for 3-4 months. Then, dry residuals were applied to the soil as fertilizers.

The experiments were carried out on Adnan Menderes University, faculty of Agriculture field in two different soil groups. The experimental method used was that of random-block design and four replications. Applications were two forms of VW. Liquid forms were applied in three different time (0.90,180 days ) and three doses (2.5, 5.0, 7.5 L m<sup>-2</sup>). Solid forms were also applied three doses ( 1.5, 3.0 and 4.5 kg m<sup>-2</sup>). Plot sizes were 2 x 2= 4 m<sup>2</sup> and there was 1 m gap between plots.

### Applications doses

- 1- Control
- 2- 2.5 L m<sup>-2</sup> VW ( as liquid, total of three applications)
- 3- 5.0 L m<sup>-2</sup> VW ( as liquid, total of three applications)
- 4- 7.5 L m<sup>-2</sup> VW ( as liquid, total of three applications)
- 5- 1.5 kg m<sup>-2</sup> VW ( as solid)
- 6- 3.0 kg m<sup>2</sup> VW ( as solid)
- 7- 4.5 kg m<sup>-2</sup> VW ( as solid)

### Physical and Chemical Analysis:

Texture : Hydrometer methods ( Bouyoucus, 1959).

Aggregation Index : (Yesilsoy and Berkman, 1975).

Aggregate Stability : (Kemler, 1966).

Suspension, Dispersion Percentage : (Akalan, 1973 and Richards, 1975).

Structure Stability Index : (Yesilsoy, 1968).

Hydraulic Properties of Soils (permeability, available water content) : Yesilsoy and Güzelis 1969).

pH : 1/2 soil/water suspension : (Anonymous, 1980).

Electrical conductivity : (Soil Survey Staff, 1951).

% CaCO<sub>3</sub> : Scheibler calsimeter (Çağlar, 1958).

% Organic Matter : Walkey- Black (Anonymous, 1980).

Total N : Kjeldahl methods (Kacar, 1972).

Exchangeable P : 0.5 M NaHCO<sub>3</sub> (Olsen, et all, 1965).

Exchangeable K, Ca, Na and Mg : 1 N NH<sub>4</sub>OAC (Kacar, 1962).

## DISCUSSION

The research has been planed to be done in two forms ( liquid and solid) in two different soil groups and for two years. The analytical data of the VW used in the project are given in table 1.

( Fiestas Ros de Ursinos, 1986; Püskülcü, et all. 1995).

As it could be seen in table 1, VW has a high P, K, and Mg contend. The results of the first year of the long term period project have been taken here. The effects of VW on chemical and physical properties of two different soil groups were determined by taking soil samples every two months. Here are the analyses of the soil samples taken in three different times. The physical and chemical analyses of research soils were given in Table 2.



Table 1. The chemical composition of VW

Chemical Content	Minimum	Maximum
PH	4.42	5.41
Solid Matter (%)	4.0	6.0
Organic Matter (%)	20.0	24.0
Salt ( $\mu$ mhos/cm)	5463	5806
Colour	Red	-
Oil (%)	0.10	1.50
N (%)	0.50	1.50
P (%)	0.50	3.85
K (%)	1.0	1.1
Ca (%)	2.36	3.98
Mg (%)	0.93	1.86
Na (%)	0.01	2.06
Fe (%)	1000	9318
Zn (%)	230	430
Mn (%)	100	977
Cu (%)	68	110
B (%)	28	35
Co (%)	negligible	0
Mineral Matters (550°C)	2085	6728
Volatile Solid Matter (ppm)	12071	40691
Biologic Oxygen Demand (ppm)	23000	44000

When the results of the analyses are considered, it is seen that there is a difference in soil structure of the surface horizons of the soils belonging to two different levels. In both soil series are sand and loam structure. It was observed that after the application of VW there was a rise in the salt contents of the soils. After the application, soil pH first lowered and then rose and reacted its former level. Likewise, in their study of maize Levi and et al (1992) had the same results for salt and pH.

It was also found out that the organic material content of Kocakir series increased more than that of the isletme series. On the other hand, there was not a considerable increase in nitrogen and calcium content of the soils increased in accordance with the doses used.

There was not a considerable increase in Mg, Na contents of the soils after the application. There was a parallelism between the rise and the amounts of doses used. Likewise, Püskülcü and et al (1995) arrived at similar results.

It was observed that there was a small increase in aggregation stability which is closely related to structure, organic material, lime and sodium contents. This is especially important for those regions where there is low aggregation stability. Yet, if the Na contents decrease as a result of the applications which will be done later, it could decrease aggregation stability. However, because VW has some positive effects on the soil the improvement of the negative factors might increase aggregation stability.

Table 2. The physical and chemical results of the soils that VW is applied on.

Sampling Series and VW Dosage	(%) Sand	(%) Silt	(%) Clay	Texture	MWD (Ag+Prim)	MWD (Prim)	Aggr Stab.	(%) Total Salt	pH	(%) CaCO <sub>3</sub>	(%) Organic Matter	(%) N	(ppm) P	(ppm) K	(ppm) Ca	(ppm) Mg	(ppm) Na
Isleime Series *	74.60	14	11.40	SL	1.01	0.84	0.17	0.002	8.63	6.56	0.33	0.072	13.07	110	2600	175	20
Kocakir Series *	78.60	12	9.40	SL	0.77	0.88	0.11	0.002	8.48	0.80	0.67	0.39	21.40	100	900	180	40
Isleime Series: ** 0								0.007	8.41	6.27	0.13	0.050	8.88	110	2500	176	40
2.5 L m <sup>-2</sup>								0.005	8.46	6.29	0.13	0.044	9.33	110	2600	180	20
5.0 L m <sup>-2</sup>								0.006	8.48	6.42	0.67	0.061	10.18	140	2400	182	40
7.5 L m <sup>-2</sup>								0.006	8.44	6.02	0.13	0.056	12.31	140	2500	188	20
Kocakir Series:**0								0.004	8.42	1.17	0.26	0.084	20.88	100	900	174	50
2.5 L m <sup>-2</sup>								0.007	8.30	0.97	0.53	0.061	23.20	110	900	177	70
5.0 L m <sup>-2</sup>								0.005	8.33	1.25	0.53	0.061	20.88	130	900	180	50
7.5 L m <sup>-2</sup>								0.005	8.42	1.06	0.80	0.067	23.09	140	1000	182	60
Isleime Series:**0					0.87	0.68	0.19	0.004	8.50	5.01	0.80	0.045	10.10	100	2700	178	40
2.5 L m <sup>-2</sup>					1.16	0.84	0.32	0.006	8.65	6.10	0.80	0.045	12.20	130	2500	204	60
5.0 L m <sup>-2</sup>					1.22	0.99	0.23	0.006	8.67	6.16	1.47	0.045	15.20	210	2400	195	70
7.5 L m <sup>-2</sup>					1.49	1.17	0.32	0.007	8.47	6.26	0.80	0.056	15.60	230	2400	199	70
Kocakir Series:**0					1.72	1.44	0.28	0.005	8.35	1.41	0.26	0.056	22.70	120	900	170	40
2.5 L m <sup>-2</sup>					1.76	1.61	0.15	0.008	8.30	1.06	1.07	0.022	22.20	130	1000	185	80
5.0 L m <sup>-2</sup>					1.81	1.56	0.25	0.007	8.47	1.19	1.20	0.095	23.40	140	1200	188	80
7.5 L m <sup>-2</sup>					2.43	1.78	0.65	0.008	8.45	1.14	1.34	0.093	24.60	180	1100	195	90

\* before application

\*\* after first application

\*\*\* after second application

MWD :Mean weight diameter

## REFERENCES

- Acunaz C., (1987). Zeytin ve Zeytin yağı Birliğine Ait Sıkma Tesisleri Arttığı Karasuyun Arıtımı ve Değerlendirilmesi. Sonuç Raporu Tarış Ar-Ge. 012.
- Akalan İ., (1973). Toprak fiziki A.Ü. Ziraat Fakültesi Yayın No: 527/172.
- Anonymous (1980). Soil and Plant Testing and Analysis as a Basis of fertilizer Recommendations. F.A.O. Soils Bulletin, 38/2 p 95.
- Alvarez A., (1979). "Actuaciones realizadas por los almazareros para la eliminación de los vertidos de alpechin a cauces publicos". XV Asamblea de Miembros del Instituto de la Grasa y sus Derivados. Sevilla, Mayo. 1979. 6p.
- Anonymous (1997). COI Report on Economic Matters CE/R 42/doc. No:24 April.
- Bouyoucos G. J., (1955). A. Calibration of the Hydrometer Method for Making Mechanical Analysis of the Soils. Agronomy Journal, Vol.4., No: 9-434.
- Çağlar K.Ü., (1958). Toprak bilgisi. A.Ü. Yayınları, No: 10.
- Fiestas Ros de Ursinos J.A. 1986. Progress Report on Research and Technologies in connection with the Question of olive VWs. International Seminar on olive oil Technology. S: 2 İzmir- TURKEY
- Hermoso M., (1983). Use of Olive by-products as fertilizers. International course on fertilization and Intensification of olive cultivation S. 65-88.
- Işıklı T., (1992). Farklı Teknoloji Uygulanan Zeytinyağı Fabrikalarında Elde Edilen Karasuyun Analitik Özelliklerinin Tesbiti Üzerine Araştırma. Tarım ve Köy İşleri Bakanlığı Zeytincilik Araştırma Enstitüsü Yayınları No: 56 Bornova/ İZMİR.
- Kacar B., (1962). Plant and Soil Analysis. University of Nebraska, College of Agriculture. Department of Agronomy, Lincoln, Nebraska, U.S.A.
- Kacar B., (1972). Bitki ve toprağın kimyasal analizleri , II. Bitki analizleri, A:Ü. Zir. Fak. Yayınları , 453.
- Kemler W.D., (1965). Agregat Stability ( C.A. Black et. al. edit) Methods of Soil Analysis Part II. Agronomy Series No:9 ASA. Inc. Pub. Madison. Wisc. U.S.A. pp.511-519.
- Levi- Minzi R., Saviozzi R., Riffaldi R., and Falzo L., 1992. Land application of vegetable water effects on soil properties. Olive No: 40 S: 20-25 .
- Llomas J.F. 1978. INIA. Estacion de Olivicultura y elayotecnia Jaen (Espana).
- Manuel Hermoso., (1984). Use of Olive By-Products as Fertilizers- International Course on Fertilization and Intensification- F.A.O: Madrid / SPAIN.
- Morisot A., 1981. "Etude de l'epandage des margines des moulins d' olives". Institut National de la Recherche Agronomique Station de Science du sol – BP 78 06602- 53, (5), 443-461.
- Olsen S.R. and Dean, L. A.; (1965). Phosphorus (Ed. C. A. Black) Methods of soil Analysis. Part 2. American Society of Agronomy. Inc. Publisher Madison Wisconsin U.S.A.
- Potenz D., Righetti E., Volpicella M., 1980. "Effetto inquinante delle acque reflue della lavorazione delle olive su terreno agrario 3. Caratteristiche e qualita delle sostanze uniche, comportamento di alcune colture erbacee". Inquinamento, 22 (2), 65-68.
- Püskülcü G., Dikmelik Ü., Akıllıoğlu A., (1995). Karasudan Elde Edilen Tortunun Zeytinde Gübre Olarak Kullanılması Üzerinde Bir Araştırma. Tarım ve Köy İşleri Bakanlığı Tarımsal Araştırmalar Genel Müdürlüğü Zeytincilik Araş. Enst. Bornova- İZMİR. Sonuç Raporu
- Richards L.A.; (1954). Diagnosis and Improvement of Saline and Alkali Soils. U.S. Agriculture Handbook No: 60. 159 S.
- Soil Survey Staff., (1951). Soil Manual Washington D.C. 339-363.
- Ursinos F.R., (1981). Differentes utilisation des margines recherches en cours, results obtenus et applications. Seminaire international sur la valorisation des sous-produits de l'olivier. P. 93-110.
- Yeşilsoy M.Ş., (1968). Toprak Strüktür Stabilitesi Tayini Toprak ve Gübre Araştırma Enstitüsü Teknik Yayınları sayı: 17. Ankara (8).
- Yeşilsoy M.Ş., and Güzelış., (1969). Topraklarda Hava- Su Permeabilite oranı ve Strüktür Stabilitesi. Türkiye Toprak İlimi Derneği Yay. No:1 Sayı.153-161.
- Yeşilsoy M.Ş., ve Berkman, A., (1975). Islak Eleme Yöntemi ile Topraklarda Agregasyon İndeksinin Saptanması Ç.Ü. Zir. Fak. Yıllığı Yıl 55. 1-2 Sayfa 95-110.



# ADVERSE EFFECTS OF UNCONTROLLED URBANISATION ON THE SUSTAINABLE AGRICULTURE IN KONYA, TURKEY

Kemal Gür, Serpil Önder, Tuğrul Polat  
Selçuk University Agricultural Faculty Campus/Konya-Turkey

## ABSTRACT

This work was carried out to enlighten the rates and the distributions of the agricultural land losses throughout the years due to uncontrolled and miss-planned urbanisation and industrialisation in Konya province since 1941. The results can be summarised as follows;

-The population of the city itself has been around 56465 in 1941, but then it has shown a high rates of increases to the present: It became 329.139 with an increase rate of 483% and 702842 with an increase rate of 1144.7 % in 1980 and 1999 respectively.

-The area arranged and left for the city settlement has shown the same patterns of the drastic and fast rate of increases in accordance with those of the increased population in the city itself: although it has been only 544 ha in 1941, it became 8016 ha with an increasing rate of 1373.5 % and 29558 ha with a increasing rate of 5333.5 % in 1981 and 1997 respectively.

-It was calculated that the distribution of the most productive agricultural soils (grouped as soil classes of I and II. ) among the lands that have been left and thus lost for the new settlements of the newly urbanised areas, were approximately 92.22 % and 65.83 % in 1981 and 1999 respectively.

-Some suggestions were made to take serious measures in order to stop the misusing of the productive agricultural lands, because of the uncontrolled and disorganised urbanisation and industrialisation in Konya.

## INTRODUCTION

The concept of sustainable agriculture in our Country is not new. For decades, farmers have applied soil management and conservation practices to the best of their ability, thinking that potential of agricultural land to produce food is finite.

A concept of sustainable land use has take into consideration that agricultural and forest land use is only one of six important uses of soil and land. Those other uses are : and for filtering, buffering and transformation in the ease of landfills or widespread deposition of adverse chemical products, the use of land and soil as biological gene reserve, as well as three more, intensively linked to human activities, such as the use of land for infrastructural development , e.g. the construction of roads, residential buildings, industrial premises, recreation and sporting areas, and the use of soil material such as clay, sand, gravel and others for the establishment of those constructions. The natural resources of the ecosystem including land have become under increasing pressure in the past few decades as they are being utilised at levels which may be higher than their inherent carrying capacity. Moreover, many lands are being misused and / or polluted. Therefore, extensive land areas in may countries like Turkey, are subjected to degradation and then to desertification. This case is particularly accentuated in the arid and sub-arid regions of the world, as in the case of Great Konya Basin, where land degradation is equated with desertification ( Gür 1987 ).

The main purpose of this paper is to discuss all these interrelated factors and make sound practical suggestions for preventing the wide-spread losses of the productive agricultural lands because of the miss-planned and uncontrolled urbanisation and industrialisation in Konya, Turkey.

## MATERIALS AND METHODS

Konya has been one of the oldest settlement of Anatolia in the History. It is located on a large plateau known as "Great Konya Basin" in the central part of Anatolia. The plateau itself is surrounded by the high mountains. The height of the plateau is about 1021 meter above the sea level. Therefore, the region has a typical terrestrial climate i.e. cold in winter, but hot and semiarid in summer. The rain falls usually in winter and spring. The mean precipitation is about 204.5 mm throughout the year. Due to its very favourable soil and climatic conditions, The Great Konya Basin has a significant agricultural potential. That's why it has been known to be the store of cereals of Turkey . The general (total) sown agricultural land comprise an area of 30.117.410 ha in

Konya. Irrigated and non-irrigated (rainfed) agricultural lands cover about 505.687 ha and 2.505.231 ha respectively (Bayraklı *et. al.* 1991).

In order to trace the land use changes in Konya during the last 58 years, the topographical soil maps having a scale of 1:100.000 and reports (Anonymous 1992), the reports and the Regulating Improvement Plan of Konya city designed up to the year of 2020 (Taşcı 1999), the tables and the maps showing the distribution of urbanisation in Konya according to the years (Önder and Gür, 1998) were used.

Using the Regulating Improvement Plans of Karatay, Meram and Selçuklu towns which are already located within the boundry of the Central Municipality of Konya, The maps having a scale of 1:100.000 and showing the present situation of urbanal land use and the classes of land-use capability. Then, the rates and the distribution of the soil losses of the productive agricultural lands due to the uncontrolled, and disorganised industrialisation and urbanisation were determined with the diagramatical and mechanical (Planymetrical) methods (Ayyıldız, 1981).

## DISCUSSION

Distributions of the population, the settlement areas, together with the land-use capability classes according to periods (years) in Konya between 1941 and 1999 were given in Table 1, Map 1 and 2 respectively.

As given in The Table 1, the population of the city its self has been around 56.465 in 1941, but then it has shown high rate of increase to the present (i.e.1999): For-example, it has become 157.934, 200.464, 329.139, 513.346 and 702.842 in 1941, 1970, 1980, 1990 and 1999 respectively (Table 1). Thus, the rates of increases among the years in which the census has been done, were as follows : unpublished 179.7 % (1941-1964), 26.9 % (1964-1970), 64.2 % (1970-1980), 56.0 % (1980-1990) and 36.9 % (1990-1999) respectively. These figures shows that, in the last 58 years, demographic outbursts and migration have led towards a great overpopulation in the Konya. The city has received large numbers of emigrants mainly from the rural areas and surrounding towns such as Taşkent, Hadim, Ermenek *etc.* It was concluded that, attractiveness of the city *vis-a-vis* suitable resorts, and better working facilities have been supposed to be the main reasons for the migration and for the overpopulation in Konya. However, all these have resulted in a disorganised and unplanned industrialisation: New settlement areas have been created to solve the housing needs in the vicinity of the city to overcome the " overpopulation" problem. During this process, usually large as well as fertile agricultural areas have been transformed into an urban land at an astounding speed, we thus, see concrete blocks budding on the prime quality fertile land accompanied by soil erosion in the form of brick production needed for the acceleration of the miss-planned and uncontrolled urbanisation. In other words, the increased pressures imposed by the uncontrolled and disorganised urbanisation and industrialisation, and other improper and misuses of the soil have created irreversible losses of highly productive agricultural lands, in Konya. The earlier conditions have been very different from the present with relatively low population density and little pressure on agricultural land. Thus, it was concluded that, the growing population pressure on the agricultural land in the last 58 years, has been one of the main cause of the present land degradation and land desertification. Unfortunately, approximately 31.286 ha of the agricultural land is being occupied by various industries and urban settlements most of which are prime quality on the other hand, the areas left for the city settlement cover about 544 ha, 1.728 ha, 4.896 ha, 10.704 ha, 22.848 ha and 31.286 ha in 1941, 1964, 1970, 1980, 1990 and 1999 respectively. It can be calculated that the city settlement area has increased approximately 3.2 times from 1941 to 1964 2.8 times from to 1964, to 1970 and 1.4 times from to 1990 respectively.

On the other hand, it was also calculated that 76.33 % of the area (i.e., 10.704 ha) that have been left for city settlement covered the most productive agricultural soil classes (I and II) in 1980. The similar distribution and patterns exist at present. For-example, as shown in the Table 1 and also on the Maps '1 and 2), it was found that 80.4 % of the total area (i.e., 31.285 ha) that have been left for the city settlement represent the most productive agricultural soil classes covering I, II, III and IV, mentioned above and as shown in the Table 1, and also on the Map 1 and Map 2. This means that, the area arranged and left for the city settlement has shown the same pathways of the drastic and fast rate of increases in the population of Konya City. Thus, it was concluded that hundreds of hectares of the most productive lands have been lost due to the misuses for non-agricultural



purposes such as disorganised industrialisation uncontrolled and miss-planned urbanisation in the last six decades. Moreover, most of orchards, mainly comprise vineyard and apricot trees, such as the historical Meram, Kum, Sille, Yaka, Köyceğiz, Alavardı, orchards etc., have been lost and now they are all being occupied by buildings and factories. Eventually, disorganised, uncontrolled and miss-planned urbanisation and industrialisation, overgrazing, overexploitation, deforestation and soil pollution are supposed to be main causative for the land degradation and desertification as far as the maintenance of the sustainable agriculture is concerned, in Konya. The reason for this retrogressive trend, of course, can not be related to just a single factor but rather includes a complex mixture of several interrelated factors, namely that of inadequate land distribution, judicial, social and economic problems, and ineffective technical services provided to the villagers for grazing management and pasture development practices.

However, some promising measures have been initiated by the Local Government were observed to minimise this soil degradation and soil desertification. The most important initiative has been the determination of the Northern part of the city with the unproductive lands that comprise soil classes of VI and VII, as the "new urban development zone".

In order to minimise the misuse of the productive agricultural land due to the uncontrolled and disorganised urbanisation and industrialisation in Konya, some general measures suggested can be summarised as follows;

- National land use and conservation policies need to be developed, considering the suitable management practices and capabilities of soil and legislative together with socio-economic factors.

- Detailed soil and land use and quality maps need to be prepared along with appropriate modelling. In this regard, universities and research institution have important role to play.

- One of the main agendas for land use policies, in Konya, also in Turkey in general, should be to establish international institutions whose prime objectives would be to tackle with the land degradation and desertification, in all aspects. International funds, of course, should be made available to materialise this.

- The national soil policy legislation and establishment of an independent organisation to implement the objectives of national soil policy in relation with degradation control, has been recommended.

- A governmental authority as the GAP (Southern Anatolian Project) must be established in the Great Konya Basin, (e.g.KOP) to deal with the inventory assessment, development, management and conservation of land water resources and plant nutrients.

- There is a need focusing on management of degradation and desertification believing that sustainability and productivity of farming practices should be improved together.

## REFERENCES

- Alkan, A., 1990. Tarihi Kentin Planlama Sorunu. S.Ü.Mühendislik-Mimarlık Fakültesi Assoc. Prof. Desertation(unpublished), s: 200. KONYA.
- Anonymous, 1992. Konya İli Arazi Varlığı. Tarım ve Köy İşleri Bakanlığı Köy Hizmetleri Genel Müdürlüğü Yayınları No: 42. ANKARA
- Anonymous, 1998. Türkiye'nin Çevre Sorunları 1999. Türkiye Çevre Vakfı Yayını No:131, Önder Matbaası. ANKARA
- Ayyıldız, M., 1980. Ölçme Bilgisi. A.Ü.Ziraat Fakültesi Yayını No:550, A.Ü.Basımevi. ANKARA
- Bayraklı, F., Karakaplan, K., GÜR, K., Fırat, B., Gezin, S., 1991. Orta Anadolu'daki Toprak ve Arazi Kullanımı. Orta Anadolu'da Tarımın Verimlilik Sorunları Sempozyumu (8-10 Mayıs, 1991), 30-39. KONYA
- Çevikbaş, R., 1991. Türkiye'de Tarım Topraklarının Amaç Dışı Kullanılması ve Yaratıldığı Sorunların Önlenmesi. Tabiat ve İnsan Dergisi, Yıl:25, Sayı:3, 11-16, Doğu Matbaası. ANKARA
- GÜR, K., 1987. Çevre Kirliliği Ders Kitabı. S.Ü Ziraat Fakültesi Yayınları No : 15, Kampis-KONYA
- ÖNDER, S. ve GÜR, K., 1998. Konya'da Kentsel Gelişmelerin Tarımsal Alan Kayıplarına Etkileri Üzerinde Bir Araştırma. S.Ü.Ziraat Fakültesi Dergisi 12(17), 105-115. KONYA.
- Taşcı, Y., 1999. Konya Büyükşehir Çevre Düzeni Revizyon Nazım İmar Planı Araştırma Raporu. Kon Plan 2020 (unpublished). KONYA



Tablo : Konya'da yıllara göre kentsel yerleşim alanları ve toprak yetenek sınıfları (ha)(Önder ve Cür 1998 ve Ananoyms 1999)Çan yararlanılarak hazırlanmıştır)

Yıllar	Nüfus*	İmarat Açılan Toplam Alan**	I	II	III	IV	V	VI	VII
1941	56465	544	-	-	-	-	-	-	-
1964	157934	1728	1728	-	-	-	-	-	-
1970	200464	4896	3744	768	-	-	-	-	-
1980	329139	10704	6960	1200	720	672	-	384	-
1990	513346	22848	12384	3792	1152	1728	-	768	384
1999	702842	31286	15072	5216	2278	2576	720	1776	2016
1999 Kentsel Alan Kullanım Durumu								2472	2952
Yerleşim									
Sanayi									
-İrorganize Sanayi ve Karatay Sanayi		22242	14138	3408	1240	1,296	720	504	936
-Organize Sanayi ve Tümosan		5002	482	432	144	680	-	1344	1920
-Meram Sanayi		2352	384	144	-	480	-	96	1248
-Şeker Fabrikası		1728	-	-	144	-	-	912	672
-Krom Magnezit		25	25	-	-	-	-	-	-
-Tatlıcak Küçük Sanayi Siteleri		73,5	73,5	-	-	-	-	-	-
-Tatlıcak Küçük Sanayi Siteleri		56	-	-	-	56	-	-	-
Universite		768	-	288	-	144	-	336	-
-SÜAlaeddin Keykubat Kampüsü		1684	68	80	720	480	-	240	96
-Meram Kampüsü		1536	-	-	720	480	-	240	96
-Tıp Fakültesi Kampüsü		68,5	68,5	-	-	-	-	-	-
-Çimenlik Veteriner FakÜlge Alanı		8	-	8	-	-	-	-	-
Askeriye		72	-	72	-	-	-	-	-
-Taktik Hava Üssü		2110	286	1296	24	120	-	384	-
-Tutlu Kırı Askeriye Tesisleri		1152	144	624	-	-	-	384	-
-Org Tural Kışlası ve Ordu Evi		600	72	384	24	120	-	-	-
-Selçuklu Askeri Kışlası		70	70	-	-	-	-	-	-
Spor ve Kültür Alanları		288	-	288	-	-	-	-	-
-Atatürk Spor Tesisleri		247	97	-	150	-	-	-	-
-Selçuklu Uluslar Arası Fuar Alanı		10	10	-	-	-	-	-	-
-Karatay Saraçoğlu Spor Kompleksi		75	75	-	-	-	-	-	-
-Selahattin Eyyubi Kültür Merkezi		150	-	-	150	-	-	-	-
GENEL TOPLAM		12	12	-	-	-	-	-	-
%		31285	15071	5216	2278	2576	720	2472	2952
		10000	4818	1667	728	8230	230	790	943

\*O Yıla Yakın Zamanda Yapılan Nüfus Sayımı Sonuçlarıdır

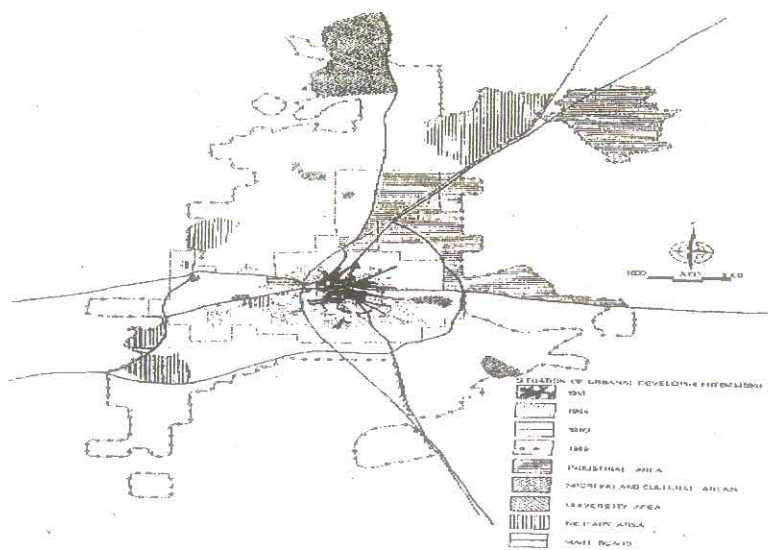
\*\* Ait Olduğu Yılda Kenite Toplam İmarat Açık Alanlar

Table 1. Distributions of the population, areas left for the settlement and the classes of land use capability according to the years between 1941-1999, (ha)  
(Önder and Gür 1998; Taşçı 1999)

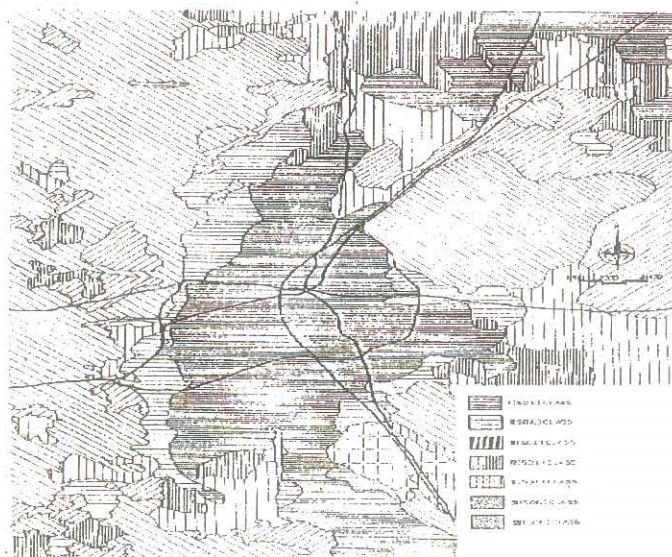
YEARS	DISTRIBUTIONS OF URBANIZED AREA	Population*	Sum of urban area **	Soil classes of the land use capability						
				I.Class soil	II.Class soil	III.Class soil	IV.Class soil	V.Class soil	VI.Class Soil	VII.Class soil
1941		50465	544	-	-	-	-	-	-	-
1964		157934	1728	1728	-	-	-	-	-	-
1970		200464	4896	3744	768	-	-	-	384	-
1980		329139	10704	6960	1200	720	672	-	768	384
1990		513346	22848	12384	3792	1152	1728	-	1776	2016
1999		702842	31286	15072	5216	2278	2576	720	2472	2952
	SETTLEMENT		22242	14138	3408	1240	1296	720	504	936
	INDUSTRY		5002	482	432	144	680	-	1344	1920
	-1.Organized Industry and Karatay Industry		2352	384	144	-	480	-	96	1248
	-2.Organized Industry and Tümosan		1728	-	-	144	-	-	912	672
	-Meram Industry		25	25	-	-	-	-	-	-
	-Sugarbeet Factory		73	73	-	-	-	-	-	-
	-Chrome Magnesite Factory		56	-	-	-	56	-	-	-
	-Tatlıcaak Small Industry Units		768	-	288	-	144	-	336	-
	SELÇUK UNIVERSITY		1684	68	80	720	480	-	240	96
	-Alaeddin Keykubat Campus		1536	-	-	720	480	-	240	96
	-Meram Campus		68	68	-	-	-	-	-	-
	-Faculty of Medicine Campus		8	-	8	-	-	-	-	-
	-Application area of the Veterinary Faculty, Çimenlik		72	-	72	-	-	-	-	-
	MILITARY AREA		2110	286	1296	24	120	-	384	-
	- Tactical Air Base		1152	144	624	-	-	-	384	-
	-Military Establishment, Dutlu Kırı		600	72	384	24	120	-	-	-
	-Org.Tural Military Barracks and Military Hall		70	70	-	-	-	-	-	-
	-Selçuklu Military Barracks		288	-	288	-	-	-	-	-
	SPORTING AND CULTURAL AREAS		247	97	-	150	-	-	-	-
	- Atatürk Sporting Establishment		10	10	-	-	-	-	-	-
	-Selçuklu International Fair		75	75	-	-	-	-	-	-
	-Sarıoğlu Sporting Complex, Karatay		150	-	-	150	-	-	-	-
	-Selahattin Eyyubi Culture Center		12	12	-	-	-	-	-	-
	GENERAL SUM		31285	15071	5216	2278	2576	720	2472	2952
	%		100.00	48.18	16.67	7.28	8.23	2.30	7.90	9.43

\* The results of population census for the periods (years)

\*\* The distribution of the land left for the settlement



Map 1. Distribution of the uses the urban areas in Konya by the end of 1999



Map 2. Distribution of the classes of land use capability (not capability classes) in Konya



# A STUDY ON THE SOIL TARE OF SUGAR BEET IN ESKİŞEHİR - TURKEY

Nazmi Oruç, Halil Güngör

TEMA, Akcamı Mah. Kurşunlu Cami Sok. No: 1 Odunpazarı, Eskişehir.

## ABSTRACT

The amount of soil delivered to the sugar factories is a major problem in beet growing countries. Analysis of the data obtained from the General Directorate of Turkish Sugar Industry indicated that the amount of soil carried away from the beet fields was a very important issue in Turkey. As an average of last ten years ( 1989 - 1999 ) the percentages of soil tares were estimated as 10.24% and 11.20% of the gross-weight of the sugar beet harvested in Turkey and Eskişehir, respectively. This means that approximately 1500000 tons of soil in Turkey and 154000 tons of soil in Eskişehir were transported from the beet fields annually. The high amount of soil delivered to the sugar factories and weighing sites not only causes a kind of Land Degradation (Soil Erosion ) but also increases the cost of handling and consequently white - sugar prices, on the other hand, the adhering soil is very rich in organic matter content as well in major plant nutrients.

Fifteen adhering soil samples were collected from five different beet delivery sites in Eskişehir in Nov. 1999, soil analysis showed that about 4200 tons of organic matter, 416 tons of total N, 16.1 tons of available P ( $P_2O_5$ ) and 30.8 tons of extractable K ( $K_2O$ ) were carried away in 154000 tons of transported soil from the beet fields in Eskişehir. From the economical and ecological points of view the transport of soil from the beet fields should be minimized by using improved methods of cultivation, mechanization and plant breeding and also sugar beet growers should be enlightened about the importance of soil tare reduction in beet growing.

## INTRODUCTION

Both sugar beet production ( indispensable rotational crop in Central Anatolia ) and sugar industry have a very significant role in Turkey's agriculture and agro-industry regarding to technological, economical and social development of rural population. Sugar beet growing area is around 360000 hectares and about 12300000 tons of sugar beet is yearly processed by 27 sugar factories in Turkey. There is about 32000 hectares of sugar beet growing area in Eskişehir. And during the campaigns of last decade, around 1500000 tons of beet have been processed by one of the oldest sugar factories established at Eskişehir in 1993 yearly. (Tarım Raporu, 1998)

Generally, in sugar beets considerable yield losses and costs occur during and after lifting the crop. The yield losses consist of root losses and sugar losses. The main costs caused at delivery of the beets to the sugar factory are brought about by the amount of tare. Apart from stones, weeds etc., it consists of top tare and dirt (soil) tare. According to the contract signed between the beet growers and Turkish Sugar Company, a regular 5% deduction is applied for the top tare by the company on the total weight of the beet delivered to the weighing sites. Amount of the soil tare is visually evaluated by the company experts at delivery sites. For determining the actual soil tare on disputed cases, randomly chosen beet samples ( about 10 kg ) are weighed before and after cleaning of the sampled beets.

In order to determine the efficiency of a cleaning machine ( Armer Salmon HI - VOL ) a series of tests were carried out at Ankara Sugar Factory in 1992. Reduction of soil tare varied from 34% to 86% depending on the weather conditions during the beet harvest time. It was reported that efficiency of cleaning machinery decreased from 57% to 34% due to the 13 mm. of rainfall received before the beet harvesting day (Sevilmiş, 1992).

Kangal (1996) reported in his M. Sci. thesis titled as "Determining the Mechanical Cleaning Efficiency of Sugar Beet Loading Unloading and Cleaning Machines", that the cleaning efficiency of machines were approximately 62.67%, the beet surface damage area was about 4.99 cm<sup>2</sup> and the machines increased the root breakage and caused the cracks on the beet surface.

It was reported by Van der Linden (1996) that the amount of soil delivered to sugar beet factories was a major problem in the Netherlands and as an average year, the percentage of soil tare varied from 5 to

15% of the gross weight of the sugar beet, representing the amount of 800.000 tons of soil coming from 115000 hectares of beet growing area. The estimated costs of handling were Dfl. 46000000. Beet growers paid 50% of the costs directly, the other was settled in the beet price. Lifting principles without pressing soil to the beet dramatically reduced the amount of adhering soil just behind the lifter. In this research cleaning systems such as compressed air, brushes, stars and axial rollers were compared with conventional systems such as turbines and angers. The different systems resulted in a reduction of 50% of the soil tare on clay soils, on sandy soils the reduction was 80%.

Koch (1996) indicated that 2-4 million tons of soil were transported from 500000 hectares of sugar beet (4-8 tons/h), yearly in Germany. In order to quantify the effects of several agronomical practices on soil tare of sugar beet, data of various field trials were evaluated by Koch. Contemporarily growing low tare varieties could reduce soil transported to sugar factories up to 20% (relative). An even higher reduction was to be reached by mechanical cleaning ( up to 60%). Tillage and N- fertilizer supply only showed a small potential to lessen soil tare. Against this, raising plant densities led to increasing soil tare (+3.6% rel. / 10000pl.) It was noticed that the unification of Germany was an overriding theme in the 1990 campaign. And average soil tare was fairly low at 13.93%, but since the lowest value was 9.25%, there was scope for further improvement ( Bucholz and Schliephake, 1991).

Günther (1996) indicating high costs in the sugar factories because of the soil delivered along with sugar beet, carried a research on cleaning off dirt tare in advance by covering the beet clamps to ensure good drying, thereby improving cleaning. The average cleaning results of the exact tests 1988 - 95 showed a degree of cleaning of about 37% with uncovered clamps, as opposed to 57% with covered clamps, with films of polythene or polypropylene. The study titled as " Different ways to reduce soil tare in sugar beet production - ongoing work in France " was summarized by Guiraud and Leveque (1996). They explained that tare depended on numbers of factors which could be partially or fully controlled during the very first stages of growing. It was particularly at the time of harvesting that means of action were possible. Some factors increased or decreased the tare in overall manner, by adding or removing a more or less significant number of tare < points> depending on their importance: climate, soil type, soil moisture, leaf stripping, placing of the clamp. Other factors were instrumental by causing a constant variation of the dirt tare removed, more or less irrespective of conditions: yield populations, varieties, distance between rows, lifting devices, length of the cleaning circuit, pick - up depth, advanced speed, turbine rotation speed, clamp cleaning."

In his paper on the breeding for improved root shape to reduce dirt tare, Brussaard (1996) argued that plant breeding could contribute considerably by modifying the traditional morphology of the sugar beet root to reduce top tare and dirt tare in addition to improved methods of cultivation and mechanization. He noticed that all sugar beet varieties had a conical root shape up till now. However it was thought that beets with a globe - shaped or oval root grooves, unbranched, with narrow crown and with a smooth skin could decrease the losses and costs considerably. Although still too low in sugar content and juice purity, the "tare - unfriendly sugar beet" was a great potential for further reduction of the amount of dirt tare and consequently a great potential for further reduction of production and processing costs.

This study is aimed to indicate the importance of soil tare and plant nutrient losses in sugar beet harvesting in Turkey and in Eskişehir. It was considered that these discussions may be useful for sugar factories, farmers and environmentalists in the context of sustainable growth.

## **MATERIALS AND METHODS**

The amounts of soil tare were calculated from the data of General Directorate of Turkish Sugar Industry. The compiled data included the figures of last ten years (1988-1998) about the sugar beet grown area, number of growers, yields delivered to the weighing-machine sites, yields paid by the sugar company, sugar beets processed by the factories and also sugar content and juice purity for the 27 different sugar factories throughout Turkey. The difference between the amount of beet delivered at that weighing sites by the growers and the amount of the beet processed by the sugar factories minus 5% regular deduction for the top tare was considered as Soil Tare. The figures used in this paper for Turkey and Eskişehir Province are the average values for the last ten years.



Fifteen adhering soil samples were collected from five different sugar beet delivery sites (3 samples from each) in Eskişehir on Nov.,1999.

Conventional methods were used for the analysis of the total organic matter. ( Walkey Black), total N (Micro Kjeldahl), available P (Olsen Method) and extractable K ( IN, pH=7 NH<sub>4</sub>OAc) levels of the soils.

## RESULTS AND DISCUSSION

The amount of soil delivered to beet weighing sites and sugar factories is a major concern in most of the sugar beet growing countries and Turkey. Results from the analysis of the data obtained from the Sugar Industry of Turkey are given in Table 1.

Table1. Average Values of Sugar Beet Growing Area, Yield, Soil Tare, Top Tare, and Soil Losses in Turkey and Eskişehir, (n=10).

	<u>Turkey</u>	<u>Eskişehir</u>
Harvested Area (ha)	360000	32205
Yield	14486093	1374497
Soil Tare %	10.24	11.2
Top Tare %	5.0	5.0
Soil Losses (tons/year)	1483337	153944
Soil Losses (tons/ha)	4.16	4.80

The percentages of soil tare and soil losses in Turkey are somewhat lower than these in Germany and in the Netherlands. Since weather conditions are much more rainy in Western Europe than in Turkey during the lifting period of beet. So, much less adhering soil of sugar beet is expected in arid Turkey, when compared to other rainy European countries in the fall. Urgently, detailed research is needed to clarify the every aspects of factors causing high soil tare in sugar beet lifting and beet transportation to the factories in Turkey. Chemical analysis results of the adhering soil samples are given in Table 2.

Table 2. Some Chemical Properties of Soil Samples collected in Eskişehir, (n=15).

	<u>Min.</u>	<u>Max.</u>	<u>Average</u>	<u>Std. Dev.</u>	<u>Median</u>	<u>Ton / Year</u>
Organic Matter%	1.27	5.00	2.72	± 1.12	2.75	4188
Total N%	0.16	0.36	0.27	± 0.14	0.28	415.8
Available P (P <sub>2</sub> O <sub>5</sub> ppm)	32	221	105.73	± 59.38	94	16.17
Extractable K (K <sub>2</sub> O mc./100g)	1.37	7.48	4.27	± 2.03	3.56	3 0.77

As it is easily seen in the Table 2. The adhering soils removed from the surface layer of beet fields are not only rich in organic matter content, but also contain appreciable amounts of essential plant nutrients such as N-P-K. So higher amounts of adhering soil cause higher losses of organic matter and plant nutrient in addition to increasing the transportation costs of beet. Beside this, most unavoidable aspect is soil erosion that results in a Unrecognized Land Degradation as year go on. From the stand point of sustainable agriculture the transport of soil should be minimized. Hence the farmers have to be convinced and enlightened on this vital issue, beside the use of improved methods of cultivation and mechanization in Turkey.

**Acknowledgment:** We wish to thank the General Directorate of Turkish Sugar Factories in Ankara and Sugar Factory in Eskişehir for supporting the data, and also the Institute of Forestry Soil Laboratory of Eskişehir for the soil analysis.



## REFERENCES

- Buchholz, K., Schliephake, D. (1991) Zuckerindustrie, 1991, 116:5, 403-420
- Guiraud, D., Leveque, E. (1996) Different Ways to reduce Soil Tare in Sugar Beet Production-Ongoing Work in France, Proceedings of the 59<sup>th</sup> IIRB Congress, February 1996, P. 469-481
- Günther, I. (1996) Intermediate Storage and Pre-Cleaning of Sugar Beets as a means of Reducing Dirt Tare. Proceedings of the 59<sup>th</sup> IIRB Congress, February 1996, P. 507-512
- Kangal, A., (1998) Pançar Boşaltma-Temizleme ve Yükleme Makinalarının Mekanik Temizleme Etkinliğinin Belirlenmesi, Yüksek Lisan Tezi Ankara Üni. Fen Bilimleri Enstitüsü. Ankara.
- Koch, H. J. (1996) Possibilities and Limits for Reducing Soil Tare of Sugar Beet through Tillage, Population Density, N-Fertilizer Supply, Variety and Cleaning. Proceedings of the 59<sup>th</sup> IIRB Congress, February, 1996 p. 483-497
- Sevilmiş, A.H, (1992) Armer Salmon HI-VOL Pançar Temizleme Makinasının Temizleme Etkinliği ve Temizleme Maliyetinin Tespit Edilmesi Çalışması. Şeker Enstitüsü, Tarımsal Mekanizasyon Şubesi, Ankara.
- Tarım Raporu (1998), Türkiye Şeker Fabrikaları A.Ş. Genel Müdürlüğü, Ankara, 58 sahife.
- Van Der Linden, J.P. (1996) Reducing Soil Tare of Sugar Beet with ' Novel ' Cleaning Technology. External Quality Proceedings of the 59<sup>th</sup> IIRB Congress, February 1996 P. 499-505

# A STUDY ON THE INCREASE OF SOIL POLLUTION BY USING INACCURACY FERTILIZER IN SAMSUN SOILS

Osman Özdemir, İbrahim Kaya Ersöz, Sevinç Alpay  
Rural Services Samsun Research Institute

## ABSTRACT

Samsun soils have very high agricultural potential, but it has been fertilizer. Some of the fertilizer started accumulate in the soil profile. Fertilizer became as a waste material in soils. In this research shows that phosphorus accumulation in soil profiles since 1966.

## INTRODUCTION

It is known fertilizer than taken from soil by plant roots. Fertilizer has major effect to crop yield but if fertilizer amount in a soil more or less than plant requirement crop will be affected. Optimum crop yields depend on management amount of fertilizer in soils. Missing part of the fertilizer can be given in soil profiles by application of fertilizer. But approximately % 50 of given fertilizer are losing from a soil, because of leaching, run off and evaporation (3). As it is known, Government supports applying fertilizer but, using fertilizer without knowledge will be increase environmental problems either agricultural or non-agricultural areas. Also there is another side losing economically income. High fertilizer application effected losing crop yield, also there is another bad affect to in habitants.

Commercial fertilizer used to be applied 350 000 tons soils in 1965 and it was 9000000 tons in 1997. However, applying fertilizer increased these years but crop yield quality and quantity did not increase some percentage. The reasons were found by some researchers. According to their results; fertilizers amounts were applied without knowledge of soil characteristics and crop requests. This land of problems has been seen around Niğde, yield of this crop very low for potato because of farmers used high amount nitrogenous fertilizer for potato. Results, in agricultural area before using any kind of fertilizers, soil analysis must be done (3).

Lately, results of the soil analysis there is no need to add phosphorous any more the soils. Because of that extreme phosphorous fertilizer has been applied to wheat, winter vegetables grown as second crop and maize, rice, sugarbeet, sunflower and summer vegetables. Using fertilizer with phosphorous without knowledge, this particular fertilizer include to 15-75 kg. Important issue is phosphorus include high metals. High metals are very important point for environment. Phosphorous fertilizers are very important source for cadmium's and they are irreversible.

Available phosphorus does not move deeper layers in a soil, but if phosphorus applies more than requirements, it starts to move downward to deeper layers. This condition can be seen easily sandy textured soils (4).

Kacar and Katkat (1997) pointed from Hemwall (1957) that, plants uses 10-30 % of applied phosphorus which fixed available phosphorus and rest of 70-90 % accumulated in the soil. The kinds and amount of phosphorous fertilizer given to soil has effected powder and granule form of fertilizer and application on phosphorus amount in soil which fixed.

In the result of interview with farmers, nitrogenous fertilizer has been consumed excessively by farmers. There have been some health problems in people eating these crops because of fertilizer has been passed structure of crops.

Uzun and Özdemir (1998), worked on using nitrogen for spinach plant. According to their results, nitrogen increased such as 0-5-10-15-20-25 kg/da also nitrate amount increased with same as in Bafra and Çarşamba plain soils. This results shows, it was more than 300 mg/kg which is highest level for human health can not be effected (8).

Either nitrogen and phosphorous fertilizer will not be increasing yield as it is known if they apply more than requirement, amount with wrong application and in wrong time.

## MATERIALS AND METHOD

In this research, some chemical characteristics of Samsun soils were checked. Also in this research results analysed between 1966 (1), 1984 (6) and year of 1999. Relationships between 1966

(1)- 1984 (6), Bafra and Çarşamba plains have been which productive soils in 1999 year were compared.

Research area includes 97 % brown forest soil, grey podzolic, chesnut brown soil and alluvial large soil groups (6).

Agricultural produces were wheat, maize, sugarbeet, sunflower, tobacco, rice, summer and winter vegetables; and hazelnut in agriculture area.

Laboratory analyses which are available phosphorus, potassium, lime (%) and organic materials (%) were tested for 0-20 cm soil depth. Soil samples passed from 2 mm sieve than waited for a while until soil become air dry. Table 1 given limits for a soil classification.

**Table 1.** Soil laboratory analysis a soil classification limits

Analysis	Classification limits	
	0 – 5	Low Calcerous
Soil lime (%)	5 – 15	Medium Calcerous
	15 <	High Calcerous
	0 – 1	Low Calcerous
Organic material (%)	1 – 2	Medium Calcerous
	2 <	High Calcerous
	0 – 20	Low Calcerous
Soil potassium (kg/da K <sub>2</sub> O)	20 – 40	Medium Calcerous
	40 <	High Calcerous
	0 – 4	Low Calcerous
Soil phosphorus (kg/da P <sub>2</sub> O <sub>5</sub> )	6 – 9	Medium Calcerous
	9 <	High Calcerous

## RESULT and DISCUSSION

This research are proposed to find out what is the results of applying phosphorus to either irrigated or non-irrigated (precipitation 735 mm) agricultural area by without knowledge. It has been considered potassium, lime and organic materials amount in soil profile for 33 years.

In Samsun agricultural areas, nitrogenous fertilizer applied depends on soil organic materials contains and how much fertilizer plant needs for optimum grown. Also, phosphorous and potassium fertilizers applied depends on how much available phosphorus and potash already has in soil. Before applying this fertilizers again need to know how much fertilizer must given to soil. To knowing, this amount can be expose field experiments.

After literature search it shows that, in Samsun area commercial fertilizer used to apply over need for soil (7). This particular situation founded out after laboratory soil analysis. Especially soils had very high phosphor in it, this situation is a danger situation for future of this soil. This result pointed to us work on phosphorus contains soil.

**LIME :** There has no chance on average lime levels for experiment soils. But in 1984 low lime soils increased 3 %, medium lime 3 % decreased. According to analyses results pH of the soils were neutral or slight alkaline. In this area soils have very little change lime contains. The reasons were leaching and plant extraction. Terme area was lowest lime contains area in total research area. Lime must be apply in this area (Table 2).

**ORGANIC MATERIAL :** According to average of province soils 1/3 percentage soils contains more organic material founded in Terme and Bafra agricultural area in 1984. Recently, highest organic material contain found in Bafra and Ladik agricultural area in 1999 rest of the areas had decrease on organic materials amount in soils (Table 3). It has been shown lowest values were in Vezirköprü (22 %), Kavak (24 %), Havza (25 %) areas between 1984-1999. The reasons were these areas receive high temperature and low precipitation.



**Table 2.** Lime (%) contents of soils in Samsun and it's towns compare according to years

Years	Criteri -ons	Percentage of Agricultural Area (%)									Averag - e of Provinc e
		Çarşı mba	Bafra	Merke z	Terme	Alaça m	Kavak	Havza	Ladik	V.Köp rü	
1966	Low	71	65	70	100	67	75	52	85	38	69
	Mediu m	25	9	19	-	30	17	33	11	42	24
	High	4	26	11	-	3	8	15	4	20	7
1984	Low	79	70	74	97	77	69	54	79	38	71
	Mediu m	19	27	23	2	18	25	24	14	40	21
	High	2	3	3	1	5	6	22	7	22	3
1999	Low	78	70	-	99	-	-	42	82	26	-
	Mediu m	18	27	-	1	-	-	39	17	47	-
	High	4	3	-	-	-	-	19	1	23	-

**Table 3.** Available organic material (%) contents of soils in Samsun and it's towns compare according to years

Years	Criteri -ons	Percentage of Agricultural Area (%)									Averag e of Provinc e
		Çarşı mba	Bafra	Merke z	Terme	Alaça m	Kavak	Havza	Ladik	V.Köp rü	
1984	Low	28	18	29	14	29	39	30	20	41	28
	Mediu m	36	32	31	30	33	37	43	39	37	35
	High	36	50	40	56	38	24	27	41	22	37
1999	Low	29	14	-	16	-	-	42	19	24	-
	Mediu m	40	29	-	37	-	-	33	31	54	-
	High	31	57	-	47	-	-	25	50	22	-

Depents on soil organic material contains will be advise amount of nitrogenous fertilizer for that particular soil. Without knowledge, fertilizers application resulted lost of money and increase environmental pollution problems. In Samsun and it's towns had many wells using for drinking water. Laboratory test results show that is water contains very high wasted contamination such as nitrit, nitrate and ammonia because of using very high amount nitrogenous fertilizer (Table 4). In some town of Samsun most of the drinking water wells installed flat areas after a slope. In this areas are agricultural field which is planted wheat, tobacco, maize. Farmers use fertilizer increasing yield for this products. After applying fertilizers chemical materials penetrates to deeper soil layers than with ground moves to surface or drainage systems. The water becomes high concentration waste nitrogen materials. Most of the wells water top level between 5-25 m and wells bottom caves from surface 20-25 m installed by user. Main source was water table for all wells. This particular reason is shows that high waste contaminant ground water has very close interaction with wells water. This particular reason shows that using or applying nitrogenous fertilizers must be very good application manegement.

**Table 4.** The pollution reasons of drinkg water wells in Samsun and it's town

Locals	Main pollution reasons of drinking water pits
Alaçam	Effect of commercial fertilizer
Bafra	Effects of commercial fertilizer and village instation
Çarşamba	Effect of commercial fertilizer
Merkez	Effects of commercial fertilizer and village instation
Ondokuzmayıs	Effects of commercial fertilizer and village instation
Tekkeköy	Effects of commercial fertilizer, village instation and establish close to surface water (creck, river)
Terme	Effects of commercial fertilizer and surface drainage canal

**Potassium (K<sub>2</sub>O) :** Table 5 shows that average application for potassium fertilizer between 1966-1984 years. Table shows that after applying fertilizer lower level potassium become medium level potassium in research areas. Highest level potassium contains areas were Havza (83 %), Bafra (88 %), Ladik (95 %) and Vezirköprü (98 %). Lower level potassium contains areas were Terme (46 %) and Çarşamba (65 %).

**Table 5.** Available potassium (kg/da) contents of soils in Samsun and it's towns compare according to years

Years	Criteri- -ons	Percentage of Agricultural Area (%)									Avera ge of Provin ce
		Çarşa mba	Bafra	Merke z	Terme	Alaç am	Kavak	Havza	Ladik	V.Köp rü	
1966	Low	-	-	-	-	13	-	-	-	-	12
	Mediu m	17	18	4	18	53	60	9	17	14	23
	High	83	82	94	82	34	40	91	83	86	75
1984	Low	2	1	3	3	6	7	2	6	5	4
	Mediu m	21	17	22	17	42	36	25	24	21	25
	High	77	82	75	80	52	57	73	70	74	71
1999	Low	8	1	-	17	-	-	-	-	-	-
	Mediu m	27	11	-	37	-	-	17	5	2	-
	High	65	88	-	46	-	-	83	95	98	-

**Phosphorus (P<sub>2</sub>O<sub>5</sub>) :** Table 6 shown that in 1966 phosphorus amount was 31 %, after 18 years it is become 37 %, 15 years later it become significant increas. In this 33 years (1966-1999) at research area used of commercial phosphorus amount increased almost 1 to 3 times. According to research results in 33 years phosphorus application increased from 39 to 49 % at lover phosphorus soils. Medium level soils also phosphorus was applied. As it is known phosphorus can not be used by plat 100 %, some part which is available phosphorus can be used for crops rest of the phosphorus will be accumulated in soil layers. Farmers, as said before did not have soil analyses. They continued give to soil same amount phosphorus. Especially reason for increasing phosphorus amount in soil, farmers planted in this field such as sugarbeet, rice, tobacco, wheat and second crops were cabbage, leek, spinach, radish initially needed phosphorus.

According to Table 6, excessice phosphorus of soils were widely planted especially second crops (Bafra and Çarşamba) and sugarbeet (Bafra, Alaçam, Havza, Ladik, Çarşamba, Vezirköprü). There was some decreasing to use of phosphorus because of crops changed from hazelnut to tobacco, in Terme had some decreasing to use of commercial fertilizer in order 40 % (1966), 24 % (1984) and 20 % (1999) because of hazelnut and poplar increases. In Kavak field had very low yield so, farmers prefer to planted wheat, tobacco and there was very high percantage movement to city. This resons cansel to use of commercial fertilizer. It was decreased between 76 to 29 %. Higher phosphorus soils



seen in Çarşamba (22, 28, 37 %), Bafra (29, 46, 66 %), Havza (25, 61, 73 %), Ladik (26, 54, 71 %) and Vezirköprü (18, 38, 67 %) in years. According to research results, there is no need phosphorous fertilizers almost more than 50 % areas. This situation will be more efficient in economical side also good for environmental side such as soil and underground water pollution.

**Table 6.** Available phosphorus (kg/da) contents of soils in Samsun and it's towns compare according to years

Years	Criteria	Percentage of Agricultural Area (%)									Average of Province
		Çarşamba	Bafra	Merkez	Terme	Alaçam	Kavak	Havza	Ladik	V.Köprü	
1966	Low	52	42	17	35	52	13	32	44	63	39
	Medium	26	29	45	25	38	11	43	30	19	30
	High	22	29	38	40	10	76	25	26	18	31
1984	Low	60	36	58	67	62	56	24	34	45	49
	Medium	12	18	12	9	12	15	15	12	17	14
	High	28	46	30	24	26	29	61	54	38	37
1999	Low	37	11	-	57	-	-	13	9	5	-
	Medium	26	23	-	23	-	-	14	20	28	-
	High	37	66	-	20	-	-	73	71	67	-

## REFERENCES

- Cengiz, Y., Başaran, R. (1966). Productivity Inventory of Blacksea Region. General Directorate of Soil and Water Technical Reports Series. Soil and Water Publications: 186. Ankara University Press. ANKARA
- D.İ.E. (1999). Statistical Yearbook of Turkey. Prime Ministry State Statistical Institute Publications. Publication No: 2240 ANKARA
- Haktanır, K., Arcaç, S., Karaca, A. (1995). Agricultural Environmental Problems and Sustainable Agriculture. Agriculture Engineers of Turkey IV. Technical Congress. Volume : 1.p.379-415. ANKARA
- Kacar, B., Katkat, V. (1977). Phosphorus In Agriculture. Trade Bourse of Bursa Publications No: 5. BURSA
- SAMSUN Rural Services Research Institute. Registration of Soil Analysis Laboratory (1999). SAMSUN
- Ministry of Agriculture, Forest and Rural. General Directorate of Soil and Water. Department Precidency of Soil Investigation and Mapping (1984). Productivity Inventory of Samsun Province and Fertilize Need Report. TOVEP Pub. No: 23 Gen. Pub. No: 760 ANKARA
- Tüzüner, A., Kurucu, N., Gedikoğlu, İ., Eyüpoğlu, F., Börekçi, M., Sönmez, B., Açar, A. (1990). Laboratories of Soil and Water Analysis Handbook. Ministry of Agriculture, Forest and Rural. General Directorate of Rural Services ANKARA.
- Uzun, Z., Özdemir, O. (1998) The Determination Requirement of Nitrogen, Phosphorus and Potassium Fertilizers in Spinach at the Bafra and Çarşamba Plains. General Directorate of Rural Services. Directorate of Samsun Research Institute Pub. Gen. Pub. No: 95. Report Series No: R-82. SAMSUN
- Ülgen, N., Yurtsever, N. (1995). Turkey Fertilizer Directory (4. Press) Prime Ministry General Directorate of Rural Services. Directorate of Soil and Fertilizer Research Pub. Gen. Pub. No: 209. Technical Pub. No: T-66. ANKARA



# ASSESSMENT OF INFILTRATION RATE PARAMETERS FOR SITE-SPECIFIC WATER MANAGEMENT<sup>1</sup>

Sabit Erşahin ve M. Rüştü Karaman

Dept. of Soil Sci., Faculty of Agriculture, Gazi Osmanpaşa University, 60100 Tokat, Turkey.

## ABSTRACT

Irrigation water should be managed wisely to conserve natural resources and to increase water application efficiency. This study was conducted to divide a field into homogenous infiltration management zones for the purpose of increasing irrigation water use efficiency and decreasing water and nutrient losses. Infiltration tests were conducted at 50 sites, on an irregular regular grid consisting of 10 columns and 2 rows, on a 8.5 ha commercial wheat field (Typic Ustifluent). Data from the tests were evaluated to obtain coefficients of the infiltration equation from Kostiakov. Parameter B varied from 3.99 to 157.71 and parameter n from -0.69 to -0.13. Based on the joint frequency distribution of the coefficients B and n in Kostiakov's equation, nine infiltration rate categories were defined, and low, medium and high infiltration rate management zones were developed in the study area. High infiltration rate zones comprised 2.63 ha, moderate infiltration rate zones 3.70 ha, and low infiltration rate zones 2.16 ha of the study area. Irrigation water should be monitored more carefully to decrease volumes of water and nutrients moving beyond the root zone and to increase water application efficiency in the medium and high infiltration rate zones. Also, to decrease the adverse effects of high infiltration rate on groundwater, deep rooted crops with greater water requirements may be grown in the regions of the field residing in high and medium infiltration rate zones.

## INTRODUCTION

Most of Turkey's land is in semi-arid climate regions where water is one of the key factors limiting agricultural production. Proper management of water is one of the key factors to increase agricultural production in these regions. In the past, due to improper use of irrigation water, serious problems such as groundwater pollution and soil alkalinity have occurred in some irrigated areas. In addition, industrial and domestic requirements for water increased dramatically, further limiting agricultural use of water and leading a great concern on prospective conflict among neighboring countries (Postel, 1993). Therefore, there is a need to adopt management practices that will help increase efficiency of water use in agriculture in these regions.

Infiltration is one of the key processes controlling the water budget and transport processes in the soil profile. The magnitude and evolution of infiltration will determine the proportions of the water moving beyond the root zone, stored in the soil profile, and available for surface runoff (Serrano, 1990).

Infiltration rates on a field may vary from very low to very high due to changes in the soil characteristics which control infiltration characteristics. If the infiltration characteristics on a field could be controlled by some means, then irrigation efficiency could be increased to a high level (Jensen et al., 1987).

Since changing soil characteristics is difficult, the same result can be achieved through site-specific application of irrigation water. Based on this concept, the field is divided into zones with homogenous infiltration characteristics, with each zone being irrigated differently. For example, while a particular surface irrigation technique can safely be operated in a zone with relatively low infiltration rate, use of the same technique may be avoided in the nearby zone with high infiltration capacity. This approach allows one to decrease water and nutrient losses from the bottom of the root zone and to increase water application efficiency.

Regression lines representing infiltration rates for different sites on a field may be combined to develop water management zones with homogenous infiltration characteristics. According to this procedure, if both slopes and intercepts of two regression lines are the same at a given level of significance, then those two lines can be combined, forming a single regression line, and the areas represented by those two regression line can be combined, too. Erşahin and Yesilsoy (1993) applied this method to combine regression lines describing infiltration rates for various test sites on the Harran

<sup>1</sup>Turkish Scientific and Technical Research Institute (TUBITAK) financially supported this study. Project No: TARP 1871.

Plain in the southeastern Turkey. They recognized that as the number of regression lines to be combined increased, the chance to meet above conditions decreased, drastically. Therefore, in the present study, this method was not considered efficient to develop water management zones with homogenous infiltration characteristics. On the other hand, the concept of joint frequency distribution may be applied to develop regions with low, medium and high infiltration rate. This procedure requires that the variables considered (here intercepts and slopes of regression lines) exhibit a normal distribution.

The objective of this study was to apply the joint frequency distribution technique to the infiltration parameters in Kostiakov's equation, to divide a 8.5 ha commercial wheat field into zones with homogenous infiltration properties so that a variable water management program could be operated for the purpose of increasing irrigation water application efficiency and decreasing water and nutrient losses through deep percolation.

## MATERIALS AND METHODS

Infiltration tests were conducted using double-ring variable-water level infiltrometers until steady-state infiltration rates were reached at 50 sites, on a irregular grids consisting of 10 columns and two rows, on a 8.5 ha irrigated field (Typic Ustifluent) located in the 25 km north of Tokat Province in Central Anatolia of Turkey. At each test site, soil samples from the topsoil (0-30 cm) and the subsoil (30-60 cm) were taken. All 100 samples were analyzed for percent clay, silt and sand by the hydrometer method (Gee and Boudier, 1986), organic matter contents by the Walkley Black method (Jackson, 1956),  $\text{CaCO}_3$  and pH with a Scheibler Calcimeter (McLean, 1986), and water contents at -0.033, -0.1 and -1.5 MPa soil water pressure with a pressure plate apparatus (Klute, 1986). In addition, at each test site, undisturbed soil samples were taken using 100 cm<sup>3</sup> steel cores from the topsoil and the subsoil to determine soil bulk density (Blake and Hartge, 1986).

According to Hillel (1980), the infiltration equation developed by Kostiakov, has the form:

$$i = Bt^n, \quad (1)$$

where  $i$  is the infiltration rate,  $t$  is time, and parameters  $B$  and  $n$  are empirical constants. These two constants can be estimated by plotting  $\log i$  against  $\log t$ , then  $\log B$  and  $n$  are calculated as the  $y$  intercept and slope, respectively, of the resulting straight line. Following the procedure from Criddle et al. (1956), parameters  $B$  and  $n$  were calculated for each test site.

Basic statistical parameters for selected properties of topsoil and subsoil, and for infiltration parameters  $n$  and  $B$  were also calculated with the statistical package StatMost (Dataxiom Software Inc., 1997).

Based on the frequency distribution of the parameters  $n$  and  $B$ , two cutoff values defining low, medium and high levels of infiltration rate were established as described below. Using these three pairs together, nine possible combinations (categories) representing a joint frequency distribution of the parameters  $B$  and  $n$  were defined (Mulla, 1989).

Infiltration rate categories from the joint frequency distributions were combined to develop infiltration management zones. This was achieved by establishing an index representing low, medium and high infiltration rate management zones. First, cutoff values of the first and the third quartiles for the frequency distributions of the parameters  $B$  and  $n$  were coded as low, medium and high levels as follows: if  $B$  is below the first quartile then code = 1, if  $B$  is between the first and the third quartiles then code = 2, and if  $B$  is above the third quartile then code = 3. Likewise, if  $n$  is below the first quartile then code = 1, if  $n$  is between the first and the third quartiles then code = 2, and if  $n$  is above the third quartile then code = 3. Second, the values of codes for each pair from the joint frequency distribution were summed to obtain an index (sum = index): if sum  $\leq 3$  then the combination was considered within low infiltration rate zone, if sum = 4 then the combination was considered within medium infiltration rate zone, and if sum  $\geq 5$  then the combination was considered within high infiltration rate zone. Finally, the combinations comprised by each infiltration rate management zone were determined and area of each management zone was calculated.

## RESULTS AND DISCUSSION

Topsoils in the study area had an average textural classification of loam, but some portions on the field were described as silt loam or clay loam. Likewise, subsoils had an average textural classification of clay loam, and some portions of the field had a sandy clay loam subsoil texture.



Percent organic matter exhibited a high variability in the subsoils, and pH exhibited a low variability in both topsoils and subsoils. All the other parameters had a medium variability in the both topsoils and subsoils. Soil pH was highly tailed and skewed to right in the both topsoils and subsoils (Tables 1 and 2).

Table 1. Selected properties of the topsoils.

Soil Property		Max.	Min.	Mean	S.D	C.V%	Skew.	Kurt.
Sand (%)		46.98	23.35	33.78	6.18	18.31	0.24	2.48
Silt (%)		50.66	33.03	41.57	4.98	11.98	0.47	2.15
Clay (%)		31.01	15.90	24.71	3.16	12.79	-0.39	2.87
Bulk Density (Mg m <sup>-3</sup> )		1.43	1.08	1.25	0.10	8.23	-0.10	1.69
Moist. Cont. (cm <sup>3</sup> cm <sup>-3</sup> )	-0.03 MPa	45.86	23.47	36.36	5.11	14.07	-0.37	2.52
	-0.1 MPa	35.95	19.14	30.12	4.41	14.64	-0.92	3.00
	-1.5 MPa	33.55	7.17	24.04	4.95	20.57	-1.08	4.61
CaCO <sub>3</sub> (%)		20.95	7.28	14.31	2.67	17.29	-0.27	3.64
OM (%)		5.26	1.91	3.60	0.84	23.36	-0.09	2.25
pH		9.71	7.03	8.12	0.37	4.51	1.72	9.47

Table 2. Selected properties of the subsoils.

Soil Property		Max.	Min.	Mean	S.D	C.V%	Skew.	Kurt.
Sand (%)		37.79	10.14	21.63	7.21	33.31	0.25	2.31
Silt (%)		56.25	35.24	43.72	4.78	10.95	0.42	2.69
Clay (%)		48.01	26.78	35.16	5.28	15.02	0.44	2.83
Bulk Density (Mg m <sup>-3</sup> )		1.63	1.14	1.33	0.13	9.76	0.54	2.31
Moist. Cont. (cm <sup>3</sup> cm <sup>-3</sup> )	-0.03 MPa	46.31	21.63	38.49	5.56	14.45	-1.04	3.86
	-0.1 MPa	40.37	17.34	32.44	4.92	15.17	-1.09	3.96
	-1.5 MPa	33.20	10.97	26.01	4.73	18.20	-1.29	4.69
CaCO <sub>3</sub> (%)		19.78	8.06	15.26	2.72	17.84	-0.56	2.93
OM (%)		4.01	0.03	1.56	0.93	59.57	0.25	2.86
pH		10.06	7.26	8.24	0.43	5.22	1.71	9.96

Both parameters, B and n, were slightly skewed to right. While parameter B had a relatively flat distribution, parameter n exhibited a relatively tailed distribution. Parameter B was more variable than parameter n (Table 3).

Table 3. Infiltration rate parameters.

Parameter	Max.	Min.	Mean	C.V%	Skew.	Kurt.
B	157.71	3.99	81.33	41.39	0.09	2.63
n	-0.13	-0.69	-0.46	22.11	0.67	5.34

Spatial patterns of parameter B and n are shown in Figs. 1 and 2. Parameter n had high values in the southwest region, between 300 and 400 meters, and some isolated portions in the east side; and parameter B had high values in the west and the east regions of the field. A high degree of negative association was found between the values of B and n ( $r = -0.74$ ,  $P < 6.5 \times 10^{-9}$ ).

Results from normality test (Shapiro-Wilks) indicated that both parameters had a gaussian distribution (results from normality tests are not given). Infiltration categories established based on the frequency distributions of these two parameters are shown in Table 4, in which high values of B were matched with high values of n to represent an area with high infiltration rate, and low values of B were matched with low values of n to represent an area with low infiltration rate. For example, category 8 represents a high infiltration rate zone, category 5 represents a medium infiltration rate zone, and category 2 represents a low infiltration rate zone.



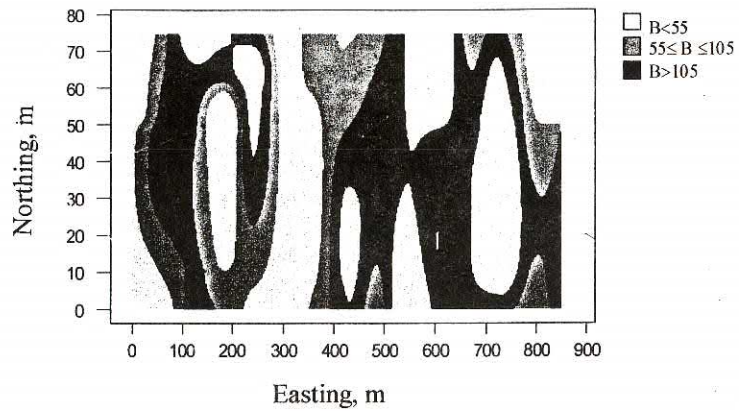


Fig.1. Spatial pattern in parameter B.

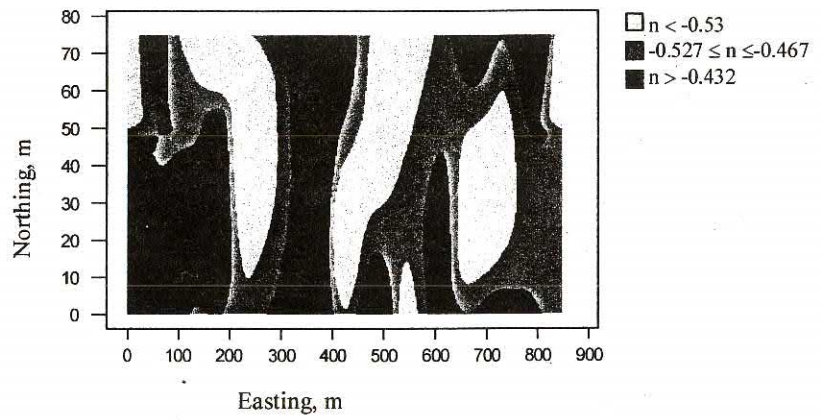


Fig.2. Spatial pattern in parameter n.

Table 4. Area covered by nine possible grouping of the joint frequency distribution for parameters B and n.

Infiltration category	Groupings	Area (ha)	Area (%)
1	$B < 54.45$ and $n < -0.527$	0	0
2	$54.45 \leq B < 105.52$ and $n < -0.527$	1.89	22.23
3	$B > 105.52$ and $n < -0.527$	0.74	8.70
4	$B < 54.45$ and $-0.527 \leq n < -0.432$	0.74	8.70
5	$54.45 \leq B < 105.52$ and $-0.527 \leq n < -0.432$	1.99	23.41
6	$B > 105.52$ and $-0.527 \leq n < -0.432$	1.61	19.02
7	$B < 54.45$ and $n > -0.432$	0.97	11.41
8	$54.45 \leq B < 105.52$ and $n > -0.432$	0.55	6.52
9	$B > 105.52$ and $n > -0.432$	0	0

Twenty five percent of the field was in the high infiltration rate zone, 44% in medium infiltration zone, and the rest of the field was in low infiltration rate zone (Table 5). Generally, the east side of the field was dominated by medium and high infiltration rate zones while the west side was occupied by low and medium infiltration rate zones (Fig. 3). Therefore, irrigation water should be monitored more carefully to decrease volumes of water and mobile nutrients (i.e. nitrate) moving beyond the root zone in the east side. In this region, since use of surface irrigation techniques would result in a lower water application efficiency due to deep percolation, their application should be avoided. In addition, growing crops with greater water use requirement or deeper rooted crop may increase water use efficiency. On the other hand, surface irrigation techniques may be practiced in the west side of the field. Further research is needed to evaluate feasibility of this approach.

Table 5. Area covered by low, medium, and high infiltration capacity zones.

Infiltration Rate Zone	Categories	Area covered (ha)	Area covered (%)
Low	1, 2, 4	2.63	30.94
Moderate	3, 5, 7	3.70	43.52
High	6, 8, 9	2.16	25.46

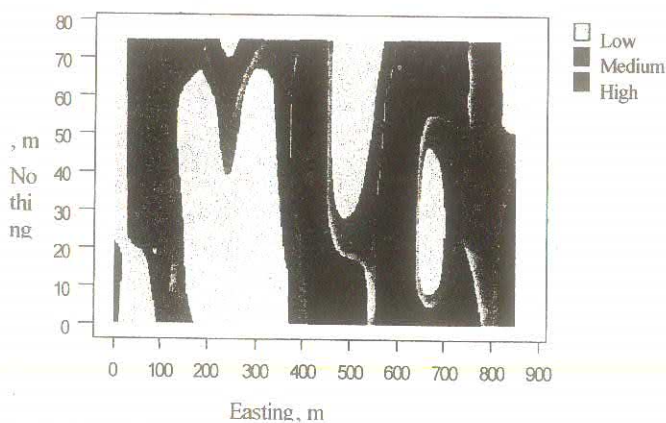


Fig.3. Locations of high, medium and low infiltration rate zones.

## CONCLUSIONS

This study was conducted to divide a field into low, medium, and high infiltration rate zones for the purpose of decreasing volumes of water and nutrients moving beyond the root zone, and increasing agricultural water use efficiency. Infiltration tests were conducted using double-ring variable water level infiltrometers at 50 sites, on a regular grid spacing of 41 m, on a 8.5 ha irrigated commercial wheat field (Typic Ustifluent), and results from infiltration tests were evaluated to obtain constants B and n in the infiltration equation from Kostiaikov. Based on the results from joint frequency distribution of the constants B and n, 25%, 44%, and 31% of the field were in high, medium and low infiltration rate zones, respectively. Irrigation water must be monitored more carefully to reduce losses of water and nutrients through deep percolation in the regions dominated by high and medium infiltration rate zones. Crop with greater water requirement and/or deep rooted annual crop may be grown to decrease volumes of water and nutrients moving beyond the root zone and to increase efficiency of agricultural water use in those regions.

## REFERENCES

- Blake, G. R., and Hartge, K. H. (1986). Bulk density. p. 363-375. In A. Klute (edit.) *Methods of Soil Analyses*. Part 1. 2<sup>nd</sup> ed. Agronomy 9. ASA and SSSA, Madison, WI.
- Criddle, D.W., Davis, S., Pair, C.H., and Shockley, D.G. (1956). *Methods for evaluating irrigation systems*. USDA Soil Conservation Service. U.S. Government Printing Office.
- Dataxiom Software Inc. (1997). *User's guide: StatMost*. 5<sup>th</sup> Ed. Dataxiom Soft. Inc., LA, CA.
- Ersahin, S., and Yesilsoy, M.S. (1993). The relationship between infiltration rates and some physical and chemical properties of six widely distributed and important soil series selected in Harran Plain. *Turkish Journal of Agriculture and Forestry*. Vol:17, No:4, 863-873.
- Gee, G. W., and Boudet, J. W. (1986). Particle size analysis. p.825-844. In A. Clute (edit.) *Methods of Soil Analysis*. Part 1, 2<sup>nd</sup> ed. Agronomy No. 9. ASA and SSSA, Madison, WI.
- Hillel, D. (1982). *Introduction to Soil Physics*. Academic Pres. Inc., London.
- Jackson, M. L. (1956). *Soil Analysis*. Adv. Course. Fourth Print. Dept. of Soil Sci. Univ. of Wisconsin, Madison. WI.
- Jensen, M.E., Swarner, L.R., and Phelan, J.T. (1987). Improving irrigation efficiencies. p.1120-1142. In R.M. Hagan, H.R. Haise, and T.W. Edminster (edit.). *Irrigation of Agricultural Lands*. Fifth Printing, Agronomy No. 11. ASA and SSSA, Madison, WI.
- Klute, A. Water retention: Laboratory methods. (1986). p.635-660. In A. Clute (edit.) *Methods of Soil Analysis*. Part 1, Agronomy No. 9. 2<sup>nd</sup> ed ASA and SSSA, Madison, WI.
- McLean, E.O. Soil pH and lime requirement (1986). p. 199-224. In Page, A. L. (ed.) *Methods of Soil Analysis*. Part 2. 2<sup>nd</sup> ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI.
- Mulla, D.J. 1989. Soil spatial variability and methods of analysis. In C. Renard, R.J van Den Beldt, and J.F. Parr (edit.), *Soil, Crop, and Water Management Systems for Rainfed Agriculture in the Sudano - Sahelian Zone*, ICRISAT, Patancheru, India.
- Postel, S. (1993). The Politics of water. *World Watch*, 10-18.
- Serrano, E. S. (1990). Stochastic differential equation models of erratic infiltration. *Water Resour. Res.*, Vol. 26, No: 4, 703-711.



# THE EFFECTS OF DRIP AND SURFACE IRRIGATION METHODS ON THE YIELDS AND QUALITY OF TOMATO CROP IN DIFFERENT SIZED PERLITE CULTURE

Tuncay Demirel<sup>1</sup>

Sabri Sener<sup>2</sup>

Şükrü Kaleli<sup>2</sup>

Çanakkale Onsekiz Mart University, Faculty of Agriculture,

(1) Soil Science Department.

(2) Agricultural Structures and Irrigation Department.

## ABSTRACT

This research has been carried out to determine the effects of drip and surface irrigation methods on the yield and quality of tomato crop in four different sized ( $\leq 1$  mm, 1.1-2.0 mm, 2.1-3.0 mm and 3.1-5.0 mm) perlite culture. Experiment has been set up as split plots in randomized block design with four replications. Fertilizer application started when seedlings were transplanted (at 4 to 6 leaves stage) in 7 liter polyethylene bags which were filled with perlite, 135 mg N/L, 58 mg P/L and 112 mg K/L fertilizer applied at constant rate every other day and 1 liter irrigation water applied daily by drip irrigation with laterals which had 50 cm emitters spacing and 1 liter volumetric measuring cans were used for surface irrigation application.

Number of fresh tomato fruit, fruit yield, average fruit weight, number of days from planting to harvest, bio-mass yield, average fruit diameter, average fruit volume, pH of the paste and soluble dry matter were evaluated and compared with LSD tests.

Research results showed that the effects of perlite size was effective on average fruit weight, fruit yield and soluble dry matter was significant at 0.01 level and on number of days from planting to harvest was significant at 0.05 level statistically. When irrigation systems were compared, better results were obtained by drip irrigation method at medium perlite size (2.1-3.0 mm).

## INTRODUCTION

Tomato production for fresh consumption and paste industry is 7 250 000 000 tons in Turkey. This amount is about 38 percent of the total vegetables produced in the country, Anon. (1995). But the quality of the tomato fruit needed to be improved for export and domestic use. The sufficient fertilizer application and convenient irrigation techniques are very important factors effecting the quality of the tomato crop.

Irrigation water is an important factor for transportation of the plant nutrients to the root zone and drip irrigation offers several potential advantages over other irrigation systems; from this point of view, primary one being the precise application of water from emitter system. Fertigation is another advantage of this system, Miller et al (1976); Clough et al (1990); Abdal and Coffey (1991).

The amount of water needed for irrigation depends not only on climatic conditions and the type of the soils to be irrigated, but also on the crops to be grown. Drip irrigation is also very effective on water use in soils having low water holding capacity, Bar-Yosef et al (1982); Schmidt et al (1988).

On the other hand soilless plant growing techniques have been investigated recently as an alternative to meet the growing food demands of the population. The perlite cultures have been most commonly used in these investigations, Altıntaş and Varış (1993). Since it is a steril and well drained material; perlite have been used for germination, growing seedlings and media for rooting, Altıntaş and Varış (1993); Hepeksay and Kara (1992). Also a high capillary force of perlite provides water extraction from the reservoir at the same rate of the plant water use, Wilson et al (1984). For this reason four different sized perlite culture with two irrigation methods (drip and surface irrigation methods) have been investigated.

## MATERIAL AND METHODS

This research was carried out at Uvecik Experimental Farm of Çanakkale Onsekiz Mart University, about 45 km south-west of Çanakkale. Typical Mediterranean climate mild and rain in winter dry and hot in summer prevails in the region. Average annual rainfall is 615,5 mm. Average annual temperature is 14,8°C coldest month is January (3,0°C) and hottest month is July (30,8°C) average relative humidity is 72 percent. Four perlite size and two irrigation methods (drip and surface irrigation) have been tested. Experiment was set up as randomized blocks in split plots design with four replications, main plots were irrigation methods and sub plots were perlite culture size.

Urbana dumpy tomato cultivator was used as test crop. Four different sized **very fine** ( $\leq 1$  mm), **fine** (1-2 mm), **medium** (2-3 mm) and **coarse** (3-5 mm) perlite culture provided from Etibank perlite establishment were used as growing culture. 7 liters perlite cultures were filled into black polyethylene bags with little pressure leaving 1 cm empty at the top. These bags were settled with 100X50 cm spacing, each bag had four drain holes three cm above the bottom, Varış (1991). Seedlings grown in the perlite culture, transplanted as one plant into each bag when they reached 4 to 6 real leaves stage. **Drip irrigation** laterals with emitters 0,05 liter per minute (1 liter in 20 minutes) discharge capacity at 50 cm spacing were used for irrigation practices.

**Surface irrigation** was applied by means of volumetric cans. Since the water holding capacity of perlite is low, irrigation water 1 liter per bag was applied daily in the afternoon for both irrigation methods. Fertilizer application and irrigation practices were started with transplanting.  $\text{KH}_2\text{PO}_4$  for phosphorus and potassium and  $\text{KNO}_3$  (13 percent N and 37 percent K) for potassium and Nitrogen and  $\text{NH}_4\text{NO}_3$  (33 percent) for Nitrogen were used in fertilizer solutions 135 mg N/L, 58 mgP/L and 112 mgK/L were applied at each bag at every other day.

After flowering and at fruit set stages 220 mgK/L was applied. Ca fertilizer application against **blossom end rot** and four times trimiltox (mancozeb %20+tetra cupper %21) was applied with six days intervals, against early leave burning.

Fruit weight (g per fruit) total yield (g per plants) number of fruits per plant, total plant weight (root+vegetative parts), average fruit volume ( $\text{cm}^3$  Per fruit), fruit diameter, pH in fruit juice, dry matter (water soluble), growing days from planting to harvest were determined. Research results were evaluated statistically and compared by LSD tests, Yurtsever (1984).

## DISCUSSION

Research results are summarized in table 1.

Table 1. Minimum, Maximum and Average Values of Experimental Data.

Parameter	Minimum	Maximum	Average
Number of fruits per plant	20	37	27,44
Fruit yield (g/plant)	1763,20	5369,76	3156,53
Single fruit weight (grams)	87,48	149,16	113,02
Number of days from planting to harvest	66,00	112,00	79,19
Dry matter (%brix)	4,16	7,03	5,45
Bio-mass yield (vegetative parts+roots) (grams)	1036,20	3019,30	1935,86
Average single fruit diameter (cm)	3,39	6,47	4,84
Average single fruit volume ( $\text{cm}^3$ )	20,00	202,00	58,66
pH	3,9	5,3	-

Research results showed that; pH, fruit volume, fruit diameter and bio-mass yield (vegetative parts+roots) were not affected from treatments; dry matter content was higher at surface irrigation and vegetative period was getting shorter when the perlite size was larger. Irrigation method and perlite size interactions were important statistically at 0,01 level for number of fruits, single fruit weight and fruit yield. For these parameters drip irrigation and medium perlite size (2,1-3,0 mm) combination were in the first group (Table.2). i.e. number of fruits were 35,75 and 29,00 for drip irrigation and surface irrigation methods respectively at the medium perlite size growth media. The similar results were obtained for coarse, fine and very fine perlite cultures (Table.2).

5113,60 gram and 3249,29 gram tomato yields per plant were obtained from drip and surface irrigation methods respectively at again medium perlite size and also similar results were observed at other perlite cultures in the favour of drip irrigation. 3927,31 gram vs. 2559,7 gram at coarse perlite, 3731,53 grams vs. 2385 grams at fine perlite and 2406,23 grams vs. 1879,33 grams at very fine perlite (Table.2).

Similar results were obtained for single fruit weight and for number of fruits. Güler et al, (1998), Altıntaş and Varış (1993), Varış (1991); Varış and Altay (1992); Munsuz et al, (1982) reported that drip irrigation has increased the number of fruits, and the quality of the crop when compared to the furrow irrigation at medium size perlite culture.



Medium and coarse perlite sized growth medium provided earliness (shorter growing period, about 75 days) at both irrigation methods. This can be explained by earlier and stronger root growth at these perlite sizes provide faster development of the plant and earlier harvest of the fruits. Weichmann (1986), Varış (1991), and Bogle et al (1989) reported similar results.

Analysis of variance and LSD test results are show in table 2.

Table 2. Anova and LSD Test Results of Experimental Data.

Treatments		Number of fruits per plant	Fruit yield (g/plant)	Single fruit weight (grams)	Number of days from planting to harvest	Dry matter (%brix)	Bio-mass yield (veg. parts+roots) (grams)	Average single fruit diameter (cm)	Average single fruit volume (cm <sup>3</sup> )	pH
Irrigation (A)	(1) Drip	29,86 a	3794,66 a	126,59 a	79,63	5,14 b	2083,73	4,82	65,81	4,38
	(2) Surface	25,00 b	2518,39 b	99,45 b	78,75	5,75 a	1788,02	4,86	51,50	4,31
LSD		1,32**	191,31**	3,80**	ns	0,45*	ns	ns	ns	ns
Perlite (B)	1 (≤1mm)	22,75 a	2142,77 c	93,09d	85,88 a	5,31	1954,20	4,85	61,75	4,35
	2 (1,1-2)	25,36 b	3058,35 b	119,28 b	82,13 ab	5,42	1834,68	5,05	48,25	4,18
	3 (2,1-3)	32,36 c	4181,44 a	129,36 a	75,00 b	5,35	1858,60	5,01	77,75	4,31
	4 (3,1-5)	29,25 d	3243,55 b	109,63 c	75,75 b	5,72	2096,03	4,46	46,88	4,54
	LSD	1,16**	200,83**	3,03**	9,43*	ns	ns	ns	ns	ns
A <sub>1</sub> X B	1 (A <sub>1</sub> B <sub>1</sub> )	24,25 d	2406,23 c	99,19 d	73,00	5,07	2265,13	4,97	71,50	4,40
	2 (A <sub>1</sub> B <sub>2</sub> )	27,00 c	3731,53 b	138,18 b	82,75	5,16	1674,50	4,73	40,50	4,23
	3 (A <sub>1</sub> B <sub>3</sub> )	35,75 a	5113,60 a	148,16 a	72,00	4,94	2061,38	5,09	101,00	4,28
	4 (A <sub>1</sub> B <sub>4</sub> )	32,50 b	3927,31 b	120,82 c	90,75	5,41	2333,93	4,49	50,25	4,60
	LSD	1,63**	270,36**	4,29**	ns	ns	ns	ns	ns	ns
A <sub>2</sub> X B	1 (A <sub>2</sub> B <sub>1</sub> )	21,25 d	1879,33 c	88,43 c	74,75	5,56	1643,27	4,74	52,00	4,30
	2 (A <sub>2</sub> B <sub>2</sub> )	23,75 c	2385,18 b	100,39 b	81,50	5,68	1994,85	5,38	56,00	4,13
	3 (A <sub>2</sub> B <sub>3</sub> )	29,00 a	3249,29 a	110,55 a	78,00	5,57	1655,83	4,92	54,50	4,35
	4 (A <sub>2</sub> B <sub>4</sub> )	26,00 b	2559,79 b	98,44 b	80,75	6,03	1858,13	4,42	43,50	4,48
	LSD	1,63**	270,36**	4,29**	ns	ns	ns	ns	ns	ns

\*, p<0,05, \*\*, p<0,01, ns; non significant.

Dry matter contents of tomato crops were higher at surface irrigation method when compared to drip irrigation method. This can be explained by stronger vegetative development of the crop at drip irrigation system prevents the sunshine of the tomato fruits which is necessary for maturing.

As a result, it can be said that the effects of perlite size were effective on average fruit weight, fruit yield and soluble dry matter was significant at 0.01 level and on number of days from planting to harvest was significant at 0.05 level statistically. When irrigation system were compared, better results were obtained by drip irrigation method at medium perlite size (2.1-3.0 mm).

## REFERENCES

- Anonymous, 1995. Tarımsal Yapı ve Üretim. D.İ.E. Yayınları, Ankara.
- Abdal, M.S., D.L., Coffey, 1991. Tomato Production With Trickle Irrigation and Raised Beds. Hort. Abst. 61(10): 90-94.
- Altıntaş, S., S., Varış, 1993. Isıtılmayan Cam Sera Toprağında ve farklı Ortamlar Üzerine Oturtulmuş 7 ve 15 Litrelik Torba Yüzüklerde Domates Yetiştiriminin Bitki Gelişmesi ve Verim Üzerine Etkisi T.Ü. Tekirdağ Ziraat Fakültesi Dergisi. (1) 178-183. Tekirdağ.
- Bar-Yosef, B. And B., Sagiv, 1982. Response of Tomatoes to N and Water Applied Via a Trickle Irrigation System: I. Nitrogen Agronomy Journal 74:633-636.
- Bogle, C.R., T.K. Hartz, C., Nunez, 1989. Comparison of Subsurface Trickle and furrow Irrigation on Plastic-Mulched and Bare Soil for Tomato Production. J. Amer. Soc. Hort. Sci. 114(1):40-43.



- Clough, G.H., S.J., Locascio and S.M., Olson, 1990. Yield of Successively Cropped Polyethylene-mulched Vegetables as affected by Irrigation Method and Fertilization Management. J. Amer. Soc. Hort. Sci. 115(6):884-887.
- Güler, S., A. Aydın, H. Kar, H. İbrikçi, 1998. Tarla Koşullarında Damla ve Karık Sulama Yöntemleri İle Yapılan Gübrelemenin Domateste Pazarlanabilir Kalitedeki verim Üzerine Etkileri.
- Hepeksay, S., S., Kara, 1992. Meyvecilikte Perlit Kullanımı. Türkiye I. Tarımda perlit Sempozyumu. 29-30 Haziran, İzmir.
- Miller, R. J., D.E., Rolston, R.S., Rsaoschkolb and D.W. Wolfe, 1976. Drip Application of Nitrogen is efficient. California. Agriculture 30 (11):16-18.
- Munsuz, N., Y. Ataman, İ. Ünver, 1982. Tarımda Yetiştirme Ortamları Perlit. Etibank Matbaası. Ankara.
- Schmidt, R.A.K., D.A. Hall, G.M., Hitchon, 1988. Development of Perlite Culture Systems for the Production of greenhouse Tomatoes. Act. Hort. 221: 371381.
- Varış, S., 1991. Sera Sebzelerinin Perlit Doldurulmuş Torbalarda Topraksız Yetiştirilmesi. T.Ü. Tekirdağ Ziraat Fakültesi Yayınları 128. Derleme No: 10.
- Varış, S., H. Altay, 1992.Torba Hacmi ve Perlit İrililiğinin, Isıtılmayan Cam Serada Perlit Torba Kültürü İle Yetiştirilen Yaprak Salatada Gelişme ve Verim Üzerine Etkisi. Türkiye I. Tarımda Perlit Sempozyumu. 29-30 Haziran, İzmir.
- Weichmann, I., 1986. The Effect of Controlled-atmosphere Storage on the sensory and Nutritional Quality of Fruits and Vegetables. Hort. Review. Vol. 8.
- Wilson, G.C.S., Hall, D.A. and Mc Gregor, A.J., 1984. Perlite Culture of Tomatoes. Technical Note No. 129. The West Of Scotland Agriculture College.
- Yurtsever, N., 1984. Deneysel İstatistikler Metodları. T.C. Tarım ve Köy İşleri Bakanlığı. Köy Hizmetleri Genel Müdürlüğü Yayın No:56, Ankara.

# RAIN-SPLASH DETACHMENT AND TRANSPORT UNDER WIND-DRIVEN RAIN

G. Erpull<sup>1</sup>, D. L. Norton<sup>1</sup>, and D. Gabriels<sup>2</sup>

<sup>1</sup> USDA-ARS National Soil Erosion Lab., 1196 SOIL Bldg, Purdue Univ., West Lafayette, IN, 47907-1196.

<sup>2</sup> Department of Soil Management and Soil Care, University Ghent, Coupure Links 653, B 9000 Ghent, Belgium.

## ABSTRACT

A series of tests to evaluate the rain-splash detachment and transport under windless and wind-driven rains were conducted in rainfall simulation facility of a wind tunnel. Windless rains and rains driven by the horizontal wind velocities of 6, 10, and 12 ms<sup>-1</sup> were applied on a soil packed in 20 by 55 cm pan placed on both windward and leeward slopes of 7, 15, and 20%. It is found that the rain-splash detachment and transport was highly influenced by rain kinetic energy rate and the angle of raindrop incidence, both being the function of horizontal wind velocity.

Mass distribution curves along the prevailing wind direction were determined, and total splash erosion based on the first moment of mass system was calculated. Unlike windless rains, wind-driven rains led to net rain-splash transport in the wind direction, and soil particles moved more than 10 m in the wind direction, especially in the windward slopes where the angle of raindrop incidence were larger than those of the leeward slopes. Results of the study depict that, in addition to its role in the detachment process, the wind plays very important role in the transport process.

## INTRODUCTION

Soil transport by rain-splash has been most widely neglected in recent erosion models because its contribution, when compared to that of transport by surface flow, is very small (Kinnell, 1991); although soil detachment by rain-splash has been widely accepted as a main process that initiates soil erosion (Ellison, 1947). Our study hypothesizes that soil detachment and transport by rain-splash under wind-driven rains would differ from that under windless rain, and the soil transported by rain-splash could be significant process to the extent that it may not be negligible process.

Soil detachment tends to increase due to the increased kinetic energy of drops (Pedersen and Hasholt, 1995) and a change in angle of raindrop incidence (Van Heerden, 1967) in wind-driven rains. Wind is also a possible factor capable of transporting detached particles by raindrop impact as well as slope and overland flow (Moss and Green, 1983). The splash process can cause net transportation in one direction under the influence of slope and wind direction (Moeyersons, 1983). De Lima (1989) demonstrates the significance of wind as mainly affecting raindrop splash anisotropy which determines the direction and extent of splash erosion.

Most of the studies on modeling spatial distribution of soil particles by rain-splash are carried out with windless rains, and some mathematical models are developed regardless of wind effects (Poesen 1986). In those studies, the rain obliquity on sloping surfaces is introduced to obtain an action of some directionally inclined affect and accordingly to achieve net soil transportation by rain-splash itself. Whereas, Moeyersons (1983) and Moss and Green (1983) reported that wind direction and velocity is the prime factor determining the rain obliquity and hence the extent of particle detachment and transport, and the rain obliquity without wind and slope is only rare or random.

The objective of this study is to present experimental results performed on detachment and transport by rain-splash in a wind tunnel facility of rainfall simulator and to indicate the magnitude and the extent of splash erosion under wind-driven rain.

## MATERIALS AND METHODS

Three agricultural soils, Kemmel1 silt loam (28.9% sand, 58.6% silt, and 12.5% clay), Kemmel2 loam (37.8% sand, 44.4% silt, and 17.7% clay,) and Nukerke silt loam (22.2% sand, 60.1% silt, and 17.8% clay) from near Gent-Belgium were used in this study. The soil samples were collected from the Ap horizon and air-dried prior to the experiment. Soil was sieved into three aggregate fractions, 1.00 - 2.75 mm, 2.75 - 4.80 mm, and 4.80 - 8.00 mm, and the weighting factors assigned to

each fraction were 28%, 32% and 40%, respectively. A 5-kg soil sample was then packed loosely into a 55-cm-long and 20 cm-wide pans after three fractions of aggregates were evenly mixed.

The study was conducted in a wind tunnel rainfall simulator facility of Gent University, Belgium (Gabriels et al., 1997). A continuous spray system of downward oriented nozzles delivered a median drop size of 1.00, 1.61, 1.54, and 1.54 mm for 0.0, 6.0, 10.0, and 12.0 ms<sup>-1</sup> wind velocities, respectively at 1.5 bar operating pressure (Erpul et al., 1998). Simulated rains without wind and driven by horizontal wind velocities of 6, 10, and 12 ms<sup>-1</sup> were applied to the soil pans under freely drained conditions for a 45 min-duration. The slope gradients were 7, 15, and 20% (4, 8.53, and 11.31°) facing to windward and leeward. Intensity was measured with 5 small collectors placed next to the soil pan and with the same slope gradient and aspect as soil pan during the simulated rains. In this way, intensity measurements were made truly representative of each run without any need for correction (Sharon, 1980; Lima 1990).

Upslope and downslope splash were collected by troughs of 18 × 120 cm and for each run, side splash was also collected by splashboards. Side splash was obtained only in windless rains and the rains driven by 6 ms<sup>-1</sup> and evaluated in total splash regardless of the distance, and it disappeared in the rains driven by 10 and 12 ms<sup>-1</sup>. The detachment and the spatial redistribution by rain-splash inside the soil pan were also included in total splash calculations (Van Heerden, 1967). On each soil and each slope aspect with two replicates, 24 runs, in total 144 runs, were performed. The particles trapped in the troughs were washed into beakers, oven-dried, and weighted. Stepwise polynomial regression analysis was performed to determine the particle trajectories and mass distribution curves, using SAS Proc-reg procedure (SAS Institute, 1990). The polynomial equations obtained from the stepwise regression procedure were integrated with 150 predicted values at every 4-cm over the length where rain-splash was observed. The distance, over which particles traveled varied with wind velocity, slope gradient and slope aspect.

$$e = \int f x dx$$

[1]

where  $e$  was splash in grams. The calculation of total splash erosion was based on the first moment of mass system, which is the center of gravity of mass distribution curves,  $x_c$ .

$$\bar{e} = \sum_{i=1}^n m_i x_i = e x_c$$

[2]

$$\sum_{i=1}^n (x_i - x_c) m_i = 0$$

[3]

$$x_c = \frac{\sum_{i=1}^n x_i m_i}{\sum_{i=1}^n m_i}$$

[4]

$\bar{e}$  is the total splash erosion and  $m_i$  is the mass of soil splashed over the distance  $x_i$ .

The kinetic energy of simulated rainfalls was measured by splash cup method (Ellison, 1947). The exponential relationship exists between the applied wind velocities (ms<sup>-1</sup>) and the kinetic energies of rains (Jm<sup>-2</sup>mm<sup>-1</sup>) in the tunnel (Erpul, et.al., 1999). Since intensities varied depending on rain inclination from vertical, slope gradient and aspect, the rate of expenditure of rainfall kinetic energy  $E_{RR}$ , of which units are Jm<sup>-2</sup>s<sup>-1</sup> (or Wm<sup>-2</sup>) was calculated:

$$E_{RR} = E_{RA} I$$

[5]



where  $E_{RA}$  is the amount of rainfall kinetic energy expended per unit quantity of rain which has a units of  $Jm^{-2}mm^{-1}$ .  $I$  is rainfall intensity  $mm s^{-1}$ .

Angle of raindrop incidence ( $\phi$ ) were calculated from the angle of rain inclination from the vertical ( $\alpha$ ) and slope gradient ( $\theta$ ) with respect to the slope aspect:

$$\phi = 90^\circ - (\theta - \alpha), \text{ windward slopes}$$

[6]

$$\phi = 90^\circ - (\theta + \alpha), \text{ leeward slopes}$$

[7]

The procedure for computation of total splash erosion rate ( $E$  in  $gcm^{-1}s^{-1}$ ) from  $\bar{e}$  was based on the starting time of overland flow because the study involved in not only evaluating rain-splash transport but also investigating overland flow transport under wind-driven rains. It is likely expected that rain-splash continued until appreciable flow depth reached during 45-min simulated rains. However, no other reference point to partition the contribution of these two processes was available except overland flow start. In this case, we assume that rain-splash transport falls by a large extent through the flow depth range of 0-2 mm, and beyond it becomes negligible (Moss and Green, 1983). Finally, the power equations were developed for every soil to examine the importance of  $E_{RR}$

and  $\sin \phi$  in total splash erosion rate,  $E$  in  $gcm^{-1}s^{-1}$ , and for this SAS Proc-reg procedure (SAS Institute, 1990) was used with the log-linear (power) regression model of:

$$\log(E) = \log(a) + b \log(E_{RR}) + c \log \sin \phi$$

[8]

## DISCUSSIONS

The rain intensity highly changed with the angle of raindrop incidence, which was function of rain inclination and slope gradient and aspect. It was greatest when rain was vertical (windless rain), and it decreased with decreasing angle of raindrop incidence (Sharon, 1980) in the wind-driven rains. It had a value as low as  $29.12 \text{ mmh}^{-1}$  in leeward slopes where angle of raindrop incidence was  $11.33^\circ$  (Table 1). In the leeward slope of  $11.31^\circ$ , rains driven by either  $10 \text{ ms}^{-1}$  or  $12 \text{ ms}^{-1}$  fell almost parallel to the soil surface with only angle of incidences  $12.25^\circ$  and  $11.33^\circ$ , respectively. With the angle of incidence higher than  $30^\circ$ , the change in the intensity was not as low and noticeable as those lower  $30^\circ$ . This led to windward rain kinetic energy rates,  $E_{RR}$ , differ from those of leeward, and Fig.1a depicts  $E_{RR}$  as influenced by wind velocities on both windward and leeward slopes.

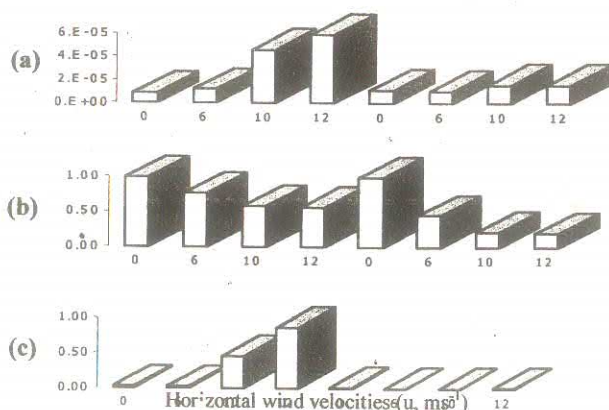


Figure 1: (a) Rain kinetic energy rate,  $E_{RR}$  in  $Wcm^{-2}$ . (b) Angle of raindrop incidence,  $\sin \alpha$  in  $^\circ$ . (c) Total splash erosion rate,  $E$  in  $gcm^{-1}s^{-1}$  influenced by the applied horizontal wind velocities (Kemell soil, windward and leeward slopes of  $11.31^\circ$ ).

Rain inclination from vertical, slope gradient, and slope aspect influenced the angle of raindrop incidence. The angles of rain inclination are  $52^\circ$ ,  $66^\circ$ , and  $67^\circ$  for the rains driven by 6.0, 10.0, and  $12.0 \text{ ms}^{-1}$ , respectively (Gabriels et.al., 1997). It was clear that increasing horizontal wind velocities resulted in decreasing angle of raindrop incidences, and this was more pronounced in the leeward slopes. Wind-driven rains mostly had the angles of incidences  $>30^\circ$  in the windward slopes, whence mostly associating with those  $<30^\circ$  in the leeward slopes (Table 1, Fig.1b). Not only lower  $E_{RR}$  but also smaller  $\phi$  resulted in decreased total splash rate (Fig.1c) in the leeward slopes.

The data obtained on  $E_{RR}$  and  $\phi$  shows a quite continuous range within the limit of the study when the data of either aspects are combined. The following power equations for the total rain-splash rate were developed by regression analysis for Nukerke silt loam, Kemmel1 silt loam and Kemmel2 loam, respectively. The analysis of variance indicated both rain kinetic energy rate and angle of raindrop incidence were significant at the 0.0001 level of significance for three soils.

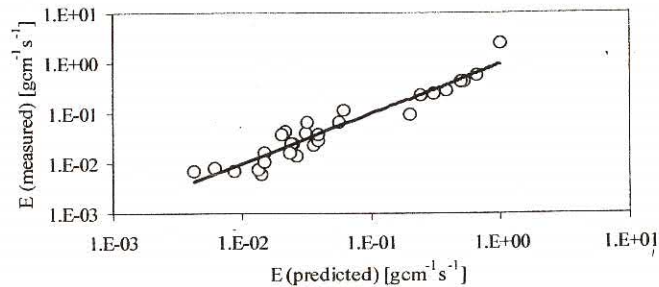
$$E = 6.829 \times 10^9 E_{RR}^{2.2593} (\sin \phi)^{1.7973} \quad (r^2 = 0.9177) \quad [9]$$

$$E = 8.9842 \times 10^{10} E_{RR}^{2.5411} (\sin \phi)^{1.6280} \quad (r^2 = 0.9311) \quad [10]$$

$$E = 2.0223 \times 10^{10} E_{RR}^{2.3872} (\sin \phi)^{1.7714} \quad (r^2 = 0.9502) \quad [11]$$

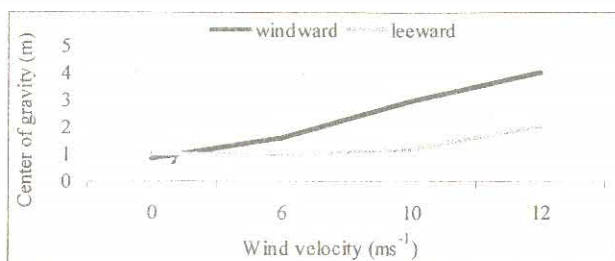
$$E = 2.2116 \times 10^{10} E_{RR}^{2.3896} (\sin \phi)^{1.7470} \quad (r^2 = 0.9170) \quad [12]$$

Equation [12] was developed for the all data obtained in the present study.  $E$  is expressed in  $\text{gcm}^{-1}\text{s}^{-1}$ , and  $E_{RR}$  in  $\text{Wcm}^{-2}$ . Measured and predicted values for Nukerke silt loam are shown in Fig.2.



**Figure 2:** Total rain-splash erosion vs values predicted by equation [9].

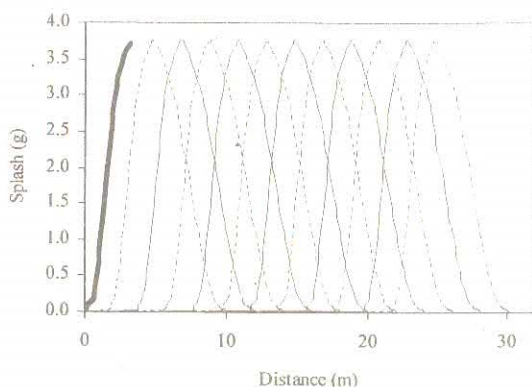
Furthermore, center of gravity of mass distribution curves could give us a significant insight about the extent and magnitude of rain-splash under the wind-driven rains. Center of gravity increases with increasing horizontal wind velocities, depending on  $E_{RR}$  and  $\phi$ . Increase was much more discernible in the windward slopes than in the leeward slopes since rain kinetic energy rates and the



**Figure 3:** Center of gravity as a criterion of rain-splash transport as influenced by the horizontal wind velocity (Nukerke silt loam, windward and leeward of slopes of  $4^\circ$ ).

angle of drop incidences were relatively higher in those slopes. For example, Fig. 3 illustrates the first moment of mass system in windward slope is notably greater than that of leeward slope at all applied wind velocities for Nukerke silt loam in the runs with slope gradient of  $4^\circ$ . In all cases of wind-driven rains, more rain-splash occurred in longer distances in the windward slopes due to both higher rain kinetic energy rates and higher angle of raindrop incidences compared to those of leeward slopes. In windless rain, change in the center of gravity with respect to slope aspect was insignificant.

In the present study, wind determined the rain-splash trajectories, directing the lifted soil particles, and this process caused net transportation in prevailing wind direction. Theoretically, we could consider that detachment and transport of rain-splash is constant over the entire uniform slope. Fig.4 presents this theoretical case at which rain-splash attains its maximum value at a given distance and remains the same from that point on (Moeyerson, 1983; Van Heerden, 1967). The extent and magnitude of this net migration process will vary with the rain kinetic energy rate and the angle of raindrop incidence.



**Figure 4:** Theoretical diagram of repeating curves: progression of mass distribution curves along uniform slope in the prevailing wind direction.

## REFERENCES

De Lima, J. L. M. P. (1989). Raindrop splash anisotropy: Slope, wind, and overland flow velocity effects. *Soil Technol.*, 2: 71-78.



- De Lima, J. L. M. P. (1990). The effect of oblique rain on inclined surfaces: A nomograph for the rain-gauge correction factor. *Journal of Hydrology* 115: 407-412.
- Ellison, W. D. 1947 (7 parts). Soil erosion studies. *Agric. Eng.* 28: 145-146; 197-201; 245-248; 297-300; 349-351; 407-408; 447-450.
- Erpul, G. D. Gabriels, D. Janssens. (1998). Assessing the drop size distribution of simulated rainfall in a wind tunnel. *Soil and Tillage Research* 45: 455-463.
- Erpul, G. D. Gabriels, D. Janssens. (1999). The effect of wind on size and energy of small simulated raindrops: a wind tunnel study. *Geophysics* (in press).
- Gabriels, D., W. Cornelis, I. Pollet, T. Van Coillie, and M. Quessar. (1997). The I.C.E. wind tunnel for wind and water erosion studies. *Soil Technology* 10: 1-8.
- Gabriels, D., K. Tack, G. Erpul, W.M. Cornelis, D.L. Norton and J. Biesemans. (1997). Effect of wind-driven rain on splash detachment and transport of a silt loam soil: a short slope wind tunnel experiment. Workshop on Wind and Water Erosion, November 17-18, 1997, Ghent-Belgium.
- Kinnell, P. I. A. (1991). The effect of flow depth on sediment transport induced by raindrops impacting shallow flows. *Trans. ASAE* 34: 161-168.
- Moeyersons, J. (1983). Measurements of splash-saltation fluxes under oblique rain. *Catena suppl.* 4: 19-31.
- Moss, A. J. and P. Green. 1983. Movement of solids in air and water by raindrop impact. Effects of drop-size and water-depth variations. *Aust. J. Soil Res.* 21(3): 373-382.
- Pedersen, H. S. and B. Hasholt. (1995). Influence of wind speed on rainsplash erosion. *Catena* 24: 39-54.
- Poesen, J. 1986. Field measurements of splash erosion to validate a splash transport model. *Z. Geomorph. N. F., Suppl.* -bd 58: 81-91.
- SAS Institute. (1990). SAS/STAT guide for personal computers. SAS Inst., Cary, NC.
- Sharon, D. (1980). The distribution of hydrologically effective rainfall incident on sloping ground. *Journal of Hydrology* 46: 165-188.
- Van Heerden, W. M. (1967). An analysis of soil transportation by raindrop splash. *Trans. ASAE* 10: 166-169.
-

# VISUALIZING SPATIO-TEMPORAL MESQUITE VARIATION ON DESERT GRASSLANDS UNDER DIFFERENT GRAZING MANAGEMENT APPLICATIONS

Hakan Mete Doğan

General Directorate of Agricultural Research, GIS & Remote Sensing Research Center,  
P.Box: 78 Yenimahalle 06171, Ankara, Turkey

## ABSTRACT

One of the most important problems in arid regions of world is desertification, which is exemplified by shrub invasion and grassland fragmentation. Identification of the spatio-temporal dynamics of such mechanisms is among the most difficult tasks related to range management decision making. In this study, statistical analyses and GIS visualization procedures are employed to display changing conditions on the Chihuahuan Desert Rangeland Research Center, New Mexico from 1982 to 1993. Results denote a proof of the notion that visualization is a substantial tool for monitoring range condition. They also indicated the dramatic mesquite (*Prosopis glandulosa*) change between the years (1982 and 1993) and some statistically significant relationships between the dependent and independent natural variables.

## INTRODUCTION

Desertification is a critical environmental problem. According to the United Nations Environment Program (1987); about 3500 million hectares of land are under pressure of desertification. Every year about 6 million hectares of land are irretrievably lost to desertification, and an additional 21 million hectares are so degraded that agricultural facilities become uneconomic. Serious desertification affected 57 million people in rural populations in 1977, and this amount reached 135 million people in 1984. The conditions became crucial in the rainfed croplands in the year 2000. In the northern Chihuahuan desert, serious changes in vegetation have been observed during the last 100 years, where vegetation dynamics are determined by the interactions of topographic position, soil development, and human impact (Buffington and Herbel 1965). Consequently, large areas of former black grama (*Bouteloua eriopoda*) grassland have been replaced by shrubland communities and dominated by creosotebush (*Larrea tridentata*), mesquite (*Prosopis glandulosa*) and tarbush (*Flourensia cernua* DC.). When arid lands are invaded by mesquite, desertification come into subject, and management of these kinds of areas become critical. Recently, geographic data that contain the measurements of three-dimensional space and time have gained great importance for the studies of spatial and temporal relationships in landscapes. Scientific visualization supports the analysis and communication of these kinds of data (Brown et al. 1995). Geographic Information Systems (GIS), the application of computer graphic visualization in 3-dimensions, is a tool that expands our understanding on a variety of spatial and temporal relationships by graphically visualizing spatial data (Watson 1992; Habb 1995).

## MATERIAL and METHOD

Chihuahuan Desert lies south of the international border and extends into parts of New Mexico, Texas and even sections of southeastern Arizona. It is the largest desert in North America. The research area, located in 20 km north of Las Cruces-New Mexico, is called the Chihuahuan Desert Rangeland Research Center (CDRRC), and it was established by New Mexico University in 1927. CDRRC has a typical semidesert grassland climate with an abundance of sunshine and a wide range between day and night temperatures. Low relative humidity and extremely variable precipitation are the important characteristics of the climate. In winters, precipitation is mostly low intensity rain, and snow is rare. On the contrary, localised high intensity thunderstorms occur in summers. Although the temperature might be favorable for plant growth about 200 days, normal growth occurs only from 90 to 100 days because of available moisture conditions. It is clear that moisture is an important determinant of plant growth in the area. The average annual precipitation from 1915 to 1962 was determined as 231.14 mm at the Range Headquarters, and 52% of that amount, 120.19 mm, recorded between July 1 and September 30 (Buffington and Herbel 1965). The precipitation data, collected



from 10 rain gauges between 1979 and 1996 (18-year period) in the CDRRC, were converted to a rain map and used for spatial analysis in this study.

According to the Soil Maps of New Mexico, specifically for the Dona Ana County Area (Bulloch and Neher 1980), the study area basically consists of two soil groups, namely *Berino-Bucklebar* association (BJ) and *Wink-Harrisburg* association (WH). The soil map that shows soil groups and experimental pastures of the study area is given in Figure 1.

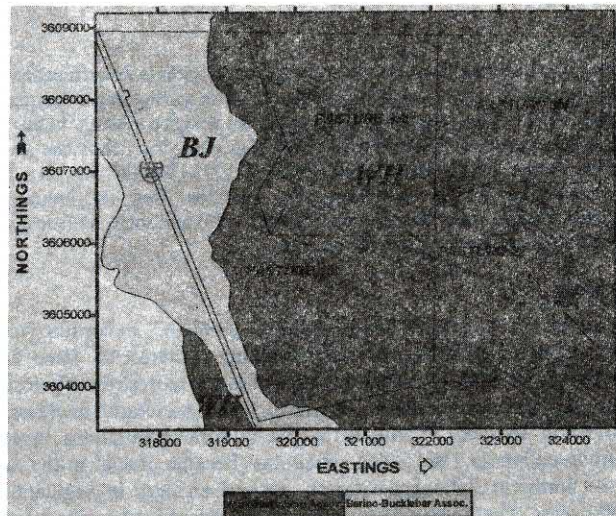


Figure 1. Soil Properties and Experimental Pastures of the Study Area

Black grama, mesa dropseed (*Sporobolus flexuosus* (Thurb.) Rydb.) and *Aristida* spp. growing on the sandy upland sites are the main grass species while tobosa (*Hilaria mutica* (Buckl.) Benth.) and burrograss constitute the main forage species in the lower areas on CDRRC. The main browse plant is fourwing saltbush (*Atriplex canescens* (Pursh) Nutt.), which normally occurs in association with mesquite (*Prosopis juliflora* (Swartz) DC. var. *glandulosa* (Torr.) Cockerell), creosotebush, and tarbush. Yucca and broom snakeweed are defined as other shrubby plants in the area (Buffington and Herbel 1965).

A grazing study, applied to the rangeland in 1967, divided the pasture area into four different grazing management pastures (Figure 1) that were named: pasture 15 (1266.82 ha), 3W (670.13 ha), 3N (501.86 ha), and 3S (499.59 ha). A year-long grazing management study was conducted in pasture 15 (control pasture), while late winter-early summer, summer, and fall grazing management schemes were applied in pasture 3N, 3S, and 3W, respectively. All of the pastures were formed according to vegetation types and condition classes (from excellent to poor condition). The studies were based on the design of a simple two-group experiment that was detailed by Spatz and Johnson (1989).

According to the 7.5-Minute Series Orthophotomap of U.S. Geological Survey (1982) maps (Selden Canyon and Summerford Mountain) the elevation of the study area changes between 1317 and 1332 meters. The highest elevations (1326-1332 m) are observed in the east (Pasture 3N and Pasture 3S) and north sides (Pasture 3W) of the area. On the other hand, the lowest elevations (1323-1317 m) are observed in the northwest and southwest (Pasture 15) of the area. Mesquite dunes around the big plants are observed in some of the northern parts. These formations that constituted some undulating topography among the big mesquite plants were not reflected in this topography map.



The data that contain canopy, density and volume values of mesquite were collected from 220 fixed transects on the pastures in 1982 and 1993 (unpublished data, CDRRC). Each transect's location was determined according to Universal Transverse Mercator (UTM) coordinates by using Global Positioning System (GPS). Each transect represents an area approximately 806 m<sup>2</sup>. Pasture 15 has the most transects (92), while pasture 3W has 48 transects. Pasture 3S and 3N have the same number of transects (40 transects for each). Volume values indicate total volume of all mesquite (m<sup>3</sup>) on the transects and density values represent the number of mesquite plants per hectare (10 000 m<sup>2</sup>). Canopy values explain how much land area was covered by mesquite plants, and they are shown as percentage (%) values.

Canopy, density and volume variables were combined with the UTM coordinate data. These coordinate data were transformed into DBase data format as X and Y values so that Surfer software (Golden Software, 1990) can use them. Mesquite variables (canopy, density and volume) were defined as the Z values of this study. Consequently, the worksheet data files that consist of XYZ values were formed to develop grid files that are necessary for producing filled contour maps. Difference maps for canopy, density and volume were produced by subtracting the map values of 1982 from the map values of 1993, and they were put together in the same figure (Figure 2). The difference maps showed the pastures where most mesquite variables' change occurred.

Statistical analyses formed an important part in this research. At the starting point, data characteristics were determined graphically and statistically. Histograms and boxplots were chosen to create the graphical representation of data. In addition, Levene and Shapiro-Wilks tests were employed to explore the data in a statistical way (Norušis 1993). SPSS (1993, 1997) and SAS (1985) softwares were used in all statistical analyses.

Graphical and statistical results showed that mesquite data set is not normally distributed. Therefore, some appropriate transformations were needed for the data set to conduct further statistical analyses in a more dependable way. A  $\ln(\text{variable} + 1)$  transformation formula was applied to mesquite data, because the data set showed **negative binomial data** characteristics depending on the distribution, mean and variance patterns (Norušis 1993). After exploring data and making transformations, Two-Way-Anova (Analysis of Variance) statistical analysis was conducted to distinguish if the differences were statistically significant or not in the four pastures for the years 1982 and 1993. After conducting Two-Way-Anova, the Least Significant Difference (LSD) test was applied to establish confidence intervals and group the pastures. Moreover, a series of regression analyses were applied to understand the nature of the relationships between the dependent (canopy, density, volume) and independent (seasonal rain, elevation, soil) variables. Statistical analyses gave the chance to establish logical connections between the mesquite data and the maps that were produced by using exploratory data analyse (EDA) methods. The residuals from regressions were investigated and mapped to check the validity of regression equations in this study.

## DISCUSSION

The filled contour maps delineated the mesquite variables' change between the years (1982 and 1993) and among the pastures. Consequently, a lot of differences that are impossible to be shown in otherwise were detected and displayed for each mesquite variable (canopy, density and volume). By using these visual tools, the nature and characteristics of mesquite establishment and invasion were understood very well in the study area. This research emphasized the importance of GIS tools to understand the spatio-temporal characteristics of geographical events.

All of the maps were interpreted and the mesquite invasion characteristics were determined. The first important mesquite invasion characteristic was detected for mesquite density increases (Figure 2). Maps indicated that mesquite establishment, specifically mesquite density increases, took place around the areas where bigger volume and canopy values were observed. Bigger and mature plants play a nucleus role for mesquite establishment in this area. This finding showed parallelism with Archer and Scifres' (1988) study. Moreover, the areas with the most changes were determined. The biggest changes were observed for the north and south side of the area where again bigger and maturer plants are located (Figure 2).

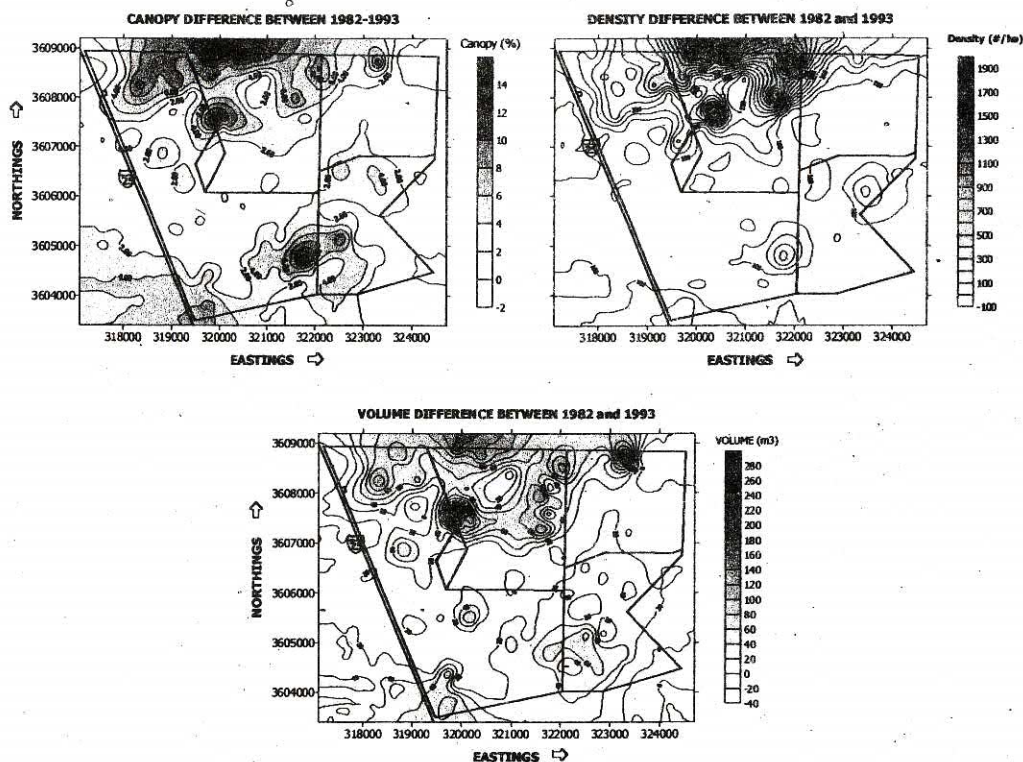


Figure 2. Difference maps for the mesquite variables (canopy, density and volume)

The two-way-Anova (Analysis of Variance) indicated that the differences between the years and among the pastures were statistically significant ( $P < 0.05$ ) for all of the mesquite variables in question. Depending on the visual displays and Two-Way-Anova statistical analysis, it might be said that mesquite density, canopy and volume variables increased significantly from 1982 to 1993. The pastures where different grazing methods were applied, have different mesquite variable characteristics. On the other hand, it is not so easy to answer why there was a dramatic mesquite increase in the north (pasture 3W and 15) and south (pasture 15 and 3S) parts of the study area, because in an ecosystem there are many factors interacting with each other, and different grazing methods might be one of these factors. Moreover, maps implied that most mesquite invasion takes place around core areas where mesquite plants are already established and big volume values were observed regardless of the grazing methods (Figure 2). Therefore, the different grazing methods may not be a factor to explain this kind of mesquite invasion.

Seasonal rain is one of the key factors in Chihuahuan Desert Environment. Although the effect of seasonal rain on the mesquite invasion is still widely debated in the literature, the mesquite density variable increased with the higher seasonal rain amounts (positive relationship) in pasture 3N, 3W and 15. Regression lines that have different slopes delineated the direction and strength of relationships between the seasonal rain and density. Pasture 3S showed a distinct character compared to the other three pastures because no significant relationship between the mesquite density and seasonal rain was detected within this pasture. The question as why there is not a significant relationship between the density and seasonal rain only in pasture 3S is worth of attention. Pasture 3S has smaller plants in both years, and it receives less rain relative to the other pastures. This could support the assumption



that most mesquite density increases take place around core areas where mesquite plants are already established, and larger plants were observed. The results also might indicate the importance of the effect of seasonal rain on mesquite density increases.

Mesquite canopy and volume variables accelerated with increasing values of seasonal rain in all of the pastures with the exception of pasture 3S. This situation might be related to the size and age of plants, infiltration and nutrient characteristics of the soil, and some drought periods that are hidden in the mean seasonal rain values. Pasture 3S has relatively smaller plants compared to the other three pastures, and receives less seasonal rain. This characteristic of the pasture 3S answers the question partially but it is not enough to explain the whole process. More data that provide detailed information about rain, soil and infiltration characteristics are necessary.

The relationships between the elevation and other dependent mesquite variables showed positive characters in pasture 3W that receives higher seasonal rain compared to the other pastures. When the elevation increases, mesquite canopy, density and volume variables also increase with different regression line slopes in pasture 3W. On the other hand, the relationships between the elevation and same dependent mesquite variables displayed negative (inverse) characters in pasture 3N and 3S that receive less seasonal rainfall within the study area. When the elevation increases, mesquite variables decrease with different slopes in pasture 3N and pasture 3S. Results imply that the elevation effect on the mesquite variables might be changed with the amount of seasonal rain. Any other variables such as some soil and rain characteristics might be important in this process. More detailed data about the rain are needed for further research.

Soil was one of the most important independent variables in this study. Maps from the Soil Survey of Dona Ana County Area (Bullock and Neher 1980) were used to investigate the soil effects on the mesquite variables. Although these soil maps were helpful to catch some important relationships for pasture 15, they did not supply enough information about pasture 3N, 3S and 3W because all of the pastures located on one type of soil except pasture 15 (Figure 1). The effects of soil and seasonal rain on mesquite variables were investigated by combining their effects for pasture 15. Some interesting relationships were determined in pasture 15. Regression lines showed the different soil responses of mesquite variables to the seasonal rain. Two relationships were observed ; (1) the relationship between the seasonal rain and canopy (1982) and (2) the relationship between the seasonal rain and density (1993). The regression graphs displayed differences between the two soil types for both relationships (Figure 3). In both graphs the slopes of regression lines that belong to Berino-Bucklebar (BJ) soil association were found higher comparing to the lines of Wink-Harrisburg (WH) soil association.

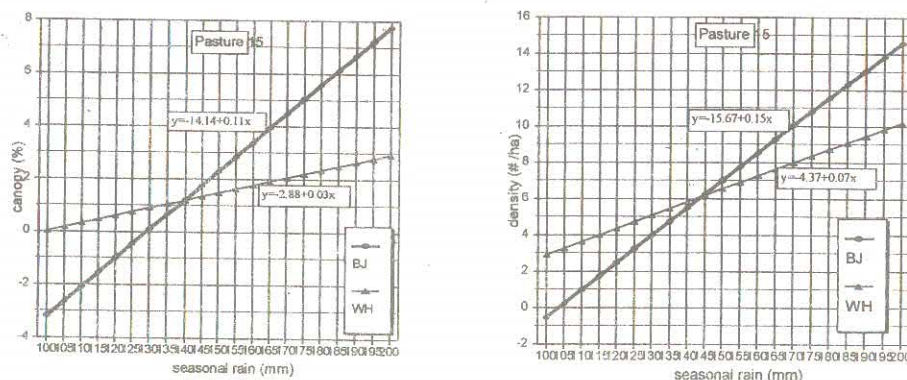


Figure 3. Different soil responses to seasonal rain in Pasture 15

According to these findings it might be suggested that the response to seasonal rain is higher in BJ soil association. Why the response of BJ soil found higher in both graphs was investigated by using the available soil information. The first important difference between two soil associations was identified in the soil texture classes. The BJ soil association contains finer soil particles such as clay



whereas no clay particles were described in the texture classes of WH soil association in any depth. As a result, higher available water capacity values were observed for BJ soil association, and this is an extremely important soil variable that is related to plant growth and its establishment in arid and semiarid environments. The higher response of BJ might come from its higher clay contents and available water capacity. These findings highlighted the importance of soil types in mesquite establishment and invasion of the study area. Results showed that, soil might be one of the most effective factors on the mesquite invasion, and the soil map of Soil Survey of Dona Ana County did not supply enough information to understand the whole process in this area. A more detailed soil map that delineates some important physical and chemical soil characteristics may be very useful for future research. The most important variables for the future soil maps might be soil texture, water holding capacity, infiltration characteristics and nutrient contents (Nitrogen, Phosphorus, and Potassium).

Although rain data produced some reasonable results, the information about the rain intensity and duration might be necessary to understand the small and younger mesquite plants' response to drought. Results also indicate that topography might be effective on the mesquite invasion in the study area. A detailed contour map (1 or 2 feet intervals) might be very useful to display micro-topography and the relationships between the elevation and other dependent mesquite variables. In addition, It might be important to know the other vegetation types and their distributions in this area. A vegetation map may be useful to search the reasons of differences between the dependent and independent variables. The key factor for the further research activities about the mesquite invasion might be hidden in the geomorphology.

## REFERENCES

- Archer S. and C.J. Scifres. 1988. Autogenic Succession and the Physiognomic Conversion of a Grassland to a Woodland. In *La Copita Research Area Consolidated Progress Report-1988*, J.W. Stuth. Texas Agricultural Experiment Station, CPR-4592, pp 2.
- Brown, W. M., M. Astley, T. Baker, H. Mitasova. 1995. GRASS as an Integrated GIS and Visualization System for Spatio-Temporal Modeling. *Twelfth International Symposium on Computer-Assisted Cartography*, Charlotte, North Carolina Volume: 4 pp. 89-99.
- Buffington, L. C. and C. H. Herbel. 1965. Vegetational Changes on a Semidesert Grassland from 1858 to 1963. *Ecological Monographs*. 35:139-164.
- Bulloch, H. E. Jr. and R. E. Neher. 1980. *Soil Survey of Dona Ana County Area New Mexico*, United States Department of Agriculture, Soil Conservation Service, in cooperation with United States Department of Interior, Bureau of Management, and New Mexico Agricultural Experiment Station. United States Department of Agriculture, Washington D.C.
- Golden Software. 1990. *Surfer Users' Guide*. Golden, Co.
- Habb, F. J. 1995. *Computer Generation and Rendering of Terrain*. Master's of Science Thesis, University of Nevada, Las Vegas, Nv.
- Norušis, M. J. 1993. *SPSS for Windows Base System User's Guide, Release 6.0*. SPSS Inc. Chicago.
- SAS. 1985. *SAS User's Guide: Basics, Version 5 Edition*. SAS Institute Inc., North Carolina.
- SPSS. 1993. *SPSS 6.0 for Windows*. SPSS Inc., Chicago.
- SPSS. 1997. *SYSTAT 7.0 for Windows: Unparalleled Research Quality Statistics and Graphics*. SPSS Inc., Chicago.
- Spatz, C. and J. O. Johnson. 1989. *Basic Statistics. Tales of Distributions*. 4ed. Brooks/Cole. Pacific Grove, Ca.
- UNEP, 1987. *Sands of Change. UNEP Environmental Brief No 2*.
- Watson, D.F. 1992. *Contouring. A Guide to the Analysis and Display of Spatial Data*. Pergamon Press. Oxford, England.

# DETERMINATION OF RELATIONS BETWEEN SOME SOIL PROPERTIES AND SOME SOIL MOISTURE CONSTANTS USING PATH ANALYSIS

Nutullah Özdemir, Coşkun Gülser, Tayfun Aşkın

Ondokuz Mayıs University, Faculty of Agriculture, Department of Soil Science, Samsun/Turkey

## ABSTRACT

The relationships between some soil physical and chemical properties such as, bulk density ( $\rho_b$ ), clay content (C), organic matter (OM), cation exchange capacity (CEC), lime content (LC) and exchangeable Na (Exc-Na) and some soil moisture constants such as, field capacity (FC), permanent wilting point (PWP) and available water capacity (AWC) were studied using path analysis on 44 surface soil samples (0-20 cm) around Samsun. Soil moisture constants showed positive relationships with C, OM, CEC and negative relationships with  $\rho_b$ , LC, Exc-Na. It was determined that the direct effects of some soil properties on AWC were in the following order;  $C > LC > \rho_b > \text{Exc-Na} > \text{CEC} > \text{OM}$ . On the other hand, the indirect effects of soil properties varied among soil moisture constants. The indirect effects of the soil properties generally became through clay content and bulk density. Clay content was the most effective soil property that affected water retention in soils.

## INTRODUCTION

Knowledge of soil water relationships is essential for determining the type of plants to be grown, plant spacing, yield and managing soil water systems. Water holding abilities of the soil are related to removing water from the soil by drainage or evapotranspiration and storing water in the soil by rainfall or irrigation. Soil water retention is a basic soil property that is influenced by some soil physical and chemical properties and is needed for the study of plant available water, infiltration, drainage, hydraulic conductivity, irrigation, water stress on plants and solute movements. In most soils, optimum growth of plants occurs, when the soil water retention is kept near the field capacity or at least does not approach the permanent wilting point (Brady, 1974). Field capacity (FC) is the percentage of water remaining in a soil after soil is wetted and allowed to drain one to two days. It represents the upper limit of water available to plants, usually defined as 0.1 to 0.3 bars tension. Permanent wilting point (PWP) represents to lower limit of water available to plants, usually defined as 15 bars tension. Water retained by soil between the field capacity and the permanent wilting point is considered available for plant use and defined as the available water capacity (AWC) (Brady, 1974).

Although the soil moisture constants are based on an equilibrium established with forces exerting differing degrees of tension on the water, they have utility for many agronomic purposes and for measuring relative differences in available water capacity within and among soils (Bauer and Black, 1992). Bahtiyar (1975) studied on relationships between field capacity, permanent wilting point and some soil properties, explained that these constants can be estimated by means of developed regression models.

A unit increase in organic carbon concentration caused a relatively larger increase in weight percentage at the field capacity than at the permanent wilting point in coarse and moderately coarse soils. But in medium and moderately fine or fine soils a unit increase in organic carbon concentration caused essentially identical increases in weight percentage at field capacity and permanent wilting point (Bauer and Black, 1992).

A soil system can be thought as a network of soil properties. Path analysis may be used to investigate the relationships among these soil properties. The path diagram gives a picture of network of relations among the characters, as quantitative evaluation is possible from the data (Wright, 1968). The objective of this study was to determine the relationships between some soil physical, chemical properties and some soil moisture constants such as field capacity, permanent wilting point and available water capacity, using path analysis.

## MATERIALS and METHODS

Soil samples were taken 44 surface soil (0-20 cm depth) around Samsun. The soils have mostly alluvial, and partly colluvial character. Annual mean of precipitation is 927.6 mm, annual evaporation is 600 mm and mean temperature is 15.2 °C (Anonymous, 1994).



Some soil physical and chemical properties were determined as follows; soil particle size distribution by the hydrometer method (Demiralay, 1993); lime content by Scheibler Calsimeter (Soil Survey Staff, 1993); pH in 1:2.5 (w/v) soil-water suspension by pH-meter (Black, 1965); exchangeable Na by ammonia acetate extraction; exchangeable Ca+Mg by titration; cation exchange capacity according to Bower method (U.S. Salinity Lab. Staff, 1954). Soil organic matter was measured by Walkley-Black method (Kacar, 1994). Bulk density was determined by means of the clod method (Demiralay, 1993). Soil water concentration by weight at the field capacity was measured on samples passing a 2 mm sieve, saturated for 24 hours and then equilibrated for 24 hours at 33 kPa on a ceramic plate. The permanent wilting point was measured on samples passing a 2 mm sieve, saturated for 24 hours, and then equilibrated for 72 to 96 hours at 1500 kPa on a pressure-plate apparatus. Available water capacity was calculated from  $AWC = FC - PWP$ . Where AWC is available water capacity (g water 100 g<sup>-1</sup> soil); FC is field capacity (g water 100 g<sup>-1</sup> soil) and PWP is permanent wilting point (g water 100 g<sup>-1</sup> soil) (Klute, 1986).

The soil moisture constants were selected as dependent variables to determine statistical relationships between some soil properties ( $\rho_b$ , C, OM, CEC, LC and Ex-Na) and the soil moisture constant such as FC, PWP and AWC. Also, direct and indirect effects of the variables were determined with path analysis (Wright, 1968), using TARIST computer package program.

## RESULTS & DISCUSSIONS

### Soil Properties

Descriptive statistical results for some soil physical and chemical properties and soil moisture constants (FC, PWP and AWC) are given in Table 1.

Table 1. Statistical results for some soil physical, chemical properties and moisture constants of soil samples (n=44).

Soil Properties	Mean	Min.	Max.	S <sub>d</sub>	S <sub>e</sub>
Sand (S), %	39.30	19.90	63.80	10.78	1.62
Silt (Si), %	26.17	9.80	51.80	6.75	1.02
Clay (C), %	34.51	14.50	52.50	9.38	1.42
Bulk density ( $\rho_b$ ), g cm <sup>-3</sup>	1.32	1.20	1.38	0.04	0.01
PH (1:2.5 soil: water suspension)	7.69	5.80	8.40	0.63	0.09
Lime content (LC), %	4.78	0.70	13.90	3.35	0.51
Organic matter (OM), %	1.76	1.20	2.70	0.39	0.06
Exchangeable Ca+Mg, me.100 g <sup>-1</sup>	26.41	8.00	37.10	6.93	1.05
Exchangeable sodium (Exc-Na), %	0.71	0.41	1.92	0.36	0.05
Cation exchange capacity (CEC), me.100 g <sup>-1</sup>	35.14	16.20	45.80	6.80	1.03
Field capacity (FC), %	35.90	19.51	51.40	8.18	1.23
Permanent wilting point (PWP), %	24.10	11.26	36.71	6.39	0.96
Available water capacity (AWC), %	11.60	7.70	15.98	2.25	0.33

S<sub>d</sub>: standard deviation, S<sub>e</sub>: standard error

According to Table 1, the results can be summarized as; soil samples have mostly fine in texture, light to moderate in pH, low in organic matter (average of 1.76 %), moderate in lime content (average of 4.78 %), and free alkaline problem (ESP<15 %) (Soil Survey Staff, 1993).

### Relationships Between Soil Properties And The Soil Moisture Constants

The correlation coefficients between some soil properties and the soil moisture constants are given with direct and indirect effects of the variables on the soil moisture constants in Table 2.



Table 2. Path analysis results on some soil moisture constants and relationships with some soil properties.

Moisture constants	Soil properties	r	Direct effect, %	Indirect effects, %					
				$\rho_b$	C	OM	CEC	LC	Exc-Na
FC	$\rho_b$	-0.48**	25.6	-	61.7	4.5	5.4	1.4	1.3
	C	0.80**	68.9	17.0	-	4.9	6.5	1.0	1.5
	OM	0.66**	8.2	16.3	64.6	-	5.5	3.8	1.6
	CEC	0.77**	7.3	16.2	69.8	4.6	-	0.3	1.7
	LC	-0.30*	58.7	7.8	19.9	5.8	0.6	-	7.1
	Exc-Na	-0.31*	20.4	11.3	47.9	3.8	5.1	11.3	-
PWP	$\rho_b$	-0.50**	21.5	-	50.3	8.7	15.6	1.1	2.7
	C	0.79**	54.7	13.9	-	9.3	18.2	0.8	3.0
	OM	0.65**	15.0	13.1	50.5	-	15.3	2.9	3.1
	CEC	0.76**	20.3	13.0	54.5	8.4	-	0.2	3.5
	LC	-0.25 <sup>ns</sup>	47.9	6.7	16.7	11.4	1.9	-	15.3
	Exc-Na	-0.36*	34.8	7.7	31.9	6.0	12.2	7.4	-
AWC	$\rho_b$	-0.33*	23.6	-	59.0	3.1	11.6	1.4	1.2
	C	0.68**	65.0	15.5	-	3.4	13.7	1.0	1.4
	OM	0.53**	5.6	15.0	62.0	-	12.0	3.8	1.5
	CEC	0.61**	15.4	14.5	65.1	3.0	-	0.3	1.6
	LC	-0.37*	60.3	7.4	19.8	4.1	1.4	-	6.9
	Exc-Na	-0.10 <sup>ns</sup>	19.1	10.3	45.7	2.6	11.0	11.2	-

\*\* : significant at  $p < 0.01$ , \* : significant at  $p < 0.05$ , <sup>ns</sup> : not significant

According to Table 2, clay content showed significant positive relations with all the soil moisture constants at  $p < 0.01$ . Direct effects of clay content on FC, PWP and AWC were found to be higher than that of the other soil properties. Also, the soil properties had higher indirect effects through clay content on the soil moisture constants. It indicates that clay content was the most important soil property that affected water retention in soils. In the indirect effects of clay content through the other soil properties on FC (17.0 %) and AWC (15.5 %), bulk density ( $\rho_b$ ) was the most effective soil property. However, the indirect of C through CEC (18.2 %) was found to be the most effective soil property on PWP. On the other hand the direct effect of CEC on PWP (20.3 %) was higher than that on FC (7.3 %) and AWC (15.4 %). Thus, the clay content play important roles in the adsorption and desorption of water molecules. The surface adsorptive forces of clay minerals greatly affect water retention because of the permanent negative charge of clay mineral particles and the polar nature of water (Petersen et al, 1996). Other than clay content, CEC and OM gave significant positive relations with all the moisture constants at  $p < 0.01$  level. Also, the higher indirect effects of OM on the soil moisture constants usually became through bulk density. Bulk density decreases with increasing organic carbon concentration (Bauer and Black, 1992). Soil organic matter influences water retention because of its hydrophilic character and its influence on soil structure and bulk density (Klute, 1986). Increasing soil organic matter increase plant available water holding capacity (Kern, 1995).

Bulk density gave the significant negative correlations with FC, PWP at  $p < 0.01$  and AWC at  $p < 0.05$  level. As known that bulk density decrease with increasing clay content in soil. It is expected that water retention is also increase with decreasing bulk density. The total porosity of sandy soils is less than that of fine textured soils (Hillel, 1982). For this study it can be expected that decreases in bulk density increase the total porosity and water retention because of the high clay content of the soils.

Other than bulk density, lime content (LC) and Exc-Na percent also showed the negative correlations with the soil moisture constants. LC had higher direct effects on all the moisture constants after clay content. Lime content was negatively related with FC and AWC at  $p < 0.05$  level and

negatively related with PWP as non significantly. The behavior of particle size distribution of LC in soils might be the similar to coarse fractions of soil texture. Macropores are important recharge pathways of water but can eventually became plugged due to accumulation of  $\text{CaCO}_3$  (Stephens, 1996). Therefore increasing the lime content may decrease water retention due to the decreasing macropores. PWP is expected to related with micropores in soils. Thus, lime content did not give highly significant correlation with PWP.

There were negative relations between Exc-Na percent with FC and PWP at  $p < 0.05$  level. Increments in Exc-Na percent in soils tend to exhibit very poor physical properties if the clay content is fairly high (Bolt and Bruggenwert, 1978).

In conclusion, soil moisture constants gave the significant positive correlations with C, CEC and OM at  $p < 0.01$  and negative correlations with bulk density, LC and Exc-Na percent. Clay and lime contents showed the higher direct effects on all the moisture constants. Except lime and clay contents, direct and indirect effects of soil properties varied among soil moisture constants. The indirect effect of the soil properties were generally became through clay content and bulk density. Clay content was found to be the most effective soil property that influenced water retention in all the soil moisture constants.

## REFERENCES

- Anonymous (1984). Samsun İli Çevre Durum Raporu. Çevre İl Müdürlüğü Yayınları, No:36.
- Bahtiyar M (1975). Toprakta su tutulması ve hidrolik iletkenliğin tahmin edilebilme olanakları üzerinde bir araştırma . Atatürk Üniversitesi Ziraat Fakültesi (Doktora tezi). Erzurum.
- Bauer A., Black A. L. (1992). Organic carbon effects on available water capacity of three soil textural groups. Soil Science Society American Journal 56:248-254.
- Black, C.A. (1965). Methods of Soil Analysis. Part 1, American Soc. of Agron. , No 9.
- Soil Survey Staff (1975). Soil Taxonomy. Agr. Hdbk. No.436, Soil Cons.Ser. USA
- Bolt, G.H. and Bruggenwert, M.G.M. (1978). Soil Chemistry. A. Basic Elements. Second revised edition, Elsevier Scientific Publishing Company.
- Brady, C.N. (1974). The nature and properties of soils. 8<sup>th</sup> edition. Macmillan Publishing Co.,Inc. New York.
- Demiralay, İ. (1993). Toprak Fiziksel Analizleri. Atatürk Üniversitesi Ziraat Fakültesi Yayınları, No:143, Erzurum.
- Hillel, D. (1982). Introduction to Soil Physics. Academic Press Limited, 24-28 Oval Road, London.
- Kacar, B. (1994). Bitki ve Toprağın Kimyasal Analizleri:III, Toprak Analizleri, s:149-165, Ankara Üniversitesi Ziraat Fakültesi Eğitim, Araştırma ve Geliştirme Vakfı Yayınları No:3, Ankara.
- Kern J. S. (1995). Evaluation of soil water retention models based on basic soil physical properties. Soil Science Society American Journal 59:1134-1141.
- Klute, A. (1986). Water Retention: Laboratory methods. In A. Klute (ed.), Methods of Soil Analysis, Part I, Second edition, Agron. Monogr. p: 635-662, 9 ASA and SSSA, Madison, WI.
- Petersen, L.W., Moldrup, P., Jacobsen, O.H. and Rolston, D.E. (1996). Relations between specific surface area and soil physical and chemical properties. Soil Sci. Vol. 161, No. 1, 9-20, USA.
- Soil Survey Staff (1993). Soil Survey Manuel. USDA Handbook No:18, Washington, USA.
- Stephens, D.B. (1996). Wadose Zone Hydrology. Lewis Publishers, p:91, New York, USA.
- U.S. Salinity Laboratory Staff (1954). Diagnosis and Improvement of Saline and Alkali Soils. Agricultural Handbook No:60.
- Wright, S. (1968). Path Analysis: Theory, Evolution and The Genetics of Populations, Volume:1, 299-324, The University of Chicago Press.



# RANGELAND-LIVESTOCK INTERACTION IN OUR NEAR HISTORY PROBLEMS AND RECOMMENDATIONS

Ali Koç<sup>1</sup>, Taşkın Öztaş<sup>2</sup>, Lütfü Tahtacıoğlu<sup>3</sup>

<sup>1</sup> Atatürk University, Agricultural Faculty, Department of Field Crops, Erzurum, Türkiye

<sup>2</sup> Atatürk University, Agricultural Faculty, Department of Soil Science, Erzurum, Türkiye

<sup>3</sup> Eastern Anatolia Agricultural Research Institute, Erzurum, Türkiye

## ABSTRACT

In order to supply food requirement of increasing world population, the increasing pressure on natural resources has led degradation of these resources. Owing to this process, productivity and biodiversity has been decreased. These negative progresses consequently has caused the expansion of the global problem of desertification. From Türkiye point of view the situation is not so different; to meet the food demand of increasing population, large amount of land, rangelands in special had been unconsciously converted into cultivated land in the past. Hence, the pressure on rangelands has been increased and degeneration of plant cover has been started. Over grazing which led to deterioration of plant cover on rangelands, was initiated in fifties and has been continued up until today. Nowadays, no single rangeland left, which do not need rehabilitation in the country. If the current pressure on rangelands is maintained, desertification of large amount of land especially rangelands, will be inevitable in near future. Therefore, control measurements should be taken soon. For this reason, preparation of adequate land tenure and range management plans which consider rangeland and livestock interactions should be accomplished.

## INTRODUCTION

In line with growing global population, increased food demand has forced the enhancement of agricultural production. As a result, environmental pressure has increased, this subsequently accelerated deterioration of natural resources. For instance, today, Mesopotamia-Basra-Nile which was known as productive crescent, has largely been desertified. At present, some 50.000-70.000 km<sup>2</sup> land is off production due to desertification (Kömuşçü and Erkan, 1998). Arid and semi-arid regions more severely suffer from desertification. In general, desert can be defined as; land with low rainfall (less than 200 mm), prevailing irregular climatic conditions, unproductive and narrow biodiversity. However, desertification was defined as "the land degradation in arid and semi-arid areas, caused by climatic changes and human impact" in United Nations Environment and Development Conference which was held in Rio de Janeiro in 1992 (Görcelioğlu, 1992). In this definition it was emphasised that, desertification was not the only the problem of arid zones but also semi-arid zones.

Although, depending on years, characteristic desert climatic conditions may be seen in Central and South Eastern Anatolia in some years (Görcelioğlu, 1992), when the long term climatic date taken into account, there is no land in our country where desert climate prevails. However, if the definition made in United Nations Environment and Development Conference taken into consideration, we should accept that a major part of our country under the risk of desertification. Because, with the exception of Black Sea Region, semi-arid climatic conditions prevail in Türkiye. The effect of increasing pressure on natural resources has an important impact on the exhibition of desertification in any place. The continuity of pressure on natural resources finally turns out as desertification. Therefore, desertification comes out as a result of certain processes. The main problem in our country is the formation of desertification after degradation of natural resources through erosion. In this respect, the rangelands are subject to the highest erosion risk in the country. Because, rangelands generally are located on steep semi-arid zones and they are sensitive to erosion. In order to emphasise desertification problems in Türkiye, we should delineate the changes in the use of natural resources, rangeland management in special in our history.



### The Changes in Land Use Systems in The Near History of Türkiye

The changes in land use from the establishment of Republic of Türkiye up to now, are presented in Table 1. The table shows that there was no significant change in land use system until 1950. Whereas, after these years, with rapid expansion of cultivated land, shrinkage of rangelands had been observed. Until seventies there had been no change in forest land, but with the legitimisation of a new forest act, the forest land was nearly doubled in 1970.

Table 1. The Changes in Land Use in Past 70 Years<sup>a</sup>.

Years	Rangeland Area (million ha)	Number of Tractor (x1000)	Arable Land (million ha)	Forage Crop Acreage (1000 ha)	Forest Area (million ha)
1930	44.5	?	15.7	?	10.5
1940	44.3	1.1	15.7	?	10.5
1950	37.8	16.6	16.0	166.8	10.4
1960	28.6	42.1	25.3	250.9	10.6
1970	26.1	105.9	27.3	253.8	18.3
1980	21.7	436.4	28.2	347.0	20.2
1990	21.7	692.5	27.9	560.1	20.2
1997	21.7	867.7	27.0	581.3	20.2

<sup>a</sup> Source; Turkish Statistic Institute.

### The Changes in Agricultural Lands

In order to determine livestock rangeland interactions in Türkiye, the changes in agricultural land use system are to be worked out. The cultivated agricultural land had been 15.7 million ha in early days of Turkish Republic and there was no considerable change until 1950. Cultivated land had rapidly expanded between 1950-1960 then it has kept a declining trend. To figure out the reasons of this rapid expansion, it is necessary to examine population growth and wheat production which is an outstanding principal crop for nourishment of our people (Table 2).

Table 2. The Interaction Between Population Growth and Wheat Production in Türkiye<sup>a</sup>.

Years	Wheat			Population (million)
	Acreage (million ha)	Production (million tone)	Per Capita Production	
1930	2.8	2.6	180.6	14.4
1940	4.4	4.1	231.6	17.7
1950	4.5	3.9	187.5	20.8
1960	7.7	8.5	309.1	27.5
1970	8.6	10.0	283.3	35.3
1980	9.0	16.5	371.6	44.4
1990	9.4	20.0	356.1	56.1
1997	9.3	18.5	283.3	65.3

<sup>a</sup> Source ;Turkish Statistic Institute.

It is well known that wheat has a special role in the nourishment of Turkish people. Thus, in order to meet the food demand of growing population some solutions were sought to improve production. Until 1950, the wheat production had been increased through the increase of wheat acreage in existing cultivated land, but between 1950 –1960 governments adopted the policy of increasing wheat production through expansion of cultivated land. In addition to population growth, the increasing tractor number (Table 1) which enabled farmers to cultivate large amount of land, was also effective. In this proc-

ess a great amount of rangeland had been converted into cultivated land. At the end of this period there was no land left to open up for cultivation so that the idea of improving production through the increase of yield was anticipated. Evidently, there has been no increase in cultivated land after 1970, even a trend of slight decrease has been observed. In comparison to thirties, against the doubled cultivated land and tripled wheat acreage, per capita wheat production was only doubled.

### The Changes in Rangeland Areas

The rangeland area was 44.5 million ha in 1930 and fell down to 37 million ha in fifties then it kept a trend of rapid decline until 1960 (Table 1). The increase in cultivated land was the single reason of the shrinkage of rangelands in that period. The decrease in rangelands in seventies was attributed to the classification of shrub land and within forest rangelands as forest land. Quite the contrary, with decreasing rangelands, livestock number was increased in this process. In line with increasing livestock number the acreage of fodder crops has not been able to expanded so that rangeland depended livestock production system became dominant. Hence, over grazing pressure on rangeland was increased deterioration of rangeland was initiated. Some indicators, between livestock and rangeland interaction are presented in Table 3.

Table 3. Some Estimations on Production and Utilisation of Rangelands.

Years	Rangeland Area (mil. Ha)	Livestock Number (mil. LU) <sup>a</sup>	Rangeland Area per LU (ha)	Available Forage (kg/ha) <sup>b</sup>	Forage Production (mil. tone)	Feed Requirement (mil. tone)	Grazing Period (days)
1930	44.5	10.0	4.55	700	31.2	36.5	312
1940	44.3	10.2	4.36	700	31.0	36.7	304
1950	37.8	10.5	3.60	700	26.4	37.8	251
1960	28.6	13.2	2.17	600	17.2	47.5	130
1970	26.1	13.2	1.98	550	14.4	47.5	109
1980	21.7	17.5	1.24	400	10.9	63.0	62
1990	21.7	14.5	1.50	400	10.9	52.2	75
1997	21.7	13.0	1.67	400	10.9	46.6	84

<sup>a</sup> Livestock Unit (LU) = 500 kg live weight of lactating cow.

<sup>b</sup> Half of the total production on rangeland (Holccek et al., 1995).

In 1930, Türkiye had 10 million LU and it did not significantly changed until 1960. Animal population rapidly increased between 1960-1980 then it kept a decreasing trend after 1980. Naturally with decreasing rangeland areas the stocking rate gradually increased. At the beginning, the stocking rate was around 0.22 (LU per ha) and it has been increased to 0.62 at present. In other words, the rangeland area per LU has dropped from 4.55 ha (in thirties), to 1.67 ha in year 1997. However, at the present the optimum stocking rate calculated as 0.2. It is estimated that, available forage production at the beginning of overgrazing was 700 kg/ha and it dropped to 400 kg/ha at present. Research results and rangeland surveys (Koç et al. 1994; Büyükbırç, 1997) also confirm this estimation. Based on this evaluation, hay production on rangelands has dropped from 31.2 (1930) million tones to 10.9 million tones in 1997. When the winter and summer feed requirements are considered the calculations indicates around fifty percent feed gap between requirement and supply. A significant negative correlation is observed between the changing overgrazing pressure on rangelands and rangeland productivity. The values in Table 3, was calculated considering optimum range management principles. These values show us that our rangeland was not subject to overgrazing until 1950 and after that intensity of overgrazing gradually increased. Grazing period changes between 150-210 days in our country (Bakır, 1987). With a pessimistic approach, if we take 200 days, we may claim that our rangelands are grazed 2-3 times more intensely than their carrying capacity.



### **Rangeland Management Systems Applied So Far**

Traditionally farmers tend to graze rangeland as long as climatic conditions are favourable for grazing. Thus, grazing is continued all year round in warm areas. On cold highlands grazing starts with the melt of snow in spring and continues until the snow fall in autumn. When rangelands are grazed, the basic principles of range management such as, carrying capacity, grazing season and grazing rotation never taken into account. Therefore, all types of misuse of rangelands can be observed in our range management system. If the existing conditions are maintained, rangelands inevitably will be out of production in near future. If the regulations foreseen in rangeland act which was legitimised in 1998 are put into practice, we may overcome these management problems. However, the lack of reliable statistical data and information on regional rangeland, make the preparation of future rangeland management plans difficult.

### **Livestock Number and Feed Requirement During Grazing Period**

We may evaluate the existing status with the assumption of putting rangeland act into practice; with respect to 1997 statistics, out of 13 million LU in the country, 1.2 million LU composed of exotic breeds and 2.6 million crossbreeds. With a rough estimation, 2 million LU are expected to feed inside and 11 million LU are expected to graze on rangeland for 200 days. Daily forage consumption per animal is calculated as 10 kg (Holechek et al., 1995), so that 22 million tones of forage is needed for grazing period. Since the forage production in rangeland is around 11 million tones (Table 3), we may conclude that this production is just enough for half of the existing animal population. If the shrub land and within forest rangelands are taken into account forage gap may be reduced. Forage production from these areas is estimated as 5 million tones (1 million ton from within forest rangelands, 4 million tones from shrub lands) and accordingly final forage gap is estimated as 6 million tones for grazing season.

### **Present Status of Rangelands**

Because of the reasons explained in ongoing paragraphs, rangelands have severely degraded. According to Gençkan et al. (1990) our rangelands has lost 90 % of their climax vegetation. This definition reveals the dimensions of rangeland degeneration in our country. Quite a big amount of studies on rangelands have been reviewed by Koç (1995) who emphasised that with respect to degradation gradient rangelands in our country were in poor and moderate categories and the degradation was too severe in lower altitudes and range conditions improve with increasing elevation. In arid and semi-arid environment, for the recovery of original vegetation in degraded rangelands in seconder succession, more than a human life time is needed (Herbel and Pieper, 1991). When the canopy cover drops below 30 %, with regard to erosion the threshold level exceeds (Marshall, 1973). The surveys proved that canopy cover in our rangelands varied between 10-35 %, but in general it was below 20 % (Koç, 1995). This situation help us to understand, how serious the risk of erosion in our rangelands. In other words, with the exception of some alpine and forest rangelands, there is no rangeland left which does not requires rehabilitation.

### **Present Status With Regard to Desertification**

One of the environmental problem in our country is the arise of desertification through the erosion and lose of soil productivity. There are different estimations about the dimension of erosion in our country. However, according to quantitative date, (Dursun, 1998) 400 million tones of fine textured soil is lost through erosion every year. Apparently, 0,5 mm of topsoil is eroded every year. The water is the main erosive factor in the country. Because, out of 66.9 million ha erosion threatened areas, only 0.33 million ha is under the risk of wind erosion. Around 90 % of non-cultivated land are subject to erosion. Thus, in desertification control measurement, these lands should be given priority. One of the main indicator of desertification on rangelands is the gradual decrease of perennial species in plant composition (de Soya et al., 1998). The increasing intensity of annual species in plant composition on lowland rangelands, is the solid evidence of desertification in our country.



If we insist not to consider rehabilitation measurements in the utilisation of our natural resources, the further deterioration of existing feature will be inevitable in near future. If the current misuse of rangelands is maintained, the degradation of plant cover will continue and after certain stage quite a large amount of land will be denuded. Under this circumstances surface reflectivity will change, leading severe differentiation of cloud formation and daily temperature changes (Thurrow and Taylor, 1999) and consequently absolute desert climate will arise. At that time, the main erosive power in our country will be the wind. Under these conditions, for the recovery of original vegetation, much more labour, technology and time will be needed. That's why, we should slow down the degradation pace to an acceptable limit. To help slow down this trend and to stop deterioration of rangeland, there is an urgent need to develop appropriate measures to restore feed resources, along with to lessen erosion risk and loss of biodiversity on rangelands

Principally, erosion is common in 250-1000 mm precipitation belt (Thurrow, 1991). In general, the rangelands intensively located in this precipitation belt in the world (Holechek et al., 1995). Therefore, like global consideration, in the control of erosion related desertification, rangelands have a special place. Since, 80 % of land under erosion risk in the world consists of rangelands (Thurrow, 1991). Low income is the main reason behind the lack of effective erosion control measurements on rangelands. In addition to loss of feed resources, because of high run off water and floods, this type of land threaten the arable land, residential areas, irrigation and road schemes and dams. If the current rates of degradation continue, most rangelands will be destroyed as an economic resource, and will not be capable of economic rehabilitation.

### **With Regard Desertification, Recommended Control Measures on Rangelands**

Precautions for the improvement of productivity, alleviation of erosion and establishment of a sustainable management system on rangelands.

- a. In order to determine current situation of rangelands, assignment and determination of rangeland which were foreseen in 1998 rangeland act should be accomplished as soon as possible. For this objective; the criteria for the classification of rangelands at national level should be defined. In these criteria, with respect to grazing and erosion, rangeland health, threshold level should be determined and improvement measures should be launched accordingly.
- b. For assignment, restriction and determination studies, fast and effective new technologies such as Geographic Information Systems, Remote Sensing and aerial photograph should be employed.
- c. After classification, preparation of action plan to ensure the use of rangelands according to management principles and investigation of appropriate improvement methods for degraded rangelands should be initiated in a rational sequence.
- d. For the control of desertification in the country, cultivation should be stopped on marginal land which comprises 6 million ha (Cangir and Boyraz, 1996) and is not suitable for crop production. After the rehabilitation process this land should be regained to rangeland.
- e. In action plans, for the alleviation of feed gap alternative solutions should be created.
- f. The infrastructure for the provision of plant material, which is needed in rangeland rehabilitation work, should be established.
- g. Fodder shrub should be given first priority in the rehabilitation of denuded step rangeland. Because of their intensive root structure, fodder shrubs are very efficient in the rehabilitation of denuded rangelands (Le Houreou, 1998).
- h. Pastoralists should be trained about the range management, they should be consulted about implementation and their active participation to range management should be supported.

It is possible to double the production through the rehabilitation of our rangelands. In that case, our rangelands may be sufficient for the current animal population. In addition, regain of marginal unproductive land; will help compensation of feed gap. One of the fundamental improvements is the development of preparation of land utilisation plans. In the preparation of these plans, livestock rangeland balance with special consideration to soil conservation should be established.

## REFERENCES

- Bakır Ö., (1987). Çayır-mer'a amenajmanı. AÜZF. Yay. No: 992, Ders Kit. No: 292, Ankara, 362 s.
- Büyükburç U. (1997). Türkiye'de mer'a çayır ve yem bitkileri ile diğer kaba yem kaynaklarının değerlendirilmesi ve geliştirilmesine yönelik öneriler. GOP Univ., Zir. Fak., Tokat, 80 s.
- Cangir C., Boyraz D. (1996). Ülkemizde yanlış ve amaç dışı arazi kullanımının boyutları ve arazi kullanımı planlamasının gerekliliği. Tarım-Çevre İlişkileri Sempozyumu, 13-15 Mayıs, 1996, Mersin, 637-648.de
- Soyza A.G., Whitford W.G., Herrick J.E., Van Zee J.W., Havstard K.M. (1998). Early warning indicators of desertification: examples of tests in Chihuahuan Desert. J. Arid Environ.,39: 101-112.
- Dursun H. (1998). Çölleşme ile mücadele çerçevesinde Türkiye toprak kaynakları varlığı ve toprak koruma. Birleşmiş Milletler Çölleşme ile Mücadele Sözleşmesi Ulusal Bilgilendirme Seminerleri, Menemen, İzmir, s. 34-51.
- Gençkan M.S., Avcıoğlu R., Soya H., Doğan O., (1990) Türkiye mer'alarının kullanımı, korunması ve geliştirilmesine ilişkin sorunlar ve çözüm yolları. Türkiye Ziraat Mühendisliği 3. Teknik Kongresi, 8-12 Ocak 1990, Ankara s. 53-61.
- Görcelioğlu E. (1992). Çöl kavramı, çölleşme olgusu ve Türkiye. İ.Ü. Orm. Fak. Derg., 42 (3-4): 1-19.
- Herbel C.H., Pieper R.D. (1991) Grazing management. In semiarid lands and deserts: Soil resources and reclamation (Ed.: J. Skujin). Marcel Dekker Inc., p. 361-385.
- Holechek J.L., Pieper R.D, Herbel C.H. (1995). Range management principles and practices. Prentice Hall, Inc, 526 p.
- Koç A. (1995). Topografya ile toprak nem ve sıcaklığının mer'a bitki örtülerinin bazı özelliklerine etkileri (Doktora Tezi). Atatürk Univ. Fen Bil. Enst., Tarla Bit. Anabilim Dalı, Erzurum.
- Koç, A., Gökkuş A., Serin Y. (1994). Türkiye'de çayır-mer'aların durumu ve erozyon yönünden önemi. Ekoloji-Çevre Der., 13: 36-41.
- Kömüscü A.U., Erkan A. (1998). Kuraklık ve çölleşme sürecinin Türkiye açısından analizi ve çözümler. Birleşmiş Milletler Çölleşme ile Mücadele Sözleşmesi Ulusal Bilgilendirme Seminerleri, Menemen, İzmir, s. 59-68.
- Le Houerou H.N. (1998). Utilisation of multipurpose fodder trees and shrubs in the arid and semi-arid Mediterranean Zones of West Asia and Northern Africa: an overview. Fodder Shrubs: Their Role In Mediterranean Arid and Semiarid Land Development and Environmental Conservation Course, 28<sup>th</sup> Sept. to 9<sup>th</sup> Oct., 1998, Rabat, Morocco, 51 p.
- Marshall J.K. (1973). Drought, land use and soil erosion. In the environmental, economic and social significance of droght. (Ed: J.V. Lovett), Angus and Robertson Publ., Inc. p. 55-77.
- Thurrow T.L., Taylor C.A. (1999). Viewpoint: the role of drought in range management. J. Range Manage., 52: 413-419.
- Thurrow, T.L. (1991). Hydrology and erosion. In grazing management an ecological perspective (Ed: R.K. Heitschmidt and J.W. Stuth), Timber Press, Inc., p. 141-159.



# HYDRAULIC PROPERTIES AND EROSION OF SOILS IRRIGATED WITH EFFLUENT WATER: EFFECT OF SOIL TEXTURE AND WETTING RATE

Mamedov Amirakh, Mikhailov Fariz

Institute of Soil, Water and Environmental Sciences, ARO, The Volcani Center, Bet Dagan, 50250, Israel. Tel: (972-3) 9683917; Fax: (972-3) 9604017; E-mail: amrakh@ias.agri.gov.il.

## ABSTRACT

In arid and semiarid zones the use of treated effluent water (EW) survey as a source of irrigation water. However long-term use of EW in cultivated lands may involve problems of soil salinization, deterioration of soils permeability by sodicity and organic colloids. Three experiment were conducted in order to evaluate the effect of long term irrigation with EW on the hydraulic properties (hydraulic conductivity - HC, infiltration rate -IR) and erosion of soils: (i) effect of water quality and rain energy; (ii) effect of soil texture (clay content 10-65%) and sodicity level; (iii) effect of gypsum (5 t/ha) and wetting rate.

Results showed that competency of irrigation with EW in changing hydraulic properties and seal formation strongly depends on soil texture, irrigation water quality and wetting rate. Irrigation with treated EW decreased HC and IR and increased soil susceptibility to dispersion and sealing processes. Soil irrigated with EW found to be more sensitive to rain energy, wetting rate and gypsum application than soils irrigated with fresh water (FW). The clay content and wetting rate predominated in determining aggregate stability and subsequent susceptibility of soil to sealing. In clay soil slow prewetting rate prevent aggregate slaking and sodicity related degradation for moderate level of ESP. On soils with clay content  $\leq 20-40\%$ , the effect of gypsum on seal formation was significantly and in contrast wetting rate was irrelevant. The mechanisms describing the effect of soil texture, wetting rate, ESP and gypsum on IR and erosion are discussed.

## INTRODUCTION

Understanding the soil degradation and structure stabilizing processes affected by irrigation water quality is essential for better management of soils and water resources. In Israel the use of EW for irrigation with the total salt concentration  $15-20 \text{ mmol}_e \text{ L}^{-1}$ , may increase in the sodium adsorption ratio (SAR) from 2 in FW to 5-10 in the EW (Feigin et al., 1991). It may leads to a similar increase in the exchangeable sodium percentage (ESP) of the soil, which can significantly increase a soil's susceptibility to reduced permeability, seal formation and erosion. This is particularly substantive during the rainy season when the soil is exposed to water containing low levels of electrolytes (Shainberg and Letey, 1984). Presence of dissolved organic matter and suspended solids in EW enhanced soil - clay dispersivity, increased clay flocculation value and was considered responsible for a decrease in the HC of soil (Tarchitzky et al., 1999).

Seal formation in irrigated soils is due to (Agassi et al., 1981; McIntyre, 1958): (i) physical disintegration of soil aggregates and compaction; and (ii) a physicochemical dispersion and formation a layer of very low permeability. The first mechanism is determined basically by the kinetic energy (KE) of the drops and the stability of the soil aggregates, while the second is controlled by the concentration and composition of the cations in the soil and applied irrigation water. (Shainberg and Singer, 1988; Levy et al., 1994). For many soils, aggregate breakdown may result even without mechanical impact, easily by slaking and depend, in addition to sodicity and electrolyte concentration and prewetting rate (Kemper and Rosenau, 1984; Truman et al., 1990; Levy et al., 1997). Prewetting at low rate maintain high HC and IR and prevent the deterioration of the primary structure, where fast prewetting disintegrates the aggregates and impairs the hydraulic properties of soils. Improving aggregate stability and preventing clay dispersion can be obtained by applying gypsum. Surface spread gypsum, by releasing electrolytes at the surface to percolating and runoff waters, decreases soil erosion (Agassi et al., 1981). For the soils varying in its texture and irrigated with EW and FW the associated effect of rain energy, ESP, gypsum and rate of wetting on seal formation and soil loss has been studied in lesser detail and were objectives of this study.



## MATERIAL and METHODS

Samples of five smectitic soils (0-25 cm) irrigated FW and treated EW was used (Table1).

Table 1. Some physical and chemical properties of the soils (CEC – cation exchange capacity; OM – organic matter).

Soil	Classification	Clay	CaCO <sub>3</sub>	CEC	OM	ESP %	
		%	%	cmolc kg <sup>-1</sup>	%	FW	EW
Hamra	Typic Rhoderxeralf	9	1	9	0.9	1.2	4.6
Loess	Calcic Haploxeralf	22	18	17	2.1	2.1	5.5
Grumusol H	Typic Chromoxeret	39	9	34	2.4	1.6	5.5
Grumusol Y		53	17	57	4.3	1.6	5.7
Grumusol E		64	6	71	5.6	1.1	4.7

HC was studied on soil columns, that were prepared by packing 120 g of air-dried (< 2 mm) soil into small cylinders (Ø 54 mm with sand at the bottom). The fast wetting (50 mm h<sup>-1</sup>) was done by saturating the soil (0.5 M chloride solution with SAR 0, 6, 10, 15) via a Mariotte bottle placed at the bottom of the column. During leaching with same solution, the leachates were collected in tubes with a fraction collector, its volume were measured. IR, runoff and interrill soil loss were studied using a drip-type rainfall simulator at two rain KE (8 and 16 kJ m<sup>-3</sup>) with intensity 36 mm h<sup>-1</sup>. Air-dried aggregates (<4 mm) were packed in 200× 400 mm trays, 20 mm deep. The trays were wetted with tap water from bottom by peristaltic pump at the rate of 8 (slow) and 64 (fast) mm h<sup>-1</sup> and then were exposed to 60 mm of distilled water rainstorm at a slope of 15%. Infiltrated water, runoff and sediments were collected regularly. On fast prewetted soil phosphogypsum (PG) spread over the soil surface prior to rainstorm with high KE. For quantitative comparison between treatments, four parameters were used: (i) relative hydraulic conductivity (RHC) of soils; (ii) the final IR at the end of the storm; (iii) the total runoff (TR); (iv) the soil loss.

## RESULTS and DISCUSSION

### 1.1 Effect of water quality on HC

The RHC of the soils as a function of effluent volume decreased with leaching (Figure 1). The difference in the RHC between the soil types can be explained by the difference in their texture. The higher the clay contents, ESP of the sample and SAR of solution, the lower were the RHC. For a given soil it was lower in EW irrigated samples. The disruptive forces associated with the fast wetting process that caused slaking of the soil, leading to the disintegration of the aggregates into microaggregates and primary particles. Differential swelling due to entrapped air was also accounted and was higher for a soil with high clay content. In EW irrigated samples (as excepted), the processes for HC deterioration as related to the ESP and/or SAR, physico-chemical mechanism and physical disintegration were more considerable.

### 1.2. Effect of rain energy and gypsum

For a given soil and type of irrigation water (FW and EW) an increase in raindrop KE resulted in (i) the lower final IR; (i) the higher runoff and soil loss. In fast prewetted samples when the low rain KE (8 kJ m<sup>-3</sup>) was used, final IR values for FW irrigated samples were practically higher (>2 mm h<sup>-1</sup>) than those for EW irrigated ones. However under high rain KE (16 kJ m<sup>-3</sup>) the surface aggregates of soils showed analogous weak resistance to the raindrops impact and as a result, the difference in IR values of soil seal were (< 1 mm h<sup>-1</sup>) insignificant (Figure 2). Total runoff and soil loss values increased with an increase in rain KE, but unlike the runoff and final IR, soil loss values of the FW irrigated samples were significantly lower (150-400 g m<sup>-2</sup>) than those of the EW samples in high rain KE too (Figure 3). Mostly notable differences (> 2.5 mm) were noted among the total runoff values (which represent the changes in the IR curve through the entire rainstorm) of soil types. In the FW irrigated samples, the soil

loss of the unstable loess, were higher than those of the grumusols, however in EW irrigated samples there were noticed opposite results due to combined effect of ESP and clay content on seal formation

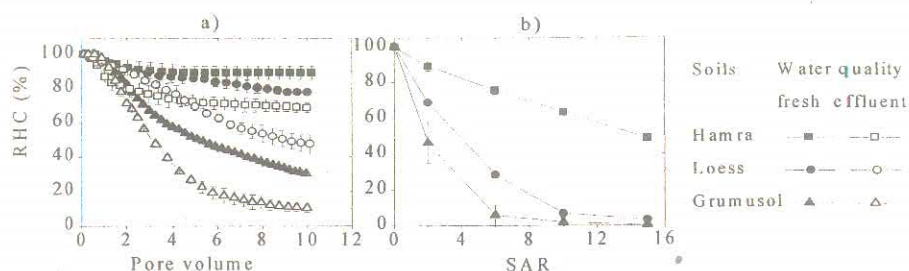


Figure 1. Effect of a) water type and b) SAR on RHC (10 pore volume) of soils

Smectitic soils are more erodible because they are more dispersive and formed a less permeable seal that generated higher levels of runoff and soil loss. Seal formation were more susceptible to the quality of irrigation water at low rain KE (as an effect of physico-chemical mechanism of seal formation) and were less sensitive at high rain KE, where the progressive breakdown of aggregates due to drop impact is very pronounced (Agassi et. al., 1981). Cultivation renders soils with a weaker structural stability and breakdown of aggregates by the impact of high rain KE played a dominant role in seal formation. Furthermore high prewetting rate of the surface aggregates was evidently rapid, and led to soils' aggregates slaking due to compressed entrapped air and/or swelling. In the presence of gypsum clay dispersion is prevented and seals formed results predominantly from drop impact. Thus, seal formation, soil loss in sandy loam (hamra) and sandy clay loam (loess) was more susceptible to the both raindrop KE and gypsum treatment.

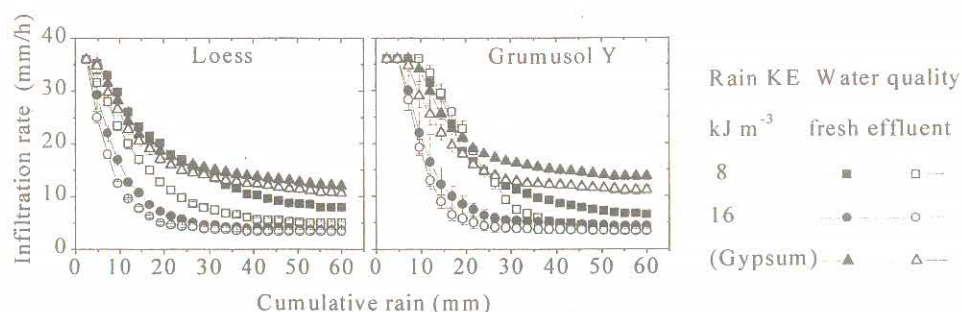


Figure 2. Effect of rain energy, water quality and PG on IR of soils

The differences in the IR curves between FW and EW irrigated samples were also the result of chemical dispersion caused by soil sodicity. When  $5 \text{ t ha}^{-1}$  of PG applied to the soil the rate of drop in the IR became more gradual compared with the non-treated soils and the high final IR values ( $> 10 \text{ mm}^{-1}$ ) maintained (Figure 2). PG was effective in controlling runoff and soil loss and reduced its values  $> 30\%$  of that obtained in untreated soil. PG prevents clay dispersion and results in bigger aggregates at the soil surface and this in turn, is less susceptible to erosion by runoff flow (Kazman et al., 1983). Effect of gypsum in absolute term was more pronounced in the more erodible soils, such as EW irrigated soils, especially in hamra and loess.



This fact is attributed to the susceptibility of the unstable soils to chemical clay dispersion, which in the PG amended soils was diminished. However final IR, runoff and soil loss of gypsum amended FW irrigated samples were considerably higher than EW irrigated samples. Efficiency of PG in soils irrigated with FW, indicate that some chemical dispersion took place even  $ESP < 2\%$ . Under less erosive conditions, in FW

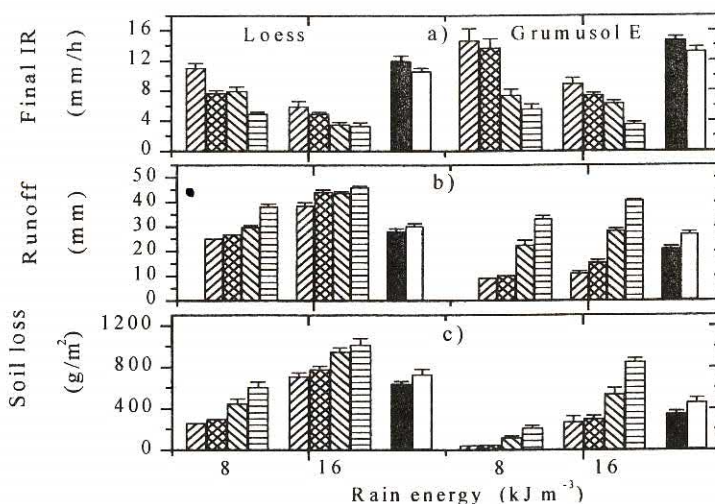


Figure 3. Effect of rain KE, water type, PWR, fresh effluent, prewetting rate (PWR) and gypsum (5 t/ha) on a) final IR, b) runoff and c) soil loss

irrigated stable soils, PG efficacy in controlling runoff and erosion are less exciting, though still important.

### 1.3. Effect of Prewetting Rate and Soil Texture

Prewetting rate prior to rainfall do influence on hydraulic properties of the soils and physical processes that control these indexes (Figure 3). For both rain KE and water quality (FW and EW), the final IR of soils are increased and runoff and soil loss values are decreased with (i) increasing in clay content; and (ii) decreasing in prewetting rate. The effect of prewetting rate was inconsequential (but still notable) in soils with clay content  $\leq 20\%$  and was very pronounced in soils with higher clay content ( $> 50\%$ ). Decreasing in the prewetting rate increased the final IR (absolute difference 0.2-2.4 mm h<sup>-1</sup> in unstable soils and 1.5-8.0 mm h<sup>-1</sup> in stable soils), decreased runoff (2-12 and 12-20 mm) and soil loss (40-300 and 70-850 g m<sup>-2</sup>). When slow prewetting rate was used, the differences in the values of final IR, runoff and soil loss between FW and WW irrigated samples was still significant in soils with lower clay content ( $< 40\%$ ). However this difference was not substantial in clay soils, suggesting that the slow prewetting rate diminish the adverse dispersive effect of soil ESP on aggregate resistance to breaking down. The higher susceptibility of the hamra, loess and grumusols (H) to irrigation with EW was attributed to their lower clay content. The higher the clay contents, the more stable the aggregates, and thus the higher the resistance of the soil to seal formation (Ben-Hur et al., 1985).

In fast prewetted samples absolute difference in soil loss between FW and WW irrigated samples were in the range (90-260 g m<sup>-2</sup>) and (70-380 g m<sup>-2</sup>) in low and high rain KE respectively,



whereas in slow prewetted soils it was found in the range (5-200 g m<sup>-2</sup>). In the presence of gypsum clay dispersion was prevented and seals formed results predominantly from drop impact. Consequently the process of seal formation was more sufficient on less stable soils. As a result decrease in runoff and erosion were more pronounced in gypsum treated soils. The role of gypsum on detachment of clay soil by raindrop impact is relatively small compared with wetting rate. Slow prewetting rate significantly reduce the effect of water quality on stable aggregated grumusol (Y) and (E) samples and thus hydraulic properties and erosion in these soils were more sensitive to wetting rate than to ESP level and PG treatment (Figure 4 and 5). Increased aggregate stability of slow prewetted soil is certainly due to the reductions of the volume of air that is entrapped during wetting. In both irrigated samples like to runoff, soil loss increase in clay content to a maximum at 20 % clay content and a further increase in clay content results a decrease in soil loss. (Ben-Hur et al., 1985; Levy et al., 1994).

The consequences of seal formation on soil loss are not simple. The decrease in IR due to sealing increases runoff, which may lead to increased erosion. Nevertheless, the detachability of seal is often lower than the detachability of the soil, so that seal formation decreased soil loss. The aggregate size distribution plays a major role in sealing because it partly controls the breakdown of the aggregates as well as the redistribution of the detached primary particles and aggregate fragments. A fragments resulting from slaking increase in size with increasing clay content. Decreasing prewetting rate further, diminish seal development that manifested itself in higher final IR, lower runoff levels and soil loss. The slow prewetting rate, gypsum decreases the amount of transportable particles and as a result detachment of soil aggregates and transport capacity of runoff are decreased (Truman and Bradford, 1990; Le Bissonnais and Singer, 1992; Levy et al., 1997).

## CONCLUSION

In the arid and semi arid zones more attention is now given to the environmental effects of irrigation with EW on cultivated soil surface degradation which favours runoff and erosion and thus increases pollution hazards by water-soluble and organic load contaminants. More interactions should occur between soil structure deterioration, sealing and erosion studies in order to determine soils suitability for EW irrigation and thus for evaluation of the land resource. The observed differences in the values of final IR, runoff and soil loss resulted from differences in the stability of the aggregates of these soils to wetting rate and aggregates' resistance to disintegration by the impact of the raindrops. PG application can be an efficient method in unstable soils where sealing mainly depends on raindrop energy and water quality. In stable soils sealing is mainly related to slaking by entrapped air compression, and impeding this processes is possible by controlling the wetting rate and little amount of PG application, which can be achieved in irrigated systems.

## REFERENCES

- Agassi, M., I. Shainberg, and J. Morin. 1981. Effect of electrolyte concentration and soil sodicity on infiltration rate and crust formation. *Soil Sci. Soc. Am. J.* 45: 848-851.
- Ben-Hur, M., I. Shainberg, D. Bakker, and R. Keren. 1985. Effect of soil texture and CaCO<sub>3</sub> content on water infiltration in crusted soils as related to water salinity. *Irrig. Sci.* 6:281-194.
- Feigin, A. I. Ravina and J. Shalhevet. 1991. *Irrigation with treated sewage effluent. Management for environmental protection.* Springer-Verlag
- Kazman, Z., I. Shainberg, and M. Gal. 1983. Effect of low levels of exchangeable Na and applied phosphogypsum on the infiltration rate of various soils. *Soil Sci.* 35:184-192.
- Kemper, W.D. and R.C. Rosenay. 1984. Soil cohesion as affected by time and water content. *Soil Sci. Soc. Am. J.* 48: 1001-1006.
- Levy, G.J., J. Levin and I. Shainberg. 1994. Seal formation and interrill soil erosion. *Soil Sci. Soc. Am. J.* 58: 203-209.
- Levy, G.J., J. Levin and I. Shainberg. 1997. Prewetting Rate and aging effect on seal formation and interrill soil erosion. *Soil Sci.* 162: 131-139.
- Le Bissonnais, Y. and M.J. Singer. 1992. Crusting, runoff, and erosion response to soil water content and successive rainfalls. *Soil Sci. Soc. Am. J.* 56: 1898-1903

- McIntyre, D.S. 1958. Permeability measurement of soil crusts formed by raindrop impact. *Soil Sci.* 85: 185-189.
- Shainberg, I. and J. Letey. 1984. Response of soils to sodic and saline conditions. *Hilgardia*
- Shainberg, I., M.J. Singer. 1988. Drop impact energy -soil ESP interactions in seal formation. *Soil Sci. Soc. Am. J.* 52:1449-1452.
- Tarchitzky, J., Y. Golobati, R. Keren, and Y. Chen. 1999. Wastewater effects on montmorillonite suspensions and hydraulic properties of sandy soil. *Soil Sci. Soc. Am. J.* 63: 554-560.
- Truman, C.C., J.M. Bradford, and J.E. Ferriz. 1990. Antecedent water content and rainfall energy influence on soil aggregate breakdown. *Soil Sci. Soc. Am. J.* 54:1385-1392.

# PHYSICAL CHANGES OF THE HARRAN SOILS BY SURGE AND CONTINUOUS FURROW METHODS

S. Şahan<sup>1</sup>, E. Akça<sup>1</sup>, S. Kapur<sup>1</sup> and R. Kanber<sup>2</sup>

<sup>1</sup> University of Çukurova, Department of Soil Science, Adana, Turkey

<sup>2</sup> University of Çukurova, Department of

## ABSTRACT

Physical and micromorphological analyses were conducted on soil samples collected from surge flow and continuous furrow experimental plots of the widely distributed Harran Soil Series in Southeastern Anatolia for the determination of the suitable irrigation method.

The surge flow method is determined to be more appropriate than the continuous irrigation by reducing irrigation water losses and improving irrigation performances. The generally increasing patterns of pore area classes in the surge flow profiles and the generally decreasing and variable patterns of the pore areas in the continuous furrow profiles from Ap to Ad/A2 may also be attributed to an advantage in the water use of plants as well as less water losses of the former irrigation method which is also a merit in increasing the already decreased physical quality of soils by the excess use of water.

## INTRODUCTION

Soil structure may be defined either in terms of the shape, size and spatial arrangement of individual soil particles and clusters of particles (aggregates), or in terms of porosity and pore size distribution (Bullock et al. 1985). The quantification of soil porosity is essential to evaluate soil structure conditions and to correlate soil porosity with root growth and water movement, which is a quality indicator of soil physical conditions (Eswaran et al. 1998).

Rapid and accurate quantitative characterisation of porosity in thin sections of soils was carried out using image analysis with Quantimet 720 (Jongerius et al. 1972).

The aim of this study is to compare the effects of surge flow and continuous furrow irrigation methods on the physical quality of soils in an area highly prone to land degradation, by determining the probable changes in pores, i.e. microstructural and physical properties following each irrigation treatment in the widely distributed Harran Soil of SE Anatolia.

## MATERIALS AND METHODS

Surge flow was compared with conventional continuous flow applications in a furrow irrigation on cotton. The field experiment was conducted in 1991 and 1992 on the Harran soil series (*Calcic Xerosol*-FAO/UNESCO (1974); *Vertic Xerochrept*-USDA 1996) located at the Koruklu Research Station of the Harran plain, Şanlıurfa, in the GAP (Figure 1). The soil profile is uniformly clayey rich in smectite with blocky subsoil structure to a depth of 85 to 135 cm. The soil contains 15 to 20% calcium carbonate which increases with depth. The average available soil water capacity is 15% by volume for a profile available capacity of 174 mm for 1.2 m.

The probable changes in the porosities were determined at surge flow (S) and continuous furrow (C) experiments conducted on 160m long and 0.7m spaced furrows of 0.14% slope, following each field test, comprising furrow and infiltration tests. A total of 26 undisturbed soil samples were taken for preparing polished blocks for image analysis (FitzPatrick, 1994) from selected sites. Treatments of (a) surge irrigation with two inflow rates of  $0.05 \text{ m}^3 \cdot \text{min}^{-1}$  ( $q_1$ ) and  $0.12 \text{ m}^3 \cdot \text{min}^{-1}$  ( $q_2$ ) and two different cycle ratios of 0.5 ( $CR_1$ ) and 0.3 ( $CR_2$ ) were compared with (b) two conventional steady flow applications with the same inflow rates in surge,  $C_1$  ( $q_1$ ) and  $C_2$  ( $q_2$ ). In 1992, the cycle ratio of 0.3 was changed to 0.33. The on-time was 30 minutes for all surge treatments. Surge treatments were made by the combination of the inflow rates and cycle ratios. These will be referred to as  $S_{21}$  ( $q_2 CR_1$ ); and  $S_{22}$  ( $q_2 CR_2$ ), respectively. The irrigation treatments were distributed in a randomized fashion. Three adjacent furrows were employed in each treatment. The advance, tail runoff, soil water and yield data were collected from one of the three furrows identically managed



for surge and continuous flow field strips. The stations along the furrows were located at 20m intervals for monitoring the advance phase. The flow advance in the furrows was measured up to 130 m in C<sub>1</sub>, and 160 m in S<sub>21</sub>, S<sub>22</sub> and C<sub>2</sub> treatments.

The porosity measurements and water retention characteristic curves were determined as specified in Vomocil (1965) and Hillel (1980). Undisturbed and disturbed soil samples for physical analyses were also collected, once before irrigation and three times after irrigation treatments from the field experiments.

The pore classes varying between 0-1500  $\mu\text{m}^2$  areas -PA (Pore Area Classes)- were measured (quantified) at 4 different plots on polished surfaces of the soil blocks by image analysis-Quantimet 520. All 4 plots were approximately chosen from similar morphologies at the microscope i.e. by attempting to take almost the same amounts of planar voids-channels at each field of view. For correlation of physical data (esp. porosity %), the quantimet measurements were calculated as sq. microns versus counts. Therefore the area classes were determined by accepting the maximum length or area for the smallest area class of a planar void-pore as 100  $\mu\text{m}$  or 100x1 $\mu\text{m}^2$  respectively and irregular and so-called rounded pores with varying dimensions between 0-100  $\mu\text{m}^2$ . The classifications and/or sorting of the dominant pore classes were also fitted to the pore classification produced by Bullock et al. (1985). The upper boundary of the smallest pores in the classification used in this study relates to the upper boundary of the resolvable pores-voids with optical microscope, but not clearly visible to the naked eye and covers the micro and the fine mesopores of Bullock et al. (1985). The remaining area classes may be partly related to meso and macropores. The macropores, as stated earlier in the materials and methods, are >10 $\mu\text{m}$  according to limits given by Hillel (1980) and Vomocil (1965). This does not seem to fit into Bullock et al's. (1985) classification of pore classes. However, the smallest area class used in this study may relate to an average 10  $\mu\text{m}^2$ .

## RESULTS AND DISCUSSIONS

### a) Soil Water Retention Characteristics and Micromorphological Properties versus Cumulative Infiltration (Z)

Results reveal an increase in the water content of the Ad/A2 horizons at saturated conditions of 0, 1S<sub>22</sub>, 1C<sub>1</sub>, 2S<sub>21</sub>, 2S<sub>22</sub>, 2C<sub>1</sub>, 2C<sub>2</sub>, 3C<sub>1</sub>, 3S<sub>22</sub> and 3C<sub>2</sub> profiles (*the numbers in front of treatment symbols refer to the evaluated irrigation events and zero shows the conditions before starting irrigation*). This may well document a higher total porosity in the Ad/A2, whereas, the water contents at saturated conditions decreased with depth in profiles 1S<sub>21</sub>, 1C<sub>2</sub> and 3S<sub>21</sub> revealing a probable gradual decrease in total porosity. Field capacities decreased with depth in profiles 0 and 2C<sub>2</sub>, decreased in the Ad/A2 of 1S<sub>22</sub>, 2S<sub>21</sub> and increased in the Ad/A2 of 1C<sub>1</sub>, 1C<sub>2</sub>, 2C<sub>1</sub>, 3S<sub>22</sub> and 3C<sub>2</sub> whereas profiles 1S<sub>21</sub>, 2S<sub>22</sub>, 3S<sub>21</sub> and 3C<sub>1</sub> showed an increase with depth. Permanent wilting points increased with depth in the profiles 1S<sub>21</sub>, 2C<sub>1</sub> and 2C<sub>2</sub> and decreased with depth in 3S<sub>22</sub>. There was an increase in the Ad/A2's of 1S<sub>22</sub>, 2S<sub>21</sub>, 2S<sub>22</sub>. Available water was found high in the surface horizons of 1S<sub>21</sub>, 1S<sub>22</sub>, 2S<sub>21</sub> and 3S<sub>21</sub> irrigated with surge flow. Inversely values showed a decrease in continuous furrow profiles 1C<sub>1</sub>, 1C<sub>2</sub>, 2C<sub>1</sub> and 3C<sub>2</sub> at the surface which is regarded a disadvantage for the continuous furrow method.

Higher water contents are related to high clay contents and micropore volumes, whereas some of the low values of water contents indicate the layers of compaction, in spite of the higher number of pores obtained in Ad/A2 than the Ap horizons of the untreated -blank- experimental plot (Figure 2).

Image analysis data revealed presence of dominant 0-100  $\mu\text{m}^2$  PAs in all Ap and Ad/A2 horizons studied (Figure 3). The dominant decreasing trends in the PAs of the Ap horizons following the 2<sup>nd</sup> irrigation treatment of the S<sub>21</sub> and S<sub>22</sub> plots are most probably indications of clogging of the pores -an advantage for the water surge-. Conversely the increase of the PAs after the 2<sup>nd</sup> irrigation in the C<sub>1</sub> and C<sub>2</sub> plots of the Ap horizons and C<sub>1</sub> plot in Ad/A2 should be considered a disadvantage causing an increase in infiltration, thus loss of irrigation water. Similarly, the step wise increasing trends of PAs in the Ad/A2 horizons of the S<sub>22</sub> and C<sub>2</sub> plots

seem to be a disadvantage in the course of irrigation treatments for water loss. However, increase of water availability, due to increasing porosity, synchronous to deeply penetrating roots in the course of crop growth may be an advantage. The cumulative infiltration values ( $Z$ ) support the data mentioned above showing similar trends to the PA in  $S_{21}$ ,  $S_{22}$  (Ap horizons) and  $C_1$  (Ad/A2 horizons) plots (Figure 3).

## CONCLUSIONS

Conventional irrigation systems, such as surface irrigation, practised on the clayey soils of SE Anatolia have been accelerating soil physical degradation in the recent years. However, methods of drip irrigation with the optimal water use are not profitable in the GAP area due to the high investment requirements of the extensive arable lands.

Thus, this study aimed to resolve the sustainable use of water with lesser damage on the soil physical qualities by comparing the surge and continuous furrow methods that are both economically irreplaceable in the area.

Surge irrigation was found to accelerate water advance rates in this 2 year study as seen in the decreasing porosities after the 2<sup>nd</sup> and 3<sup>rd</sup> irrigations of the  $S_{21}$  and  $S_{22}$  treatments. Hence, surge irrigation appears to be a promising alternative for decreasing drainage volumes in the Harran Plain, where the soils have high infiltration capacities when using the existing surface irrigation systems and increasing loss of water. Consequently, surge irrigation seems to cause less damage on the soil physical quality than the continuous furrow irrigation method.

## REFERENCE

- Bullock, P., Fedoroff, N., Jongerius A., Stoops, G., Tursina, T., 1985. A Handbook for Soil Thin Section Description. Waine Research Publications. The Netherlands. p150.
- FAO/UNESCO., 1974. Soil Map of the World 1/5.000.000. Vol 1, Legend. UNESCO Paris Working Group on Land Use Planning. Rome. p 121
- FitzPatrick, E.A., 1994. Soil microscopy and micromorphology. John Wiley and Sons. New York. p 304.
- Eswaran, H., Kapur, S., Reich, P., Akça, E., Şenol, S., Dinç, U. 1998. Impact of Global Climate Change on Soil Resources Conditions: A Study of Turkey. In: M. Şefik Yeşilsoy International Symposium on Arid Region Soil, 21-24 September 1998, Menemen, Turkey. pp. 1-14.
- Hillel, D., 1980. Fundamentals of soil physics. Academic Press, New York. p 487
- Vomocil, J.A., 1965. Porosity. In: Methods of Soil Analysis, Part 1, (Eds. C. A. Black et al.), No.9, ASA Inc. Pub. Madison, Wisconsin. p 299-314.
- USDA, 1996. Keys to soil taxonomy. USDA, Natural Resources Conservation Service. Seventh Edition. Washington DC. p 644



# A RESEARCH ON RECLAMATION OF PHYSICAL PROPERTIES OF BOLU-YENİÇAĞA PEAT AS PLANT GROWING MEDIUM

Gökhan Çaycı<sup>1</sup>, Abdullah Baran<sup>1</sup>, Cihat Kütük<sup>1</sup>, Yener Ataman<sup>1</sup>, Hüseyin Öztekin<sup>2</sup>, Orhan Dengiz<sup>1</sup>

<sup>1</sup> Department of Soil Science, Faculty of Agriculture, University of Ankara

<sup>2</sup> Department of Soil Science, Faculty of Agriculture, University of Selçuk

## ABSTRACT

Aim of this study was to determine physical properties of Bolu-Yeniçağa peat and improve its physical properties as plant growing medium. For this idea, five organic soil profiles were excavated. Then, those profiles were described, and some physical and physicochemical properties of organic soil samples taken from each horizon were determined.

While some soil characteristics were ascertained in 0-2.00 mm fraction, moisture characteristic values of samples were determined in 0-4.00 mm and 0-6.35 mm fractions.

Air capacity, easily available water and water buffering capacity values indicating air-water balance of growing medium were obtained in two different fractions. When air capacities of the samples take into consideration, eleven of 56 samples were found at optimum air capacity. A great part of the samples was found insufficient with respect to air capacity. As we consider air capacity and easily available water together, eleven samples were found in optimum ranges in all the soil samples. However, it was observed that unsuitable samples with regard to air-water balance can be improved by using of different particle sizes in mixtures.

## INTRODUCTION

In last decades, soilless culture and growing media have drawn attention in Turkey as all over the world. Several materials are used for this idea in Turkey. Peat, perlite and pumice are used the most common materials as growing medium or a component of the medium in Turkey. The desired principal properties in growing medium can be pointed out as follow; firstly the growing medium should have a good air-water balance, and then should not comprise toxic elements or compounds to plant growth. In addition to those basic properties, cheapness, availability and regional customs are effectual factors to prefer the growing medium (Ataman, 1988).

Peatlands in Turkey include approximately 240 km<sup>2</sup> area (Çaycı et al. 1989). When we compare the peatlands in Turkey, Bolu-Yeniçağa peatland has better physical and chemical properties than the others. Besides, this area is close to big municipalities. These advantages make it the most favoured peatland in Turkey. Nevertheless, Yeniçağa peatland has some unfavourable properties resulting from its eutrophic formation, the changes in groundwater composition and seasonal fluctuation of groundwater level in peatland.

While the basic properties of commercial peat such as water and air capacity, CEC and amounts of nutrients are well-known and standartized in Europe, there is no any standard of commercial peat sold in Turkey as growing medium. Further, the native peat producers can not benefit from some physical and chemical amendments to improve the quality of peat because of a lack of knowledge.

The aim of this study was to determine the properties of Bolu-Yeniçağa peat, to evaluate its properties as growing medium and suggest some recommendations in order to improve its unfavourable physical properties.

## MATERIAL AND METHODS

### Material

Lake Yeniçağa, peatland was occurred around it, is located in a depressional area between Bolu Plain and Gerede Town. Lake Yeniçağa is not only tectonic but also affected from karstic occurrences. At first, organic soils around the lake were checked with random grid method and auger examinations based on land observations. Afterwards, five profiles representing the peatland were excavated.

Soil samples taken from each horizon were dried to workable moisture content in laboratory conditions, then, they were sieved and fractured as 0-4 mm and 0-6.35 mm for physical analysis.



Physicochemical analyses were carried out on 0-2.00 mm fraction. Moreover, undistributed soil samples were taken from each of horizon in order to determine bulk density of soils in situ.

In peat samples, fiber content was determined by (Soil Survey Staff, 1975) bulk density (U.S. Salinity Lab. Staff, 1954), moisture-tension values (De Boodt et al. 1973), mechanical analysis was done within the mineral part after combustion of organic fraction by hydrometer (Bouyoucos, 1951) and pipette methods (U.S. Salinity Lab. Staff, 1954), pH was measured in saturated medium and EC was determined in saturated medium extract (Kirven, 1986), organic matter was determined by (DIN, 1978).

## DISCUSSIONS

Organic soils in the study area were formed on a flat land. Their formation result from the accumulation of decomposed organic residues in an anoxic conditions and decrease in water level within the time related to mineral sedimentation and organic matter accumulation. Therefore, organic soils in the region have an eutrophic (nutrient rich) character and they are classified as basin organic soils. Some physical and physicochemical properties of the soil samples taken from each horizon are given Table 3.1.

The soil properties significantly change on account of profiles (Table 3.1). Organic matter ranges from 12.5 % to 91.5 %, fiber content ranges from 4.3 % to 91.5 %, bulk density changes from 0.09 to 0.78 g cm<sup>-3</sup>, pH and EC values ranges 5.38 to 7.92 and 0.50 to 3.80 dSm<sup>-1</sup>, respectively in Bolu-Yeniçağa samples. As we consider mineral matter content of organic soils after combustion, sand, silt and clay contents of soil samples range between 0.73 % - 3.92 %, 40.70 %, - 74.77 % and 24.15 % - 57.30 %, respectively. These substantial differences among the organic soil samples result from eutrophic occurrence, botanical origin, decomposition degree, topography, differences in groundwater composition and land use management.

As we take into account peat samples as growing medium, some physical properties such as air capacity, easily available water (EAW) and water buffering capacity (WBC) with related to air-water balance have a great importance. Those physical properties are affected from mainly particle size distribution of material (Çaycı et al., 1994). For this reason, those properties of peat samples as growing medium were determined in 0-4.00 mm and 0-6.35 mm fractions. Air capacity, easily available water and water buffering capacity values of the peat samples are given Table 3.2.

Table 3.1. Some physical and physicochemical properties of the peat samples

Profile No	Horizon	Depth (cm)	Organic matter (%)	Fiber content (%)	Bulk* Density (g cm <sup>-3</sup> )	pH	EC dS m <sup>-1</sup>	Texture		
								Sand (%)	Silt (%)	Clay (%)
1	O <sub>a</sub>	0-11	36.0	15	0.78	6.35	1.20	2.21	57.96	38.93
	Oi <sub>1</sub>	11-42	88.5	87	0.20	6.26	0.80	1.15	51.70	47.15
	O <sub>e</sub>	42-67	81.0	46	0.17	5.96	1.08	1.03	58.60	40.37
	Oi <sub>1</sub> <sup>†</sup>	67-94	71.5	75	0.21	5.38	2.24	0.91	57.10	41.99
	C	94-108	12.5	-	0.40	6.86	2.80	0.78	65.45	33.77
	Oi <sub>2</sub>	108-136	57.0	48	0.15	6.90	3.80	1.17	56.85	41.98
	C <sup>†</sup>	+136	34.5	14	0.43	7.18	1.70	1.17	61.83	37.00
2	O <sub>a</sub>	0-20	42.5	4.5	0.54	7.19	1.42	1.61	55.85	42.54
	Oi <sub>1</sub>	20-31	74.0	77.0	0.16	7.49	1.00	1.52	60.50	37.98
	O <sub>e</sub>	31-51	80.5	49.0	0.17	7.59	0.80	1.86	62.50	35.64
	Oi <sub>1</sub> <sup>†</sup>	51-64	75.0	58.0	0.12	7.64	0.62	1.02	66.53	32.45
	Oi <sub>2</sub>	64-91	57.0	75.0	0.12	7.10	0.80	1.37	53.44	44.86
	Oi <sub>3</sub>	91-130	56.5	70.0	0.13	6.82	0.50	0.98	55.14	43.88
3	O <sub>a1</sub>	0-13	41.0	1.5	0.61	7.49	1.80	0.98	50.88	48.14
	O <sub>a2</sub>	13-29	77.0	7.3	0.49	7.02	1.42	0.91	48.95	50.14
	Oi <sub>1</sub>	29-84	85.0	81.5	0.14	6.85	0.98	0.85	56.92	42.33
	Oi <sub>2</sub>	84-121	73.5	74.0	0.14	6.24	0.84	0.73	63.00	36.27
	C	121-130	18.5	-	0.18	6.46	2.40	0.54	62.21	37.25
4	O <sub>a</sub>	0-15	32.0	4.3	0.62	7.92	0.80	0.75	55.15	44.10
	O <sub>e</sub>	15-31	78.0	39.4	0.20	7.04	1.30	0.97	65.96	33.07
	Oi <sub>1</sub>	31-63	91.0	83.8	0.12	7.02	2.40	0.89	74.25	28.86
	Oi <sub>2</sub>	+63	76.5	87.5	0.09	6.88	0.60	1.08	74.77	24.15
5	O <sub>a</sub>	0-16	57.5	5.3	0.32	7.32	1.20	2.00	40.70	57.30
	O <sub>e</sub>	16-28	55.1	21.3	0.22	6.96	1.00	3.92	40.78	55.30
	O <sub>i</sub>	28-71	85.0	88.1	0.13	6.50	1.30	3.60	51.06	45.34
	C <sub>g</sub>	71-85	22.0	28.0	0.32	6.37	2.20	1.95	55.10	42.65
	Oi <sup>†</sup>	85-108	91.5	91.5	0.15	6.05	3.20	2.20	52.10	45.70
	C <sub>g</sub> <sup>†</sup>	108-160	29.0	31.0	0.31	6.97	2.20	1.75	58.90	39.35

† Undisturbed sample

Table 3.2. Air-water balance parameters of peat samples

Profile No	Horizon No	Particle size (mm)	Bulk density*** (g cm <sup>-3</sup> )	Pore space (%)	Air capacity (%)	FAW (%)	WBC (%)
1	1/1	0-4	0.49	69.79	9.81	17.11	3.22
	1/1**	<6.35	0.53	66.83	10.43	18.37	4.90
	1/2*	0-4	0.07	80.44	19.67	31.86	4.70
	1/2*	<6.35	0.06	74.17	25.38	20.54	5.28
	1/3*	0-4	0.09	84.79	18.41	29.99	4.78
	1/3*	<6.35	0.08	79.08	22.27	20.59	5.72
	1/4*	0-4	0.10	76.94	23.84	24.25	3.20
	1/4*	<6.35	0.12	77.28	27.88	17.59	2.19
	1/5	0-4	0.34	55.87	11.79	11.64	2.17
	1/5	<6.35	0.40	60.21	15.70	6.78	3.50
	1/6**	0-4	0.16	75.08	10.50	29.12	3.97
2	2/1	0-4	0.44	67.46	11.63	10.32	3.14
	2/1	<6.35	0.47	64.74	8.47	10.07	3.10
	2/2**	0-4	0.12	83.33	17.65	36.54	5.75
	2/2**	<6.35	0.10	77.26	15.31	27.76	5.43
	2/3**	0-4	0.09	79.78	12.70	31.12	5.90
	2/3*	<6.35	0.07	75.06	20.40	24.35	5.21
	2/4*	0-4	0.06	73.03	24.68	23.64	4.42
	2/4*	<6.35	0.08	76.92	26.28	24.25	3.90
	2/5*	0-4	0.11	71.89	26.20	24.10	3.00
	2/5	<6.35	0.14	68.93	24.55	18.05	3.38
	2/6	0-4	0.11	74.82	32.01	16.48	3.12
3	3/1	0-4	0.47	72.83	8.16	18.08	7.50
	3/1	<6.35	0.48	73.26	8.33	15.58	8.35
	3/2	0-4	0.25	77.38	8.31	26.09	7.70
	3/2**	<6.35	0.24	76.91	11.54	20.13	10.60
	3/3*	0-4	0.06	77.67	31.41	32.58	5.55
	3/3*	<6.35	0.06	79.07	24.19	25.09	5.15
	3/4	0-4	0.08	70.01	1.33	39.90	4.15
	3/4	<6.35	0.06	63.78	9.76	30.28	3.52
	3/5**	0-4	0.46	75.33	18.67	21.55	3.70
	3/5**	<6.35	0.47	58.60	13.31	15.18	2.40
	3/5**	<6.35	0.47	58.60	13.31	15.18	2.40
4	4/1	0-4	0.45	72.26	9.02	22.10	2.73
	4/1**	<6.35	0.44	61.70	10.78	10.82	2.81
	4/2**	0-4	0.12	79.35	6.5	34.54	4.72
	4/2	<6.35	0.10	70.60	10.7	23.50	4.50
	4/3	0-4	0.06	69.43	2.11	41.50	3.12
	4/3	<6.35	0.06	69.70	8.30	36.66	3.99
	4/4**	0-4	0.04	58.44	12.27	28.41	2.03
	4/4	<6.35	0.07	69.94	7.11	40.84	2.85
5	5/1	0-4	0.23	75.83	4.80	27.62	3.87
	5/1	<6.35	0.20	72.64	7.83	22.83	4.40
	5/2	0-4	0.11	71.29	2.46	36.10	3.40
	5/2	<6.35	0.11	74.09	3.39	35.09	4.60
	5/3	0-4	0.07	66.30	2.45	39.50	3.78
	5/3	<6.35	0.06	64.85	6.43	32.60	3.45
	5/4	0-4	0.66	65.73	8.93	16.60	2.02
	5/4	<6.35	0.63	67.11	6.03	17.27	3.35
	5/5**	0-4	0.08	67.61	14.95	29.65	2.44
	5/5**	<6.35	0.10	65.79	16.28	20.61	1.70
	5/6	0-4	0.33	55.94	9.03	11.25	1.05
	5/6**	<6.35	0.40	59.20	13.00	17.39	1.60

\* Air-water balance is suitable

\*\* Air-water balance is relatively suitable

\*\*\* Disturbed sample



Verdonck (1984) classified growing media in five groups according to their air volume and easily available water content (Table 3.3).

Table 3.3. Classification of air capacities of media as regards air volume and easily available water (Verdonk 1984)

Class of Medium	Air Volume (%)	Easily Available Water (%)
Very low air capacity, I	0-10	>30
Low air capacity, II	10-20	>20
Optimum air capacity, III	20-30	>20
High air capacity, IV	30-40	>10
Very high air capacity, V	>40	>5

As we take into consideration this classification, the most suitable medium to plant growth is the third class. Eleven samples of totally 56 samples are included in this group. The ratio of this group to all samples is only 19.6 %. Fifteen samples are included in the second class according to Verdonck's Classification. The ratio of the samples in the second class to the all samples is 26.8 %. The rest of the samples are not suitable especially because of their low air capacities.

The most suitable peat samples can not show differences according to fraction size while relatively suitable samples are mainly included in 0-6.35 mm fraction. Other peat samples, unsuitable with respect to air-water balance, can be improved by mixing of different particle sizes. For example, as we examine the Table 3.2, 0-6.35 mm fraction of 4/4 sample, easily available water content is very high, can be mixed with 0-6.35 mm fraction of 2/6 sample having low easily available water, nearly at the rate of 50 %. The peat samples having low air capacities, also can be improved with application of various materials having high air capacity such as pumice and perlite.

The second important property with respect to air-water balance is water buffering capacity. This value is desired almost 5-7 %. As we consider buffering capacities of the samples, it can be seen that a great part of samples has lower values than optimum values. It means that growing medium requires more frequent irrigation.

As it can be seen from the results, the physical properties of Bolu-Yeniçağa peat as growing medium change significantly dependent on locations and depths. The regional producers, excavating peat from Bolu-Yeniçağa peatland, do not realize or consider those differences. The producers should take into consideration the properties of Bolu-Yeniçağa peat to evaluate it properly and produce a good quality commercial peat as growing medium.

## REFERENCES

- Ataman Y. (1988). Sakı kompostlarının bazı önemli fiziksel ve kimyasal özellikleri. Ankara Üniversitesi Zir. Fak. Yayınları No:82.
- Bouyoucos G.D. (1951). A recalibration of the hydrometer method for making mechanical analysis of the soil. *Agronomy Journal*, 43, 434-438.
- Çaycı G., Ataman Y., Ünver İ., Munsuz N. (1989). Distribution and horticultural values of the peats in Anatolia. *Acta Horticulturae*, 238, 189-196.
- Çaycı G., Baran A., Özkan İ. (1994). Tane büyüklüğünün peatin bazı fiziksel özellikleri üzerine etkisi. *Ankara Üniversitesi Zir. Fak. Yılığ*, 44(1, 2):131-139.
- De Boodt M., Verdonck O., Cappaert I. (1973). Method for measuring the water release curve of organic substrates. *Proceeding Symposium Artificial Media in Horticulture*. 2054-2062.
- DIN, 11542. Torf für Gartenbau und Landwirtschaft.
- Kirven D.M. (1986). An industry viewpoint: Horticultural testing-is our language confusing. *Hort. Sci.*, 215-217.
- Munsuz N., Ünver İ., Çaycı G. (1999). Türkiye suları. Ankara Üniversitesi Zir.Fak. Yayınları No:1505.
- Soil Survey Staff (1975). *Soil Taxonomy. A basic system of soil classification for making and interpreting soil surveys*. USDA. Agriculture Handbook No 436. Washington D.C.
- U.S. Salinity Lab. Staff (1954). *Diagnosis and improvement of saline and alkali soils*. USDA Agriculture Handbook, No.60, 160 s.
- Verdonck, O. 1984. New developments in the use of graded perlite in horticultural substrates. *Acta Horticulture*. 150. 575-581.

# EFFECT OF BEER FACTORY SLUDGE ON YIELD COMPONENTS OF WHEAT AND SOME SOIL PROPERTIES

Cihat Kütük<sup>1</sup>, Gökhan Çaycı<sup>1</sup>

Department of Soil Science, Faculty of Agriculture, University of Ankara

## ABSTRACT

Influence of beer factory sludge (BFS) on the growth of wheat (*Triticum aestivum* cultivar Kızıltan 91) and some physical and chemical properties of wheat planted soil have been investigated in the field experiment.

For this purpose, BFS were applied at the different rates (0, 10, 20, 40 and 80 ton ha<sup>-1</sup>) into the 20 cm of soil depth two months earlier before seeding. In addition, all plots were fertilised at the recommended rates for wheat with chemical fertilisers.

Total yield, grain yield, grain mineral content and some botanical characteristics of wheat were determined after harvesting. Besides, pH, EC, organic matter, lime and aggregate stability were evaluated in the soil samples.

At the end of the experiment, considerable changes were found in the grain yield, crude protein, thousand kernel weight, nitrogen and phosphorus contents of wheat in respect to control treatment. The highest grain yield was obtained from 10 ton ha<sup>-1</sup> treatment. But, values of crude protein were found higher at 40 ton ha<sup>-1</sup> and 80 ton ha<sup>-1</sup> treatments. Effect of BFS on spike length was found significant ( $P<0.01$ ). Spike lengths have shown variation between 5.82 cm and 7.07 cm. The highest plant height was determined in 10 ton ha<sup>-1</sup> treatment. N and P contents of grain increased continuously with increase in the levels of BFS. On the other hand, significant changes were determined in soil properties. As the rate of BFS increase in the soil, value of EC and organic matter content, and water stable aggregates increased generally. Nevertheless, value of pH and lime content decreased with related to increased BFS rates in the soil.

## INTRODUCTION

Recently, waste materials depending on increased industry and urbanisation result in problems for environment due to difficulties in their store. Combustion of these materials may be an alternative way to decrease energy cost reached high prices. But, it needs a storage area, even if this way is selected. On the other hand, applying waste materials to field is another alternative way and this way is easier, cheaper and more beneficial. Therefore, studies concerned with applying waste materials derived from plant, animal and also, industrial activity have increased and various research have been conducted about this matter in our country and other countries since the beginning of 1960's. In these researches, it was determined that various organic wastes caused positive effects on soil and plant (Tripepi et al., 1996; Kacar et al., 1996; Saviozzi et al., 1994; Palaniswami and Ramulu, 1994; Brohi, 1991). In addition, it is pointed out that if waste materials use in this way, substantial benefits can be obtained for environmental protection.

Different materials are used to improve the soil properties dealing with their characteristics. Sewage sludge is commonly used as waste material world wide. Since sewage sludge has a high organic matter content and produced large amounts, it is preferred. But, pathogenic organisms and heavy metal contents limit their usage (Benckiser and Simarmata, 1994). Regarding sludge applications, some authors warn about their high contents in organic and phenols as well as in salts and of their high pH value (Logan et al., 1995) and of their effect on nitrogen immobilisation in soil and on plant growth (Riffaldi et al., 1993).

Interesting and important results have been obtained in various researches performed with waste materials. As reported by Brohi (1989), tobacco wastes positively affected on the yields of wheat, corn, rice and potato. In the other study, it was determined that tobacco wastes increased the dry weight of clover plant (Sungur, 1978). Özgüven and Kaya (1984) explained that tobacco wastes increased the dry weight of sunflower and corn plant, but applications of high levels influenced negatively. Kacar et al. (1996) found that dry weights obtained from grass, barley and corn were higher in enriched tea waste treatment with respect to control and farmyard manure treatments. In the study performed by Cervata and Silva (1986), it has been determined that leather factory waste has increased crop yields of corn and wheat plant. On the other hand, Özgüven et al. (1999) found that tobacco wastes were augmented protein content of corn plant grown as first and second crop. Some researchers studying with organic wastes (Arcak et al., 1997; Palaniswami and Ramulu, 1994; Saviozzi, 1994; Sacigarcic et al., 1986) reported that different wastes affected positively on biological properties of the soils.

Organic matter content of wastes used in agriculture need to be high levels. It is well known that addition of organic material is the most convenient method for improvement of soil physical and chemical



properties. Organic matter increase aggregate stability and improve water-air balance in soil. Moreover, it increase resistance against erosion and also, enrich plant nutrients in soil.

Beer factory sludge have been occurred by Efes Pilsener Beer Factory in Ankara-Kazan. Factory have 1.5 million hectolitre year<sup>-1</sup> capacity and produce 5 tonnes sludge per day depending on marketing conditions (Baran et al., 1998). This product has already been dumped into landfill, therefore, various environmental and managing problems could appear in time.

Wheat is the most important crop in our country. More than half of cereals are planted in Central Anatolia plateau and transitional zones (Aydın et al., 1998). However, precipitation is insufficient and soil organic matter content is low in the wheat growing areas.

The aim of this study was to determine the effects of beer factory sludge on growth, yield, botanical characteristics of wheat plant and some soil properties.

## MATERIALS AND METHODS

This study was carried out in experiment field of Soil Science Department. Wheat (*Triticum aestivum*, cultivar Kızıltan 91) was used as trial crop. Field trial was established in the randomized block design in five treatments with three replications. All plots had the dimensions of 2 m x 4 m = 8 m<sup>2</sup> and total experimental area was 216 m<sup>2</sup>. Beer factory sludge (BFS) at the different rates (0, 10, 20, 40 and 80 ton ha<sup>-1</sup>) were applied into the soil at 20 cm depth two months earlier before seeding and mixed by using hoe. Wheat was sowed (as 250 kg seeds ha<sup>-1</sup>) after incorporation of BFS to the soil. The fertilizers used as 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (at sowing) and 70 kg N ha<sup>-1</sup> (half of it at sowing, the other at tillering).

Before harvesting, heights of twenty plants chosen at random were recorded. Also, spike lengths were measured and numbers of grains in the spike were determined in the same plants (Özbek and Özgümüş, 1998). Plants were harvested in the middle rows using by sickle in 15.7.1999. After harvesting, total weights (spike + straw), grain yields (Kaya and Tepe, 1999), thousand kernel weights (Taban et al., 1998) and numbers of grain in spike (Kenbaey and Sade, 1998) were recorded for each plot. Total N, P, and K contents of grain were determined according to Kacar (1972). Protein content of grain was calculated as reported by Gezgin (1998).

Texture was obtained by hydrometer method (Bouyoucos, 1951). pH and electrical conductivity (EC) were determined in 1:2 soil (or waste) – water extract (Gabriels and Verdonck, 1992). Organic matter was obtained as described by Jackson (1962) and calcium carbonate was determined by calcimeter (Çağlar, 1958). Total N, available P and exchangeable K were obtained as explained by Kacar (1994). Cation exchange capacity (CEC) of soil and BFS was determined according to U.S. Salinity Lab. Staff (1954). Water stable aggregate (WSA) was obtained by the wet-sieving technique (Kemper, 1965).

Statistical analysis of results were done by MINITAB and MSTAT computer package programs and evaluated according to Düzgüneş et al. (1983).

## RESULTS AND DISCUSSION

Various properties of soil and BFS used in the research are given in Table 1. As it is seen from this table that soil of the experimental field was clay loam in texture, slightly alkaline and low in organic matter. Total N content of soil is low, but P and K contents are high. On the other hand, pH value of BFS is low (acid) and organic matter content of this material is high. Total N content of BFS is high and, P and K contents are in middle levels.

Total yield, grain yield and also, some botanical properties such as thousand kernel weight, spike length and plant height are affected by applications of BFS (Table 2). The highest total yield was obtained in 10 ton ha<sup>-1</sup> treatment. As it is seen from Table 2 that BFS applications in different levels to the soil greatly affected on grain yield and differences among treatments were found significant (P<0.01). The highest grain yield was found in 10 ton ha<sup>-1</sup>, while the lowest grain yield was obtained in 80 ton ha<sup>-1</sup> treatments. This situation shows that positive effects of BFS on soil and plant occur to the certain levels. Similar results have been reported by various researchers (Özgiiven et al., 1999; Çağatay, 1998; Brohi, 1991; Kacar et al., 1980). It is thought that the reason of decrement in total yield and grain yield resulting above 10 ton ha<sup>-1</sup> can be related to high amounts of inorganic nitrogen forms occurred with mineralisation. This idea has been confirmed with the laying of wheat in plots receiving BFS more than 20 ton ha<sup>-1</sup> and low grain yield in these plots. Also, maturation of spikes was negatively affected as nitrogen level was high in the soil. Baran et al. (1998) determined that high levels of NH<sub>4</sub>-N and NO<sub>3</sub>-N were released from the soil after BFS applications. Researchers studying with BFS and evaluating its effect on growth of sugar beet plant reported that high levels NO<sub>3</sub>-N were released after BFS applications at high doses (Kütük et al., 2000). As explained that by



Gök et al. (1998), tobacco wastes significantly increased  $\text{NO}_3\text{-N}$  content of soil. Thousand kernel weights of wheat were significantly found in difference at  $10 \text{ ton ha}^{-1}$  treatment with respect to control.

Table 1. Some properties of soil and BFS

Properties	Soil	BFS
Texture class	CL	
Clay, %	34.15	
Silt, %	35.85	
Sand, %	30.00	
PH	7.81	5.59
$\text{CaCO}_3$	5.35	Trace
$\text{EC, mS cm}^{-1}$	0.22	4.80
Organic matter, %	1.65	25.56
Total N, %	0.11	2.69
Total P, %		0.69
Total K, %		0.79
Available P, $\text{mg kg}^{-1}$	15.10	
Exchangeable K, $\text{mg kg}^{-1}$	549.90	
CEC, $\text{me } 100 \text{ g}^{-1}$	27.25	135.08

Table 2. Effects of BFS on total yield, grain yield and some botanical characteristics of wheat

Applications of BFS, $\text{Ton ha}^{-1}$	Total yield, $\text{kg ha}^{-1}$	Grain yield, $\text{kg ha}^{-1}$	Thousand kernel weight, g	Spike length, cm	Number of grain in spike,	Plant height, cm
0	11494 AB	3297 A	45.43 BC	5.82 B	26.70*	68.45 B
10	13412 A	3993 A	54.25 A	7.07 A	32.47	74.70 A
20	12683 A	3327 A	49.60 B	6.71 A	31.93	70.93 AB
40	11473 AB	1906 B	45.25 BC	6.69 A	32.75	69.65 AB
80	9175 B	1592 B	44.13 C	7.01 A	29.52	65.20 B

\* Non-significant

Effect of BFS on spike length was found significant ( $P < 0.01$ ), but its effect on number of grain in spike was not significant. Spike lengths of wheat plant was found in difference in all applications of BFS with respect to control (Table 2). Spike length have shown variation between 5.82 cm (control) and 7.07 cm ( $10 \text{ ton ha}^{-1}$ ). Özgüven et al. (1999) determined that tobacco wastes increased spike length of wheat plant grown as first crop and the best result was obtained from  $22.5 \text{ ton ha}^{-1}$  treatment. Effect of BFS on plant height was found significant and the highest height was determined in  $10 \text{ ton ha}^{-1}$ . Similar results also have been reported by Özgüven et al. (1999).

N, P, K and protein contents of wheat grain have been given in Table 3. As it is seen from this table, effect of BFS applications on N, P, and protein content of grain was found significant ( $P < 0.01$ ), but its effect on K content was not significant. N content of grain was increased continuously with increase in the levels of BFS. The lowest N content was determined in control (% 2.03) treatment.

In contrast to other parameters, the highest N content was obtained in  $80 \text{ ton ha}^{-1}$  (% 3.66) treatment. On the other hand, P content of grain increased with increase in the levels of BFS and reached the highest value in the applications of 40 and 80 tonnes  $\text{ha}^{-1}$  (Tablo 3). It is thought that the reason of this fact can be related with chemical properties of BFS (Table 1) and availability of plant nutrients. Some nutrients and various compounds occurred by mineralisation may affect the nutrient contents of grain. Kütük et al. (2000) determined that N and P contents of sugar beet were increased by the application of BFS. As explained by Tisdale and Nelson (1975), soil organic matter increase the availability of phosphorus. Differences between grain potassium contents were not found significant. This situation may resulted from accumulation of potassium occurs in straw at maturity. As reported by Kacar and Katkat (1999), potassium was accumulated significant rates in straw towards maturation period.

Table 3. Effects of BFS on N, P, K and protein contents of wheat grain

Applications of BFS, Ton ha <sup>-1</sup>	N, %	P, %	K, %	Protein, %
0	2.03 B	0.40 B	0.60*	11.57 B
10	2.93 AB	0.46 B	0.61	16.70 AB
20	3.44 A	0.55 A	0.66	19.63 A
40	3.45 A	0.56 A	0.65	19.67 A
80	3.66 A	0.57 A	0.63	20.86 A

\*Non-significant

Protein content of grain is affected by the applications of BFS and protein content increases with increase in the levels of BFS (Table 3). The lowest protein content was obtained in control (% 11.57) treatment, while the highest protein content was found in 80 ton ha<sup>-1</sup> (% 20.86) treatment. This fact may be related with the increment of nitrogen in the grain. Arnold and Dilz (1970) indicates that a close correlation is obtained between nitrogen content and protein content and protein content increases depending on the increment of nitrogen in plant, also. Kütük et al. (2000) determined that protein content of sugar beet was increased with increase in the levels of BFS. Similar results has been explained by Özgüven et al. (1999).

Some significant differences were determined in the experimental soil in relation to BFS application levels (Table 4). With application of increasing levels, pH and CaCO<sub>3</sub> values decreased. In addition, pH and CaCO<sub>3</sub> values determined at 40 and 80 ton ha<sup>-1</sup> applications were found lower than the initial values. In contrast, values of EC, organic matter and aggregate stability were determined higher than the beginning values and increased with increase in the levels of BFS. This fact indicated that BFS affected on some soil properties. In a study performed by Kütük et al. (2000), similar results were obtained. Researchers reported that the pH value is decreased by the increasing levels of BFS, while EC and organic matter values are increased. Since aggregate stability was higher in soil applied BFS with respect to control at the end of the experiment, it is inferred that BFS significantly affected the aggregation of soil particles. This situation shows that BFS application have a great function for protection of the soil against erosion.

Table 4. Effects of BFS on some properties of the soil after harvesting

Applications of BFS, ton ha <sup>-1</sup>	pH	EC, mS cm <sup>-1</sup>	CaCO <sub>3</sub> , %	Organic matter, %	Aggregate stability, %
0	7.96	0.21	5.78	1.45	49.42
10	7.89	0.24	5.69	1.71	55.34
20	7.78	0.33	5.64	1.80	61.63
40	7.58	0.59	5.23	1.88	63.65
80	7.59	0.65	5.02	1.97	61.14

## REFERENCES

- Arcak S., Kütük A.C., Haktanır K. and Çaycı G. (1997). Çay atıklarının toprakta enzim aktivitesi ve nitrifikasyon üzerine etkileri. Pamukkale Üniv.Müh.Fak. Mühendislik Bilimleri Dergisi 3(1):261-266.
- Arnold G.H. and Dilz K. (1970). Nitrogen fertilizing of cereals. Production of high-quality wheat by nitrogen fertilizing on trial fields and in practice. 1969 trial. Stikstof 6:133-139.
- Aydın M., Kalaycı M., Atay F. and Katkat A.V. (1998). Effect of early growth, water use and stored water on grain yield of wheat and barley cultivars. M. Şefik Yeşilsoy International Symposium on Arid. Region Soil, 103-108, 21-24 September. Menemen-Izmir.
- Baran A., Çaycı G. and Sözüdoğru Ok S. (1998). The effect of beer factory sludge on some chemical and physical properties of a clay loam soil. M. Şefik Yeşilsoy International Symposium on Arid. Region Soil, 179-193, 21-24 September. Menemen-Izmir.
- Benckiser G. and Simarmata T. (1994). Environmental impact of fertilising soils by using sewage sludge and animal wastes. Fertilizer Research 37(1):1-22.
- Bouyoucos G.D. (1951). A recalibration of the hydrometer method for making mechanical analysis of the soil. Agronomy Journal, 43, 434-438.



- Brohi A.R. (1989). Çimlerde tütün tozunun gübre olarak kullanılması. Toprak İlimi Derneği 10. Bilimsel Toplantı Tebliği No:5, Ankara.
- Brohi A.R. (1991). Sigara fabrikasından çıkan tütün atıkları ile Tekel'in depolarında imha için bekletilen düşük kaliteli tütün yapraklarından gübre olarak yararlanma olanaklarının araştırılması. C.Ü. Tokat Ziraat Fakültesi Yayınları 7. Bilimsel Araştırma ve İncelemeler 4.
- Cervata A. and Silva S. (1986). The use industrial sludges in agriculture. I. Production of maize and wheat crops grown in succession. Annali della Facolte di Agraria, Università Attolica del Sacro Couro, 26(2):165-187.
- Çağatay K. (1998). Şlempeinin Tokat yöresinde buğday, kuru fasulye, şekerpancarı verimine ve çevre kirliliğine etkisi. M. Şefik Yeşilsoy International Symposium on Arid. Region Soil, 413-418, 21-24 September Menemen-İzmir.
- Çağlar K.Ö., (1958). Toprak İlimi, A.Ü. Ziraat Fakültesi Yayını, Ankara, 258 s.
- Düzgüneş O., Kesici T. and Gürbüz F. (1983). İstatistik Metodları I., A.Ü.Z.F. Yayınları 862, Ankara.
- Gabriels R. and Verdonck O. (1992). Reference methods for analysis of compost. In: Composting and compost quality assurance criteria, 173-183.
- Gezgin S. (1998). Farklı form ve dozlarda yaprakattan uygulanan çinkonun buğdayın verim ve verim unsurlarına etkisi, 213-221 I. Ulusal Çinko Kongresi, 12-16 Mayıs, Eskişehir.
- Gök M., Ottow J.C.G., Benckiser G., Coşkan A., Onaç I., Karip B., Sağlamtimur T., Tansı V. and Sağlamtimur F. (1998). Residual effect of organic fertilization on nitrogen mineralization, denitrification and some biological properties on corn cultivated field followed wheat plant. M. Şefik Yeşilsoy International Symposium on Arid. Region Soil, 673-678, 21-24 September Menemen-İzmir.
- Jackson M.L. (1962). Soil Chemical Analysis, New Jersey, Prentice Hall Inc., 183 p.
- Kacar B. (1972). Bitki ve Toprağın Kimyasal Analizleri, II. Bitki Analizleri, A.Ü. Ziraat Fakültesi Yayınları:453. Uygulama Kılavuzu:155, A.Ü. Basımevi, Ankara.
- Kacar B. (1994). Bitki ve Toprağın Kimyasal Analizleri III. Toprak Analizleri. A.Ü.Z.F. Eğitim, Araştırma ve Geliştirme Vakfı Yayınları No:3, 705 s, Bizim Büro Basımevi, Ankara.
- Kacar B. and Katkat A.V. (1999). Bitki Besleme. U.Ü. Güçlendirme Vakfı Yayın No:127, Vipaş Yayınları:3.
- Kacar B., Kovancı İ. and Atalay İ.Z. (1980). Utilization of the tea waste products of tea factories in agriculture. A.Ü.Z.F. Yılığ 29(1):158-173.
- Kacar B., Taban S. and Kütük A.C. (1996). Çay atıklarının zenginleştirilmiş organik gübreye dönüştürülerek kullanılması araştırma-geliştirme-uygulama projesi. (Kesin Rapor). Çay İşletmeleri Genel Müdürlüğü, Rize.
- Kaya İ. and Tepe İ. (1999). Van yöresinde kışık buğdayda sorun olan kekre (*Acratilon repens* (L) DC) ve düğün çiçeğinin (*Ranunculus domescenus* Boiss and Gaill) verime etkileri ve ekonomik zarar ilişkilerinin saptanması üzerine araştırmalar. Turkish Jour. of Agriculture and Forestry 23(1):53-61.
- Kemper W.D. (1965). Aggregate stability. In: Methods of Soil Analysis Part I (Black C.A. ed.). Amer. Soc. of Agr. Inc. Madison. Wisconsin, USA, 511-519 pp.
- Kenbaey B. and Sade B. (1998). Konya kıraç koşullarında arpa çeşitlerinin (*Hordeum vulgare* L.) çinko dozlarına tepkilerinin belirlenmesi. I. Ulusal Çinko Kongresi, 339-348, 12-16 Mayıs, Eskişehir.
- Kütük A.C., Çaycı G., Baran A. and Başkan O. (2000). Bira fabrikası atıklarının tarımsal amaçlı kullanım olanaklarının belirlenmesi. A.Ü. Araştırma Fon Projesi (98-11-10-01), Kesin Rapor.
- Logan T.J., Harrison B.J., Goins L. And Hatfield N. (1995). Soil Substitute from Alkaline Stabilization. BioCycle 36:9, 80.
- Özbek V. and Özgümiş A. (1998). Farklı çinko uygulamalarının değişik buğday çeşitlerinin verim ve bazı verim kriterleri üzerine etkileri. I. Ulusal Çinko Kongresi, 183-190, 12-16 Mayıs, Eskişehir.
- Özgülven M. and Kaya Z. (1984). Tütün atıklarının tarımda gübre olarak kullanılma olanakları üzerinde bir araştırma. Ulusal Çevre Sempozyumu Tebliğ Metinleri, Adana, TÜBİTAK Yayınları No:12.
- Özgülven M., Kaya, Z., Yılmaz, M.A., Kırıcı, S. and Tansı, S. (1999). Sigara fabrikası tütün atıklarının gübre olarak değerlendirilmesi. Turkish Jour. of Agriculture and Forestry 23(1):43-581.
- Palaniswami C. and Ramulu U. S.S. (1994). Effect of continuous irrigation with paper factory effluent on soil properties. Jour. of the Ind. Soc. of Soil Sci. 42(1):139-140.
- Riffaldi R., Levi-Minzi R., Saviozzi A., Vanni G. and Scagnozzi A. (1993). Effect of the disposal of sludge from olive processing on some soil characteristics: Laboratory experiments. Water, Air and Soil Pollution 69:257-264.
- Sacigarić B., Velagić H.E. and Mijatović T. (1986). Effect of waste tobacco dust on the growth of ficus species, Radovi Poljoprivrenog, Fakulteta Univerziteta Sarajevu, 34(38):125-131.
- Saviozzi A., Levi-Minzi R., Riffaldi R. and Cardelli R. (1994). Suitability of a winery-sludge as soil amendment. Bioresource Technology 49(2):173-178.



- Sungur M. (1978). Fabrikasyon atığı tütün tozunun gübre değerinin saptanması. Toprak ve Gübre Araştırma Enst. Araştırma Raporu No:13, Genel Yayın No:76, 578.
- Taban S., Alpaslan N., Güneş A., Aktaş M., Erdal İ., Eyüboğlu H. and Baran İ. (1998). Değişik şekillerde uygulanan çinkonun buğday bitkisinde verim ve çinkonun biyolojik yararlanılabilirliği üzerine etkisi. I. Ulusal Çinko Kongresi, 147-155, 12-16 Mayıs, Eskişehir.
- Tisdale S. and Nelson W. (1975). Soil Fertility and Fertilizers, 3<sup>rd</sup> Ed. Macmillan Pub. Co. Inc. USA.
- Tripepi R.R., Zhang X.G. and Campbell A.B. (1996). Use of raw and composted paper sludge as a soil additive or mulch for cottonwood plants. Compost. Science and Utilization 4(2):26-36.
- U.S. Salinity Lab. Staff (1954). Diagnosis and Improvement of Saline and Alkali Soils. USDA Agricultural Handbook, No.60, 160 s.

# SOME CHEMICAL CHARACTERISTICS OF HUMIC ACIDS EXTRACTED FROM DIFFERENT ORGANIC WASTES

Turkan Unsal, Sonay Sözüdoğru Ok

Soil Science Department , Agricultural Faculty, Ankara University, 06110 Ankara Turkey

## ABSTRACT

Humic acids extracted from different organic wastes have been characterised by chemical methods. The chemical properties of HAs showed changes depending on the source from which they were obtained. The C content in HAs from organic wastes fluctuated around the C value in soil HA with the exception of CB and TD. Compared with soil HA, The N contents of HAs from SS and BFS and TD were much higher and those in HAs from CCSM and CGM are slightly higher whereas N contents of HAs from RTW and CB were lower. E4:E6 ratios for HAs in organic wastes were found generally higher than that for soil HA which indicating that low degree of condensation and humification. The carboxyl and phenolic-OH group contents ranged from 0.51 to 2.23 and from 11.10 to 20.73 respectively. High values of carboxyl and phenolic-OH contents indicated that materials still within early stages of humification.

## INTRODUCTION

Organic matter content strongly affects the soil fertility by increasing the availability of plant nutrients, by improving the soil structure and the water-holding capacity, and by acting as an accumulation phase for toxic, heavy metals in the soil environment (Stevenson, 1985). Therefore the recycling of organic wastes through their application to the soil can be an important, promising practice for agricultural activities. The soil has almost unlimited capacity to accept large quantities of those materials and transform them through biodegradation processes leading to humic substance synthesis. Part of this newly formed organic matter (humic acids) has a great influence on soil fertility (Lee and Bartlett, 1976), due to its carboxyl and phenolic-OH groups that interact with various soil components. A better understanding of the chemical and physical characteristics of these acids is necessary to comprehend the transformations the acids will undergo after different times in the soil environment.

The aim of this study was to investigate chemical characteristics of humic acids already present in organic wastes, before they are added to soil, and compare with those of soil HA.

## MATERIALS & METHODS

### Materials

Sewage sludge (SS), beer factory sludge (BFS), raw tea waste (RTW), composted grape marc (CGM) and composted spend mushroom (CSM), composted bark (CB), and tobacco dust (TD) were as used organic waste samples. An inorganic soil sample also was used for comparison.

### Methods

The extraction of humic acids (HAS) from raw samples was performed according to Schnitzer (1982), (Figure 1).

Before extraction raw organic waste samples were analysed for moisture, pH (Gabriels and Verdonck, 1992), organic matter (DIN, 1978), organic C (Nelson and Sommers, 1982) and total nitrogen (Bremner, 1982) content.

Humic acids obtained after extraction were subjected to moisture, ash and E4:E6 (Chen et al. 1977), organic C (Nelson and Sommers, 1982) total nitrogen (Bremner, 1982), total acidity and carboxyl groups (Martin et al. 1963) content analyses. Phenolic-OH were obtained by difference.

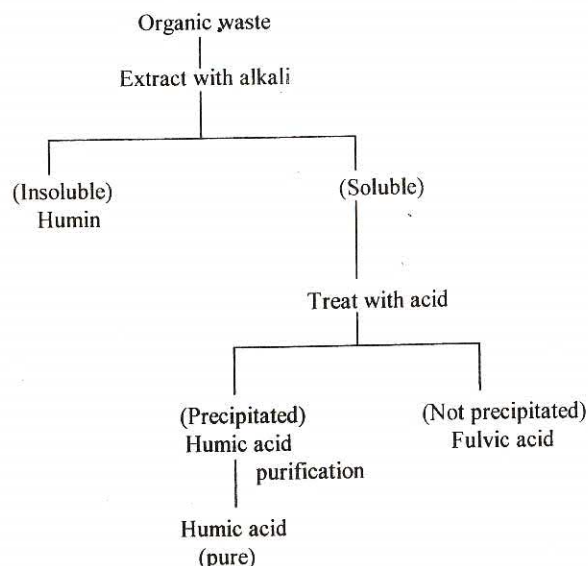


Figure 1. Extraction, fractionation and purification of humic acids.

## RESULTS & DISCUSSION

Analytical data for the organic wastes investigated are presented in Table 1. The analytical data illustrate important differences among the wastes.

Table 1. Some characteristics of original materials

Origin	PH (1/3)	Org. Matter (%)	Org. C (%)	N (%)	C/N
Sewage sludge	7.42	17.20	6.87	1.36	5.05
Beer factory sludge	6.99	27.85	13.60	3.10	4.38
Raw tea waste	5.32	94.89	44.92	1.90	23.27
Composted grape marc	7.92	84.75	36.00	2.45	14.69
Composted bark	5.22	57.76	28.47	2.36	12.06
Tobacco dust	5.53	81.12	46.92	2.95	15.90
Composted spend mushroom	7.36	52.16	20.00	1.62	12.35
Inorganic soil	5.29*	2.90	1.68	0.19	8.84

\* (1/2.5 soil-water)

PH values of SS, CGM and SMW were alkaline while CB, RTW and TD had an acidic pH, and BFS had the neutral pH.

The organic matter content of the samples ranged from 17.20 to 94.89 %. RTW had the highest organic matter wastes. The organic C content of RTW, with the exception of TD, was much higher than those of the others.

The N content was highest in BFS followed by TD>CGM>CB>DTW>SCM>SS and lowest in the soil as expected.

Depending on the stage of decomposition that organic wastes have undergone, C/N ratios ranged from 4.38 to 23.27.

All these findings agree closely with those of several authors who worked with similar organic wastes (Baran et al. 1995; Kütük et al. 1995; Birben, 1998; Ataman 1999; Baran et al, 1998)



## Humic acids

Yield of extracted and purified humic acids from organic wastes and the soil expressed as  $\text{mg g}^{-1}$  and as % of organic C are presented in Table 2.

Table 2. Some characteristics of extracted humic acids\*

Origin	Org. C (%)	N (%)	E <sub>4</sub> :E <sub>6</sub>	C/N	HA $\text{mg g}^{-1}$	HA (As Org. C (%))
Sewage sludge	48.30	6.25	2.17	7.68	109.25	7.03
Beer factory sludge	48.38	6.59	2.33	7.38	134.00	4.83
Raw tea waste	44.47	2.83	1.88	15.70	173.63	0.98
Composted grape marc	41.11	3.76	3.28	10.93	189.60	1.14
Composted bark	60.33	2.98	4.52	20.24	313.50	2.12
Tobacco dust	63.23	4.58	3.16	13.80	78.15	1.34
Composted spend mushroom	48.80	3.79	5.75	12.87	92.00	2.44
Inorganic soil	46.84	3.40	2.13	13.77	66.50	27.88

\* Oven-dry and ash-free basis

Among sources the yield of HAs was the maximum for CB followed by CGM>RTW>BFS>SS>CSM>TD and the soil. This was probably due to the variation in the composition and differential degradation of lignins.

The highest yield of CB HAs is probably due to the greater content of humified organic matter caused by longer period of bark decomposition. The very low amount of HAs extracted from TD, which has a much higher content of organic C might be attributed not only to the shorter period of decomposition but also to the slow humification process of tobacco dust.

Organic C and N content, C/N ratio, and E<sub>4</sub>:E<sub>6</sub> ratios of humic acids are shown in Table 2.

The C content in HAs from organic wastes fluctuated around the C value in soil HA, with the exception of CB and TD. Compared with soil HA, the N contents of HAS from SS and BFS and TD were much higher and those in HAs from TD, CSM and CGM are slightly higher, whereas N contents of HAs from RTW and CB were lower. As a consequence the C/N ratios of BFS and SS HAs were much lower, those of CGM and CSM were lower and those of TD, RTW on CB were higher than value measured for soil HA. All these findings are close to the values found by other authors for similar materials (Schnitzer and Khan, 1972; Hernandez et al. 1993).

The great difference between the N content of the HA extracted from the composts and that from the sludges is due to the short transformation processes that the materials have undergone which are not sufficient to degrade the nitrogen compounds (Hernandez et al. 1993).

The E<sub>4</sub>:E<sub>6</sub> ratios for HAs in organic wastes were found generally higher than that for soil HA (Table 2). The results suggest that HAs in organic wastes are characterised by a low degree of condensation and humification with respect to soil HA (Senesi and Brunetti, 1992).

The carboxylic and phenolic-OH group contents and as a consequence, the total acidity of HAs of organic wastes are much higher, or higher than the corresponding value for soil HA (Table 3). As can be seen from the Table, the majority of total acidity of HAs consists of phenolic-OH groups. With few exceptions, the values for those parameters generally were higher than those of other studies for similar wastes. However in several studies phenolic-OH group content were also found to be higher than that of carboxylic group (Senesi and Brunetti 1996). This may be attributed to using different methods for the determination of functional groups. Composting studies indicate that, with increasing time of composting phenolic -OH contents decreases and COOH group content increases.

On the other hand higher values than in soil HA are reported for carboxyl group content in HAs from composted bark and farmyard manure and for phenolic-OH group content in some sewage sludge HAs (Senesi and Brunetti 1996).

Table 3. Functional group content of humic acids\*

Origin	Total acidity	COOH	Phenolic-OH
	meq g <sup>-1</sup>		
Sewage sludge	21.90	1.17	20.73
Beer factory sludge	15.71	0.88	14.83
Raw tea waste	13.73	1.20	12.53
Composted grape marc	13.12	1.72	11.40
Composted bark	16.30	2.23	14.07
Tobacco dust	11.61	0.51	11.10
Composted spend mushroom	13.54	1.94	11.60
Inorganic soil	10.00	0.87	9.13

\* Oven-dry and ash-free basis

The results indicated that the chemical, properties of humic acids changed depending on the source from which they were obtained.

Senesi et al. (1995) stated that, soil application of partially humified organic wastes of any origin affects, to a measurable extent, the composition, structure and chemistry of nature soil HA. These modifications appear to be more extensive in the FAS than in HAS of an amended soil. With increasing time after amendment addition, however, the observed structural and chemical modifications which have occurred in the amended soil humic substances become less and less apparent, especially in the HA fraction, with a clear trend approaching the molecular properties typical of native soil humic substances (Senesi and Brunetti, 1996). Therefore this is an important result which supports the application of recycling partially humified organic wastes as beneficial soil amendments.

## REFERENCES

- Ataman Ş. (1999). Ankara atıksu arıtma tesisi, arıtma çamurunun toprak biyolojik aktivitesi üzerine etkisi. Master Tezi. Ankara Üniversitesi, Ziraat Fakültesi Toprak Bölümü. Ankara.
- Baran A., Çaycı G. ve İnal A. (1995). Farklı tarımsal atıkların bazı fiziksel ve kimyasal özellikleri. Pamukkale Üniv.Müh.Fak.Mühendislik Bilimleri Dergisi. 1 (2-3): 169-172.
- Baran A., Çaycı G. and Sözüdoğru Ok S. (1998). The effects of beer factory sludge and some soil properties. International Symposium on Arid Region Soil. Menemen-İzmir-Turkey, 21-24 September.
- Birben H. (1998). Atık mantar kompostunun begonya (Begonia Semperflorens) bitkisinin gelişimi üzerine etkisi. Master Tezi. Ankara Üniversitesi Ziraat Fak.Toprak Böl. Ankara.
- Bremner S.M. (1982). Total nitrogen. Methods of Soil Analysis. Part 2. 595-624, ASA-SSSA.USA.
- Schnitzer M. and Khan S.U. (1972). Humic substances in the Environment. Marcel Dekker. Newyork. 57-60.
- Chen Y., Senesi N. and Schnitzer M. (1977). Information provided on humic substances by E4/E6 ratios. Soil Sci. Am.J. 41: 352-358.
- DIN 11542 (1978). Torf für Fartenbau und Lanwirtschaft.
- Gabriels R. and Verdonck O. (1992). Reference methods for analysis of compost. In: Composting and compost quality assurance criteria. 173-183.
- Hernandez M.T., Morena J.J. and Costa F. (1993). Infrared spectroscopic characterisation of sewage sludge humic acids. Evidence of sludge organic matter-metal interactions. Agrachim 37:12-17.
- Kütük C., Çaycı G., Baran A., (1995). Çay atıklarının bitki yetiştirme ortamı olarak kullanılabilme olanakları. Tarım Bilimleri Dergisi. 1 (1) s: 35-40.
- Lee Y.S. and Bartlett R.J. (1976). Stimulation of plant growth by humic substances. Soil Sci. Soc. Am. J. 40:876-879.
- Martin F., Dubach P., Mehta N.C. and Devel H. (1963). Bestimmung der funktionellen gruppen von huminstoffen, 2. Pflanzenernahrung Düng. Bodenkunde. 103:29-39.

- Nelson D.W. and Sommers L.E. (1982). Total carbon, organic carbon and organic matter, Methods of soil analysis. Part 2. 539-579. ASA-SSSA.
- Schnitzer M. And Khan S.U. (1972). Humic substances in the environment. Marcel Dekker, New York.
- Schnitzer M. (1982). Organic matter characterisation methods of soil analysis part 2. ASA-SSSA Madison, USA.
- Senesi N., Miano T.M. and Brunetti G. (1995). Humic-like substances in organic amendments and effects on native soil humic substances. In: Piccolo A., (ed.) Humic Substances in Terrestrial Ecosystems. Amsterdam, Elsevier (in press).
- Senesi N. and Brunetti G. (1996). Chemical and Physico-Chemical Parameters for Quality Evaluation of Humic Substances Produced During Composting. The Science of Composting, European Commun Int. Symp-Blackie Academic Professional.
- Stevenson F.J. (1985). Geochemistry of soil humic substances. In: Humic substances in soil, sediment and water. 6-R. Aiken, D.M. Mc Knight, R.L. Wershaw and P. Mac Carthy, Wiley-Interscience, New York. p. 13-52.



# EFFECT OF HUMIC ACID ON SOME SOIL PROPERTIES

Cihat Kütük, Gökhan Çaycı, Abdullah Baran, Oğuz Başkan  
Soil Science Department, Agricultural Faculty, Ankara University, 06110- Ankara Turkey

## ABSTRACT

In this research, effect of humic acid and incubation period on some soil properties were determined. Liquid humic acid was used in the research. Seven rates of humic acid (0, 100, 250, 500, 1000, 2000 and 4000 ppm) were added to the soil at three incubation periods (30, 60 and 90 days). At the end of the each incubation period, the changes in some physical and chemical soil properties were determined.

Generally, humic acid (HA) addition decreased pH values at the first incubation period. EC values were increased depending on humic acid rates at the all incubation periods. It was seen that the effect of HA on available Fe, Mn and Zn contents of the soil were more clear above 500 ppm rates of HA. Available Fe, Mn and Zn contents of the soil were found higher at first incubation period than in other periods. The amount of water stable aggregates were found higher than the control at rates of 2000 and 4000 ppm of HA.

## INTRODUCTION

The effect of organic matter on soil properties such as physical, chemical and biological is well known for a long time. The organic matter content of soils in Turkey is, generally, low (Eyüpoğlu 1998). Soil organic matter contains residues of plants and animals and primary and high polymer organic compounds decomposing from them. Soil organic matter has not certain chemical formula due to its dynamic structure.

Soil organic matter are mainly consists of humic and fulvic acids which called humin materials (Schinitzer 1982; Andriesse 1988). They are mainly produced from nitrogenous compounds containing decomposed amino acids and aromatic complexes (Andriesse 1988). Those organic complexes affect soil properties and physiological properties of plant due to carboxyl (-COOH) and phenolic (-OH) groups (Lee and Barlett 1976; Schinitzer 1992). It was reported that humic acid affects physical and chemical properties of soils (Vaughan and Linehan 1976; Boyle et al. 1989; Schinitzer 1992). However, their effects on soil have not already been clearly concluded.

The aim of this study was to determine the effect of humic acid used commercially on water stable aggregates, pH and EC and availability of some micro nutrients.

## MATERIALS & METHODS

### Materials

Soil sample used in the study was taken from depth of 0-20 cm in Agricultural Faculty Research Area. Humic acid used, extracted from leonardite, contains at the rate of 9.5 % humic acid.

Soils were sieved through 0-2 mm and filled into 400 cm<sup>3</sup> volume of plastic pots. Soil were brought to 70 % of field capacity. Humic acids were added to each pots at the rates of 0, 100, 250, 500, 1000, 2000 and 4000 ppm, then, incubated at 25 °C during 30, 60 and 90 days. Properties of the materials used in the research were given in Table 1.

Table 1. Some properties of the materials used in the research.

Material	Sand %	Loam %	Clay %	Texture	pH	EC dS/m	Org. Carbon %	lime %	Field Capacity %	Wilt. Point %
Soil	23	41	36	CL	7.75	0.38	1.02	8.2	26	16
HA					8.98	26.4	12.04			

### Methods

Texture (Bouyoucos 1951), pH and electrical conductivity (EC) (U.S. Salinity Lab. Staff 1954), lime (Çağlar 1958), organic carbon (Jackson 1962), water stable aggregates (Kemper 1965), field capacity and wilting point (U.S. Salinity lab. Staff 1954) and available Fe, Mn, Zn and Cu (Lindsay and Norvell 1969) were determined.

Statistical analyses were evaluated by ANOVA and differences among the groups were separated by LSD.

## DISCUSSIONS

Changes in pH and EC values of soils were given in Table 2.

Table 2. Changes in pH and EC values of soils depending on humic acid rates and incubation periods.

Incubation (days)	Humic acid (ppm)	pH	EC (dS/m)
30.	0	7.67	0.42
	100	7.47	0.44
	250	7.41	0.44
	500	7.43	0.46
	1000	7.50	0.48
	2000	7.45	0.54
	4000	7.44	0.66
60.	0	7.63	0.43
	100	7.60	0.45
	250	7.59	0.44
	500	7.61	0.44
	1000	7.57	0.48
	2000	7.54	0.52
	4000	7.63	0.64
90.	0	7.40	0.51
	100	7.41	0.50
	250	7.38	0.50
	500	7.38	0.54
	1000	7.39	0.50
	2000	7.40	0.58
	4000	7.42	0.69

Where differences in pH values depending on incubation periods and rates of HA were noticed. pH values were decreased partially due to incubation periods. However, that decreasing is not regular when we consider the humic acid rates. Especially, pH values significantly decreased in 90<sup>th</sup> days with respect to the other incubation periods.

Where no differences in EC values depending on both incubation periods and humic acid rates were noticed, except 2000 and 4000 ppm of humic acid rates. EC values in 2000 and 4000 ppm of HA were higher than in the other rates of HA.

Humic acid, occurring complexes with metallic ions related to carboxyl(-COOH) and phenolic(-OH) groups in its structure, supplies nutrients to the soil (Schinitzer 1992). These complexes being non water-soluble forms, prevent leaching of the metallic ions from the soil, as a result growth medium enrich for those plant nutrients. Andriesse (1988) has reported that efficiency of humic acid on uptakes of nutrients in the mineral soils is more considerable than the organic soils. However, many scientist emphasised that adding of humic acid to the mineral and organic soils improve plant growth and uptake of some micro nutrients.

As shown in Table 3, the highest available Fe contents were determined at the first incubation period.

Available Fe contents of the soil samples were higher at the first incubation period than the other periods depending on humic acid rates and incubation periods. Especially over 500 ppm rates of humic acid were more efficient on availability of Fe. Garcia et al (1995) reported that iron-humic complexes under adverse soil conditions supply Fe to the soils and stimulate to the plant growth. These results are consistent with the findings of Barnard et al (1992).

Manganese and Zinc contents of the soils changed with humic acid rates and incubation periods (Table 4 and 5). Available Mn contents of the samples were significantly increased at the first incubation period. However, Mn and Zn contents of the samples were lower in the other incubation periods.



Table 3. Changes in available Fe contents of the soils (ppm).

Humic acid, ppm	Incubation, days		
	30	60	90
0	0.94 Ca	0.67 Bb	0.71 Bb
100	0.93 Ca	0.75 Bb	0.62 Bb
250	0.85 Ca	0.61 Bb	0.62 Bb
500	1.68 Aa	0.73 Bb	0.67 Bb
1000	1.76 Aa	0.75 Bb	0.89 Ab
2000	1.66 Aa	0.73 Bb	0.83 Ab
4000	1.43 Ba	1.17 Ab	0.96 Ac

Means followed by the same letter are not significantly (Duncan's multiple-range test  $P < 0.05$ )

Capital letters for each column, small letters for each row

Table 4. Changes in available Mn contents of the soils (ppm)

Humic acid, ppm	Incubation, days		
	30	60	90
0	0.74 Ea	0.22 Ab	0.27 Ab
100	0.65 Ea	0.32 Ab	0.31 Ab
250	1.28 Da	0.25 Ab	0.30 Ab
500	1.41 Da	0.21 Ab	0.30 Ab
1000	2.05 Ca	0.22 Ab	0.27 Ab
2000	2.33 Ba	0.24 Ab	0.32 Ab
4000	3.51 Aa	0.30 Ab	0.31 Ab

Means followed by the same letter are not significantly (Duncan's multiple-range test  $P < 0.05$ )

Capital letters for each column, small letters for each row

Table 5. Changes in available Zn contents of the soils (ppm)

Humic acid, ppm	Incubation, days		
	30	60	90
0	0.53 Da	0.55 Ba	0.58 Ba
100	0.56 Ca	0.51 Ba	0.52 Ba
250	0.65 Ca	0.54 Bb	0.55 Bb
500	0.66 Ca	0.67 Aa	0.61 Aa
1000	0.75 Ba	0.55 Bb	0.61 Ab
2000	0.78 Ba	0.52 Bc	0.65 Ab
4000	0.92 Aa	0.68 Ab	0.69 Ab

Means followed by the same letter are not significantly (Duncan's multiple-range test  $P < 0.05$ )

Capital letters for each column, small letters for each row

As shown in Table 6, Cu contents of the soils changed irregularly. Attraction order of metals is reported as  $\text{Cu} > \text{Pb} > \text{Zn} > \text{Ni} > \text{Co} > \text{Mn} > \text{Ca} > \text{Ba}$  (Andriesse 1988). For this reason, Cu and Zn can be more easily bound by the organic components than the other metals. Therefore, their availability will be less than the others.

Table 6. Changes in available Cu contents of the soils (ppm).

Humic acid, ppm	Incubation, days		
	30	60	90
0	1.01 Ba	0.97 Aa	1.02 Aa
100	1.03 Ba	1.05 Aa	1.01 Aa
250	1.18 Aa	0.87 Bb	0.88 Bb
500	1.00 Ba	0.89 Ba	0.91 Aa
1000	1.23 Aa	0.89 Bb	0.91 Ab
2000	1.17 Aa	0.81 Bb	1.07 Aa
4000	0.98 Ba	0.95 Aa	0.96 Aa

Means followed by the same letter are not significantly (Duncan's multiple-range test  $P < 0.05$ )

Capital letters for each column, small letters for each row



In this research, it was determined that the availability of both Fe and Mn can be significantly decreased within the time depending on humic acid rates and incubation periods. These situation shows that applying of humic acid within a few times during the plant growth will be more suitable for plant yield.

As a conclusion, although 1000 ppm rate of humic acid was found more suitable dose with related to availability of micro nutrients and economical reasons, it should be considered that application rate of HA can change with environmental conditions.

Water stable aggregates of the soil were affected by the humic acid rates and incubation periods (Table 7).

Table 7. Changes in water stable aggregates of the soil (%)

Humic acid, ppm	Incubation, days		
	30	60	90
0	36.84 Ba	29.42 Bb	15.51 Cc
100	21.21 Db	29.31 Ba	22.57 Bb
250	35.04 Ca	25.25 Bb	19.82 Cb
500	30.36 Ca	29.00 Ba	26.78 Ba
1000	30.80 Ca	29.23 Ba	22.61 Bb
2000	40.65 Ba	42.28 Aa	32.67 Ab
4000	56.31 Aa	38.78 Ab	26.24 Bc

Means followed by the same letter are not significantly (Duncan's multiple-range test  $P < 0.05$ )

Capital letters for each column, small letters for each row

Water stable aggregates of the control sample in the first incubation period was highest (36.84). Visser and Cailier (1988) have reported that low concentrations of humic acid cause in dispersion of soil particles, and high concentrations of humic acid cause to flocculation in humic clayey soils. Water stable aggregates decreased in the third incubation period in all humic acid rates comparing to other incubation periods. A relative decreasing was observed in the second incubation period. It was well known that soil organic matter, especially, humic materials are cementing agents in soil particles, however, certain organic components can play a role paradoxically as a dispersion element in clay-water systems (Tarchitzky et al. 1993). Shanmuganathan and Oades (1983) have reported that addition of anions to soils cause to dispersion in clay fraction associated with decreasing isoelectric point, and it is known that fulvic acids especially, are the most efficient anions.

## REFERENCES

- Andriessse, J.P. (1988). Nature and management of tropical peat soils. FAO Soils Bulletin No. 59, 165.
- Eyüpoğlu, F. (1998). Türkiye topraklarının verimlilik durumu. Toprak-Gübre Araştırma Enst.Yay. Genel Yayın no.220.
- Barnard, R.O., Van der Watt, H. H., Dekker, J., Cronje, I., Mentz, W. H., Cillie, G.E.B., Laker, M.C. (1992). Application of Fe and Zn to lime-rich soils in the form of formulated coal products. Science of the Total Environment, 117 / 118, 569 - 574.
- Bouyoucos, G.J. (1951). A recalibration of the hydrometer method for making mechanical analysis of the soil. Agronomy Journal (9): 434-438.
- Boyle, M., Frankenburger, W.T.Jr., Stolysz, L.H. (1989). The influence of organic matter on soil aggregation and water infiltration. Journal of Production Agriculture. 2: 4, 290 - 299.
- Çağlar, K.Ö. (1958). Toprak ilmi. Ank.Üniv.Zir.Fak. Yayınları, 241.
- Garcia, M.J.M., Sanchez, D.M., Iniguez, J., Abadia, J. (1995). The ability of several iron (II)-humic complexes to provide available iron to plants under adverse soil conditions. Iron Nutrition in soils and Plants. Proc. of the 7<sup>th</sup> Int. Symp. on Iron Nutrition and Interactions in Plants, Zaragoza-Spain, 27 June-July, 1995, 235-239; Developments in Plant and Soil Sciences Vol 59.
- Jackson, M.L., (1962). Soil chemical analysis. Prentice Hall Inc. Eng., Englewood Cliffs, N.J.
- Kemper, W.D. 1965. Aggregate stability. In: Methods of Soil Analysis. Part I. (Black C. A., ed.) Am. Soc. of Agr. Inc., Madison, Wisconsin, 511-519.
- Lee, Y.S., Bartlett, R.J. (1976). Stimulation of plant growth by humic substances. Soil Sci. Soc. Am. J., 40:876-879.

- Lindsay, W.L., Norwell, W.A. (1969). Development of a DTPA micro-nutrient soil test. *Soil Sci. Amer. Proc.* 35: 600-602.
- Shanmuganathan, R.T., Oades, J.M. (1983). Influence of anions on dispersion and physical properties of the A horizon of a red-brown earth. *Geoderma*. 29, 257-259.
- Schnitzer, M. (1982). Organic matter characterisation. In: *Methods of Soil analysis. Part 2.* (eds: A.L. Page, R.H. Miller and D.R. Keeney) Soil Science Society of America Madison, WI, 581-594.
- Schnitzer, M. (1992). Significance of soil organic matter in soil formation, transport processes in soils and in the formation of soil structure. *Soil Utilization and Soil Fertility. Volume 4, Humus budget*, 206, 63-81.
- Tarchitzky, J., Chen, Y., Banin, A. (1993). Humic substances and pH effects on sodium-and calcium-montmorillonite flocculation and dispersion. *Soil Sci. Soc. Am. J.* 57, 367-372.
- Vaughan, D., Linehan, D.J. (1976). The growth of wheat plants in humic acid solutions under axenic conditions. *Plant and Soil*, 44, 445-449.
- Visser, S.A., Caillier, M. (1988). Observations on the dispersion and aggregation of clays by humic substances: I. Dispersive effects of humic acids. *Geoderma*. 42, 331-337.
- U. S. Salinity Lab. Staff. (1954). *Diagnosis and improvement of saline and alkali soils*. USDA, Handbook No.60, Washington, D.C. 160.

# USE OF COMPOSTED MUNICIPAL SOLID WASTES TO IMPROVE SOIL PROPERTIES AND TO INCREASE CROP YIELD<sup>(\*)</sup>

Mehmet Aydın<sup>1</sup>, Okan Şener<sup>1</sup>, Tamer Sermenli<sup>1</sup>, Aydın Ozkan<sup>2</sup>, Suphi Aslan<sup>1</sup>, Necat Ağca<sup>1</sup>, Kemal Doğan<sup>1</sup>, Murat Tiryakioğlu<sup>1</sup>, Kazım Mavi<sup>1</sup>, SEREF Kılıç<sup>1</sup>

(1) Mustafa Kemal University, Faculty of Agriculture, Antakya-TURKEY

(2) Mustafa Kemal University, Faculty of Arts and Sciences, Antakya-TURKEY

## ABSTRACT

In order to determine a suitable mixture for main composting treatment, some amount of garbage material was separated physically to mix up with different materials such as dry bay leaves, barnyard manure, dry leaves of trees, cotton stems, forest residues in different ratios. About 20 kg air-dry materials were put in the bins and left to be decomposed.

According to the results of pre-treatments, the most suitable mixture was determined as "75% separated garbage + 15% dry bay leaves + 10% barnyard manure." Therefore, 7.5 tons organic garbage (separated from municipal solid wastes of Antakya) were well mixed with 1.5 tons bay leaves and 1 ton barnyard manure. The composting process was continued for 4 months (mid-May-mid-September). The samples taken at the end of the composting treatment were analyzed in the laboratories in Turkey and Germany.

As a result of the analysis, the quality of the compost was found in an applicable form. The field experiments were carried out by planting tomato and wheat crops in Amik Plain, Turkey. In these experiments, applications of traditional commercial fertilizer, 20, 40, 60, 80 ton/ha compost and 80 ton/ha barnyard manure and control were compared. The experimental design was randomized blocks with three replications. According to the results of a two-year field experiment of wheat, compared to the control, the increases of the grain yield by the application of commercial fertilizer, different doses of compost and barnyard manure were determined as 21%, 18-29% and 32%, respectively. In the case of tomato experiment, compared to the control, the increases of the yield by the application of commercial fertilizer, different doses of the compost and barnyard manure were determined as 61%, 39-107% and 54%, respectively. Moreover, positive effects of the compost on some properties of the soil were monitored.

## INTRODUCTION

Many countries have been investigating for the different solutions in order to eliminate the negative effects of the residential garbages on the environment. It has been pointed out by most of the researchers that making the compost from the garbages is the best solution. However, there are a few aspects of this process that can potentially create problems. Fertilization via organic wastes may result in an accumulation of heavy metals in the soils. Therefore, metal analysis is becoming a fairly standard procedure for many wastes materials, particularly those which are destined to be used in agricultural or horticultural settings (Porter, 1989; Golueke and Diaz, 1990; Kowald et al., 1990; Richard and Chadsey, 1990; Spencer, 1990; Yalçuk, 1984; Kovancı-et al., 1984; Goto et al., 1997; Gajdos, 1997; Guerrero et al., 1999).

In this study, it was aimed to investigate the effects of the compost from the Antakya house-originated solid wastes, on the soil properties and the crop yield by the application in the agricultural areas.

## MATERIALS and METHODS

Approximately 30 tons of domestic garbage were collected from the central Antakya and its suburbs (Kanatlı, Sumerler, Eski Antakya) in order to prepare compost. Before starting main composting treatments, some amount of garbage material was separated physically to mix up with different materials such as dry bay leaves, barnyard manure (animal manure), dry leaves of trees, cotton stems, forest residues in different ratios. About 20 kg air-dry materials were put in the bins and left to be decomposed. The moisture contents of the mixtures were provided between 40-50% on the

---

<sup>(\*)</sup> Funded by the State Planning Organization (DPT, Turkey)



gravimetric basis during the period of treatment. The material in the each bin was mixed twice in the first week and once in the following weeks. During the experimental period, depending on seasonal changes, the temperatures of the composting materials varied between 35-70 °C. The decomposition processes were completed in a period of 8 weeks to 15 months.

According to the results of pre-treatments, the most suitable mixture was determined as "75% separated garbage + 15% dry bay leaves + 10% barnyard manure." Therefore, 7.5 tons organic garbage (separated from municipal solid wastes of Antakya) were well mixed with 1.5 ton bay leaves and 1 ton barnyard manure resulting in a heap of 1.5 meter height in the corner of a field. During the period of decomposition, the moisture content of the mixture was kept between 30-40%. The compost heap was mixed twice a month. Temperature values, ranged between 50-55 °C at the beginning, sometimes reached up to 70-75 °C in 50 cm heap depth, approximately. The composting process was continued for 4 months (mid-May-mid-September). The samples taken at the end of the composting process were analyzed in the laboratories in Turkey and Germany.

Later on, field experiments were carried out by planting tomato and wheat crops in Amik Plain, Turkey. In these experiments, applications of traditional commercial fertilizer (160kg N/ha and 80 kg P<sub>2</sub>O<sub>5</sub>/ha for wheat; 105 kg N/ha and 80 kg P<sub>2</sub>O<sub>5</sub>/ha for tomato), 20, 40, 60, 80 ton/ha compost and 80 ton/ha barnyard manure and control were compared. The experimental design was randomised blocks with three replications.

Disturbed and undisturbed soil samples were taken from two different depths (0-10 and 10-20 cm) in the research plots and analyzed to investigate the effects of composted materials on some physical and chemical properties of the soils.

## RESULTS and DISCUSSION

The finished compost produced was analyzed for both its fertilizer value as well as any potential contamination that might limit the product's use.

As a result of analysis, the quality of the compost was found in an applicable form (Table 1).

Table 1. Physico-chemical characterization of the municipal compost

Properties	Content/Value	Properties	Content/Value
Gravimetric water content	30 %	Na	0.236 %
pH (in water) (1:1)	7.33	Si	0.224 %
Electrical Conductivity	11.04 mS/cm	Fe	0.640 %
Total Soluble Salts	0.33 %	Cd	0.39 ppm
Oxidable organic matter	30.8 %	Pb	10.05 ppm
Total N	1.160 %	Cu	13.95 ppm
P	0.102 %	Zn	127 ppm
K	0.524 %	Mn	323 ppm
S	0.112 %	Ni	155 ppm
Ca	2.442 %	B	36.30 ppm
Mg	2.031 %	Cr	68.50 ppm

According to the results of a two-year field experiment of wheat, compared to the control, the increases of the grain yield by the application of commercial (chemical) fertilizer, different doses of compost and barnyard (animal) manure were determined as 21%, 18-29% and 32%, respectively. In the case of tomato experiment, compared to the control, the increases of the yield by the application of commercial fertilizer, different doses of the compost and barnyard manure were determined as 61%, 39-107% and 54%, respectively (Table 2).

Due to the increased compost rate, the bulk density values tended to decrease gradually in the upper layers of the soil. Similarly, those values were found lower in the animal manure treatments according to the control. The total porosity values, especially for 0-10 cm layer, increased due to organic matter application. The highest rate of compost and animal manure application resulted in 2-3 % net increase in total porosity. In comparison with the control, the compost treatments and animal manure increased the available water content noticeably due to the increased field capacity. The compost application increased the amount of available water by 2.3 % in some plots (Table 3 and 4).

Table 2. Effects of chemical fertilizer, compost and animal manure treatments on crop yield

Treatments*	Wheat (kg/ha)			Tomato (kg/plot)		
	Year		Average increase (%)	Year		Average increase (%)
	1998	1999		1998	1999	
K0	3447	1433	-	9.275	9.283	-
CF	3846	1862	20.77	15.681	14.213	61.08
K2	3745	2147	29.24	15.390	14.023	58.49
K4	3813	2005	25.28	12.435	13.363	39.01
K6	3920	1613	13.14	16.674	16.150	76.87
K8	3889	1765	18.00	23.942	14.393	106.59
A8	3947	2152	32.36	16.210	12.326	53.78

\*K0: Control K2: 20 tons compost/ha

K4: 40 " "

K6: 60 " "

K8: 80 " "

A8: 80 tons animal manure/ha

CF: Chemical fertilizer (160 kg N and 80 kg P<sub>2</sub>O<sub>5</sub>/ha for Wheat; 105 kg N and 80 kg P<sub>2</sub>O<sub>5</sub>/ha for Tomato)

The decreases in pH values matched well with the higher compost rate applications. It was also observed that the compost and animal manure increased the total soluble salt content slightly. In the plots to where garbage compost and animal manure were applied, organic matter content was found to be considerable high. This increase was notable in the upper layer of 0-10 cm with the increasing level from 1.13 % to 1.98 % in the wheat plots, and from 1.09 % to 1.76 % in the tomato plots (Table 3 and 4). Similar results were reported by other researchers (Guerreo et al., 1999; Kowald et al., 1990; Yalcuk, 1984).

Table 3. Effects of compost and animal manure treatments on some soil properties in wheat plots.

Soil properties	Soil depth (cm)	Treatments			
		K0	K4	K8	A8
Textural class	0-10	C	C	C	C
	10-20	C	C	C	C
Dry bulk density (gr/cm <sup>3</sup> )	0-10	1.41	1.40	1.28	1.34
	10-20	1.40	1.39	1.33	1.38
Total porosity (%)	0-10	50.70	51.44	53.67	54.03
	10-20	51.26	51.41	54.70	51.29
Macro porosity (%)	0-10	10.70	10.49	13.14	13.72
	10-20	10.61	10.57	14.01	10.64
Field capacity (Volumetric %)	0-10	40.00	40.95	40.53	40.31
	10-20	40.65	40.84	40.69	40.65
Wilting point (Volumetric %)	0-10	26.20	26.31	26.82	25.95
	10-20	24.35	24.03	24.30	24.38
Available water (Volumetric %)	0-10	13.80	14.64	13.71	14.36
	10-20	16.30	16.81	16.39	16.27
pH (in water)	0-10	7.63	7.51	7.36	7.41
	10-20	7.58	7.59	7.59	7.58
Total soluble salts (%)	0-10	0.052	0.055	0.067	0.083
	10-20	0.055	0.061	0.055	0.070
Organik matter (%)	0-10	1.13	1.96	1.98	1.80
	10-20	1.05	1.29	1.10	1.49



Table 4. Effects of compost and animal manure treatments on some soil properties in tomato plots.

Soil properties	Soil depth (cm)	Treatments				
		K0	K4	K6	K8	A8
Textural class	0-10	SCL	SCL	SCL	SCL	SCL
	10-20	SCL	SCL	SCL	SCL	SCL
Dry bulk density (gr/cm <sup>3</sup> )	0-10	1.39	1.38	1.37	1.33	1.24
	10-20	1.48	1.48	1.44	1.45	1.42
Total porosity (%)	0-10	45.58	45.07	47.83	48.00	48.04
	10-20	45.13	46.87	46.90	47.16	47.47
Macro porosity (%)	0-10	15.45	13.75	15.02	15.00	15.09
	10-20	12.72	13.43	12.14	13.07	13.68
Field capacity (Volumetric %)	0-10	30.13	31.32	32.81	33.00	32.95
	10-20	32.41	33.44	34.76	34.09	33.79
Wilting point (Volumetric %)	0-10	17.03	16.96	17.51	17.62	17.45
	10-20	17.55	17.54	18.08	18.13	18.41
Available water (Volumetric %)	0-10	13.10	14.36	15.30	15.38	15.50
	10-20	14.86	15.90	16.68	15.96	15.38
PH (in water)	0-10	7.62	7.60	7.60	7.54	7.61
	10-20	7.59	7.55	7.51	7.48	7.56
Total soluble salts (%)	0-10	0.045	0.047	0.050	0.051	0.056
	10-20	0.046	0.045	0.048	0.048	0.047
Organic matter (%)	0-10	1.09	1.31	1.72	1.76	1.54
	10-20	1.00	1.22	1.25	1.29	1.17

## REFERENCES

- Gajdos, R. (1997). Product- oriented composting: from open to closed bioconversion systems. Acta Universitatis Agriculturae Sueciae. Agraria, No:68, Alnarp, SWEDEN, 62 p.
- Golueke, C.G., Diaz, L.F. (1990). Understanding the basics of composting. BioCycle, April 1990: 56-59.
- Goto, S., Chino, M., Yamagishi, J., Kumazawa, K. (1997). Heavy metal accumulation in soil associated with long-term application of sewage sludge compost. Japanese Journal of Soil Science and Plant Nutrition, 68(2): 156-162.
- Guerrero, C., Solera, J.M., Gomez, I., Moral, R., Navarro-Pedraño, J., Beneyto, J.M. (1999). Effects of municipal solid wastes compost application in the evolution of micronutrients in a soil affected by forest fire (poster). Soil with Mediterranean Type of Climate, 6<sup>th</sup> International Meeting, BARCELONA, 4-9 July 1999.
- Kovancı, İ., Haker'ler, H., Oktay, M. (1984). İzmir Halkapınar çöp fabrikasında üretilen ham çöp kompostlarının olgunlaştırma yöntemleri ve bunların içerdiği besin maddeleri kapsamının aylık ve mevsimsel değişimleri üzerinde araştırmalar. TÜBİTAK-TOAG, Proje No: TOAG-451 (Kesin Rapor), 75 s.
- Kowald, R., Yardımcı, N., Şahin, H. (1990). Erzurum'da çöp kompostu üretimi ve kullanımı üzerine bir araştırma. Giessen Justus-Liebig Üniversitesi, Landeskultur Enstitüsü.
- Porter, J. W. (1989). Waste management: A look to the future. Journal WPCF, 61 (5): 600-604.
- Richard, T., Chadsey, M. (1990). Environmental impact on yard waste composting. BioCycle, April 1990: 42-46.
- Spencer, R. (1990). Food waste composting in Canada. BioCycle, June 1990: 30-32.
- Yalçuk, H. (1984). İzmir ili çöplerinin işlenmesi ile elde edilen gübrenin toprakların bazı fiziksel ve kimyasal özellikleri üzerine etkisi (Doktora). Menemen Bölge Topraksu Araştırma Enstitüsü Müdürlüğü Yayınları. Genel Yayın No: 104, Rapor Serisi No: 67, 81 s.



# DETERMINATION OF THE EFFECT OF THE SLUDGE FROM WASTE WATER TREATMENT STATION NEAR SOFIA-CITY FERTILIZER

Svetla Morinova Garvanska

N.Poushkarov Institute of Soil Science and Agro-ecology, 1080 Sofia, Bulgaria,  
E-Mail: [marinov@ie.bas.bg](mailto:marinov@ie.bas.bg), fax. (+359 2) 24-89-37; 7, Highway Bankya Street

## ABSTRACT

For determination of the effect of the sludge from the waste waters treatment stations as a fertilizer is made field experiment on the experimental place of the village Coubratovo, near Sofia-city's waste waters treatment station. The type of the soil is alluvium-meadow. The experiment is made with silage maize as a mono-plant for about seven years by using of different norms of sludge in pure state and on the background of mineral fertilization. Every year is sent sludge into the soil from the vacuum-filter of the waste waters treatment station near Sofia-city and it is analyzed for the content of the basic micro- and macro-elements and heavy metals, using standard methods. By the harvesting of the silage maize we have regular determined the crop yield production and analyzed this production.

## INTRODUCTION

Relating to the building of many waste water treatment stations was necessary to study the characteristics of the sludge. The sludge is concentrated in the area of the waste waters treatment stations and makes their work difficulty. Sludge is bio-matter rich on micro- and macro-elements and they can be used in the agriculture keeping some requirements relating on the heavy metals and micro-elements, which can pollute the environment.

The agro-chemical and the chemical estimation of the sludge determines its ability and its richness for the plants. It is necessary to make additional studies for determination of the effect of the sludge as a fertilizer for different agriculture plants.

We have made different field and green-house experiments with sludge. In our paper we will show our study over the effect of the sludge from the waste waters treatment station in Sofia-city as a fertilizer. We have made field experiments in the experimental field in Coubratovo-village over alluvium-meadow soils. We have studied the vegetable and earthed-up crops for long time period – seven years. We have studied the physical, chemical and microbiological changes in the soil, the chemical nutrition of the crop yield production etc.

## MATERIAL AND METHODS

The aim of that study is to determine the effect of the sludge from the waste waters treatment station near Sofia-city as a fertilizer by the field experiments and for the cultivation of the vegetable plants. The period of study is seven years over the alluvium-meadow soils in the experimental field in Coubratovo-village near the waste waters treatment station. We have used sludge, taken from the vacuum-filter of the Sofia-city's waste waters treatment station and we have sent it every year into the soil by the autumn treatment of the soil. We have studied 2, 4 and 6 MT/dca sludge in pure condition and on the background of mineral fertilization, and two controls – pure soil and NPK. Before the sending of the sludge we have analyzed it for the content of the basic micro- and macro-elements and heavy metals. And have used standard methods. The experimental area is 60 sq. m with 3 time repetition. By the harvesting of the vegetables we have estimated the crop production and we have analyzed the crop yield production for the content of micro-and macro-elements and heavy metals using the standard methods.

## RESULTS AND DISCUSSION

On the table 1 is shown the chemical characteristic of sludge from waste waters treatment station near Sofia-city, which is taken into the soil every year in the autumn by the deep soil cultivation. for the period 1986 – 1994. From the data it is shown, that they are no heavy metals in concentrations over the limited.

**CHEMICAL CHARACTERISTIC OF SLUDGE FROM THE VACUUM-FILTER  
FROM WASTE WATERS TREATMENT STATION NEAR SOFIA-CITY  
USED BY THE EXPERIMENTS IN THE EXPERIMENTAL FIELD BY  
COUBRATOVO-VILLAGE PER YEARS**

Table 1.

Parameters	1986	1987	1988	1989	1990	1991	1992	1993
Abs. Dry matter %	56,03	no	86,53	63,82	54,15	66,70	no	19.34
Ashes	87,37	sludge	86,10	70,35	79,31	38,05	sludge	44,73
Ammonium N %	0,08	sent	0,02	0,05	0,01	0,03	sent	0,39
Common N %	0,43	into	0,4	0,8	0,74	0,69	into	0,89
Common P <sub>2</sub> O <sub>5</sub> %	0,36	the	0,27	0,1	0,96	0,87	the	0,12
Common K <sub>2</sub> O %	0,12	soil	0,37	0,15	0,11	0,22	soil	0,09
Na %	0,02		0,05	0,06	0,08	0,05		0,04
Mg %	0,24		0,34	0,2	0,89	0,19		0,11
Ca %	1,71		0,39	0,46	0,58	0,64		0,7
n mg/kg dry matte	815		579	475	1237	1212		2000
Cu	88		161	281	294	239		710
Mn	168		675	150	330	314		460
Co	6		5	13	0	7		8
Pb	81		92	69	110	120		237
Ni	18		50	25	0	50		40
Cd	5		8	3	22	15		12
Cr	96		292	78	320	350		396
Fe	10943		34250	-	-	-		-
pH	11,9		8,5	8,8	11,1	8,9		9,2

On the table it is shown, that the first group of the cultivated plants, the lettuce, the cabbage and the potato developed good (table 2). We have shown the positive trends for all cultivated plants. The crop yield production by the control is lower, after that is the crop production from sludge and higher are the crop production by the mineral fertilization. This is normal, because of the mineral fertilization is sent into the soil in soluble condition and can be taken from the plants in the year of the sending into the soil.

By the next period 1991 – 1994 we have studied another vegetables – carrots, pumpkins for cooking, pumpkins, beans and okra. The results for the studied years (table 3) show, that the influence of the fertilization with sludge gives higher crop production – probably as a result of long-term accumulation of sludge from the years before and the mineralisation of the organic matter. It is shown trends of increase of the crop with the years, probably with the influence of the climate in the years.

The results of the plant analyze of the different plants are shown on the table 4.

The first tree cultivated vegetable plants the most of the nitrogen was taken from the lettuce, by all studied variants and years. On the second place are the cabbage and on the end – the potato. The ratio P, K by the lettuce, the cabbage and the potato has no considerable difference.

Na, Mg and Ca are necessary for the development of the plants by the whole period of the vegetation in minimal quantities. The values of the Mg are relative the same and are not different by the variants. The Ca increases its values relative low. The highest is the content of Ca by the variants with mineral fertilization. From the microelements we show use of Zn, Mg



from the vegetables – lettuce and cabbage. The potato is not so moderated in that condition. The same is for the Fe too.

Middle Crop Production in years and plants by the field experiment in Coubratovo-village

Table 2.

Variants	19 87		19 88		19 89		Middle
	kg/dca	Rel.prod.	kg/dca	Rel.prod.	kg/dca	Rel.prod.	
Lettuce							
Controle	5461	100%	3893	100%	4241	100%	4532
NPK	6030	110,4 %	5431	139,5 %	6378	150,4 %	5946
Sludge - 4T/dca	5943	108,8 %	4369	112,2 %	5452	128,5 %	5255

GD 10% 275,3 2003,4

GD 5 % 358,6 2609,1

GD 1% 594,6 4326,7

GD 0,1 % 1112,1 8091,6

Variants	19 87		19 88		19 89		Middle
	kg/dca	Rel.prod.	kg/dca	Rel.prod.	kg/dca	Rel.prod.	
Cabbage							
Controle	4674	100%	6152	100%	5756	100%	6861
NPK	5570	119,7 %	8079	128,5 %	7402	95,4 %	7817
Sludge - 4T/dca	5796	124,5 %	75221	104,5 %	6667	98,8 %	7328

GD 10% 1803,4 677,7

GD 5 % 2356,5 882,6

GD 1% 3907,8 1463,7

GD 0,1 % 7308,2 2737,3

Variants	19 87		19 88		19 89		Middle
	kg/dca	Rel.prod.	kg/dca	Rel.prod.	kg/dca	Rel.prod.	
Potato							
Controle	1815	100%	2765	100%	1165	100%	1915
NPK	3088	170,1 %	4458	161,2	1258	107,9	2935
Sludge - 4T/dca	2455	135,3	3923	141,8	1173	100,7 %	2517
GD 10%	2455	135,3	3923	141,8	1173	100,7 %	2517

GD 10% 342 332,4

GD 5 % 445,4 433

GD 1% 738,6 718

GD 0,1 % 1381,3 1342

NPK is N18P16K16

After tree years period this vegetables are changed with carrot, pumpkins, spinach, pumpkins for cooking, beans and okra.

By the pumpkins for cooking the values for the nitrogen (table 4) are relative nearly by the variants and increase. The phosphorus is not relative different in the years. The changes of the Ca are low. The Na has the same trends. The Mg too. From the microelements the changes of the values are shown in the third year. For Mg and for the Cu. There are no essential changes for the Fe. The Pb, Cd, Cr and Ni are shown as microelements.



The carrots are studied only two years – 1991 and 1992. The content of common nitrogen is low and increases in the second year, relative good by mineral fertilization. On contemporary, the phosphorus content decreases about 3 time. The K increases by the variants with mineral fertilization double.

### Middle Crop Production from the Experimental Field in Coubratovo - village

Table 3

Variants	1991 kg/dca			1992 kg/dca			1993 kg/dca			1994 kg/dca		
	carrot	pumpkins	spinach	pumpkins	pumpkin-cook.	carrot	bean	pumpkins	pumpkin-cook.	green beans	okra	pumpkin
Control	232	2207	no	1117	1518	200	no	1000	1180	175	133	250
NPK	371	2431	no	2600	1842	425	no	1620	1132	192	143	650
Sludge	687	4694	no	1333	2627	500	no	1900	1180	183	205	830

Sludge 4 T/dca  
NPK N18P16K16

In the year 1992 has the control higher content of Mn, Fe, which can be explained with the relative low crop production of carrots. The heavy metal content in all variants corresponds to the normal values, and in some cases lower. They don't show the accumulation in the years. For examples the yearly increase of the Zn in the soil by the variant with sludge from the waste waters treatment station near Sofia-city, is between 7 and 8 mg/kg. The sending of Zn into the soil for 6 years is about 45 mg/kg without any influence over the value of the Zn in the production.

The analyze of the spinach shows, that the N and P content is higher in the control, which is difficult to be explained. The values of the K are higher by the tree variants. The spinach has the ability to save to accumulate the heavy metals in the crop production, and can be used as a katalyator for cleaning of the soil.

The white pumpkins are cultivated in the years 1992 and 1994. In the year 1992 it is shown high content of common nitrogen by the variant 2,3 with mineral fertilization and sludge. The phosphorus content is relative low. K increases by the variant with mineral fertilization and sludge.

The green bean was cultivated in the years 1993 and 1994. The content of N is high by all the variants, for K are shown high values. The values of P is low. Zn, Cu and Mn have no changes in comparison to the control.

### References

1. Marinova, S., "Condition, characteristic and utilization of sludge from Stations for biological purification of sewage sludge", Intern. Conference "Wasteless Technologies", 1986, Budapest, Hungary.
2. Marinova, S., etc., "The sludge from Purificating station of the Bourgas-city - characteristic and use related to the Environment". Eco-92, Bourgas, Bulgaria, International Symposium, 1992.

CHEMICAL CHARACTERISTIC OF PLANT SAMPLES FROM CABBAGE, POTATOS, LETTUCE, CARROTS, PUMPKINS,  
PUMPKINS FOR COOKING, GREEN BEANS, AND OKRA FROM THE FIELD EXPERIMENT IN THE EXPERIMENTAL FIELD IN  
COUBRATOVO-VILLAGE IN DRY CONDITION /MIDDLE VALUES/

Table 4.

Table 4.																													
VARIANTS		N		D		Ê		Na		Mg		Na		mg / 1 000 g PLANT MATTER															
		%		%		%		%		%		%																	
1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
CABBAGE 1987, 1988, 1989 ã.																													
1. Control		2.28		0.60		3.69		0.49		0.14		0.21		14		16		7		71		0.15		0.04		0.22		-	
2. N18 D16 Ê16		3.43		0.24		3.55		0.58		0.14		0.23		16		22		9		57		0.23		0.06		0.29		-	
3. Sludge-4t/dka		2.83		0.67		4.06		0.72		0.16		0.21		18		21		10		60		0.16		0.05		0.30		-	
POTATOES 1987, 1988, 1989 ã.																													
1. Control		1.55		0.68		2.15		0.05		0.12		0.04		17		4		5		54		0.25		0.05		0.22		-	
2. N18 D16 Ê16		1.82		0.75		2.36		0.05		0.11		0.03		20		6		8		89		0.33		0.05		0.21		-	
3. Sludge-4t/dka		1.61		0.76		2.56		0.04		0.11		0.02		20		6		8		81		0.26		0.05		0.17		-	
LETTUCE 1987, 1988, 1989 ã.																													
1. Control		3.05		0.83		4.32		0.56		0.38		0.40		47		55		7		429		0.27		0.13		-		0.01	
2. N18 D16 Ê16		3.25		0.83		4.47		0.76		0.51		0.49		55		80		8		462		0.30		0.13		-		0.03	
3. Sludge-4t/dka		3.66		0.72		5.04		0.69		0.35		0.48		61		59		10		446		0.33		0.14		-		0.02	
CARROTS 1991, 1992 ã.																													
1. Control		0.57		0.11		1.41		0.15		0.07		0.25		12		3		3		153		0.23		0.10		0.20		0.13	
2. N18 D16 Ê16		0.71		0.12		2.11		0.26		0.09		0.45		20		3		4		151		0.40		0.10		0.46		0.13	
3. Sludge-4t/dka		0.73		0.16		1.71		0.23		0.07		0.21		21		3		4		154		0.40		0.30		0.36		0.13	

SPINACH 1991 ā.														
1. Control	0.48	0.47	3.60	0.46	0.29	1.21	7	160	1	4005	9	0.40	2	1
2. N <sub>18</sub> Ð <sub>16</sub> Ē <sub>16</sub>	0.90	0.40	3.30	0.20	0.68	1.20	8	194	2	7300	10	0.30	3	2
3. Sludge-4t/dka	0.72	0.40	2.20	0.32	0.78	1.81	10	180	1	5155	12	0.50	2	2
PUMPKINS FOR COOKING 1991, 1992, 1993 ā.														
1. Control	1.64	0.38	2.83	0.31	0.25	0.23	37	10	9	135	0.03	-	0.60	0.13
2. N <sub>18</sub> Ð <sub>16</sub> Ē <sub>16</sub>	1.93	0.34	2.80	0.32	0.25	0.36	38	10	10	201	0.03	-	0.96	0.20
3. Sludge-4t/dka	1.75	0.38	2.88	0.29	0.22	0.30	44	11	10	165	0.03	-	1.00	0.16
PUMPKINS 1992, 1994 ā.														
1. Control	1.46	0.08	1.72	0.29	0.12	0.06	20	3	3	46	0.25	0.11	0.40	ñě.
2. N <sub>18</sub> Ð <sub>16</sub> Ē <sub>16</sub>	2.75	0.17	3.22	0.66	0.29	0.07	42	12	7	118	0.40	0.20	2.00	ñě.
3. Sludge-4t/dka	1.91	0.19	3.00	0.55	0.27	0.06	40	13	9	85	0.50	0.50	2.20	ñě.
GREEN BEANS 1993, 1994 ā.														
1. Control	3.69	0.46	2.72	0.49	0.28	0.03	45	20	14	160	0.15	-	1	-
2. N <sub>18</sub> Ð <sub>16</sub> Ē <sub>16</sub>	3.80	0.49	2.90	0.47	0.28	0.04	45	21	8	145	0.70	-	1	-
3. Sludge-4t/dka	3.88	0.47	2.92	0.45	0.28	0.02	50	19	13	130	0.80	-	1	-
OKRA 1994 ā.														
1. Control	2.40	0.47	2.00	0.56	0.30	0.01	52	13	1	50	0.20	0.20	1.10	ñě.
2. N <sub>18</sub> Ð <sub>16</sub> Ē <sub>16</sub>	2.40	0.44	2.75	0.61	0.29	0.01	58	12	4	60	0.30	0.20	1.10	ñě.
3. Sludge-4t/dka	2.51	0.46	2.60	0.64	0.29	0.01	70	15	8	70	0.30	0.30	1.10	ñě.



# INVESTIGATIONS ON SEWAGE SLUDGES: CHEMICAL COMPOSITION AND EFFECTS ON SOME CHEMICAL PROPERTIES OF SOIL

Seyiñc Arcak<sup>1</sup> Ayten Karaca<sup>1</sup> Koray Haktanir<sup>1</sup>

<sup>1</sup>Soil Science Department, Faculty of Agriculture, Ankara University, Ankara

## ABSTRACT

Wastewater sludge has for many years posed disposal problems. Its content of N, P and organic matter makes it a very valuable fertilizer and soil amendment material. Wastewater sludges often contain relatively high concentrations of certain heavy metals compared with the amounts found unpolluted soils. However, amounts in wastewater sludge are frequently in proportion to the degree of industrialization of the area that the municipal wastewater treatment plant serves. When sludge from plant treating industrial wastewater is applied to land, the ability of soil to bind heavy metals and accumulate them in plant rooting zones raises a serious question as to the influence of the more soluble metals on biological life and activities in soils. In our country where environmental awareness is developing and rapid industrialization occurs, wastewater treatment facilities is growing up in number resulting in a huge amount of sewage sludge of secondary wastes. This increase in secondary wastes direct researches towards studies with regard to the problems, attributes and utilization possibilities of the material. The purpose of this work was to determine the effect of the continuous applications of digested municipal sludge originating from ASKI (Ankara Central Wastewater Treatment Plant) to soil. Within the context of the study, physical and chemical properties by setting incubation trials were determined. Following the incubation periods of 1, 7, 14, 28, 42, 56, 70, 105 and 140 days of soil samples which were mixed with certain rates of sludge (control, 20, 40, 80, and 160 t ha<sup>-1</sup>) samples were analyzed for the determination of electrical conductivity, pH, ortho-P, NH<sub>4</sub><sup>+</sup>-N, NO<sub>3</sub><sup>-</sup>-N, extractable Fe, Zn, Cu, Mn, Co, Ni, and Cd. High NH<sub>4</sub><sup>+</sup>-N value obtained at the first two weeks of the incubation brought about increase in pH values. The application of sewage sludge significantly increased the NH<sub>4</sub><sup>+</sup>-N, available Cd and Zn the differences being greater for the highest rates of sewage sludge applied.

## INTRODUCTION

Sewage sludges consist of multi-element organic wastes that are used commonly as manures (Ottabang et al., 1997). Sludges applications to most agricultural soils are regulated by various guidelines and regulations, and these are usually based on the heavy metal concentrations in the sludges (Alloway and Jackson, 1991).

Waste application on agricultural lands, however, has caused concerns. It is often argued that heavy metals such as cadmium (Cd), nickel (Ni) or lead (Pb) in sludge, when applied to soils, may enter the food chain through plants or animals, contaminate surface and ground water, and thus cause health hazards (Hue et al., 1994). In reality, metal concentrations in sewage sludge vary widely (Sommers, 1977), depending on several factors, including (1) sludge origin (e.g., industrial wastes usually contain high levels of heavy metals than residential wastes), and (2) sludge pretreatment processes (e.g., raw v.s. anaerobically treated). In addition, when applied to soils, the bioavailability of sludge-borne metals is further influenced by soil properties (e.g., pH, sesquioxide content, organic matter) as well as sludge application rate (Sommers et al., 1987; Logan and Chaney, 1983). This explains the lack of metal accumulation in plants grown on certain sludge-amended soils and the beneficial effects of sludge on soil fertility and plant nutrition (Hue, 1988; Corey et al., 1987; Chang et al., 1978). Given this background, a better understanding of the basic chemistry of wastes and their interactions with soil will help sludge managers make intelligent decisions on the use of sludges on lands (Hue et al., 1994). Thus, the objectives of this study were (1) to determine the chemical composition of sewage sludge from Ankara Central Wastewater Treatment Plant and (2) to evaluate sludge/soil interactions.

## MATERIALS and METHODS

### Soil and Sludge Description:

The soil used was a clay taken from Sincan-Tatlar village near Ankara. The sewage sludge used in this experiment from a domestic source on Ankara, was digested and dried before being used. Sewage sludge and soil were air dried and sieved (>2 mm) before analysis.

### Experimental Design:

The soil was amended with sewage sludge. Sewage sludge was applied at four rates: 20, 40, 80, and 160 t ha<sup>-1</sup>. Control is established (soil) and five treatments were carried out. For each treatment three replications were done. Each pot consisted of 300g of coarsely sieved soil with various amendments. The water content of the soil was adjusted to 70% of field capacity. The pots were placed in an incubator at 28 °C. Throughout the incubation period, water losses exceeding 10% of the initial values were compensated for by addition of distilled water.

### Sampling and Analysis:

Samples were taken at 1, 7, 14, 28, 42, 56, 70, 105, and 140 days of the incubation period for the following analyses. For each sample, pH and electrical conductivity (EC) were measured in a 1:2.5 water extract (Richards, 1954); organic material by using modified Walkley-Black Method (Jackson, 1962); grain size distribution by Bouyoucos (1951); soil cation exchange capacity (CEC) was determined by saturation with ammonium acetate at pH 7 (Chapman, 1965); soil available P was extracted with sodium bicarbonate (Olsen et al., 1954) and the content determined by the Murphy and Riley method (Murphy and Riley, 1962). Total nitrogen was assessed using the Kjeldahl method, as specified by Bremner (1965). For NH<sub>4</sub><sup>+</sup>-N and NO<sub>3</sub><sup>-</sup>-N, moist soil was placed in 150 ml Erlenmeyer flasks with 100ml of 2M KCl. Flasks were placed on a rotary shaker for 30 min and contents filtered through whatman filter paper No. 42. Soil extracts were used for the measurement of NH<sub>4</sub><sup>+</sup>-N and NO<sub>3</sub><sup>-</sup>-N by steam distillation using MgO and Devarda's alloy (Bremner, 1965). Soil samples were extracted for available Fe, Cu, Zn, Mn, Co, Ni, and Cd in DTPA solution (0.005M DTPA+0.005M CaCl<sub>2</sub>+0.1M TEA (triethanolamine) pH 7.3), (Lindsay and Norvell, 1978). All the solutions of Fe, Zn, Cu, Mn, Co, Ni, and Cd were analyzed by atomic absorption spectrophotometer (AAS) with flame or graphite furnace when required.

## RESULTS and DISCUSSION

The physical and chemical characteristics of the sludge and soil are shown in Table 1. The sewage sludge was slightly alkaline (pH 7.08). The soil had a pH of 7.90. Sewage sludge and soil gave the moderate values of conductivity (2.10 and 0.49 dSm<sup>-1</sup>, respectively). Digested sludge possessed a relatively high content of organic carbon (14.2 %) and the soil had a lower content (0.70 %), as expected. In terms of basic nutrients, such as total nitrogen and extractable phosphate, the sewage sludge had the moderate levels. Table 1 list the extractable contents of various heavy metals. In general, sludge contained lower levels of extractability metals.

**Table 1.** Selected physical and chemical properties and extractable Fe, Cu, Zn, Mn, Ni, Co, and Cd amounts of the soil and sewage sludge samples

	PH	EC	O.M.	C	CEC	P	N	Sand	Silt	Clay
	1:2.5	dSm <sup>-1</sup>	%	%	cmolg <sup>-1</sup>	mgkg <sup>-1</sup>	%	%	%	%
Soil	7.90	0.49	1.21	0.70	30.00	17.48	0.13	15.00	35.00	50.00
S.Sludge	7.08	2.10	25.00	14.20	67.00	581.00	1.54	-	-	-

	Fe	Cu	Zn	Mn	Ni	Co	Cd
	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>
Soil	4.75	2.15	0.35	8.18	0.78	0.17	0.075
S.sludge	28.80	14.40	109.00	72.50	1.47	0.53	0.12

O.M., organic matter; CEC, cation exchange capacity; P, available phosphate; N, total nitrogen



The effects of adding waste materials to the soil properties are illustrated in Table 2, 3, 4, 5, and 6. During the incubation period, pH is slowly decreased and the differences are not significant at the higher rates. The values of EC were raised after addition of the wastes and higher levels were obtained with higher application rates (Table 2). Till the 7<sup>th</sup> day of the incubation there was no statistically significant increase both in the control and the increased sludge-added pots. However, as for the 14<sup>th</sup> day of incubation, depending on doses, considerable increase was observed in EC values of the soils ( $P < 0.05$ ).

Table 2. pH and EC extracted from soil as affected by sewage sludge amendments

Inc. Time (days)	pH					EC				
	0	20	40	80	160	0	20	40	80	160
1	7.90 ns	8.01 ns	8.02 ns	8.00 ns	7.97 ns	0.49 a	0.49 a	0.49 a	0.49 a	0.49 a
7	7.90 ns	7.91 ns	7.99 ns	7.95 ns	7.95 ns	0.54 b	0.48 b	0.62 a	0.49 b	0.52 b
14	7.92 ns	7.94 ns	7.75 ns	7.97 ns	7.97 ns	0.76 d	0.92 c	0.98 c	1.24 b	1.36 a
28	7.97 ns	7.90 ns	7.90 ns	7.97 ns	7.97 ns	0.36 c	0.40 c	0.46 c	0.53 b	0.73 a
42	7.93 ns	7.98 ns	7.92 ns	7.88 ns	7.86 ns	0.33 d	0.43 c	0.51 bc	0.57 b	0.83 a
56	7.77 ns	7.74 ns	7.76 ns	7.68 ns	7.63 ns	0.32 c	0.38 b	0.46 b	0.46 b	0.85 a
70	7.65 ns	7.72 ns	7.47 ns	7.40 ns	7.48 ns	0.30 c	0.37 b	0.42 b	0.45 b	0.78 a
105	7.62 ns	7.60 ns	7.44 ns	7.38 ns	7.42 ns	0.26 c	0.34 b	0.37 b	0.42 b	0.73 a
140	7.60 ns	7.50 ns	7.33 ns	7.33 ns	7.09 ns	0.31 c	0.33 c	0.39 b	0.47 b	0.69 a

LSD= 0.104

EC expressed as  $\text{dSm}^{-1}$ , Inc. time, incubation time (day); 0, control; 20, 40, 80, and 160, doses of each sewage sludge as expressed  $\text{t ha}^{-1}$ . Significant differences between doses at  $P < 0.05$  level indicated by different letters.

Tables 3, 4, and 5 list the extractable metal contents of the clayey soil after applications of various sludge levels. Application of sludge, especially at higher application rates, generally raised the extractable concentrations of heavy metals of the clayey soil. During the incubation period, depending on increased sludge doses, available Cd increased in the sludge-added soils in comparison to the control ( $P < 0.05$ , Table 3).

Table 3. Extractable Cd and phosphorus extracted from soil as affected by sewage sludge amendments ( $\text{mg kg}^{-1}$ )

Inc. Time (days)	Phosphorus					Cd				
	0	20	40	80	160	0	20	40	80	160
1	17.50 c	30.53 c	37.80 c	57.07 b	79.53 a	0.074 b	0.074 b	0.082 b	0.086 b	0.096 a
7	22.00 c	51.33 d	95.33 c	125.33 b	234.67 a	0.067 b	0.082 a	0.085 a	0.090 a	0.093 a
14	32.60 c	60.73 d	71.53 c	89.20 b	108.93 a	0.061 b	0.085 a	0.086 a	0.089 a	0.094 a
28	30.73 b	50.13 b	63.47 a	62.13 a	77.60 a	0.068 d	0.086 c	0.092 b	0.100 a	0.106 a
42	17.47 c	31.40 bc	46.8 b	49.93 b	70.80 a	0.074 d	0.087 c	0.095 c	0.110 b	0.128 a
56	4.67 d	9.93 cd	29.47 b	24.80 c	71.20 a	0.072 c	0.087 b	0.091 b	0.117 a	0.164 c
70	4.60 c	9.10 c	21.10 b	24.23 b	48.67 a	0.071 c	0.083 c	0.089 c	0.101 b	0.166 a
105	4.54 b	8.93 b	17.45 b	20.06 a	37.21 a	0.070 c	0.080 c	0.086 c	0.105 b	0.180 a
140	5.34 a	7.91 a	10.34 a	12.12 a	20.52 a	0.074 c	0.081 b	0.083 b	0.090 b	0.190 a

LSD= 0.1766

LSD= 0.0102

Inc. time, incubation time (day); 0, control; 20, 40, 80, and 160 doses of each sewage sludge as expressed  $\text{t ha}^{-1}$ . Significant differences between doses at  $P < 0.05$  level indicated by different letters.

It was observed that the extractability of Cu increased with the addition of sewage sludge ( $P < 0.05$ , Table 4). The extractable Zn content increased when the sludges were added to the soil, because the Zn content was higher than that of the soil (Table 4). At the beginning of the experiment (sample time 1) the samples were not humified. This Zn fraction decreased during the



experiment in soil presumably due to the insolubilization with time of the Zn released in the degradation of organic matter (Hernandez et al., 1990).

Until the 56<sup>th</sup> day extractable Mn and Ni increased depending on the increased sludge doses ( $P < 0.05$ , Table 5). At the first day of incubation, extractable Co increased depending on the increased doses ( $P < 0.05$ , Table 5), however, differences between the control and the doses were found statistically insignificant in the other incubation times.

Amounts of  $\text{NH}_4^+\text{-N}$  and  $\text{NO}_3^-\text{-N}$  during the incubation of the soil mixed with sewage sludge are shown in Table 6. Depending on the incubation period and the increased doses, there was considerable changes in  $\text{NH}_4^+\text{-N}$  of the sludge-added soils. The highest  $\text{NH}_4^+\text{-N}$  amounts was determined in soils being applied the highest sludge of  $160 \text{ t ha}^{-1}$  ( $P < 0.05$ ).  $\text{NH}_4^+\text{-N}$  of the control samples reached their peak level at the 14<sup>th</sup> day of the incubation, then, gradually decreased depending on the incubation time.  $\text{NH}_4^+\text{-N}$  levels in the samples being applied different doses of sludges continuously decreased due to  $\text{NH}_4^+$  oxidation till the 70<sup>th</sup> day of the incubation. Sludge application at the  $80 \text{ t ha}^{-1}$  level retarded nitrification. This may be due to the high concentration of ammonia which accumulated in the soil (Justice and Smith, 1962).

Yoneyama and Yoshida (1978) have reported that the high amount of ammonia appears to retard the oxidation of ammonia to nitrite, and a similar amount than that may depress the oxidation of nitrite to nitrate; thus resulting in an accumulation of nitrite in the soil.

As decreased in this, the application of a large amount of sewage sludges may cause the accumulation of ammonia, nitrite or nitrate in high concentration, and the excessive inorganic nitrogen may be reduced to a suitable extent by a simultaneous application of organic matter low in nitrogen content.

Depending on doses and time  $\text{NO}_3^-\text{-N}$  increased in the soils being added sewage sludge until the 28<sup>th</sup> day ( $P < 0.05$ ).  $\text{NO}_3^-\text{-N}$  showing decrease till the 105<sup>th</sup> day of incubation increased at the 105<sup>th</sup> day, then decreased again at the last day of the incubation.

Table 6.  $\text{NH}_4^+\text{-N}$  and  $\text{NO}_3^-\text{-N}$  extracted from soil as affected by sewage sludge amendments ( $\text{mg kg}^{-1}$ )

Inc. Time (days)	$\text{NH}_4^+\text{-N}$					$\text{NO}_3^-\text{-N}$				
	0	20	40	80	160	0	20	40	80	160
1	221.13d	297.6 c	403.0 b	472.7 a	511.3 a	192.05 c	204.86 c	220.0 c	328.45b	480.29a
7	218.90d	330.0 c	499.5 b	507.8 b	1158.9 a	254.15 d	279.85 d	366.25 c	457.87 b	947.05 a
14	224.8 c	372.0 d	505.0 b	493.4 b	769.2 a	305.56 c	317.67c	560.05 a	501.75b	574.21 a
28	208.1c	252.4 b	264.3 b	233.1 bc	397.9 a	260.0 c	282.88c	366.37 b	389.49b	448.28 a
42	117.3d	166.1cd	209.7 bc	259.6 b	383.9 a	183.63 c	198.33bc	217.89bc	246.29 b	366.40 a
56	69.4 c	121.6 bc	122.1bc	126.9 b	226.3 a	115.98 b	159.60 b	161.23 b	138.86 b	283.32 a
70	47.6 b	64.1 b	65.7 b	94.7 b	155.6 a	107.07 b	155.90 a	138.86 a	130.72 a	159.97 a
105	358.3 c	360.4 c	440.4 b	525.8 a	536.3 a	671.27 c	790.8 b	836.83 a	850.85 a	870.87 a
140	92.8 b	114.1 b	147.7 a	190.2 a	160.2 a	98.74 d	142.14 c	178.15 b	209.40 a	262.92 a
LSD= 50.80					LSD= 46.76					

Inc. time, incubation time (day); 0, control; 20, 40, 80, and 160 doses of each sewage sludge as expressed  $\text{t ha}^{-1}$ .  
<sup>1</sup>. Significant differences between doses at  $P < 0.05$  level indicated by different letters.

In general, it can be said that sewage sludge applied at  $20 \text{ t ha}^{-1}$  did not a significantly increase the soluble compounds released at any time, excluding obviously  $\text{NO}_3^-\text{-N}$  (Dalmau et al., 1989). The application of sewage sludge significantly increased the  $\text{NH}_4^+\text{-N}$ , extractable Cd and Zn the differences being greater for the highest rates of sewage sludge applied.

#### ACKNOWLEDGEMENTS

This project has been supported by TUBITAK through contract No: TOGTAG-1712.

## REFERENCES

- Alloway, B.J., Jackson, A.P. (1991). The behaviour of heavy metals in sewage sludge-amended soils. *The Sci. of the Total Environ.* 100: 151-176.
- Bouyoucos, G.J. (1951). A Calibration of the Hydrometer for Making Mechanical Analysis of Soils. *Agronomy Journal* 43: 9.
- Bremner, J.M. (1965). Total Nitrogen. In *Methods of Soil Analysis 2*; (C.a. Black, Ed),. American Society of Agronomy, Madison, Wis., 1145-1178.
- Chang, A.C., Page, A.L., Lund, L.J., Pratt, P.R., Bradford, G.R. (1978). Land application of a sewage sludge-a field demonstration, final report for regional wastewater solid program. Dept. Of Soil and Environ. Sci. Univ. of California, Riverside, CA.
- Chapman, H.D. (1965). *Methods of soil analysis Part 2. Chemical microbiological properties*. Ed. C.A. Black. Amer. Soc. Of Agron. Inc. Publ. Agron. Series no: 9, Medison, Wis, USA.
- Corey, R.B., King, L.D., Lue Hing, C., Fanning, D.S., Street, J.J., Walker, J.M. (1987). In all page, T.J. Logan, and J.A. Ryan (eds). *Land application of sludge*, Lewis Publishers Inc., Chelsea, MI.
- Dalmau, J.L.I., Garau, M.A., Felipo, M.T. (1989). Laboratory prediction of soluble compounds before soil recycling of wastes. *Intern. J. Environ. Anal. Chem.*, 39: 141-146.
- Hernandez, T., Moreno, J.I., Costa, F. (1990). Influence of sewage sludge application on crop yields and heavy metal availability. *Soil Sci. Plant Nutrient.* 37(2): 201-210.
- Hue, N.V. (1988). Residual effect of sewage sludge application on plant and soil profile chemical composition. *Commun. Soil Sci. Plant Anal.* 19: 1633-1643.
- Hue, N.V., Subasinghe, A., Ranty, T.H. (1994). Sewage sludges in Hawaii: Chemical composition and reactions with soils and plants. *Water, Air and Soil Pollut.* 72: 265-283.
- Jackson, M.L. (1962). *Soil chemical analysis*. Prentice Hall Inc. Eng. Cliffs. U.S.A..
- Justice, J.K., Smith, R.L. (1962). Nitrification of ammonium sulfate in a calcareous soil as influenced by combinations of moisture, temperature and levels of added nitrogen. *Soil Sci. Soc. Am. Proc.*, 26: 246-250.
- Lindsay, W.L., Norwell, W.A. (1978). Development of a DTPA soil test for Zn, Fe, Mn and Cu. *Soil Sci. Soc. Am. J.* 42: 421-428.
- Logan, T.I., Chaney, R.L. (1983). Utilization of municipal wastewater and sludge on land-Metals. In: Page, A.L. et al., eds. *Proc workshop on utilization of municipal wastewater and sludge on land*. Riverside, CA: University of California.
- Murphy and Riley (1962). A modified single solution method for the determination of phosphate in natural waters. *Anal. Chem. Acta*, 27: 31-36.
- Otobbang, E., Sadovnikova, L., Lakimenko, O., Nilsson, I., Persson, J. (1997). Sewage sludge: soil conditioner and nutrient source. II. Availability of Cu, Zn, Pb and Cd to barley in a pot experiment. *Acta Agric. Scand., Sect. B, Soil and Plant Sci.* 47: 65-70.
- Olsen, S.R., Cole, V., Watanabe, F.S., Dean, L.B. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. Of Agr. 939. Washingt, D.C.
- Richards, L.A., ed. (1954). *Diagnosis and improvement of saline and alkali soils*. U.S.D.A. Handbook 60.
- Sommers, L.E. (1977). Chemical composition of sewage sludge and analysis of their potential use as fertilizer. *J. Environ. Qual.* 6: 225-232.
- Sommers, L.E., Volk, V.V., Giordano, P.M., Sopper, W.E., Bastian, R. (1987). *Land application of sludge*. Lewis Publishers Inc., Chelsea, MI.
- Yoneyama, T., Yoshida, T. (1978). Nitrogen minerilization of sewage sludges in soil. *Soil Sci. Plant Nutr.* 24 (1): 139-144.



Table 4. Extractable Fe, Cu, and Zn extracted from soil as affected by sewage sludge amendments (mg kg<sup>-1</sup>)

Inc. Time (days)	Fe			Cu			Zn								
	0	20	40	80	160	0	20	40	80	160					
1	4.75 e	6.24 d	7.82 c	9.57 b	12.26 a	2.06 c	2.13 c	2.34 bc	2.90 ab	3.47 b	0.42 e	1.84 d	3.15 c	6.00 b	10.72 a
7	4.58 d	5.30 d	7.43 c	10.17 b	11.66 a	3.69 a	1.89 d	2.83 c	2.92 bc	3.49 ab	0.28 e	1.80 d	2.98 c	5.96 b	10.34 a
14	2.96 d	5.36 c	6.18 c	7.96 b	10.93 a	3.88 a	2.18 c	2.29 c	2.98 b	3.53 ab	0.25 e	1.97 d	3.17 c	5.15 b	10.84 a
28	1.67 c	3.10 b	3.38 b	6.09 a	7.46 a	1.10 b	1.58 b	1.58 b	2.58 a	3.06 a	0.31 d	1.33 cd	2.03 c	4.49 b	8.46 a
42	2.88 d	3.45 cd	4.70 bc	5.02 ab	6.30 a	1.46 c	1.54 c	1.69 bc	2.16 ab	2.71 a	0.33 d	1.31 d	2.45 c	4.29 b	8.36 a
56	1.66 b	1.85 ab	2.32 ab	3.21 a	3.33 a	0.93 c	1.11 bc	1.26 bc	1.67 ab	1.97 a	0.37 d	0.98 cd	1.79 c	3.35 b	5.34 a
70	1.74 b	2.66 ab	2.29 ab	2.83 ab	3.48 a	0.90 b	1.13 ab	1.0 ab	1.54 a	1.58 a	0.35 c	0.98 c	1.41 c	2.57 b	4.83 a
105	0.38 a	0.59 a	0.71 a	0.93 a	1.21 a	0.43 b	0.56 b	0.72 ab	0.93 ab	1.3 a	0.22 c	0.50 c	0.98 c	2.26 b	4.09 a
140	1.03 b	1.55 b	1.76 ab	1.98 ab	3.05 b	0.80 b	1.10 b	1.26 ab	1.18 b	1.81 a	0.41 d	1.0 cd	1.59 c	3.01 b	5.41 a

LSD= 1.375

LSD= 0.583

LSD= 1.025

Table 5. Extractable Mn, Co and Ni extracted from soil as affected by sewage sludge amendments (mg kg<sup>-1</sup>)

Inc. Time (days)	Mn			Co			Ni								
	0	20	40	80	160	0	20	40	80	160					
1	8.18 c	10.41 c	14.33 b	14.90 b	21.33 a	0.17 d	0.25 cd	0.30 bc	0.35 a	0.41 a	0.78 c	0.97 bc	1.04 bc	1.12 b	1.35 a
7	12.80 b	9.42 c	12.26 bc	16.53 a	18.76 a	0.31 a	0.20 b	0.23 b	0.33 a	0.33 a	1.48 a	0.83 d	0.94 cd	1.14 bc	1.36 ab
14	10.70 bc	7.34 d	8.66 cd	12.56 ab	15.56 a	0.28 b	0.21 c	0.21 c	0.30 ab	0.35 b	1.56 a	0.88 c	0.82 c	1.14 b	1.33 b
28	2.48 d	4.77 cd	6.35 bc	8.91 ab	10.79 a	0.25 a	0.21 a	0.25 a	0.23 a	0.25 a	0.44 c	0.54 c	0.63 bc	0.81 ab	0.91 b
42	3.28 b	3.84 b	4.42 b	6.10 ab	8.26 a	0.23 a	0.21 a	0.25 a	0.21 a	0.25 a	0.83 ab	0.70 b	0.67 b	0.85 ab	0.98 a
56	0.92 ns	1.22 ns	1.14 ns	2.18 ns	2.38 ns	0.23 ns	0.20 ns	0.20 ns	0.20 ns	0.20 ns	0.42 ns	0.52 ns	0.58 ns	0.60 ns	0.52 ns
70	0.93 ns	1.00 ns	1.07 ns	1.75 ns	1.79 ns	0.20 ns	0.20 ns	0.20 ns	0.20 ns	0.20 ns	0.50 ns	0.44 ns	0.52 ns	0.57 ns	0.54 ns
105	0.20 ns	0.33 ns	0.34 ns	0.52 ns	0.74 ns	0.20 ns	0.20 ns	0.20 ns	0.20 ns	0.20 ns	0.21 ns	0.21 ns	0.27 ns	0.35 ns	0.37 ns
140	1.06 ns	1.60 ns	1.50 ns	1.53 ns	2.66 ns	0.20 ns	0.20 ns	0.20 ns	0.20 ns	0.20 ns	0.41 ns	0.44 ns	0.44 ns	0.46 ns	0.61 ns

LSD= 3.051

LSD= 0.0651

LSD= 0.227

Inc. time, incubation time (day); 0, control; 20, 40, 80, and 160 doses of each sewage sludge as expressed t ha<sup>-1</sup>. Significant differences between doses at P<0.05 level indicated by different letters.



# A STUDY ON POTENTIAL AGRICULTURAL USE OF SEWAGE SLUDGE OF ANKARA WASTEWATER TREATMENT PLANT

Sevinç Arcaç<sup>1</sup>, Cafer Türkmen<sup>2</sup>, Ayten Karaca<sup>1</sup>, Emrah Erdoğan<sup>1</sup>

<sup>1</sup>Soil Science Department, Faculty of Agriculture, Ankara University, Ankara

<sup>2</sup>Soil Science Department, Faculty of Agriculture, Çanakkale Onsekiz Mart University, Çanakkale

## ABSTRACT

The plant nutrients nitrogen, phosphorus, and others present in smaller quantities, as well as organic matter, make sludge disposal on land an attractive option. Nitrogen has received most attention and it is normally the most abundant sludge nutrient. One of the best alternatives to waste disposal is through the soil-plant system as a fertilizer. Based on contrasting properties, different wastes can be co-recycled in order to take simultaneously the best profit and minimize environmental pollution. An experiment was carried out with a calcareous soil to which six different doses of a sewage sludge were treated. A crop barley (*Hordeum vulgare* L. 'Tokak-501') was grown in the amended soils. The application of sewage sludge to a calcareous soil lowered the pH of the soil, although the value was always around 7.75-7.91 at the end of the experiment. In the barley plants it was observed that the higher the yield, the higher the N contents. Electrical conductivity rose with organic amendment. As anticipated, such an amendment improved the nutritional level of the soils, particularly total N and available P.

## INTRODUCTION

Sewage sludge is the insoluble residue from wastewater treatment after either aerobic or anaerobic digestion processes. Sludge comprises resistant organic compounds (60% organic matter), nitrogen (3%), phosphorus (2%,  $P_2O_5$ ), other macronutrients (0.5%  $K_2O$ , 5%  $CaO$ , 1.5%  $MgO$ ), a wide range of macronutrient and nonessential trace metals, organic micropollutants, microorganisms and eggs of parasitic organisms. The substantial N and P concentrations in sludge render it a useful fertilizer material and its organic constituents give it beneficial soil conditioning properties. The improved aeration and drainage following sludge amendments can have indirect effects on the soil-plant relationships of heavy metals through affecting growth, nodulation in leguminous plants and other properties (Heckman et al., 1986; Roberts et al., 1988).

There is an increasing interest in the agricultural application of sludges obtained in wastewater treatment plants, due to the possibility of recycling valuable components; organic matter, N, P, and other plant nutrients (Sommers, 1977; Chaussod et al., 1978; Suss, 1979).

In general, it has been shown that the addition of sludge to agricultural land increases crop production. Dowdy et al. (1978) reported that the increase of crop yield by sludge application often exceed that of well-managed fertilized controls.

On the other hand, since sewage sludge contains high concentrations of potentially toxic elements such as Zn, Ni, Cd, and Cu problems may arise when sludge is applied to an agricultural soil (Sanders et al., 1986; Omran and Waly, 1988) and heavy metal accumulation in the plant tissues may also occur. The fertility benefit must be balanced against the potential hazards of metal contamination through application of sludge to agricultural productive land.

Sewage sludge produced in Ankara regions (Sincan-Tatlar Village) is used for the improvement of soil fertility and crop production. Therefore, studies on sludges are important due to the economic and environmental implications of widespread application of these materials to agricultural lands.

There is no information available on fertilizer value of Ankara sewage sludge. This paper describes investigations into the fertilizer nitrogen and phosphorus value of Ankara sewage sludge using the pot experiments under greenhouse conditions.

## MATERIALS and METHODS

### Soil and Sludge Description:

The soil was used a clayey taken from the surface horizon of Sincan-Tatlar village near Ankara. The sludge was of the activated type and was municipal sewage sludge. The soil and sludge samples were air dried and crushed so as to pass a 2 mm sieve. The physical and chemical characteristics of the sludge and soil are shown in Table 1.

Table 1. Selected physical and chemical properties and extractable Fe, Cu, Zn, Mn, Ni, Co, and Cd amounts of the soil and sewage sludge samples

	PH	EC	O.M.	C	CEC	P	N	Sand	Silt	Clay
	1:2.5	dSm <sup>-1</sup>	%	%	cmolkg <sup>-1</sup>	mgkg <sup>-1</sup>	%	%	%	%
Soil	7.90	0.49	1.21	0.70	30.00	17.48	0.13	15.00	35.00	50.00
S.Sludge	7.08	2.10	25.00	14.20	67.00	581.00	1.54	-	-	-

	Fe	Cu	Zn	Mn	Ni	Co	Cd
	Mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>
Soil	4.75	2.15	0.35	8.18	0.78	0.17	0.075
S.Sludge	28.80	14.40	109.00	72.50	1.47	0.53	0.12

O.M., organic matter; CEC, cation exchange capacity; P, available phosphate; N, total nitrogen

### Experimental Design:

Each pot consisted of 5000g of coarsely sieved soil with various amendments.

**Treatment I:** Sludge nitrogen was compared with inorganic nitrogen (ammonium nitrate). Three replicates of each nitrogen treatment were assembled as follows:

1. The control pots were unamended.
2. Soils were supplemented with  $\text{KH}_2\text{PO}_4$  to yield 40 ppm ( $\text{N}_0$ ,  $\text{N}_0+\text{S}_0$ , and  $\text{S}_0$ ).
3. Soils were supplemented with  $\text{KH}_2\text{PO}_4$  to yield 40 ppm and  $\text{NH}_4\text{NO}_3$  to yield 30, 60, 120, 240, and 480 ppm ( $\text{N}_1$ ,  $\text{N}_2$ ,  $\text{N}_3$ ,  $\text{N}_4$ , and  $\text{N}_5$ ).
4. Soils were supplemented with  $\text{KH}_2\text{PO}_4$  to yield 40 ppm and  $\text{NH}_4\text{NO}_3$  to yield 15, 30, 60, 120, and 240 ppm and sewage sludge were added to soil at 5, 10, 20, 40, and 80 t ha<sup>-1</sup> ( $\text{N}+\text{S}_1$ ,  $\text{N}+\text{S}_2$ ,  $\text{N}+\text{S}_3$ ,  $\text{N}+\text{S}_4$ , and  $\text{N}+\text{S}_5$ ).
5. Soils were supplemented with  $\text{KH}_2\text{PO}_4$  to yield 40 ppm and sewage sludge were added to soil at 10, 20, 40, 80, 160, and 320 t ha<sup>-1</sup>, chosen to supply amounts of available N similar to the ammonium nitrate rates. ( $\text{S}_1$ ,  $\text{S}_2$ ,  $\text{S}_3$ ,  $\text{S}_4$ ,  $\text{S}_5$ , and  $\text{S}_6$ ).

The pots were seeded with barley (*Hordeum vulgare*, L. 'Tokak-501'), 20 seed per pot and the plants were thinned 15 after germination. The water content of the soil was adjusted to 70% of field capacity. The pots were placed in greenhouse.

### Sampling and Analysis:

Three months after seeding, the plants were harvested for nutrient composition and chemical analysis. Samples were analyzed for soil sample, pH and EC were measured in a 1:2.5 water extract (Richards, 1954); lime was determined according to Richards (1954); organic material by using modified Walkley-Black Method (Jackson, 1962); soil cation exchange capacity (CEC) was determined by saturation with ammonium acetate at pH 7 (Chapman, 1965). For plant, P was determined according to Kitson and Mellon (1944) and Borton (1948). K was determined by flame photometry (Johnson and Ulrich, 1959). For soil sample, available P was determined according to Olsen et al (1954) and the content determined by the Murphy and Riley method (Murphy and Riley, 1962). Total nitrogen was assessed using the Kjeldahl method, as specified by Bremner (1965). Soil samples were extracted for available Fe, Cu, Zn, Mn, Co, Ni, and Cd in DTPA solution (0.005M DTPA+0.005M  $\text{CaCl}_2$ +0.1M



TEA (triethanolamine) pH 7.3), (Lindsay and Norvell<sup>1</sup>, 1978). All the solutions of Fe, Zn, Cu, Mn, Co, Ni, and Cd were analyzed by atomic absorption spectrophotometer (AAS) with flame or graphite furnace when required.

## RESULTS and DISCUSSION

Table 2 shows dry matter production and the macronutrient contents in barley crops for the various treatments. It was observed that the application of sewage sludge enhanced soil fertility and that crop yield in the amended soils was higher than in the control. P and K were the macronutrients less absorbed by the barley crop. However, N was the macronutrients most absorbed when sludge was applied to soil. With sewage sludge, the low rate of application did not significantly change dry matter production on either of the soils. On the heavy textured soil, efficiency decreased with increasing rate of sludge.

It can be observed that the contents of total N in the soil increased when the sewage sludge added, the largest values of total N being recorded when the sludges were applied than that inorganic fertilizers. The application sewage sludge resulted in the largest increase of available P content. The amended soils, particularly those to which high doses of sludge (320 t ha<sup>-1</sup>) had been applied, showed a higher nitrogen and phosphorus content than the control (Table 2). Since the same amount of inorganic fertilizer was applied to the soils these differences could be attributed to the organic amendment. This phenomenon can be expected since sewage sludge contains both high quantities of proteinic material (Serna and Pomares, 1992), as can be seen from the high values for N in Table 2, and of polyphosphorated compounds from detergents. The effects of sludge on barley potassium values were variable, but generally small.

The soil pH is of paramount importance in controlling the plant absorption of heavy metals since it conditions their mobility in soil. According to Pluquet (1984) an increase of one unit in pH reduces heavy metal absorption by plants by 14 %. When sewage sludge (whether or not contaminated by heavy metals) was applied, the soil pH decreased in all the cases, but fell by approximately half a unit when the maximum dosage (320 t ha<sup>-1</sup>) was used (Table 2). Electrical conductivity also varied when the sludge amendment was carried out and it increased compared to the control (Table 2) due to the formation of metallic salts (complexes of organic matter and heavy metals). EC of the maximum sludge amended soil was 4.48 times higher than the control. In the soil amended with sewage sludge (especially S<sub>5</sub> and S<sub>6</sub> dosages) the CEC content significantly increased. There was no significant differences between the control and CEC in nitrogen and nitrogen + sludge treatments. The amount of organic matter determined in the soil (Table 2) was not significantly different between the control and nitrogen treatment soils. But, significant difference in organic matter was found between the control and sludge amended soils.

In general, in terms of nutritional status, the amended soils at the end of the experiment showed higher N and P contents than the control soil, but a similar content of CEC, EC, confirming the theories proposed by several authors (Zucconi and Bertoldi, 1987). Thus the yield decrease caused by the organic amendments must be due to both, to the heavy metals contained in these materials and to the increased conductivity.

In conclusion, the sewage sludge used in this study was very poor sources of P for plant growth, primarily because Fe and Al treatments were used to precipitate P in the sludge P in these sludge was in organic form so microbial mineralization had little effect on P availability.

## ACKNOWLEDGEMENTS

This project has been supported by TUBITAK through contract No: TOGTAG-1712.



## REFERENCES

- Arden, D.A. (1977). The agricultural use of sewage sludge. In: R.C. Loehr (ed.), Land as a waste management alternative. Springer-Verlag, Berlin, pp. 583-603.
- Barton, C.J. (1948). Photometric analysis on phosphate rock. *Ind Eng. Chem. Anal.*, Ed. 20: 1068-1073.
- Bremner, J.M. (1965). Total nitrogen. In *Methods of Soil Analysis Part 2*; (C.A. Black, Ed.), American Society of Agronomy, Madison, Wis., 1145-1178.
- Chapman, H.D. (1965). *Methods of soil analysis Part 2. Chemical microbiological properties*. Ed. C.A. Black. Amer. Soc. of Agron. Inc. Publ. Agron. Series no: 9, Madison, Wis, USA.
- Chaussod, R., Germon, J.C., Catroux, G. (1978). Determination de la valeur fertilisante des boues residuaires. Aptitude a liberer l'azote. Ministe' re de l'environnement et du cadre de vie. Convention d'etude n. 74050 (in French).
- Dowdy, R.H., Larson, W.E., Titrud, J.M., Latterell, J.J. (1978). Growth and metal uptake of snap beans grown on sewage sludge amended soil. A four-year field study. *J. Environ. Qual.* 7: 252-257.
- Heckman, J.R., Angle, J.S., Chaney, R.L. (1986). Soybean nodulation and nitrogen fixation on soil previously amended with sewage sludge. *Biol. Fertil. Soils*, 2: 181-185.
- Heckman, J.R., Angle, J.S., Chaney, R.L. (1987). Residual effects of sewage sludge on soybean: I, Accumulation of heavy metals. *J. Environ. Qual.* 16: 113-114.
- Jackson, M.L. (1962). *Soil chemical analysis*. Prentice Hall Inc. Eng. Cliffs. U.S.A..
- Johnson, C.M., Ulrich, A. (1959). Analytical methods for use in plant analysis II. *California Agri. Exp. Sta. Bull.* 766.
- Kitson, R.E., Mellon, M.G. (1944). Calorimetric determination of phosphorus as molybdovanadophosphoric acid. *Ind. Eng. Chem. Anal.*, Ed. 16: 379-383.
- Lindsay, W.L., Norwell, W.A. (1978). Development of a DTPA soil test for Zn, Fe, Mn and Cu. *Soil Sci. Soc. Am. J.* 42: 421-428.
- Murphy and Riley (1962). A modified single solution method for the determination of phosphate in natural waters. *Anal. Chem. Acta*, 27: 31-36.
- Olsen, S.R., Cole, V., Watanabe, F.S., Dean, L.B. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. Of Agr. 939. Washingt, D.C.
- Omran, M.S., Waly, T.M. (1988). Effect of sewage irrigation on yield, three components and heavy metals accumulation in navel orange trees. *Biol. Wastes*, 23: 17-24.
- Pluquet, E. (1984). Die bodentung des tangehaltes und des pH-wertes fü die Schwermetaleufnahme einiger kuhurrflanzen aus kontaminierten bönen, UBA Texte 40, Berlin.
- Richards, L.A., ed. (1954). *Diagnosis and improvement of saline and alkali soils*. U.S.D.A. Handbook 60.
- Roberts, J.A., Daniels, W.L., Bell, J.C., Martens, D.C. (1988). Tall rescue production and nutrient status on southwest Virginia mine soils. *J. Environ. Qual.* 17: 55-62.
- Sanders, J.R., Trevor, McM.A., Christensen, B.T. (1986). Extractability and bioavailability of Zn, Ni, Cd, and Cu in three Danish soils sampled 5 years after application of sewage sludge. *J. Sci. Food Agric.* 37: 1155-1164.
- Serna, M.D., Pomares, F. (1992). Indexes of assessing N availability in sewage sludges. *Plant Soil*, 139: 15-21.
- Sommers, L.E. (1977). Chemical composition of sewage sludge and analysis of their potential use as fertilizer. *J. Environ. Qual.* 6: 225-232.
- Suss, A. (1979). Nitrogen availability in sewage sludge. In *Concerted Action E.E.C. Treatment and Use of Sewage Sludge*, Cost Project 68 bis, Dison.
- Zucconi, F., De Bertoldi, M. (1987). Compost specifications for the production and characterization of compost from municipal solid waste. In *compost: Production, quality and use*, E.d. M. De Bertoldi, M.P. Ferranti, P.L. Hermite, Zucconi, F., p. 30-51, Elsevier Applied Science, New York.

Table 2. Dry matter, nitrogen and phosphorus extracted from plant and total nitrogen and available phosphorus, cation exchange capacity (CEC), EC and pH extracted from a calcareous soil as affected by different nitrogen (NH<sub>4</sub>NO<sub>3</sub>) and sewage sludge amendments.

Treatment	PLANT				SOIL				pH (1:2.5)	O.M. %	CaCO <sub>3</sub> %
	Dry matter yields (g Dmpot <sup>-1</sup> )	N %	K %	P mg kg <sup>-1</sup>	N %	P mg kg <sup>-1</sup>	CEC cmolkg <sup>-1</sup>	EC dSm <sup>-1</sup>			
Control	25.42 b	2.17 b	1.64 ns	0.22 c	0.10 ns	19.32 ns	30.00 ns	0.49 b	7.90 bc	1.21 ns	20.37 a
N <sub>0</sub>	27.93 a	2.32 b	1.81 ns	0.32 a	0.12 ns	19.38 ns	29.51 ns	0.49 b	7.91 b	1.21 ns	19.81 a
N <sub>1</sub>	25.71 b	2.09 b	1.53 ns	0.21 c	0.10 ns	19.40 ns	31.50 ns	0.51 a	7.93 b	1.23 ns	19.56 ab
N <sub>2</sub>	28.03 a	2.35 b	1.53 ns	0.21 c	0.12 ns	19.45 ns	32.65 ns	0.54 a	7.96 a	1.26 ns	19.85 a
N <sub>3</sub>	28.47 a	2.46 b	1.63 ns	0.32 a	0.11 ns	19.38 ns	33.00 ns	0.57 a	7.95 ab	1.24 ns	20.01 a
N <sub>4</sub>	29.04 a	3.64 a	1.51 ns	0.29 ab	0.10 ns	19.42 ns	33.00 ns	0.56 a	7.96 a	1.24 ns	19.90 a
N <sub>5</sub>	31.28 a	3.23 a	1.85 ns	0.26 b	0.12 ns	19.40 ns	33.00 ns	0.58 a	7.98 a	1.26 ns	19.18 b
LSD <sub>0.05</sub>	4.070	0.582	-	0.039	-	-	-	0.140	0.373	-	1.031
Control	25.42 ab	2.17 d	1.64 ns	0.22 b	0.10 d	19.32 b	30.00 ab	0.49 d	7.90 b	1.21 b	20.37 a
N <sub>0</sub> +S <sub>0</sub>	27.93 a	2.32 d	1.81 ns	0.32 a	0.12 c	19.38 ab	29.51 b	0.49 d	7.91 b	1.21 b	19.81 b
N+S <sub>1</sub>	25.97 ab	2.30 d	1.77 ns	0.27 ab	0.12 c	19.35 ab	33.00 a	0.57 d	7.95 a	1.23 ab	18.90 b
N+S <sub>2</sub>	25.35 ab	2.42 d	1.70 ns	0.28 a	0.14 bc	19.37 ab	33.25 a	0.63 c	7.94 a	1.26 a	19.23 b
N+S <sub>3</sub>	26.95 a	2.76 c	1.69 ns	0.31 a	0.15 b	19.42 a	33.84 a	0.74 c	7.91 b	1.28 a	19.46 ab
N+S <sub>4</sub>	27.28 a	3.38 b	1.88 ns	0.29 a	0.10 d	19.47 a	34.00 a	0.92 b	7.87 c	1.35 a	19.12 b
N+S <sub>5</sub>	24.43 b	3.85 a	1.81 ns	0.29 a	0.17 a	20.45 a	34.17 a	1.34 a	7.89 c	1.49 a	18.75 b
LSD <sub>0.05</sub>	3.576	0.381	-	0.048	0.167	1.07	4.21	0.117	0.331	0.279	1.010
Control	25.42 b	2.32 c	1.64 ns	0.22 c	0.10 c	19.32 b	30.00 b	0.49 e	7.90 a	1.21 c	20.37 a
S <sub>0</sub>	27.93 a	2.17 c	1.81 ns	0.32 bc	0.12 bc	19.38 b	29.51 b	0.49 e	7.91 a	1.21 c	19.81 ab
S <sub>1</sub>	25.39 b	2.53 c	1.38 ns	0.30 bc	0.09 c	19.57 b	34.00 ab	0.57 e	7.90 a	1.28 c	19.73 ab
S <sub>2</sub>	26.29 ab	2.63 c	1.72 ns	0.31 bc	0.13 bc	19.80 b	34.75 a	0.68 d	7.86 b	1.37 c	18.90 b
S <sub>3</sub>	26.84 ab	2.64 c	1.77 ns	0.32 b	0.12 bc	19.97 b	35.50 a	0.79 d	7.81 c	1.50 b	19.22 b
S <sub>4</sub>	25.74 ab	3.38 b	1.41 ns	0.34 ab	0.15 b	20.27 b	36.50 a	0.93 c	7.80 c	1.58 b	19.70 ab
S <sub>5</sub>	25.17 b	4.18 a	1.44 ns	0.36 a	0.16 b	21.67 ab	37.32 a	1.47 b	7.75	1.84 b	19.81 ab
S <sub>6</sub>	22.28 b	4.42 a	1.64 ns	0.39 a	0.25 a	24.12 a	38.81 a	2.20 a	7.65	2.03 a	19.06 b
LSD <sub>0.05</sub>	4.36	0.625	-	0.054	0.054	2.70	5.190	0.156	0.317	0.324	1.023

Significant differences between treatments at P<0.05 level indicated by different letters; ns, not significant.



# EFFECTS OF THE SEWAGE SLUDGE OF ANKARA WASTE WATER TREATMENT PLANT ON SOME SOIL BIOLOGICAL ACTIVITIES

Sule Ataman<sup>1</sup>, Sevinç Arcak<sup>2</sup>

<sup>1</sup> Republic of Turkey, Ministry of Environment, Ankara

<sup>2</sup> Department of Soil Science, Faculty of Agriculture, University Ankara, Ankara

## ABSTRACT

Soil sample was treated with different levels of sewage sludge (20,40,80 and 160 t ha<sup>-1</sup>) urease, alkaline phosphatase activity and CO<sub>2</sub> evolution were assayed after 1,7,12,28,42,56,70,105 and 140 days of incubation. Results showed that when soil was treated with the sewage sludge, urease activity was often inhibited at the lower dosage rate (20 t ha<sup>-1</sup>), but was enhanced substantially with the higher application rates (40 t ha<sup>-1</sup> and 80 t ha<sup>-1</sup>). Urease activity in the sewage sludge amended soils decreased at various times of incubation. Inhibition of the enzyme activity (urease and alkaline phosphatase) was attributed to the presence of heavy metals in the sludge. The increased activity of urease and alkaline phosphatase in the sludge amended soil at the highest application rate. Enhanced urease activity was believed to be due to the additional source of organic matter and nutrients supplied by the sludge which stimulated microbial activity and subsequent urease synthesis. The amount of CO<sub>2</sub> evolved decreased with the incubation time. These results were found statistically significant at 0.01 level. Soil enzyme activities are often used as indices at microbial growth and activity in soil. Quantitative information concerning which soil enzymes most accurately reflect microbial growth and activity is lacking.

## INTRODUCTION

Current interest in assessing the quality of soil resources has been triggered by increasing awareness of soil as a component of the earth's biosphere. Soil has a role not only in the production of food and fibre but also in the maintenance of environmental quality. Thus, it is critical to define and evaluate the quality of soil resources. Conceptually, soil quality is defined as the capacity of soil to function within ecosystem boundaries to sustain biological productivity, to maintain quality of the environment and to promote plant and animal health (Doran and Parkin, 1994). Soil biology is a significant component of soil quality and is the catalytic agent responsible for many of the transformations occurring in soil, most notably the reactions involved in nutrient cycling. Thus, it is meaningful to evaluate the biological aspects of soil quality within the context of overall system function (Karlen et al., 1997).

There is limited information available on how sewage sludge application can influence soil microbial and bio-chemical characteristics with respect to maintaining soil quality.

The effects of heavy metals on the soil microbial community, with emphasis on specific microbial activities, have been reported (Brookes et al., 1986; Reber, 1992)

Generally, the application of low metal sludges had beneficial effects on microbial biomass, organic C and on the soil microbial activity, whereas, higher heavy metal contamination of soil resulted in considerable decrease in biomass C (Fließbach et al., 1994; Knight et al., 1997). Kandeler et al. (1996) demonstrated that microbial biomass and enzyme activities decreased with increasing heavy metal pollution using salts of heavy metals but the amount of decrease differed among the enzymes. They also observed that heavy metal pollution severely decreased the functional diversity of the soil microbial community. However, Sastre et al., (1996) showed that sewage sludge applications at recommended rates increased microbial activity in soil. It appears from various studies that soil and sewage sludge tie up the heavy metals making them unavailable to plants and soil. Thus, metals contained in sludge have less effect than equivalent loadings as inorganic salts. The availability of metals in sludge depends upon the concentration of heavy metals present in the sewage sludge and the nature of the sludge itself. Nevertheless, scientific evidence to support the selection of sludge application limits is still inadequate, particularly as the sensitivity of soil microorganisms to relatively modest metal contamination has only recently been reported (Lorenz et al., 1992). Thus, an integrative concept based on soil microbial and biochemical components that would predict nutrient availability from sewage sludge and its toxicity at different rates and frequencies of application is still lacking.

Although the effects of trace elements on bio-chemical transformations have been studied extensively, very little information is available on the relative effects of sewage sludges on these



transformations. We have determined the effects of sewage sludges containing high levels of heavy metals on urease alkaline phosphatase activity and CO<sub>2</sub> evolution in soils.

## MATERIALS and METHOD

The soil used was surface samples (0-20cm). Before use soil sample was sieved (< 2 mm). The chemical and physical properties of the soil and sludge used in this study (Table 1) were determined as described by Page (1982). The sewage sludge sample was collected from Ankara Wastewater Treatment Plants. Treatment processes, sewage flow and BOD (biological oxygen demand) are reported in Table 2. The sample was dried at 65 °C, ground (<1mm) and then stored in polyethylene bags at room temperature. The soil was amended with the sewage sludge (20,40,80 and 160 t ha<sup>-1</sup>) and thoroughly mixed. Each treatment was replicated three times giving a total of 135 pots. The sewage sludge amended and unamended soils (control samples) were incubated for 140 days at 28 ± 2 °C in 500 g capacity plastic pots and soil moisture maintained gravimetrically at 60% water-holding capacity throughout study period. Soil samples were taken at 1, 7, 12, 28, 42, 56, 70, 105 and 140 for analytical purposes. Soil respiration (mg CO<sub>2</sub> 100 g<sup>-1</sup> 24 h) was determined by titration of the NaOH solution with 0.1 M HCl in an excess of BaCl<sub>2</sub>. The method of Hoffman and Teicher (1957) was used to assay urease activity. Phosphatase activity was determined by the method of Hofmann and Hoffman (1966). At various times up 140 days of incubation, triplicate samples were assayed for urease, phosphatase enzyme activity and soil respiration.

Table 1. Selected physical and chemical properties and extractable Fe, Cu, Zn, Mn, Ni, Co, and Cd amounts of the soil and sewage sludge samples

	pH	EC	O.M.	C	CEC	P	N	Sand	Silt	Clay
	1:2.5	dSm <sup>-1</sup>	%	%	cmolkg <sup>-1</sup>	mgkg <sup>-1</sup>	%	%	%	%
Soil	7.90	0.49	1.21	0.70	30.00	17.48	0.13	15.00	35.00	50.00
S.Sludge	7.08	2.10	25.00	14.20	67.00	581.00	1.54	-	-	-

	Fe	Cu	Zn	Mn	Ni	Co	Cd
	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>	mgkg <sup>-1</sup>
Soil	4.75	2.15	0.35	8.18	0.78	0.17	0.075
S.sludge	28.80	14.40	109.00	72.50	1.47	0.53	0.12

O.M., organic matter; CEC, cation exchange capacity; P, available phosphate; N, total nitrogen

Table 2. Description of Treatment plants sampled

City	Type of sludge	Human population (x10 <sup>3</sup> )	Average daily sewage flow (m <sup>3</sup> day <sup>-1</sup> )	Sludge cake (t day <sup>-1</sup> )	BOD (t day <sup>-1</sup> )	Comments
Ankara	Anaerobically digested	3.100	517124	388.8	79.2	Polymer added

## RESULTS and DISCUSSION

The source and selected general characteristics of the sewage sludge studied are shown in Table 2. The sludge was anaerobically digested with a mixture of primary and waste activated sludge typically entering the digester. Some additional comments on sludge treatment are shown in Table 2.

The chemical characteristics of the sludge are presented in Table 1. Anaerobically digested sludges are devoid of NO<sub>3</sub><sup>-</sup> when samples are collected directly from the digester. Since several of the anaerobically digested sludges contained > 500 mg NO<sub>3</sub><sup>-</sup>-N kg<sup>-1</sup>, it is obvious that the sludge samples were slowly dried allowing nitrification occur. Similarly, the NH<sub>4</sub><sup>+</sup>-N contents are likely a reflection of NH<sub>3</sub> volatilization losses which occurred during air or oven drying of the sludges. The organic N levels in the sludges ranged from 0.50 to 6.81 % N with a mean of 2.18 % (SD=1.45 %).

Urease and alkaline phosphatase activities increased with high application dosage rates (Figure 1 and 2). And this changes was found statistically significant. (p<0.01). Increasing in CO<sub>2</sub> evolution with incubation time was found statistically significant (p<0.05) (Figure 3).

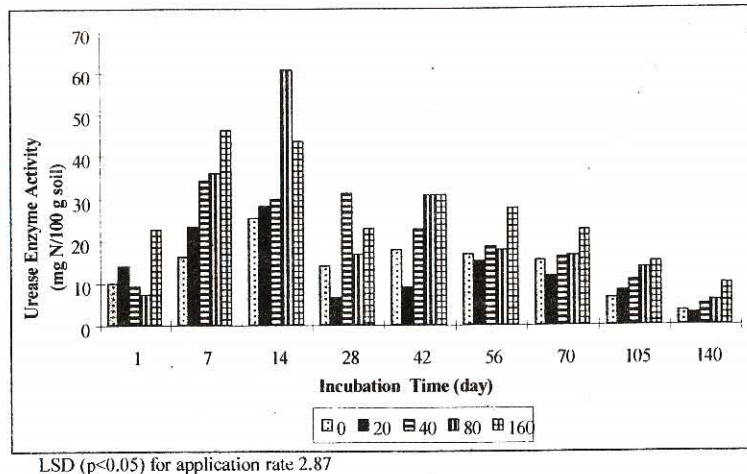


Figure.1. Effects of sewage sludge on urease activity in soil

In most cases, urease activity in the sewage sludge-amended soil increased with time but began to decline after 14 days (Figure 1). Inhibition of urease activity was frequently observed when soils were treated with the lower loading rates of sewage sludge. Enhancement of urease activity was observed when these soils were treated with 40 and 80 t ha<sup>-1</sup> (Figure 1). The increased activity of urease in the amended soil when treated with the highest application rate (80 t ha<sup>-1</sup>).

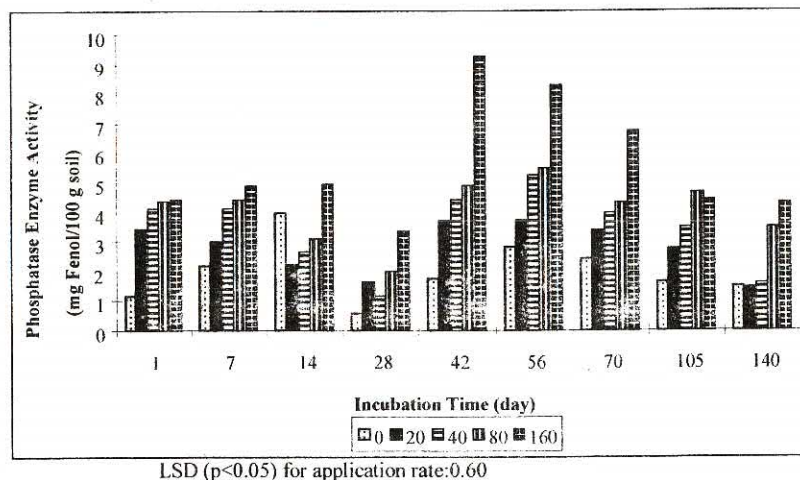


Figure.2. Effects of sewage sludge on phosphatase activity in soil

Inhibition of urease activity when sewage sludge was applied at the lower loading rates may possibly be due to concentration of heavy metals present in the sludge. Table 1 gives the chemical composition of sewage sludge sample. The metal ions that should be of the greatest concern in regards to the inhibition of urease activity are: Cu, Zn, Cr, Ni, Cd and Pb (Shaw, 1954; Shaw and Raval, 1961; Hughes et al., 1969; Tabatabai, 1977).

Shaw and Raval (1961) reported that metal ion inhibition was non-competitive and postulated that the inhibition involved the reaction of metal ions with sulphydryl groups in the catalytic site of urease.

In our study, inhibition of urease activity was probably due to several metals and not solely to one metal component.

In most cases, heavy metal pollution has little effect on CO<sub>2</sub> evolution at low levels of contamination, but with higher doses the soil respiration rate decreases. Bond et al. (1976) and Chaney et al. (1978) also found increased respiration rates at low amendment levels of sewage sludge, but they used rather short incubation times.

Soil respiration rate is easy to measure and appears to be a sensitive measurement with which to detect heavy metal pollution, especially under standardized conditions. (Bäåth, 1989). CO<sub>2</sub> evolution in the sewage sludge amended soil (except highest application rates) increased with time but began to decline after 14 days (Figure 3). The decreased CO<sub>2</sub> evolution in the amended soil when treated with the highest application rate. Carbon and nitrogen turnover in soils occurs through heterotrophic microorganisms and lower concentration of heavy metal has not influenced their catabolic activities. However, at higher concentrations more soluble forms of heavy metal seems to have exposed microbes to free metal, therefore, resulting in adverse effects on mineralization processes. The presence of clay, organic matter, hydrous oxides and phosphatas seem to have influenced the metal mobility through adsorbtion or chelation on clay minerals, exchangeable organic residues and oxide fractions.

It was observed that CO<sub>2</sub> evolution increased at the 20 t ha<sup>-1</sup> dosage in all incubation periods and it decrease with the application dosage rate. It was observed that CO<sub>2</sub> evolution decreased with incubation time. Inceraising of CO<sub>2</sub> evolution is because of the inhibition of the active microorganisms in soil system (Tyler, 1974).

Several measurements of enzyme activities have been used in relation to heavy metal pollution in soil. The activity of phosphatase appears to be a good indicator of pollution. Urease appears in many cases to be equally or even more sensitive to heavy metal pollution as phosphatase.

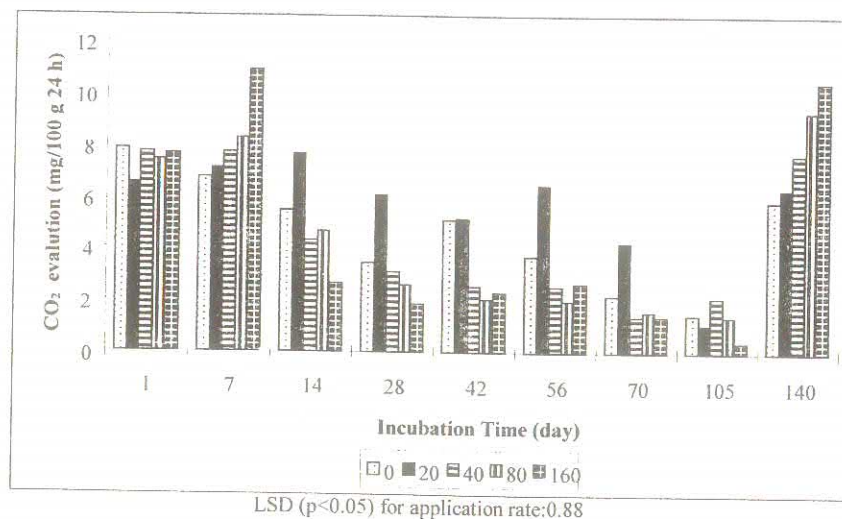


Figure.3. Effects of sewage sludge on CO<sub>2</sub> evolution in soil.

Low enzymatic activity in soil can be due to low concentrations of the enzyme, or metal inhibition of the enzyme masking of active groups, by protein denaturation, by other effects on enzyme configuration or by competition with activating metal ions (Tyler, 1981).

Bäåth(1989) showing that metal inhibition partly explained the decrease in enzyme activities in soil with high metal contents. A decrease in enzyme concentrations was, however still evident.



Reddy et al. (1987) found that dehydrogenase and phosphatase enzyme activity was inhibited in all their experimental sludge soils and was related to their heavy metal concentrations. Increasing rates of sludge application reduced urease activity in some soils, but increased it in others.

The decline in enzyme activities found in several investigations is probably mainly an effect of a decreased enzyme synthesis associated with inhibited microbial growth rather than to direct enzyme inhibition by the metals.

Assays of potential enzyme activity are important in estimating the effects of metal pollution on the soil environment. It is difficult, however, to establish whether low enzymatic activity is because of metal inhibition or from low concentrations of the enzyme, resulting from impeded microbial growth and enzyme synthesis (Tyler, 1974). Nevertheless, soil enzymatic activity is believed to be a sensitive indicator of the effect of environmental factors on microbial functions. (Dick, 1994). Thus, because of their role in nutrient cycling, enzymes like arylsulfatase, acid phosphatase and alkaline phosphatase are suggested to be good indicators of potentially beneficial or harmful effects on the ecosystem. In the present investigation, sludge application had relatively little effect on any of the enzymes studied, potential soil enzyme activities were generally increased or not affected by the sludge application. Similar results were observed for the potential activities of acid and alkaline phosphatase (Banerjee et al, 1997).

## REFERENCES

- Bääth E. (1989). Effects of heavy metals in soil on microbial processes and populations (A review) *Water, Air and Soil Pollution* 47:335-379.
- Banerjee M.R. Burton D.L. Depoe S. (1997). Impact of sewage sludge application on soil biological characteristics. *Agriculture, Ecosystems and Environment* 66, 241-249.
- Bond H., Lighthart R., Shmabul'u R., Russel L. (1977). Some effects of cadmium on coniferous forest soil and litter microcosms. *Soil Science* 121,278-287.
- Brookes P.C., Heijnen E., McGrath S.P., Vance E.D. (1986). Soil microbial biomass estimates in soils contaminated with metals. *Soil Biol. Biochem.* 18, 383-388.
- Chaney W.R., Kelly J.M., Strickland R.C. (1978). *J. Environ. Qual.* 7, 115.
- Dick R.P. (1994). Soil enzyme assays as indicators of soil quality. *Soil Sci. Soc. Am. Special Publication No:35, Soil Science Soc. of Am. Madison*, 107-124.
- Doran J.W., Parkin T.B. (1994). Defining and assessing soil quality. In: Doran, J.W., Coleman, D.C., Bezdicek D.F., Stawart, B.A. (Eds). *Defining soil quality for sustainable environment*, Soil Science Soc. Am. Special Publication No:35. Soil Science Society of America, Madison, WI, pp 3-21.
- Fließbach A., Martens R., Reber H.H. (1994). Soil microbial biomass and microbial activity in soils treated with heavy metal contaminated sewage sludge. *Soil Biol. Biochem.* 26, 1201-1205.
- Hoffman G.G., Teicher K. (1957). Das Enzyme System Unserer Kultur Boden 7, *Proteosan 11 Zeitschrift Für Pflanzenernährung Und Bodenkunde*, 77-1227, B.
- Hofmann E., Hoffman G. (1966). Die Bestimmung Der Biologischen Tätigkeit In Boden Mit Enzymmethoden. Reprinted From *Advance In Enzymology And Related Subject Of Biochemistry*, V. 28, 365-390.
- Hughes R.B., Sidney A.K., Subbina S.E. (1969). Inhibition of urease by metal ions. *Enzymologia* 36, 332-334.
- Isermayer H. (1952). Eine Einfache Methode Zur Bestimmung Der Bodenatmung Und Kohlenate In Boden. *Z. Pflanzenernährung, Düngung Und Bodenkunde*, 56, 26-8.
- Kandeler E., Kampichler C., Horak O. (1996). Influence of heavy metals on the functional diversity of soil microbial communities. *Biol. Fertil. Soils* 23, 299-306.
- Karlen D.L., Mausbach M.J. Doran J.W., Cline, R.G., Harris, R.F., Schuman, G.E. (1997). Soil quality: a concept, definition, and framework for evaluation. *Soil Sci. Soc. Am. J.* 61, 4-10.
- Knight B.P., McGrath S.P., Chaudri A.M. (1977). Biomass carbon measurements and substrate utilization patterns of microbial populations from soils amended with cadmium, copper, and zinc. *Appl. Environ. Microbiol.* 63, 39-43.
- Lorenz S.E., McGrath S.P., Giller K.E (1992). Assessment of free-living nitrogen fixation activity as a biological indicator of heavy metal toxicity in soil. *Soil Biol. Biochem.* 24, 601-606.
- Page A.L. et al (ed). (1982). *Methods of soil analysis. Part 2 (Agronomy g, SSSA Madison, WI.*

- Reber H.H. (1992). Simultaneous estimates of the diversity and the degradative capability of heavy-metal-affected soil bacterial communities. *Biol. Fertil. Soils*. 13, 181-186.
- Reddy M.R., Faza A., Bennett, R. (1987). Activity of enzymes in rhizosphere and non-rhizosphere soils amended with sewage sludge. *Soil Biology Biochem.* 19: 203-205.
- Sastre I., Vicente M.A., Lobo, M.C. (1996). Influence of the application of sewage sludges on soil microbial activity, *Bioresour. Tech.* 57, 19-23.
- Shaw W.H.R, Raval D.N. (1961). The inhibition of urease by metal ions at pH 8.9. *Journal American chemical Society* 83, 3184-3187.
- Shaw W.H.R. (1954). The inhibition of urease by various metal ions. *Journal American Chemical Society* 76, 2160-2163.
- Tabatabai M.A. (1977). Effects of trace elements on urease activity in soils. *Soil Biology and Biochemistry* 9, 9-13.
- Tyler G. (1974). Heavy metal pollution and soil enzyme activity. *Plant Soil*: 41, 303-311.
- Tyler G. (1981). *Soil Biochemistry* 5, in E.A. Paul and J.N Ladd (eds.), Marcel Dekker, New York and Basel, p. 371.

# THE HEAVY METAL CONTENTS OF THE GOLIA WHEAT IN THE CENTER AND TÜRKÖĞLU TOWNS IN KAHRAMANMARAS

Fecir Elinç, Esin Güvercin, and Ali Rıza Demirkıran  
Agriculture Faculty, Soil Science Section, Kahramanmaraş-Turkey

## ABSTRACT

In this study the wheat leaf samples at the beginning of the heading stage and the soils samples from the 0-20 cm depth collected together from the 26 representative farmer fields. Some properties of the soil samples and the heavy metal contents of the leaf samples were determined.

The results obtained showed that the DTPA+TEA extractable Fe, Mn and Cu contents of the soils were in the sufficient levels for the crops growth. Whereas the zinc contents of the soils were low. Therefore the total Fe, Mn and Cu contents of the wheat leaves were sufficient, but the zinc contents of all the leaf samples were in the deficient level. The DTPA+TEA extractable lead contents of the soils were in the acceptable level, however the nickel contents of the soils slightly high. The total nickel contents of the leaves might be considered slightly higher than the suggested critical tolerance level of nickel for plants.

According to the linear correlation analysis results the zinc contents of the wheat leaves decreased significantly by the increasing available phosphorus level of the soils. Although the available zinc levels of the soils were low, the total nickel contents of the leaves decreased by the increasing zinc level of the soils.

Considering the results of the study it is to be suggested that it will be useful to avoid the usage of excess level of phosphorous fertilizer to control the zinc deficiency and the nickel accumulation in the plant tissue. In this way the quality and the quantity of the crop yields are to be increased in the point of view public health.

## INTRODUCTION

The research results showed that chemical elements in plant or plant parts are related to dependent variables such as yield (Macy 1936, Tyner 1947).

Shear et al. (1948), indicated that if all other factors were constant, plant growth was a function of two nutrition variables, intensity and balance. Thus, maximum growth and yield occur only with being of optimum intensity and balance of nutrients. Leaf composition represent a measure of all environmental factors both internal and external which influenced nutrient accumulation by the plant.

The possibility of using minimum values of an inorganic nutrient as a basis for determining deficiencies has been recognized for many decades. In this manner it was found that growth decreases when the concentration of any element in the leaves fall below a minimum value for different crops.

Peck et al. (1969), showed that regression analysis as independent variables revealed several significant relationships which indicated that critical level of any particular nutrient varies with leaf levels of other nutrients.

Briefly the level of nutrients absorbed by plants is related to the amount of available nutrients in the soil. Therefore the purpose of this study was to determine heavy metal contents of the soils and the wheat leaves surrounds of the Center and Türkoğlu towns in Kahramanmaraş.

## MATERIAL and METHODS

The soil samples from the 0-20 cm depth and the wheat leaf samples at the beginning of the heading stage were collected together from the 26 representative farmer fields. After collecting, the soils were air dried and sieved from a 2 mm screen. The soil pH was determined with a soil:solution ratio of 1:2.5 (w:v) with deionized water, organic matter was determined by a modified Walkley-Black method, exchangeable calcium, magnesium, potassium and sodium were determined by neutral ammonium acetate (Jackson, 1962), calcium carbonate was determined by Schleiber-Procedure (Hızalan and Ünal, 1966) and available phosphorus were determined by sodium bicarbonate extraction (Olsen, 1954). The heavy metal concentrations of the soils, such as Fe, Mn, Zn, Cu, Ni and Pb were determined by 0.005 M DTPA+0.01 M TEA+0.1 M CaCl<sub>2</sub> (pH=7.3) extraction solution (Lindsay and Norvell, 1969) with AAS Perkin Elmer 3110.



The leaf samples dried at 70<sup>o</sup> C for 48 hour and grinded. The total Fe, Mn, Zn, Cu, Ni and Pb contents of the leaf samples determined in the dry ashed solutions of the leaf samples (Kacar, 1972) by using AAS Perkin Elmer 3110.

The simple correlation analysis were used between concentrations of heavy metals in the wheat leaves and soils variables (Steel and Torrie, 1960).

## RESULTS and DISCUSSIONS

### Some properties and heavy metal levels of the soils:

The results of the soil analyses summarized in the Table 1 for the two locations. As shown in the Table 1, the soils were alkali in the soil reaction, high level in calcium carbonate, medium level in organic matter. The exchangeable calcium and magnesium contents of the soils were high. The exchangeable potassium contents of the soils were high, except two soils. The soils had not sodium and salinity problems. The available phosphorus contents of the soils were high than the need of the wheat plant, except four soils in the Türkoğlu town.

Table 1. Minimum, maximum and average values of the some properties of the soils

Soil variables	Center			Türkoğlu		
	Min.	Max.	Average	Min.	Max.	Average
PH	7.51	8.33	7.95	7.76	8.26	8.10
Salinity	0.048	0.139	0.090	0.034	0.157	0.100
CaCO <sub>3</sub> , %	2.31	37.37	13.49	2.91	28.64	16.87
OM., %	0.60	7.05	2.60	1.01	12.52	4.10
Ca <sup>++</sup> , me 100 g <sup>-1</sup>	9.35	34.78	21.33	11.60	34.27	26.39
Mg <sup>++</sup> , me 100 g <sup>-1</sup>	2.65	22.64	10.28	3.21	24.93	12.16
K <sup>+</sup> , me 100 g <sup>-1</sup>	0.22 <sup>1</sup>	0.78	0.67	0.25	0.75	0.59
Na <sup>+</sup> , me 100 g <sup>-1</sup>	0.05	0.39	0.15	0.06	0.41	0.17
P, mg kg <sup>-1</sup>	8.14	28.57	16.63	2.55 <sup>2</sup>	36.89	14.81

<sup>1</sup> The one soil had less than 0.3 me 100 g<sup>-1</sup> exchangeable potassium

<sup>2</sup> The four soils had less than 7 mg kg<sup>-1</sup> available phosphorus

The DTPA+TEA extractable heavy metal contents of the soils summarized in the Table 2. As shown in the Table 2, the extractable iron contents of the soils were ranged from 4.52 mg kg<sup>-1</sup> to 16.54 mg kg<sup>-1</sup> that were higher than the sufficient level of 4.5 mg kg<sup>-1</sup> of the method.

The extractable manganese contents of the soils were ranged from 0.61 mg kg<sup>-1</sup> to 44.23 mg kg<sup>-1</sup> that were higher than the sufficient level of 1 mg kg<sup>-1</sup> of the method, except one soil.

The extractable copper contents of the soils were ranged from 1.40 mg kg<sup>-1</sup> to 3.07 mg kg<sup>-1</sup> that were more than the 0.2 mg kg<sup>-1</sup> sufficient level of the method.

The zinc contents of the soils were ranged from 0.09 mg kg<sup>-1</sup> to 1.23 mg kg<sup>-1</sup> that were lower than the sufficient level of 1 mg kg<sup>-1</sup> of the method, excepts two soils.

The nickel contents of the soils were ranged from 1.09 mg kg<sup>-1</sup> to 21.53 mg kg<sup>-1</sup>. Considering the maximum cumulative levels of 4.48-26.88 mg kg<sup>-1</sup> nickel in soils given by Risser and Backer (1991) and the critical concentrations of nickel in the soils from 6 mg kg<sup>-1</sup> to 112 mg kg<sup>-1</sup> for different plants given by Ascher (1991) the nickel contents of the some soils were slightly high.

The lead levels of the soils were ranged from 0.82 mg kg<sup>-1</sup> to 1.61 mg kg<sup>-1</sup>. Considering the maximum cumulative levels of 44.8-268.8 mg kg<sup>-1</sup> lead in soils (Risser and Backer, 1991) the lead contents of the soils were in the acceptable level.

Table 2. Minimum, maximum and average values of the DTPA+TEA extractable heavy metal levels in the soils

Heavy metal	Center			Türkoğlu		
	Min.	Max.	Average	Min.	Max.	Average
Fe, mg kg <sup>-1</sup>	5.96	16.54	9.95	4.52	36.07	14.09
Mn, mg kg <sup>-1</sup>	4.81	43.42	10.84	0.61 <sup>1</sup>	44.23	12.56
Zn, mg kg <sup>-1</sup>	0.12	1.23 <sup>2</sup>	0.44	0.09	0.60 <sup>3</sup>	0.25
Cu, mg kg <sup>-1</sup>	2.05	3.07	2.20	1.40	3.95	2.64
Ni, mg kg <sup>-1</sup>	1.09	21.53	5.45	2.45	15.44	6.14
Pb, mg kg <sup>-1</sup>	0.82	1.39	1.13	0.82	1.61	1.26

<sup>1</sup> The one soil had less than 1 mg kg<sup>-1</sup> manganese

<sup>2</sup> The two soils had more than 1 mg kg<sup>-1</sup> zinc

<sup>3</sup> The one soil had more than 0.5 mg kg<sup>-1</sup> zinc

#### The heavy metal contents of the wheat leaves:

The heavy metal contents of the leaf samples presented in the Table 3. As shown in the Table 3, the average iron and manganese contents of the leaf samples taken from Center were higher than that of Türkoğlu. The five leaf samples had less than 50 mg kg<sup>-1</sup> total iron, but according to the sufficient level of total iron 10-300 mg kg<sup>-1</sup> for winter wheat given by Jones et al. (1991), the total iron contents of the leaves were sufficient for the yield. However this explanation, it is to be recommended to run researches on the iron status of the soils and on the iron contents of the other crops on the area for the quality and quantity of the crop yields.

Table 3. Minimum, maximum and average values of the heavy metal contents of the wheat leaves

Heavy metal	Center			Türkoğlu		
	Min.	Max.	Average	Min.	Max.	Average
Fe, mg kg <sup>-1</sup>	44.54 <sup>1</sup>	131.94	86.75	18.18 <sup>2</sup>	131.94	71.26
Mn, mg kg <sup>-1</sup>	59.61	234.36	123.88	13.39 <sup>3</sup>	254.17	71.47
Zn, mg kg <sup>-1</sup>	9.40	14.35	12.35	9.99	17.28	13.52
Cu, mg kg <sup>-1</sup>	9.22	14.16	12.02	11.07	12.92	12.31
Ni, mg kg <sup>-1</sup>	3.06	21.82	12.56	8.42	19.14	14.35
Pb, mg kg <sup>-1</sup>	-	-	-	-	11.97 <sup>4</sup>	1.68

<sup>1</sup> The one sample contained less than 50 mg kg<sup>-1</sup> total iron

<sup>2</sup> The four samples contained less than 50 mg kg<sup>-1</sup> total iron

<sup>3</sup> The one sample contained less than 20 mg kg<sup>-1</sup> total manganese

<sup>4</sup> In the two samples, the three samples contained 5.99 mg kg<sup>-1</sup>, the nine samples did not contain lead

The total manganese and copper contents of the leaves were in the sufficient ranges, except one sample for manganese, give by Lones et al., (1991) 16-200 mg kg<sup>-1</sup> and 5-50 mg kg<sup>-1</sup> for manganese and copper, respectively.

The total zinc contents of the all leaf samples were in the deficiency level compared to the suggested sufficient ranges of zinc 21-70 mg kg<sup>-1</sup> for the winter wheat given by Lones et al. (1991). In addition this the total zinc contents of the leaves were lover than the level of zinc crops need, for this reason it is to be recommended to pay attention on the zinc contents of the plants and available zinc contents of the soils on this region considering the public nourishment and the yields of crops.

The total nickel levels in the leaves were high than the suggested tolerance level of 3 mg kg<sup>-1</sup> for plants given by Risser and Backer (1990), but it was discussible according to the critical



nickel concentrations in the different plants given by Asher (1991), which changed up to the plant space from 7 mg kg<sup>-1</sup> to 56 mg kg<sup>-1</sup> of total nickel in the tissue for bermuda grass and pangola grass, respectively.

Although the two leaf samples contained 11.97 mg kg<sup>-1</sup> and the three leaf samples contained 5.99 mg kg<sup>-1</sup> total lead, the twenty one leaf samples had not contained the total lead.

#### The relationships between the soil variables:

The linear correlation coefficient analysis results of the soil variables given in the Table 4. As shown in the Table 4, the soil pH increased significantly by the rising calcium carbonate ( $r = 0.488^*$ ) and exchangeable calcium ( $r = 0.438^*$ ). The soil salinity increased by the rising exchangeable magnesium ( $r = 0.654^{***}$ ) and sodium ( $r = 0.407^*$ ). The exchangeable calcium was in relation with the percent calcium carbonate ( $r = 0.583^{**}$ ). The increasing of the percent organic matter contents of the soils increased the exchangeable sodium ( $r = 0.432^*$ ), available phosphorus ( $r = 0.450^*$ ) and nickel extraction ( $r = 0.434^*$ ). Whereas the rising of soil pH decreased the extraction of the available phosphorus and the rising of organic matter contents decreased the copper extraction ( $r = -0.529^{**}$ ). The lead extraction increased by the exchangeable calcium ( $r = 0.506^{**}$ ). There was a significant positive correlation between the exchangeable magnesium and exchangeable sodium ( $r = 0.545^*$ ).

Table 4. The linear correlation coefficients for the relationships between soil variables ( $r$ )

Soils	CaCO <sub>3</sub>	Ca	Mg	Na	P	Cu	Ni	Pb
PH	0.488*	0.438*	0.168	0.368	-0.490*	0.322	-0.490*	0.104
Salinity	-0.051	0.319	0.654***	0.407*	0.377	0.039	0.384	0.238
O.M.	0.057	0.304	0.209	0.432*	0.450*	-0.529**	0.434*	0.331
CaCO <sub>3</sub>	-	0.583**	-0.234	0.071	-0.366	0.073	0.355	0.278
Ca		-	-0.205	0.135	0.103	0.047	-0.289	0.506**
Mg			-	0.545*	0.118	0.083	0.568**	-0.095
P					-	-0.460*	0.260	0.195

The results of this study in agreement with the others findings such as Agboola and Corey (1973), found significantly positive correlations between the soil pH and exchangeable calcium and between the soil organic matter and available phosphorus. The decrease effect of rising of soil pH on the available phosphorus has been a well known effect of soil reaction on soil phosphorus.

#### The relationships between the heavy metal contents of the leaves and the soil variables:

The linear correlation coefficient analysis results between the heavy metal contents of the wheat leaves and the soil variables given in the Table 5. As shown in the Table 5, the heavy metal contents of the leaves were not effected by the soil reaction. The total iron contents of the leaves decreased significantly by the increasing levels of the organic matter ( $r = -0.363^*$ ), exchangeable calcium ( $r = 0.483^*$ ) and extractable lead ( $r = -0.410^*$ ). Although the extractable lead level of the soils were low it decreased significantly the iron contents of the leaves. The decrease effect of the rising exchangeable calcium on the iron uptake of the plants or reducing of iron function in the plant metabolism was a well known effect of the soil calcium, calcium carbonate, carbonate or bicarbonate. This event occurred in this study because of the high exchangeable calcium contents of the soils. The arid climate conditions of the area was caused of the accumulation of the basic cation such as calcium. Elinç (1988), found a significantly negative relation between the iron contents of plant and soil organic matter.

The total manganese levels of the leaves decreased significantly by the increasing calcium carbonate ( $r = -0.469^*$ ). Agboola and Corey (1973), found a significantly negative relation between the manganese contents of plant and soil calcium.

The total zinc contents of the leaves decreased significantly by the increasing of organic matter ( $r = -0.370^*$ ) and the increasing of available phosphorus ( $r = -0.418^*$ ) levels in the soils.



Whereas there were synergetic effects of the extractable iron and manganese on the zinc contents of the leaves. It is well known that phosphorus has an antagonistic effect on the zinc uptake or zinc contents of plants, which effect of the phosphorus occurred in this study. It is to be recommended that to use of the phosphorus fertilizer has to be taken under control and to avoid excess usage of the phosphorus fertilizer. Elinç (1987), found a significantly negative relation between the soil organic matter and zinc contents of plant.

The total copper contents of the leaves decreased significantly by the increasing calcium carbonate ( $r = -0.426^*$ ) and exchangeable calcium ( $r = 0.538^*$ ). Whereas there was a synergetic effect of the exchangeable magnesium on the copper contents of the leaves.

The total nickel contents of the leaves decreased significantly by the increasing soil zinc ( $r = -0.409^*$ ). The antagonist effects of the divalent cations is a well known relations. That antagonistic effect of the soil zinc on the nickel contents of the leaves gained importance considering the slightly high level nickel contents of the leaves. It is to be said zinc fertilization would be recommended on the area in the point of view to increase zinc contents and decreased the nickel contents of the crops. In this way the quality and the quantity of the crop yields are to be increased.

Table 5. The linear correlation coefficients for the relationships between soil variables and the heavy metal contents of the wheat leaves (r)

Soils variables	The heavy metal in the wheat leaves				
	Fe	Mn	Zn	Cu	Ni
PH	-0.064	-0.197	0.176	-0.216	0.144
CaCO <sub>3</sub>	-0.326	-0.469*	0.017	-0.426*	0.246
O.M.	-0.363*	-0.384	-0.370*	-0.160	0.073
Ca	-0.483*	-0.251	-0.147	-0.538*	0.027
Mg	0.105	0.043	0.171	0.453*	-0.294
P	-0.139	0.167	-0.418*	0.095	-0.063
Fe	0.145	-0.076	0.421*	-0.360	-0.049
Mn	-0.123	-0.146	0.448*	0.248	-0.114
Zn	-0.274	-0.174	0.184	-0.360	-0.409*
Cu	0.103	0.067	0.192	0.199	-0.050
Ni	-0.243	-0.233	0.134	0.323	-0.040
Pb	-0.410*	0.233	0.119	0.229	-0.035

## CONCLUSIONS

The results obtained indicated that the zinc contents of the wheat leaves decreased significantly by the increasing available phosphorus level of the soils. Although the available zinc levels of the soils were low, the total nickel contents of the leaves decreased by the increasing zinc level of the soils.

Considering the results of the study it is to be suggested that it will to be useful to avoid the usage of excess level of phosphorous fertilizer to control the zinc deficiency and the nickel accumulation in the plant tissue. In this way the quality and the quantity of the crop yields are to be increased in the point of view human and animals nourishment and public health.

## REFERENCES

- Agboola A.A., and Corey R.B. (1973) The relationship between soil pH, organic matter, available phosphorus, exchangeable potassium, calcium, and nine elements in the maize tissue. *Soil Sci.*, No: 5, Vol: 115, p. 367-375.
- Ascher C. J. (1991) Beneficial elements, functional nutrients, and possible new essential elements. Chapter, 18, p. 713. In J.J. Mortvedt, F.R. Cox, L.M. Shuman and R.M. Welch, eds. *Micronutrients in Agriculture*, SSSP Book Series: 4, Second Edition, Madison, Wisconsin, USA.

- Elinç F. (1987) Meriç Havzası Vertisol ve Kireçsiz Kahverengi Topraklarda II. Yarayışlı Zn, Fe, Mn, Cu ve B düzeyleri ile bazı toprak özellikleri arasındaki ilişkiler. I. Trakya Toprak ve Gübre Sempozyumu, Trakya Üniversitesi, Tekirdağ, say. 253-256.
- Hızalan E., ve Ünal H. (1966) Topraklarda Önemli Kimyasal Analizler. A.Ü. Ziraat Fakültesi Yayınları, 278, Yardımcı Ders Kitabı, 97, A.Ü. Basımevi, Ankara.
- Jackson M. L. (1962) Soil Chemical Analysis. Printice-Hall, Inc., 183.
- Jones J.B.Jr., Wolf B., and Mills H.A. (1991) Plant Analysis Handbook. I. Methods of Plant Analysis and Interpretation. Micro-Macro Publishing Inc., USA.
- Kacar B. (1972) Bitki ve Toprağın Kimyasal Analizleri: II. Bitki Analizleri. A:ü: Ziraat Fakültesi Yayınları, 453, Uygulama Klavuzu, 155. A.Ü. Basımevi, Ankara.
- Lindsay W. L., and Norvell W.A. (1969) Development of DTPA micronutrient soil test. Agron. Abstr. 84.
- Macy P. (1939) The quantitative mineral nutrient requirement of plants. Plant Physiol. 11:749-764.
- Olsen S.R., Cole V., Watanabe F.S., and Dean L.A. (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. of Agr. Cir. 939, Washington, D.C.
- Peck T.R., Walker W.M., and Borne L.V. (1969) Relationship between corn (*Zea mays L.*) yield and leaf levels of ten elements. Agron. J. 61:299-301.
- Risser J.A., and Becker D.E. (1991) Testing soils for toxic metals. Chapter, 11, p. 284. In R.L. Westerman, J.V. Baird, N.W. Christensen, P.E. Fixen, and D.A. Whitney, eds. Soil Testing and Plant Analysis, SSSP Book Series: 3, Third Edition, Madison, Wisconsin, USA.
- Sims J.T. (1986) Soil pH effects on the distribution and plant availability of manganese, copper, and zinc. Soil Sci. Soc. Am. J. Vol. 50, No. 2, p. 367-373.
- Shear C.B., Crane H.L., and Myers A.T. (1948) Nutrient element balance. Application of the concept to the interpretation of foliar analysis. Proc. Am. Soc. Hort. Sci. 5:319-326.
- Steel R.G.D., and Torrie J.H. (1960) Principles and Procedures of Statistics with Special References to The Biological Sciences. McGraw-Hill Book Company, Inc. New York.
- Tyner E.H. (1947) The relationship of corn yield to leaf phosphorus, and potassium content. Soil Sci. Soc. Am. Proc. 11:317-323.

# WORLDWIDE DISTRIBUTION AND SUSTAINABLE MANAGEMENT OF SOILS WITH GYPSUM

A.A. Jafarzadeh<sup>(1)</sup>, J.A. Zinck<sup>(2)</sup>

<sup>(1)</sup> University of Tabriz, Faculty of Agriculture, Soil Science Department, Tabriz, I.R. Iran

<sup>(2)</sup> ITC, PO Box 6, 7500 AA Enschede, the Netherlands

## ABSTRACT

The prosperity and even the very existence of humankind depend on the food produced from the agricultural resources, with a global demand for food, fiber and bio-energy products growing at an annual rate of 3.2% in developing countries (FAO, 1989). To maintain and enhance the sustainability of agriculture and meet the basic food needs of rising population, it is necessary to use appropriate land management practices, especially in problem-soils. Soils with gypsum are a kind of problem-soils when gypsum is present in considerable amount. According to available information (Driessen and Dudal, 1989; FAO, 1990; Mashali, 1993, 1996; Boyadgiev and Verheye, 1996; among others), the worldwide extent of gypseous soils exceeds 100 million ha, but an inventory carried out at country level shows that it might be as large as 186 million ha (1.5% of the worldwide soil cover), including countries of the Middle East, Eurasia, the Mediterranean belt, Africa, North America and Australia. This paper also summarizes the management practices applied to gypseous soils for sustainable management, as reported by several authors during the last decades. Chemical, physical, biological, hydrological and human features, which affect the productivity and management of gypseous soils, are highlighted.

## INTRODUCTION

Problem-soils are frequent in arid and semi-arid environments, including soils with high amounts of gypsum. It is thus important to assess the distribution and suitability of gypseous soils for sustainable management, since the possibility of incorporating new land into the agricultural production is limited whereas food requirements are steadily increasing. World population is projected to rise from 5.3 billion people in 1990 to 8.5 billion in 2025 and 10 billion by 2050 (Bongaarts, 1994). In contrast, the land resources are finite, fragile and nonrenewable, because land suitable for agricultural use is only a small fraction of the total land area (22% of all land). There are vast areas with gypsum in the world, but precise information about their distribution and extent is still lacking. The present paper draws attention on the worldwide distribution of gypseous soils, the production constraints caused by high gypsum content and the management experience gained during the last decades.

## EXTENT AND DISTRIBUTION OF GYPSEOUS SOILS

Gypseous soils are found in arid and semi-arid areas on gypsiferous rocks and sediments of different origin, where rainfall is insufficient to leach the gypsum out of the soil mantle. They usually occur in the same regions as calcareous soils but are much less widespread. For being of marginal interest to agricultural use, they were given little attention in the past until it was realized that they have potential for both rainfed and irrigated agriculture. Figures provided in the literature about the worldwide extent of gypseous soils are far from accurate. According to earlier estimates (Van Alphen and De Los Rios Romero, 1971), these soils would cover roughly 85 million ha, mainly in North and East Africa, South Europe and Southwest Asia. More recent figures (Driessen and Dudal, 1989; FAO, 1990) increase the extent of gypseous soils to 100-150 million ha, with major areas in the Middle East and the southern parts of the former USSR. Also at regional level, data provided by Boyadgiev and Verheye (1996) show that gypseous soils are widespread in North, Central and East Africa (51.1 million ha), in North-Central Asia (16.5 million ha) and South-Central Asia (2.1 million ha). This might still be an underestimation of the real extent, when data from individual countries are taken into account. Iran, for instance, has about 10 million ha of gypseous soils according to the above-mentioned global information sources, while a recent estimate



based on the land capability map of the country at 1:250,000 scale, reaches a figure of 27-28 million ha, representing 16-17% of the country area (Mahmoodi, 1998). In an attempt to update the knowledge about the worldwide extent and distribution of gypseous soils, existing countrywide data were compiled as presented in table 1, using earlier inventories from Van Alphen and De Los Rios Romero (1971), Driessen and Dudal (1989), FAO (1990, 1993, 1998), Jafarzadeh (1991, 1996), Mashali (1993, 1996), Eswaran, Van den Berg and Almarz (1993), Boyadgiev and Verheye (1996), Mahmoodi (1998), among others. In total, gypseous soils amount to approximately 186 million ha, representing 1.5% of the worldwide soil cover. Spatial aggregation shows a large concentration of gypseous soils in three main geographic regions, the Middle East (72 million ha), Eurasia (51 million ha) and the Mediterranean belt (37 million ha), together with minor areas unevenly distributed over the rest of the world. In some countries, gypseous soils cover as much as one-third of the total land area.

### SOIL CONSTRAINTS AND CROP TOLERANCE

FAO (1993) has estimated the potential rainfed production area worldwide at 2580 million ha, which is considerably in excess of the land presently cultivated (756 million ha) in 91 developing countries, excluding China. In arid and semi-arid regions, low-productivity gypseous soils might be increasingly put under agriculture, but they require appropriate management practices to make their use sustainable in the future. Many factors affect plant growth in gypseous soils, including gypsum content within the root zone, depth to a gypsic layer, depth to impermeable layers, crop tolerance level and gypsum solubility. Also physical properties are often unfavorable, causing low water availability, slaking of loamy topsoils, piping and collapse of irrigation canals. Most research on nutrition and performance of crops grown in gypseous soils has been done under greenhouse and laboratory conditions, with little field experimentation. The tolerance, yield and product quality of many agricultural crops grown on soils with gypsum are not yet well known. FAO (1990) and Mashali (1996) have classified the main agricultural crops into five groups according to their sensitivity to gypsum: (1) tobacco is sensitive; (2) cotton, groundnut, potato and sunflower are semi-sensitive; (3) broad beans, sugar beet, sorghum, corn, soybean and sesame are semi-tolerant; (4) alfalfa, trifolium, wheat, barley, lentil, oat, tomato and onions are tolerant. When the gypsum content in the root zone is more than 40%, land is considered unsuitable for cropping. The management of gypseous soils requires a set of agronomic practices depending on a careful definition of crop requirements. This should be based on investigation of topography, soil characteristics (structure, texture, water holding capacity, salinity, drainability and forms of gypsum), climate, community conditions (economic, social, political and cultural environment), local knowledge and existing farming systems (Mashali, 1996).

### CHEMICAL PROPERTIES AND FERTILIZER REQUIREMENTS

The effect of gypsum on crops depends on several factors including nature, solubility, form, amount, horizontal and vertical distribution, and depth of gypsum accumulation in the soils (Mashali, 1996). Nitrogen, phosphorus and trace elements are virtually always needed to optimize crop production, together with potassium and magnesium in some cases. In soils with gypsum, almost all crops show deficiency of most plant nutrients, in particular phosphorus and micronutrients. Barzanji et al. (1981) reported that soil fertility can be a limiting factor for crop production, especially in places where excessive gypsum (>50 %) is present at shallow depth. Considering the influence of gypsum content on structure, aeration, moisture retention, solubility of gypsum as a function of seasonal soil moisture conditions, and the crop tolerance level, Boyadgiev and Verheye (1996) distinguished five classes of gypsum content in the solum and root zone: 0-3% low, 3-10% medium, 10-25% medium to high, 25-40% high and >40% very high, the latter being unsuitable for cropping. Therefore, fertilizer requirements should be assessed for various crops with regard to depth and amount of gypsum. Similarly, the rates of fertilizer application should be based on farming practices, local conditions, crop species and varieties, and soil characteristics (Mashali, 1996).

In the irrigation scheme of the Ebro Valley, Spain, 70 kg N per ha as ammonium nitrate are applied before wheat and sugar beets are sown (Mashali, 1996). Sugar beets receive an additional 100 kg N per ha. For wheat, a top dressing of 50-60 kg N per ha as ammonium nitrate or ammonium sulphate is applied. In places where wheat is sown in the cold season when nitrification is inhibited, it is more profitable to apply complex fertilizers with about half of the nitrogen content in the form of nitrate rather than ammonium or urea, since the nitrate-N is preferred for uptake by wheat before the soil warms up. In Mexico, the rate of nitrogen application to wheat and sugar beet ranges between 70 and 140 kg per ha (FAO, 1990). On Typic Haplogypsis in the Balikh Basin of Syria, wheat and sugar beet need 150 kg N per ha (Mardoud, 1996a), while Barzanji et al. (1981) recommended a dose of 80-160 kg N per ha for wheat in Irak, depending upon the initial soil fertility status, for a soil having a gypsic layer at shallow depth (25-50 cm). The grain/straw ratio of wheat decreased with increasing levels of N but increased by adding phosphate (Mashali, 1996).

In gypseous soils there are more calcium ions in the soil solution and, for this reason, crops need higher phosphorus application than in non-gypseous soils. Like N application, phosphorus application should be according to crop requirements, local conditions, amount of gypsum and gypsic layer depth. Sugar beets and cotton receive 45 and 50 kg P<sub>2</sub>O<sub>5</sub> per ha as superphosphate, respectively, but irrigated alfalfa is given up to 450 kg per ha (Van Alphen and De Los Rios Romero, 1971). In Tunisia, Amami et al. (1967) reported a dressing of only 150 kg P<sub>2</sub>O<sub>5</sub> per ha as superphosphate for irrigated alfalfa. On Typic Haplogypsis, wheat, cotton and sugar beet need 80-100 kg P<sub>2</sub>O<sub>5</sub> per ha and corn needs 50 kg P<sub>2</sub>O<sub>5</sub> per ha (Mardoud, 1996b).

Discussion about the need for potassium fertilizer on irrigated and non-irrigated gypseous soils has been under way for some time. In general, at equal content of exchangeable K, the concentration of potassium in the soil solution varies considerably depending on pH, amount and type of CaCO<sub>3</sub>, amount and type of clay, and amount and form of gypsum present (FAO, 1990). The K:Ca and Mg:Ca ratios in the soil solution are very low when the gypsum content is high, resulting in a very low uptake of K and Mg from the soil solution, which accounts for low crop yields (Van Alphen and De Los Rios Romero, 1971). In general, it is recommended to apply 30-50 kg K<sub>2</sub>O per ha to a range of crops including wheat, maize, alfalfa and cotton in irrigated land, but Barzanji et al. (1981) found no response of wheat to potassium application. Under rainfed conditions, plants grown in gypseous soils may not suffer from K or Mg deficiencies, because potassium and magnesium cations leached during the wet season can return to the surface during the drier part of the year and become available to plants. Potassium fertilizer application is essential on soils with gypsum in places where fruit trees, vegetables and grasses are intensively cropped, because potassium increases the resistance to certain diseases, helps to overcome water stress and improves the quality of crops.

The availability of micronutrients is affected by the presence and level of gypsum, but also by the negative effect of phosphorus and possibly potassium fertilizers added in large doses (FAO, 1990). The application of zinc in gypseous soils reduces the rate of uptake of Cu, Mn and, to some extent, Fe because of ion competition (Safaya, 1976). In Iraq, Barzanji et al. (1981) found negative correlation between gypsum content and Mn and Fe availability, but only weak negative correlation with Zn and Cu. They concluded that the availability of Mn, Fe and maybe Cu and Zn, is likely to be adversely affected by excessive gypsum content near the soil surface. In general, yield is not limited by one kind of micronutrients alone. Major factors influencing the micronutrient status and requirement include pH, gypsum content, calcium content, irrigation water quality, amount and application system (Devaux, 1980), soil texture, increasing use of NPK (Finck, 1984; Fritz et al., 1984), use of high yielding varieties (El-Fouly, 1983; Fritz et al., 1984;) and climatic conditions (Sillanpaa and Vlek, 1985). Therefore, more information is needed on the interactions between micronutrients and conditioning factors.

## PHYSICAL CONDITIONS AND TILLAGE

In general, the physiographic setting where gypseous soils tend to occur favors runoff. High erosion rates were registered on Gypsic Calcisols with lithic phase. Microtopography is mostly irregular to



undulating, with elevation differences of less than one meter (Mashali, 1996). Often land leveling is needed to increase irrigation water use efficiency and application uniformity, especially in furrow, flood and basin irrigation systems. Irrigation must be carefully conducted to avoid excessive water percolation beneath the root zone to gypsum-rich layers.

Special consideration must be given to tillage in soils with hard gypsum layer or surface crusting. Tillage is carried out to prepare the seedbed, break the surface crust and improve water infiltration, but tillage might also contribute to the formation of an impermeable layer if improperly executed. The selection of the right plough type, tillage sequence, ploughing depth and moisture content at the time of ploughing should provide good tilth, improve soil structure and break surface crusts (Mashali, 1996). In soils with surface crust and in shallow soils, germination rate is low and it is difficult to obtain a satisfactory stand of crops. According to Jafarzadeh et al. (unpublished), penetration resistance of gypsum crust is controlled by texture (38%), NaCl (21%), water table height (15%), gypsum (9%) and CaCO<sub>3</sub> (5%).

### EFFECT OF ORGANIC MANURE

According to Hazzah et al. (1986), organic manure in amounts of 12-24 t per ha improved the chemical and physical properties of gypseous soils with a significant increase in crop production (e.g. millet). They have reported that poultry manure had more effect on vegetative growth, while cattle manure had more effect on soil physical properties and root growth. Studies on the gypseous soils of the Aldoor experimental farm in Iraq showed that addition of 12-24 t cattle manure per ha improved soil water retention, infiltration rate, structure and aggregate stability, with yield increase of wheat and broad beans (Mashali, 1996). Nafie (1989) also mentioned that the application of organic manure in gypseous soils of Iraq significantly increased the fresh and dry weight of shoots and roots, plant height, tiller height and number, while decreasing the compressive strength of wheat.

### WATER MANAGEMENT, IRRIGATION AND DRAINAGE

Yields of 3-4 t of wheat grain per ha were obtained in Spain, Syria and Iraq using irrigation on soils with gypsum. The suitability of gypseous soils for irrigation in arid and semi-arid regions depends on several factors such as texture, structure, water holding capacity, relief and micro-relief, depth to a layer limiting root penetration, form and content of gypsum in different layers, salinity and drainage, with their relative importance related to factors such as climate, type of crops and soil management (Van Alphen and De Los Rios Romero, 1971). Soils with a gypsic layer at 30-60 cm depth are moderately suitable for irrigated agriculture and give relatively good yields for many crops, provided the surface layer is fine-textured. If the texture of the surface layer is medium to coarse, the suitability is poor. Mousli (1981) stated that a soil with a gypsic layer at 60 cm depth and a maximum of 20% gypsum content in the top 60 cm can be placed under irrigation, preferably sprinkler irrigation. In general, shallow soils containing less than 15% gypsum in the surface 20 cm and a maximum of 40% in the 30-60 cm layer may be used with some reservation for irrigated shallow-rooted crops, using localized irrigation or sprinkler systems with precisely metered water application rates (Mashali, 1996). But the quality of the water that can be stored in the root zone becomes marginal when a gypsic or calci-gypsic layer is at less than 60-75 cm depth (Driessen and Dudal, 1989; FAO, 1990). Using slightly saline water, having common ions with gypsum (i.e. Ca<sup>2+</sup> or SO<sub>4</sub><sup>2-</sup>), will decrease gypsum solubility. Using well water with high concentrations of calcium and sulphate ions, even if it contains similar amounts of chloride or sodium, inhibits terrain subsidence and sinkhole formation (Mashali, 1996).

The method and frequency of irrigation and the amount of irrigation water applied are of prime importance when gypseous soils are put under irrigation. Al-Kubaisi (1988) observed gypsum mobilization after dissolution under flood irrigation because of the high amounts of irrigation water applied in short periods. This did not occur with sprinkler irrigation. He also noted that the germination rate was higher (90%) with sprinkler irrigation than with flood irrigation (80%), probably due to the hardness of the surface crust formed under flood irrigation. Leaching requirements depend on the salt content of the soil and



irrigation water and on the maximum salt concentration permissible in the soil solution, which in turn depends on the salt tolerance of the growing crop. An effective drainage system is required to maintain the water table low and control salinity. The optimum depth and spacing of field drains are governed by several factors, of which the most important are the construction costs, soil texture and structure, depth to and gypsum content of the gypsic layer, hydraulic properties of the soil mantle, optimum depth to the water table and its salinity (Mashali, 1996).

## THE HUMAN CONTEXT

Gypseous soils often occur in densely populated areas within arid and semi-arid environments with irrigated agriculture. With increasing population, land management needs to be improved to increase and sustain crop yields. According to Mashali (1996), attention must be given to the following aspects: (1) development of appropriate technology; (2) adequate infrastructure and appropriate socio-economic conditions for the application and adoption of proper technology; and (3) strong and effective extension service able to support technical improvements. In general, gypseous soil management decisions should be based on cost-benefit analysis, including feasibility studies and environmental impact assessment (Mashali, 1996). A special development authority is necessary for the organization, operation and maintenance, and a sufficient budget of local funds must be reserved.

## CONCLUSION

Worldwide, soils with gypsum cover 186 million ha, representing 1.5% of world land surface reported by FAO (1993). Although the properties and productivity of gypseous soils have been studied by many researchers at country level, measures have not always been directed to the heart of the problem. A basic precaution to be taken before development of gypseous soils for agriculture is studying their chemical, physical, biological and hydrological properties and calling for appropriate management practices in an integrated system. This could be achieved through technology transfer between countries and adaptive research on a regional and global basis.

## REFERENCES

- Al-Kubaisi A.A.J. (1988) Effect of sprinkler and basin irrigation methods on some properties of Al Dour gypsiferous soils and growth of corn plant. MSc. Thesis, University of Baghdad, Iraq.
- Amami S., El-Baldy Ch., Pouget M.J. (1967) Rénovation d'une palmeraie littorale ancienne, étude de la remise en culture intensive. Annales Inst. Nat. Rech. Agron. de Tunisie, Vol.40, Fasc.8.
- Barzanji A.F., Paliwal K.V., Mittu K.T., Abbas H.A. (1981) Fertility status of the gypsiferous soils of Iraq. Technical Bulletin 94. Research Centre for Gypsiferous Soils, Aldour, Iraq.
- Bongaart J. (1994) Can the growing human population feed itself? Scientific American, March 1994: 36-42.
- Boyadgiev T.G., Verhey W.H. (1996) Contribution to a utilitarian classification of gypsiferous soils. Geoderma 74: 321-338.
- Devaux R. (1980) Fertilization of the citrus in Morocco. In: M.M. El-Fouly (ed). Proceedings 2nd Workshop on Micronutrients in Plant Nutrition. Mariut, Egypt: 89-111.
- Driessen P.M., Duda! R. (eds) (1989) The major soils of the world. Lecture notes on their geography, formation, properties and use. Agricultural University Wageningen, the Netherlands, and Katholieke Universiteit Leuven, Belgium.
- El-Fouly M.M. (1983) Micronutrients in arid and semi-arid areas: levels in soils and plants and the need for fertilizers with reference to Egypt. Proceedings 17th Colloquium of the International Potash Institute: 163-173.
- Eswaran H., Van den Berg E., Almarz R. (1993) Global distribution of Aridisols and their characteristics. Proceedings Int. Workshop on Classification and Management of Arid Desert Soils. Urumqi, China: 388-405.

- FAO (1989) Yearbook. Rome, Italy.
- FAO (1990) Management of gypsiferous soils. Soils Bulletin 62. Rome, Italy.
- FAO (1993) Agriculture: Toward 2010. Rome, Italy.
- FAO (1998) World Reference Base for Soil Resources. World Soil Resources Report 84. Rome, Italy.
- Finck A. (1984) Micronutrient problems in high yield cropping. In: E. Watte and I. Szabolcs (eds). Proceedings 9th World Fertilizer Congress. Budapest, Hungary, 1: 263-267.
- Fritz A., Jurgens G., Wichmann W. (1984) Micronutrient fertilization. Means to increase and secure production. International Colloquium Optimization of Plant Nutrition. Montpellier, France.
- Hazzah A.H., Al-Rawi A.A.H., Abdul Ameer A.R. (1986) Effect of some organic fertilizers on the properties of gypsiferous soils and the growth of millet (*Panicum miliacum*). Symposium on Gypsiferous Soils - Their Effect on Construction and Agricultural Production. Baghdad. Iraq.
- Jafarzadeh A.A. (1991) Experimental studies of gypsum migration and deposition in soil profiles. PhD Thesis, Wye College, University of London, U.K.
- Jafarzadeh A.A. (1996) Gypsum formation and classification of gypsiferous soils. Agricultural Sci. Scientific J. Vol.6 (1,2). College of Agriculture, University of Tabriz, Iran.
- Jafarzadeh A.A., Zinck J.A., Burnham C.P. (unpublished). Penetration resistance of gypsum crust from laboratory experiments.
- Mahmoodi S. (1998) Gypsiferous soils: characteristics, management and land suitability evaluation. Soils and Water, Special Issue, Vol.12 (3).
- Mardoud T. (1996a) Behavior of roots and properties of soils with different content of gypsum under irrigation (Balikh Basin, Syria). In: R.M. Poch (ed). Proceedings Int. Symp. on Soils with Gypsum. Lleida, Spain.
- Mardoud T. (1996b) Main results of field experiments on irrigated soils with gypsum in Granada Station, Syria (1977-1984). In: R.M. Poch (ed). Proceedings Int. Symp. on Soils with Gypsum. Lleida, Spain.
- Mashali A.M. (1993) Management practices for gypsiferous soils under irrigated conditions. Proceedings Int. Workshop on Classification and Management of Arid Desert Soils. Urumqi, China.
- Mashali A.M. (1996) Soil management practices for gypsiferous soils. In: R.M. Poch (ed). Proceedings Int. Symp. on Soils with Gypsum. Lleida, Spain.
- Mousli O.F. (1981) Methods of evaluation and classification of gypsiferous soils and suitability for irrigated agriculture. Soil Taxonomy Workshop, ACSAD, 1980: 278-320.
- Nafie F.A.A. (1989) The properties of highly gypsiferous soils and their significance for land management. PhD Thesis, Wye College, University of London, UK.
- Safaya N.M. (1976) Phosphorus-zinc interaction in relation to adsorption rates of phosphorus, zinc, copper, manganese and iron in corn. Soil Science Society of America Journal 40: 719-722.
- Sillanpaa M., Vlek P.G.L. (1985) Micronutrients and the agroecology of tropical and Mediterranean regions. Fertilizer Research 7: 151-167.
- Van Alphen, De Los Rios Romero F. (1971) Gypsiferous soils, notes on characteristics and management. Int. Inst. of Land Recl. and Improv. Bulletin 12. Wageningen, the Netherlands.

Table 1: Worldwide distribution and extent of gypseous soils (area x 1000 ha)

Regions/countries <sup>1</sup>	Total land area <sup>1</sup>	Arable and permanently cropped land <sup>1</sup>	Irrigated land <sup>1</sup>	Gypseous soils <sup>2</sup>	
				Area	%
<b>Middle East</b>					
Bahrain	68	2	1	6	8.8
Iran	163600	18150	9400	28851	17.6
Iraq	43737	5450	2550	12503	28.6
Jordan	8893	405	63	81	0.9
Kuwait	1782	5	2	355	19.9
Oman	21246	63	58	7649	36.0
Qatar	1100	5	-	<1	-
Saudi Arabia	214969	3740	435	20250	9.4
U. A. Emirates	8360	39	5	<1	-
Yemen	52797	1481	360	2931	5.6
Total				72626	
<b>Eurasia</b>					
Afghanistan	65209	8054	2760	<1	-
China	932641	95975	49872	21056	2.3
India	297319	169650	48000	1500	0.5
Mongolia	156650	1401	80	61	<0.1
Pakistan	77088	21250	17100	1500	1.9
Former USSR				27450	-
Total				51567	
<b>Mediterranean belt</b>					
Algeria	238174	7850	555	7966	3.3
Cyprus	924	158	39	<1	-
Egypt	99545	2800	2800	10000	10.1
Lebanon	1023	306	86	<1	-
Libya	175954	2170	470	5000	2.8
Morocco	44630	9920	1258	1116	2.5
Spain	49944	19656	3453	3500	7.0
Syria	18378	5775	906	4095	22.3
Tunisia	15536	4952	285	5250	33.8
Turkey	76963	27535	3674	395	0.5
Total				37322	
<b>Africa</b>					
Ethiopia	100000	12650	190	2500	2.5
Mali	122019	2503	78	3050	2.5
Mauritania	102522	208	49	513	0.5
Namibia	82329	622	6	5328	6.5
Somalia	62734	1030	180	10163	16.2
Sudan	237600	12975	1946	785	0.3
Total				22339	
<b>North America</b>					
Mexico	190869	24730	6100	1100	0.6
USA				1400	-
Total				2600	
<b>Australia</b>				23	
<b>Global total</b>				<b>186477</b>	

<sup>1</sup> FAO, 1994; <sup>2</sup> FAO, 1990; Mashali, 1993, 1996; Boyadgiev and Verheye, 1996; among others.



## PENETRATION RESISTANCE OF GYPSUM CRUST FROM LABORATORY EXPERIMENTS

A.A. Jafarzadeh<sup>(1)</sup> and J.A. Zinck<sup>(2)</sup>

<sup>(1)</sup> University of Tabriz, Faculty of Agriculture, Soil Science Department, Tabriz, I.R. Iran

<sup>(2)</sup> ITC, PO Box 6, 7500 AA Enschede, the Netherlands

### ABSTRACT

A literature review revealed important knowledge gaps on the relation between mechanical resistance of gypsum crusts and root elongation. There is no known research on the penetration resistance of gypsum crusts. To discriminate between factors controlling the strength of gypseous surface crusts, a soil column experiment, with four gypsum-saturated water table heights, four textures and three chemical treatments, was conducted for 120 days. Sandy loam accumulated the highest amount of gypsum at any water table height, followed by medium-fine sand and silt loam. Acid-washed medium sand was comparatively less efficient in conducting and concentrating gypsum in the surface layer. Penetration resistance (PR) substantially increased upon drying of the crust. In fine materials, PR decreased as gypsum content increased because of granular crystallization and structure improvement. In coarse materials, gypsum caused cementation and reinforced the strength of the crust. In general, PR decreased with the addition of  $\text{CaCO}_3$  and increased with the addition of  $\text{NaCl}$ . PR values of the dry soil materials are significantly correlated with texture, sodium chloride and the strength of the moist soil materials, in this order. The factors contributing to the total variation of dry PR values are : texture (38%),  $\text{NaCl}$  (28%), water table height (15%), gypsum (9%) and  $\text{CaCO}_3$  (5%). Measurements of PR with a 1 mm probe are highly aleatory as they are controlled by short-distance variations of the soil microfabric. Seedling emergence and root elongation may be severely hindered by gypsum crusting.

### INTRODUCTION

Gypsum crusts have been reported from many (semi-) arid regions. Their geographic distribution closely coincides with the areas receiving less than 250 mm rainfall per year (Watson, 1982). Low temperature limits their development and this is why they appear to be rare in the cold deserts (Watson, 1979). Extensive gypsum crusts have been described in Middle East countries, where they are a major limitation for crop production because water infiltration rate, seedling emergence and crop growth are largely controlled by the thickness and gypsum content of the crust (Chartres et al., 1985; Nafie, 1989). The severity of the mechanical hindrance that gypsum crusts oppose to crop development can be assessed by measuring penetration resistance. The effect of moisture and gypsum content on the penetration resistance of gypsiferous horizons has been studied by Poch and Verplancke (1997), but gypsum crusts developing on the soil surface have not been given yet the same attention. The objective of the present paper is to investigate the effect of selected soil properties, including texture, moisture, chemical additive and water table level, on the penetration resistance of gypsum crusts.

### MATERIALS and METHODS

To examine the penetration resistance (PR) of gypsum crusts, column experiments with different water table heights, soil textures and chemical treatments, were conducted (Jafarzadeh, 1991). Four natural soil materials, originally free of gypsum, were used in the main experiment, including silt loam, sandy loam, medium-fine sand and acid-washed medium sand. Very fine and very coarse materials were avoided because of their negative effect on water movement. The materials represent four textural conditions sufficiently differentiated to significantly influence the ascending water movement from a constant, gypsum-saturated water table at variable depths. The textural differentiation is reinforced by differences in porosity, clearly separating the loamy materials (50% porosity) from the sandy materials (40% porosity).

The soil materials were air-dried, sieved at 2 mm, and then packed into columns. Polyethylene tubes 6 cm in diameter and 7.5 cm, 12.5 cm, 25 cm, and 50 cm in height, were used in the main experiment on

surface crust formation. Additionally, columns 1 m high and 9 cm in diameter were used with two textures (silt loam and medium-fine sand) to determine the maximum height of the water table ascent. All samples were placed in gypsum-saturated water, prepared from Paris plaster and distilled water, in saucers (samples with 7.5 cm height) and beakers (samples with 12.5 cm, 25 cm, 50 cm height).

The core experiment was conducted on natural soils submitted to gypsum enrichment from the ascending water table, but without other chemical additives. In a parallel experiment, the natural soil materials were artificially enriched with calcium sulfate, calcium carbonate and sodium chloride, respectively, to study the effect of salts usually present in gypseous soils. The sun heat in desert was simulated during the experimental period (120 days) by means of continuously glowing 100-watt radiant lamps placed 20 cm above the soil surfaces. A constant water table level was maintained at the bottom of the soil columns until the experiments were terminated.

After 120 days, samples were cut from the top 7.5 cm (0-7.5 cm) of the columns. The pipes were divided by heat except the columns of 7.5 cm height. Samples from the experiments were selected and their mechanical resistance measured using a laboratory penetrometer with a 1 mm probe. A modified version of the apparatus described by Gooderham (1973) was used to let the samples move upwards on the platform of the penetrometer at a speed of 100 mm/hour. All treatment samples of the four different experiments were tested with five replicates, randomly distributed over three samples according to a sequence of 2-1-2. Penetration resistance was measured before and after drying for samples with no chemical additives and only after drying for all other samples (table 1). Samples were exposed to drying for 45 days in an oven at 38-40°C.

## RESULTS

### GYPSUM CONCENTRATION AND CRUST FORMATION

During the conduction of the experiment lasting 120 days, gypsum moved upwards in the columns from the constant, gypsum-saturated water table at the bottom. Gypsum ascent was stimulated by the artificial heat applied on top of the columns. After oven-drying, gypsum accumulating in the upper part or on top of the columns formed a crust, with gypsum content varying between 0 and 18%. Sandy loam was the material with the highest amount of gypsum (11 to 18%) at any water table height, followed by medium-fine sand and silt loam. Acid-washed medium sand was comparatively less efficient in conducting and concentrating gypsum.

These results show that the balanced particle size distribution of the sandy loam material, with 44% silt + clay and 39% fine and very fine sand, is more favorable to capillary rise than the other textures. High amount of fines in the silt loam creates more retention of the soil solution than upward conduction. A high amount of sand coarser than fine sand breaks the capillary continuity in the acid-washed medium sand. Fines are not necessary to secure the ascent of the soil solution, even up to 50 cm height, if there is enough fine and very fine sand (e.g. 22% in the medium-fine sand material).

For all materials, with only a slight deviation in the case of silt loam, largest surface accumulation of gypsum was obtained when the depth to the water table was 12.5 cm. Smaller amounts of gypsum concentrated with water table heights of 7.5 cm and 25 cm. Surficial gypsum accumulation was very low or even null in the case of silt loam and clean medium sand, when the water table was as deep as 50 cm. Maximum elevation of gypsum accumulation was 40-42 cm for acid-washed medium sand, 46-47 cm for silt loam and 60-70 cm for medium-fine sand (the last two in tubes 1 m high and 9 cm internal diameter). For all four soil materials, the surficial concentration of gypsum decreased from 12.5 cm to 25 cm to 50 cm water table height. This seems to reflect the efficiency of the capillary rise in each case. The lower accumulation of gypsum for the shortest capillary rise (7.5 cm) responds to a different mechanism, where concentration is retarded because of the shallow water table, close to the soil surface, causing pores to be permanently water-filled. The thickness of the crust formed by the surficial gypsum concentration varied between 1 and 3 cm according to the texture of the material. The thickest gypsum crust was found on sandy



loam + 13% gypsum, the shallowest on acid-washed medium sand. In columns where 2% NaCl was added to medium-fine sand, upheaval of the material occurred and a crust 3-4 cm thick grew outside the tubes.

#### EFFECT OF SURFACE DRYING ON PENETRATION RESISTANCE

Water content has been reported as an important factor controlling penetration resistance of horizons with gypsum (Callebaut et al., 1985; Poch and Verplancke, 1997). But there is no information about the effect of moisture on the penetration resistance of gypsum crusts and the change in crust strength upon drying. As the strength of the surficial layer, enriched in gypsum, is supposed to increase upon drying, PR was measured before and after drying. To evaluate the magnitude of the change and its effect on the strength of the surface layer before and after drying, a simple index relating moist and dry PR values was established ( $\text{index} = [\text{dry PR} - \text{moist PR}] / \text{dry PR}$ ).

In general, the absolute values of dry PR are higher than those of moist PR, with large variations from less than one time to almost eight times higher. Except one case, the index is higher for silt loam and medium-fine sand than for sandy loam and acid-washed medium sand in each column height, respectively. In general, the index values are higher in the 7.5 columns than in the others, but no strong trend is visible. In spite of five measurement replications, some data seem to be aleatory, even erratic. For instance, in three cases moist PR = 0, in three cases moist PR is higher than dry PR and in one case dry PR and moist PR = 0. In the cohesionless acid-washed medium sand, dry PR is lower than moist PR probably because of the effective stress caused by the pressure from the water films between particles. In general, data inconsistency can be explained by strong variations occurring in the soil microfabric at short distance. Small cracks, packing voids and sand grains make PR measurements aleatory when using an instrument of size (1 mm probe) similar to that of the microfabric features.

#### EFFECT OF SOIL TEXTURE ON PENETRATION RESISTANCE

As soil texture plays a significant role in the development and stability of soil structure, it can also be expected to influence the susceptibility of soils to crusting. In fine-textured gypseous soils, movement and evaporation of gypsum-saturated water are very slow and accumulation of gypsum at the surface takes a long time to produce a crust.

In the experiments conducted, fine materials with low percentage of gypsum cause high penetration resistance. Silt loam texture, with 97% fine particles (<212  $\mu\text{m}$ ), many well connected water-filled pores of fine calibre which slow down the water movement, and low organic matter content of 0.3 %, shows high penetration resistance in all experiments, even in samples with 50 cm water table height and no gypsum accumulation at the surface (table 1). Sandy loam texture, with 83% fine particles (<212  $\mu\text{m}$ ), many well connected, medium sized water-filled pores and very few air-filled pores, and 1.2% organic matter, shows lower penetration resistance than silt loam samples in the majority of the experiments. In both cases, a high percentage of gypsum reduces the penetration resistance. In silt loam samples with 7.5 cm height and 7.7% gypsum and in silt loam samples with 50 cm height and no gypsum, penetration resistance is higher than in silt loam samples with 25 cm height and 12.6% gypsum (table 1). Also in sandy loam samples with 7.5 cm height and 14% gypsum, penetration resistance is higher than in sandy loam samples with 12.5 cm height and 18% gypsum and with 25 cm height and 16% gypsum. Thus, in the presence of fine particles (<212  $\mu\text{m}$ ), penetration resistance decreases with increasing gypsum content, which causes flocculation of clay particles and improvement of the soil structure.

In sandy materials, gypsum formed bridges between the skeleton grains, promoting cementation and strengthening the crust. Strongest cementation occurred in medium-fine sand with 22% fine particles, dirty grains carrying thick water films and few obstructing coarse air-filled pores. In acid-washed medium sand with only 7% fine particles, clean grains carrying thin water films and large-size pores which give many barrier air spaces, cementation was weaker. Sometimes, penetration resistance was affected by sand particles during the recording with the penetrometer, as has occurred in medium-fine sand samples with 25 cm height and acid-washed medium sand samples with 7.5 cm height.



## EFFECT OF GYPSUM CONCENTRATION ON PENETRATION RESISTANCE

There is no significant correlation between the amount of gypsum concentrated in the upper part of the columns and PR values ( $R^2 = 0.09$ ,  $F = 1.41$ ). Neither is there a clear relationship between gypsum percentage, on the one hand, and texture and water table height on the other. The amount of gypsum which has moved upwards from the constant, gypsum-saturated water table does not seem to be enough to create significant strength differences in the crust formed on top of the columns. To better isolate and assess the effect of gypsum on penetration resistance, sandy loam samples were mixed with 13% gypsum and submitted to the same additional treatments as the gypsum-free soil material (four water table heights, drying, + 10%  $\text{CaCO}_3$ , + 2%  $\text{NaCl}$ ). In this experiment, gypsum accounted for 94% of the regression in relation to sandy loam samples without supplementary gypsum.

## EFFECT OF CHEMICAL ADDITIVES ON PENETRATION RESISTANCE

Calcium carbonate 10% and sodium chloride 2% were mixed with all four natural soil materials and with the sandy loam enriched with 13% gypsum to assess their effect on crust formation and penetration resistance, since these chemicals are frequently associated with gypsum in soils of (semi-) arid environments. In general, the addition of  $\text{CaCO}_3$  decreases the penetration resistance of the gypsum crust, but there is no clear trend in the relationship between PR values and the two supposedly controlling factors, texture and height of the water table. Calcium carbonate could have opposite effects on PR, improving the structure and decreasing the cementation in the loamy soils while favoring laminar crust formation in the sandy soils.

Unlike with  $\text{CaCO}_3$ , the PR values in general increase and some decrease only very slightly with the addition of  $\text{NaCl}$ . This trend is particularly visible in the case of the 7.5 cm high columns for all textures and in the case of the silt loam material in all columns. Sodium chloride, being more mobile than calcium sulfate and carbonate, largely controls the chemistry of the surface crust and enhances its strength in sandy materials, where  $\text{NaCl}$  crystals occupy the bulk of the crust. In loamy materials, sodium chloride might contribute to dispersion and cause PR values to raise. Additional gypsum, as in the crust of sandy loam + 13% gypsum, tends to decrease penetration resistance.

## DISCUSSION

PR values of the dry soil materials are significantly correlated with texture, sodium chloride and the strength of the moist soil materials, in this order. Texture alone explains 38% of the variation of the PR values, which increases to 61% when texture and  $\text{NaCl}$  are considered together (table 2). Sodium chloride, for being more mobile than calcium sulfate, has a stronger influence on the strength of the crust than gypsum ( $R^2 = 0.28$  for  $\text{NaCl}$  versus  $R^2 = 0.09$  for  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ). Regression of PR against gypsum improves after logarithmic transformation of the dry PR values ( $R^2 = 0.19$ ). Moist PR is only a loose predictor of dry PR because of the important physical changes which take place in the surficial soil layer upon drying, leading to crystallization and crust formation. The water table height does not significantly influence the dry PR values. PR values of samples enriched with  $\text{CaCO}_3$  are more (negatively) correlated with the height of the water table than samples enriched with  $\text{NaCl}$  or  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ , because of the lower solubility and mobility of calcium carbonate. The strongest relation of gypsum is with texture, indicating that gypsum probably accumulates as granular material rather than cementing the receiving soil material, as already observed by Poch and Verplancke (1997). This causes short-distance irregularities in the crust structure and might explain the low correlation or lack of between some explaining factors and PR values. The factors contributing to the total variation of dry PR values are: texture (38%),  $\text{NaCl}$  (28%), water table height (15%), gypsum (9%) and  $\text{CaCO}_3$  (5%).

In spite of five replications for each measurement, PR values seem inconsistent in relation to the factors contributing to the formation and strength of the crust, such as texture, gypsum,  $\text{NaCl}$  and  $\text{CaCO}_3$ . The 1 mm probe used in the experiments is very sensitive to short-distance variations of the microfabric caused by small cracks, packing voids, coarse skeleton grains, crystals or local concentration of chemical

precipitates. Thus measurements of the resistance encountered by the needle when penetrating the crusted surface layer are highly aleatory. This calls for a different approach, based on high-density grid survey of the crust and application of geostatistics to account for micro-spatial variations, using spatial interpolation via kriging.

A conical steel probe maybe a good simulator of a root in silicate soil material, but less appropriate in crystalline gypsum. Since gypsum crystals rate hardness 2 and steel about 6 on Moh's scale, a steel needle readily crushes or perforates a gypsum crystal and thus penetrates into the crust. A root in the same condition probably would not pierce a gypsum crystal and, therefore, root elongation may be severely hindered by a gypsum crust.

## CONCLUSION

Crusting is a major problem for crop production in gypseous soils, in which seedling emergence is largely controlled by the thickness, gypsum content, strength, texture, moisture condition and pattern of crystallization of the crust. Drying up of the soil surface layer causes gypsum precipitation, changes crystallization patterns and reinforces the crust strength. In coarse-grained materials, gypsum accumulation leads to cementation which causes PR values to increase, while granular crystals form in the presence of fine particles, contributing to decrease penetration resistance. The total variation of the dry PR values is controlled by texture, sodium chloride, water table height, gypsum and calcium carbonate, in this order.

## REFERENCES

- Callebaut F., Gabriels D., Minjauw W., De Boodt M. (1985) Determination of soil surface strength with a needle-type penetrometer. *Soil and Tillage Research* 5: 227-245.
- Chartres C.J., Green R.S., Ford G.W., Rengasamy P. (1985) The effect of gypsum on macroporosity and crusting of two red duplex soils. *Aust. J. Soil Res.* 23: 467-679.
- Gooderham P.T. (1973) Soil physical conditions and plant growth. PhD Thesis, University of Reading, UK.
- Jafarzadeh A.A. (1991) Experimental studies of gypsum migration and deposition in soil profiles. PhD Thesis, Wye College, University of London, UK .
- Nafie F.A.A. (1989) The properties of highly gypsiferous soils and their significance for land management. PhD Thesis, Wye College, University of London, UK .
- Poch R.M., Verplancke H. (1997) Penetration resistance of gypsiferous horizons. *European Journal of Soil Science* 48: 535-543.
- Watson A. (1979) Gypsum crust in deserts. *J. of Arid Environments* 2: 3-20.
- Watson A. (1982) The origin, nature and distribution of gypsum crusts in deserts. PhD Thesis, University of Oxford, UK.

## Acknowledgment

This paper is based on data produced by the first author in the framework of his doctoral research at the Wye College, University of London, UK, under the supervision of Prof. Dr. C.P. Burnham.

Table 1. Penetration resistance values of surficial gypsum crust (kPa)

Water table height	7.5 cm	12.5 cm	25 cm	50 cm
SIL	1056	855	870	991 (no gypsum)
SILCa	771	1250	1048	953
SILNa	1128	1181	829	1143
SIL b.d.	216	440	190	1033 (no gypsum)
SL	1166	850	722	604
SLCa	695	988	425	262
SLNa	1067	668	338	672
SL b.d.	570	836	608	0
SLG	1193	1014	1026	980
SLGCa	1132	1075	946	775
SLGNa	1067	665	505	1227
SLG b.d.	657	646	722	410
MFS	570	744	798	615
MFSCa	1208	642	532	380
MFSNa	1026	957	475	1090
MFS b.d.	133	509	0	79
AWMS	832	737	0	0
AWMSCa	490	1155	1041	0
AWMSNa	1242	676	834	0
AWMS b.d.	796	976	152	0

All PR values are oven-dry at 38-40 °C, unless otherwise indicated. SIL = silt loam; SL = sandy loam; MFS = medium-fine sand; AWMS = acid-washed medium sand; Ca = +10 % CaCO<sub>3</sub>; Na = + 2 % NaCl; G = + 13 % gypsum; b.d. = before drying.

Table 2. Regression statistics

Predictor	Dependent variable	R	R <sup>2</sup>	F	Sign.	t	Sign.
PR moist	PR dry	0.52	0.27	5.10	0.040	2.258	0.040
Texture	PR dry	0.61	0.38	8.44	0.012	2.905	0.012
Texture	PR dry(CaCO <sub>3</sub> )	0.27	0.08	1.14	0.304	1.066	0.304
Texture	PR dry(NaCl)	0.08	0.01	0.09	0.766	0.304	0.766
Texture /PR dry (NaCl)	PR dry	0.78	0.61	10.11	0.002	-	-
Gypsum %	PR dry	0.30	0.09	1.41	0.254	1.188	0.254
Gypsum %	PR dry (log)	0.43	0.19	3.26	0.093	1.804	0.093
PR dry (CaCO <sub>3</sub> )	PR dry	0.21	0.05	0.65	0.433	0.808	0.433
PR dry (NaCl)	PR dry	0.53	0.28	5.32	0.037	2.306	0.037
Water table height	PR dry	0.38	0.14	2.37	0.147	-1.536	0.147
Water table height	PR moist	0.25	0.06	0.96	0.345	-0.978	0.345
Water table height	PR dry (CaCO <sub>3</sub> )	-0.51	0.26	5.00	0.042	-2.236	0.042
Water table height	PR dry (NaCl)	0.46	0.21	1.72	0.217	-1.871	0.082
PR sandy loam (CaCO <sub>3</sub> )	PR sandy loam	0.51	0.26	0.71	0.488	0.844	0.488
PR sandy loam (NaCl)	PR sandy loam	0.78	0.61	3.07	0.222	1.752	0.222
PR sandy loam	PR sandy loam	0.97	0.94	28.89	0.033	5.375	0.033
+ 13% gypsum							
PR sandy loam (CaCO <sub>3</sub> ) +	PR sandy loam	0.86	0.74	5.74	0.139	2.396	0.139
13% gypsum							
PR sandy loam (NaCl) +	PR sandy loam	0.12	0.01	0.03	0.884	0.166	0.884
13% gypsum							

PR = penetration resistance; CaCO<sub>3</sub> = + 10%CaCO<sub>3</sub>; NaCl = + 2%NaCl; log = logarithmic transformation



# LABORATORY STUDIES OF EVAPORATION RATE IN GYPSEOUS SOILS IN RELATION TO : TIME, WATER TABLE, TEXTURE, AND TREATMENTS

A.A. Jafarzadeh

Associate Prof. and Head of Soil Science, Department, Faculty of Agriculture, Tabriz University, Tabriz. I.R. Iran.

## ABSTRACT

An important mechanism by which soils become gypseous is the upward movement of ground water with dissolved calcium and sulphat and its subsequent evaporation at the soil surface. High soil evaporation rates, which cause salt accumulation on the surface of these soils, can thwart all efforts to increase crop production.

Evaporation in gypseous soils experimentally (over 140 days) was studied by French workers, which they have shown decreases of evaporation for first thirty days and there after irregularly changes. Later this opinion has confirmed by Nafie (1989). But the present study not only evaluates the evaporation in gypseous soils with time, but also examines the relation of evaporation rate to different textures, water table level and treatments. The highest evaporation occurred during the first ten days and then tended to decrease in the second ten days with regularity for 40 to 50 days. From 50-120 days, it became irregular but never returned to the first value(table.1). Evaporation rate in acid washed sand was slower that the other texture while maximum rate and hence of capillary rise, was with sandy loam. Lowring of water table is not effective unless to one meter or more, just in sandy loam+13% gypsum and 50 cm height results show a lower rate than sandy loam + 13% gypsum with 25cm height. All samples with NaCl show lower evaporation and presence of  $\text{CaCO}_3$  increase evaporation except in sandy loam with 50 cm and acid washed sand with 25cm heights. Also the high concentration of gypsum in samples of sandy loam + 13% gypsum reduced evaporation rate. It also investigates three quite different effects of capillary movement such as (a) height of rise(b) speed of rise and (c) volume transmitted to the surface at equilibrium. Results grouping in gypseous soils a water table at  $< 1\text{m}$  as a suitable mapping unit in coarse and fine textures. Also speed of rise in these soils not only related to texture but also differs according to different solution, total porosity and different size of pores.

## INTRODUCTION

Many studies on the patterns of water movement in soil provide detailed descriptions of the dynamics of soil moisture, but they do not, as a rule, fully elucidate the problems connected with movement of salt solutions. This reduces the value of these studies, because the liquid phase of the soil is not pure water but solutions of gypsification, one most take into account the quantity of gypsum in the liquid and movement through the soil profile in relation to different factors.

Movement per ascensum where gypsum is moved upwards by capillary rise and deposited at the surface following evaporation. This is sometimes from a water table, but may be in moisture from previous rain or dew.

Upward movement of water from the water table and subsequent evaporation at soil surface is an important feature of some gypseous soils, especially in fallow land. The process of evaporation from the soil surface can hardly be overemphasised in arid regions of the world with hot climate and low rainfall, and when one considers the importance of evaporation from soils is an important consideration in the program of many farming operations in both irrigated and dry land agriculture.

French workers, Mme Christine Plet-Lajoux, Gerard Monnier and Georges Pedro (Glangeaud 1971) have shown that evaporation rates in soil columns in contact with gypsum saturated water for 140 days show a decrease during the first thirty days and thereafter change irregularly but never return to the original value. Nafie (1989) has described evaporation rates of gypsum saturated water in four different soil columns 30 cm in height, over six weeks, and confirms the result of the French workers that for thirty days there is a regular decrease. Therefor no large amount of investigative work concerning evaporation in gypseous soils has been conducted, and with regard to the basic process or

the effect of the complexity of the soil or the continuously changing variables associated with atmosphere, much remains to be learned. But the present paper not only evaluates the evaporation with time and other factors but also investigate three quite different effects of capillary movement such as (a) height of rise (b) speed of rise and (c) volume transmitted to the surface at equilibrium.

## MATERIALS and METHODS

The study was carried out with laboratory columns involving five different soils [silt loam (ZL), sandy loam (SL) sandy loam with 13% gypsum, medium fine sand (MFS), acid washed medium sand (AWS)] and all with three different treatments (soil, soil plus 10%  $\text{CaCO}_3$  and soil plus 2%  $\text{NaCl}$ ). Sandy loam with 13% gypsum/ acid washed sand and all samples with 10%  $\text{CaCO}_3$  and 2%  $\text{NaCl}$  were prepared in the laboratory. The natural soils, free of gypsum, were collected from four areas of Kent (UK) as follow:

- 1) Silt loam : Btc horizon at about 50-100 cm depth from the Hamble series at Withersdane. Wye. Kent.
- 2) Sandy loam: Bw horizon at about 20-35 cm depth from the Bearsted series at the Hothfield Common, near Ashford, Kent.

- 3) Medium-fine sand: Cretaceous Folkestone Beds sand from Hinxhill. near Ashford, Kent.

- 4) Acid- washed medium sand : beach sand from Kingsgate. Thanet. Kent. which was washed with hydrochloric acid for one week, then with hot water and finally with distilled water, and dried in the laboratory. The pipette method was used for particle size analysis. After boiling with hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) for the destruction of organic matter, dispersion was performed by shaking in a 10% sodium hexametaphosphate solution for 16 hours. Particle separation followed the procedure proposed by Tinsley (1970). The wet combustion method of Tinsley (1970) was used for organic matter content determination. All selected materials are essentially finer grained than sand ( $<600\mu$ ) (table 3,4). The two loamy materials are mainly finer than medium sand ( $<212\mu$ ), but the silt loam has twice as much silt + clay that the sandy loam. The sandy materials slightly vary in their dominantly medium sand content, and the beach sand has been additionally cleaned by acid- washing. Thus the materials represent four textural conditions sufficiently differentiated to significantly influence the ascending water movement from a constant, gypsum saturated water table at variable depths. All samples were placed in gypsum saturated water (prepared from plaster of paris and distilled water) in beakers. The sun heat in deserts was simulated during the experimental periods (120 days) by men of continuously glowing 100 watt radiant lamps placed 20 cm above the soil surfaces.

Evaporation rate in relation to different factors were studied in columns with 25 and 50 cm length and 6 cm internal diameter and measured every two days (later every three days) during the experiments (120 days) and calculated for every ten days (Table.1). But for the study of capillary movement effects, columns 7.5cm high with 6cm id, columns 1 m in length and 9 cm internal diameter were used. Volumetric water content and water retention of soils were studied by the pressure plate method. The porosity of the disturbed samples, representing a condition similar to that of the materials packed in the experimental tubes, was studied and capillary continuity was confirmed using the suction method in a pressure plate at tensions of -5 kPa, -20 kPa, -50 kPa, -100 kPa (table 2).

## RESULTS and DISCUSSION

The simulated arid zone environmental conditions induced a high evaporation rate when the water table was close to the soil surface. Experimental information about gypsum dissolution and transport was obtained from both experiments by introducing gypsum saturated water (gsw) to the bottom of soil columns in relation to different factors. The highest evaporation occurred during the first ten days and then tended to decrease in the second ten days for both experiments (five different soils and each with three different treatments [soil - soil 10%  $\text{CaCO}_3$  and soil + 2%  $\text{NaCl}$ ]) with regularity for forty to fifty days. From 50 to 120 days, the evaporation rate became irregular, but never returned to the first value, which confirms the findings of previous workers about evaporation rate and its relation with time in gypseous soils. The evaporation rate was measured in this study with regard to four different textures (ZL, SL, MFS and AWS).



The water rose from the water table to the surface of the soil columns by capillarity, and was evaporated from the surface. The sandy loam in both experiments (25cm, 50cm) with three replications in each experiment shows a lower rate than medium fine sand. Therefore texture of soil affects capillary conductivity by its influence on the size and continuity of the interspaces or pores, which results obtained from experiments can be as follows:

SL > MFS > ZL > AWS

Moore (1939) has shown that saturated permeability increases with increasing coarseness of texture from shallow water tables.

Sand > fine sandy loam > light clay > clay

But according to the results observed from both experiments evaporation rate in AWS is slower than the other textures, while the maximum rate of evaporation and hence of capillary rise, is with sandy loam. Thus the results from these experiments do not agree with Moore's (1939). However, they do confirm the result described by Nafic (1989) about medium acid washed sand and also suggest an explanation for the effect of texture on capillary rise and evaporation rate. In order to study the relation between evaporation rate and depth to the water table, columns as described earlier were packed with soil, with a perforated aluminium foil in the bottom of each column. The simulated water tables were 25 cm and 50 cm which in each experiment all previously explained soils and treatments were used. Lowering the water table from 25 cm to 50cm in all different soils except sandy loam almost sandy loam with 13 percent gypsum would decrease the evaporation rate by a factor of height (Table.1). Therefore upward movement and evaporation of water is possible with water table as deep as 50 cm and although the rate will be slow, accumulation of harmful amounts of gypsum is possible if the ground water contains substantial amounts of calcium and sulphate ions and sufficient time is allowed. In such a case the lowering of water table is not effective, unless to 1.0cm or more. Table.1 confirm this effect which the evaporation rate in sandy loam with 13% gypsum and 50cm height shows a lower rate than sandy loam with 13 percent gypsum with 25cm height in comparison with sandy loam samples.

The concentrations of different treatments (soil, soil + 10% CaCo<sub>3</sub>, soil + 2% NaCl and so soil + 13% gypsum in sandy loam texture) were determined for all soils with three replications in both experiments. Evaporation of water samples with NaCl differs from that of just soil in that under comparable conditions, the gypseous soils + NaCl has a lower evaporation rate than others. There are three principal reasons for this. In the first place, as water evaporates from the surface of the soil, the salt concentration in the soil surface increases, which lowers the vapour pressure of the solution and increases its osmotic pressure. This reduces its rate of evaporation, and so allows solution to move up from the subsoil for a longer time than if no NaCl were present. Secondly the soil surface becomes dry and covered with salt crust, the rate of evaporation drops just as in a salt-free soil. Thirdly sodium chloride collapses the soil structure, and with cementing and pushing up of the particles causes a low evaporation rate (table.1).

The results obtained from the five soils in two different experiments with three replications confirm this idea about gypseous soil with NaCl.

But the results of the samples with 10 percent calcium carbonate in both experiments except SL + 10% CaCo<sub>3</sub> (50cm height) and AWS + 10% CaCo<sub>3</sub>, (25cm height) show a high evaporation rate in comparison with Haplogypsid samples. Leenheer (1964) has described how application of calcium carbonate has sometimes given a marked visible improvement in the structure of soils low in organic matter, even if they were neutral, and there is evidence that excess calcium carbonate may reduce the cohesion between clay particles in moist clods (Russel and Basinki 1954) and reduce the size of the water-table crumbs in a soil (Williamson 1959). therefore the results confirm the effect of calcium carbonate in the improvement of soil structure in calcigypsid in comparison with Haplogypsid.

Also a high concentration of gypsum has reduced evaporation rate in sandy loam samples with 13 percent gypsum in comparison with sandy loam samples which refers to gypsum concentration that reduce total porosity and therefore it causes low evaporation rate.



## CONCLUSION

The results obtained from the present column experiments polyethylene tubes of one metre length and 9cm internal diameter, with silt loam and medium fine sand textures confirm the result of szabolcs and Lestaks (1971) experiment for eight months with sulphate, that during a four month experiment, the gypsum saturated water never reached the surface, and indeed there was no accumulation of gypsum in the surface (0-1cm) of silt loam samples with 50 cm height. Therefore with regard to results (during 8 months and 4 months) and the studied profiles with water table at 60-85cm depth (BAH3 and BAH15) (Jafarzadeh 1991) grouping soils with a water table at  $< 1\text{ m}$  is suitable as a mapping unit in gypscous soils with coarse and fine textures. This limit however should be related to the nature of soil particles, since results of column experiment with 50cm height show that gypsum saturated water does not reach to the surface and there is even no evidence of gypsum accumulation at 44cm depth from the top in acid washed medium sand samples with clean particles. Also the results of capillary movement speed with time during the first fifteen and thirty days in column experiment of 50cm water table height confirm both ideas of previous workers, ie that gypsum saturated water after fifteen days reaches to soil surface of columns in sandy loam samples with enough connected, medium size pores, but in other textures such as silt loam with clean particles and large pores there is no evidence of gypsum accumulation in the soil surface and even in acid washed medium sand samples with 50cm height gypsum saturated water does not reach to the surface. Therefore the speed of capillary rise is not only related to the texture, but also differs according to different solutions, for all samples show sodium chloride accumulation at the surface after fifteen days, even acid washed medium sand. There was confirmation of previous authors results about texture, in that Premi and Oswal (1984) reported greater capillary rise in sandy loam than in sand or sandy loam/sand mixtures, in agreement with results obtained from the present study (table.1). Porosity was studied and capillary continuity confirmed in different textures with the pressure plate ( Suction method ) in different pressures of -5 kPa, -20 kPa, -50 kPa and -100 kPa.

Total porosity of samples was first measured by saturation and without any pressure. The results (Table. 2) refer to silt loam with an abundance of well connected water filled pores, but they are of fine calibre and so water movement is slower (Tables 2 and 3). Sandy loam has an abundance of well connected, medium sized water filled pores and very few air filled pores (Tables 2 and 3). Natural medium fine sand with dirty grains carries thicker water films and has fewer obstructing coarse air filled pores (tables 2 and 3) than acid washed medium sand with clean grains carrying thin water films and having large size of pores give many barrier air spaces (Tables 3 and 4).

Table.1 - Amount of Water Evaporation (mm) During Experiments 1 and 2

Time (Days)	25 Cm			50Cm			25Cm			50Cm	
	ZL	+CaCo3	+NaCl	ZL	CaCo3		+NaCl	SL	CaCo3	MFS	+CaCo3
10	299	344	253	436	640		370	312		660	545
20	246	292	69	113.5	324		301	105.5		626.5	450
30	243	292	42.5	92	228		298.5	90.5		295	245
40	206	238	39	88.5	201		220	85		324	237
50	140	152	27	88.5	194.5		147	69		271.5	212.5
60	146	152	34	84.5	172.5		153	71		192.5	180
70	170	217	30.5	84.5	161.5		215	76		194.5	171.5
80	134	214	30	83.5	160		223	73.5		183.5	162
90	125	148	32.5	75	153		145	78		154.5	148.5
100	125	146	34	77	160.5		131	84		147	147.5
110	124	151	34	74.5	153.5		150	89		148.5	144
120	124	147	36	77	153		150	91		148	147.5
Total (mm)	2082*	2493	661.5	1374.5*	2701.5		2520.5	1224.5		3344.5*	2896.5

+CaCo3=Soil + 10% CaCo3

+NaCl = Soil + 2% NaCl

Table.1 - (contd)

Time (Days)	+CaCo3			+NaCl			SL+13% Gypsum			+CaCo3			+NaCl			MFS			+CaCo3			+NaCl		
	SL+13% Gypsum			+CaCo3			SL+13% Gypsum			+CaCo3			+NaCl			+CaCo3			+CaCo3			+NaCl		
10	364	370	324	324	324	324	500	648	605	348	317	151	645	646	295	645	646	295	645	646	295	645	646	295
20	292	281	112	112	112	112	363	447	209.5	310.5	244	36	162.5	456	38	162.5	456	38	162.5	456	38	162.5	456	38
30	210	224	99	99	99	99	270	205	53	272	190	24.5	250	277.5	35.5	250	277.5	35.5	250	277.5	35.5	250	277.5	35.5
40	173	198	89	89	89	89	231.5	192	44	187	172.5	30	192.5	254.5	26	192.5	254.5	26	192.5	254.5	26	192.5	254.5	26
50	119	144	59	59	59	59	173	169.5	39	128	124	19	147	216	19.5	147	216	19.5	147	216	19.5	147	216	19.5
60	117	147	83	83	83	83	171	135.5	37	129	131	34	109	152	21	109	152	21	109	152	21	109	152	21
70	111	217	87	87	87	87	140.5	124	35.5	132.5	134	38	101.5	139.5	21	101.5	139.5	21	101.5	139.5	21	101.5	139.5	21
80	90	178.5	83.5	83.5	83.5	83.5	51.5	110	29.5	119.5	128	34	95	112.5	21	95	112.5	21	95	112.5	21	95	112.5	21
90	92	147	87	87	87	87	51	110.5	29	121	122	52	91.5	112.5	27	91.5	112.5	27	91.5	112.5	27	91.5	112.5	27
100	88	137	81	81	81	81	51	103	32	128	133	42.5	90	90	27	90	90	27	90	90	27	90	90	27
110	80	150.5	65	65	65	65	49	100	34.5	129	132	54	83.5	70.5	28	83.5	70.5	28	83.5	70.5	28	83.5	70.5	28
120	81	151	57	57	57	57	47	105	35	125	128	52	96.5	34.5	23	96.5	34.5	23	96.5	34.5	23	96.5	34.5	23
Total (mm)	1817*	2345	1226.5	1226.5	1226.5	1226.5	2098.5*	2449.5	1183	2129.5*	1955.5	567	2334*	2561.5	282	2334*	2561.5	282	2334*	2561.5	282	2334*	2561.5	282

+CaCo3=Soil + 10% CaCo3

+NaCl = Soil + 2% NaCl

Table2. - Volumetric water content of Samples at Different Pressure

	0 (Total Prosimy) %	-5 kPa %	-20 kPa %	-50 kPa %	-100 kPa %
Silt loam	49.96	38.09	28.67	22.26	19.00
Sandy loam	49.01	44.69	21.25	14.12	10.63
Meddium fine Sand	40.77	16.70	7.28	5.72	4.96
Acid washed Medium sand	39.09	6.27	2.30	1.83	1.22

Table.3 - Partical size Analysis of Samples

	> 600 $\mu$ %	600 $\mu$ -212 $\mu$ %	20-212 $\mu$ %
Silt loam	0.30	2.25	12.25
Sandy loam	1.60	15.50	38.95
Meduim fine Sand	1.70	76.77	21.20
Acid washed Meduim sand	0.50	93.00	6.50

Table. 4 - Partical Analysis of Samples

	Fine Sand %	silt + Clay %	Finer than 212 $\mu$
Silt loam	12.3	85.1	97.4
Sandy loam	39.0	43.9	82.9
Meduim fine Sand	22.1	0.3	22.5
Acid washed Meduim sand	6.5	0	6.5

## REFERENCES

- Glangeaud L 1971. Authors: C plet-lajoux, G Monnier and G Pedro Pedologie-Etude experimental sur la genese et al place des encroutements gypseux. C R Acad Sc, Paris T 272 (14 Juin 1971).
- Jafarzadeh, A.A. 1991. Experimental studies of gypsum migration and deposition in soils profiles. PhD. Thesis. Wye College. University of London.
- Leenheer L de 1964. Preservation of soil structure on mechanised farms in Belgium. Trans 8th Int Congr Soil Sci 2:561-570.
- Moore R E 1939. Water condition from shallow water tables. Hilgardia 6^383-426.
- Nafie, F A 1989. The properties of highly gypsiferous soils and their significance for land management. PhD Theis, Wye College, University of London.
- Premi S C and Oswal M C 1984. Comparison of observed and predicted maximum rise of water in soil. J Indian Soc Soil Sci 32: 654-657.
- Russell E W and Basinski J J 1954. The effect of heavy dressings of calcium salts on the consistency of clay soils and subsoils. Trans 5th Int Congr Soil Science 2: 166-173.
- Szabolcs I and Lestak V 1971. Capillary movement of sodium salt solutions in soil columns. Soviet Soil Science 483-488.
- Tinsley, J 1970. A manual of experiments for students of soil science. Soil Scinence Department Aberdeen University.
- Williamson W T H, Pringle J and Coutts J R H 1959. Short and longly rotations and soil structure in the north east of Scotland. Proc Int Symp Soil Structure 1958, 176-187.



# REFLECTION VALUES OF SALINE SOILS OF GREAT MEANDER BASIN IN LANDSAT TM IMAGES AND THEIR STATISTICAL RELATIONSHIPS

Yusuf Kuruçu, Unal Altınbaş, Mustafa Bolca, Burcin Cokuysal, Sezai Delibacak  
Agricultural Faculty of Ege University, Soil Science Department, Bornova, 35100, Izmir-Turkey

## ABSTRACT

Objects on the Earth reflect the sun lights in different intensity and wavelengths. This is the base of remote sensing techniques, which is intensively use in many fields at the last quarter of the 20-century. In that context, borders of saline soils in Great Meander Basin, were determined by taking consider into reflection values of 7 3 2 bands of Landsat 5 TM satellite

According to results of land observations and laboratory analyses that saline soils were classified as Typic Halaquept. Typic Halaquepts were located on over flow mantle land physiography in valley landscape type. Since, poor drainage condition and high evaporation range intensive salt accumulation causes, especially in surface soils. They are usually used as nature land and land use capability classes of the soils are VIsw and VIIsw.

The arithmetic mean, median, mode, minimum and maximum values of reflection values of saline soil from each band were determined, in addition variance for all parameter was calculated. Statistical relationships of reflection values from different bands were determined according to correlation and regression analyses procedures by computer.

## INTRODUCTION

The remote sensing technique has been using for many of agricultural aims such as soil study, land cover and soil map. Use of remote sensing technique obtains some important advantages on mapping of some soil properties, espatically if the soils has poor drainage condition, saline or alkaline properties, texture differences etc. The Great Meander Basin has a very large delta, which were formed by various types of soils. Most of them are saline and have poor drainage condition. Decision-makers need to know detail of soil properties of the region and their boundaries to create a well design land use plan. Soils and other objects of The Earth reflect or absorb the sunlight. The reflected electromagnetic energy can be visible and invisible such as infrared and thermal wavelength. Sensors of the satellites can record separately both type of electromagnetic energy and they can be monitoring by the computer facilities.

There are several results of the salt accumulation in the soils, such as rising up salty ground water by capillarite in soils and, irrigating by salty water. Salt can also be carried from sea through the lands, by waves, aquifers and winds. Evapotranspiration is also a reson of salt accumulation around the lake and lagoony systems of the sea. The research area formed by accumulation of deposits, which were carried by Great Meander River through the Aegean Sea.

Salinity problem has been detected in the soils which covers 1.7% (1.518.746ha) of Turkey and 3.8% (837.405 ha) of agricultural land of Turkey. Surface of the saline soils of the research area is 50.696ha (4). It is known that during the summer time, seawater moved through the land by aquifers.

Satellite images were taken from Landsat 5 TM and 732 of band combination were used to delineate the distribution of the saline soil for this research. It is shown that, drawing the boundary of saline soils is easy and takes less time by use of Remote sensing technique, comparing with the conventional methods.

## MATERIALS and METHODS

The research area were located on The West part of The Turkey and 100 km South of the Izmir. Main landscape type of the area is a valley. Saline soils were located on mostly delta and some of depression relief type of the valley.

Satellites are permanent data source for land information, such as land cover and soil types, and they offer unique futures in the field . Landsat 7 TM images were used for the project. Their ground resolution is 30mx30m. TM is a scanning optical mechanic sensor system that records reflected and emitted energy in visible, reflective infrared , middle infrared , far and thermal infrared

portions of the electromagnetic spectrum. The images are performed 7 spectral bands, which cover 0.45-0.52 $\mu$ m (1. blue) , 0.52-0.60 $\mu$ m (2.green), 0.63-0.69 $\mu$ m (3. red), 0.76-0.90 $\mu$ m (4. near infrared), 1.55-1.75 $\mu$ m (5. middle infrared), 2.08- 2.35 $\mu$ m (7. far infrared), 10.4-12.50 $\mu$ m (6. thermal).

Saline soils were recognised by combination of 7.3.2 bands. Research were done in three stage, first, processing the images, second, gathering data from field work, soil sampling and analysing in laboratory and last stage for again image processing for drawing final maps.

In first stage, some band combinations were tested to find best combination and band combination of 732 was found as best combination to use for this research. Image was enhanced and geometrically corrected before unsupervised classified. According to results of unsupervised classification of the image , we had 7 soil groups in draft soil map of the research area.

In second stage, soil groups were visited and 5 soil profile were dug and 35 soil samples were picked from each horizon to laboratory analyse. Besides total salt (soluble) contents of soils, the soils samples were analysed for measuring of organic mater, pH, texture cation exchange capacity and exchangeable cations. Data about general attributes of soil and environment were gathered during the fieldwork.

In the last stage, satellite image was reclassified according to rules of supervised classification method . In this process, field observations and laboratory analyses were taken consider into and final map were completed.

## DISCUSSION

Saline soils were recognised in two different types of relief in valley landscape system. Mostly, they were located on delta relief which near the Aegean Sea. They have usually dry surface soil, although their deep soils are moist or almost wet and they were covered by thin salt crust (Figure 1). Because of salt crust, the soils can be distinguished with very high pixel values and light colour in satellite images.

The other relief type of the saline soils were located in basin. During the alluvial plain formation, slightly higher lands ,with medium or coarse soil texture such as terraces, over flow mantle and levee relief types, and lower lands with fine and medium soil texture such as basin or depression relief types were formed.

Main problem of the alluvial plain is poor drainage condition. Ground water table is very close the surface in lower lands. Quality of the ground water is not available to use for irrigation because of high content of salt. The soils which are located in the Basin relief type of valley have been affected by salty ground water. They usually have medium or high amount of clay in their soil texture, because of that , their moisture content is higher than that the other soils which located in higher lands and they don't have salt crust. On the contrary of the salt crust covered soils, the moist soils can be distinguish with lowest reflection values and dark colour in satellite images (Figure 2).

Fifteen test areas were determined for each soil units to measure reflection values of them. At least 10.000 pixels for each test area were studied and their statistical analyses were done (Table 1). According to the results, the highest reflection values in three bands were observed on salt crust covered area in delta relief, Although have high salt contents, the lowest reflection values were observed in basin relief, because basins have the most moist soil of research area. It is known that , moist soils can absorb the most of the sun light. The other soils were observed with the reflection values in between delta and basin relief (Figure 3).





Figure 1. Salt crust covered soils in the delta relief type

According to the results of the laboratory analyses, water soluble salt content of soils were determined in the range from 0,15% to 2,3%. Percentage of salt content in soil samples, which picked from salt crust covered area, were determined more than 2%. The salt content of soil samples from basin relief type were analysed in the range from 1,73% to 0,88%. Organic material content of the soil samples were determined mostly less than 1 %, only a few soil samples include organic material in the range from 2% to 3%.



Figure 2. Landsat TM colour – composite , with bands 7,3,2 displayed as red, green, blue.



REPETITION	DELTA			BASIN			OV. FLOW MANTLE			ALLUVIAL FAN			LEVEE		
	B7	B3	B2	B7	B3	B2	B7	B3	B2	B7	B3	B2	B7	B3	B2
1	177	165	178	57	70	58	76	71	59	93	70	57	77	77	68
2	163	165	165	45	62	54	78	73	60	90	65	54	92	92	70
3	150	161	161	71	72	60	81	79	65	95	68	56	93	92	71
4	140	156	157	58	67	54	79	81	66	117	80	63	88	88	68
5	123	127	127	57	68	57	78	78	63	109	72	58	91	90	71
6	120	124	124	44	57	49	80	79	64	70	57	49	96	95	74
7	120	122	121	50	62	53	83	83	68	77	62	52	78	77	68
8	136	141	142	66	66	56	78	77	63	74	65	53	82	81	69
9	123	125	124	58	62	53	69	70	58	77	61	52	90	89	65
10	128	142	142	59	58	50	78	75	61	90	68	56	84	83	70
11	130	141	141	74	68	58	77	75	62	84	67	55	87	87	71
12	112	119	116	63	60	51	78	75	62	80	63	53	91	90	75
13	106	112	110	63	65	54	79	76	63	84	63	53	86	85	65
14	82	89	87	47	64	55	65	68	56	70	58	60	92	91	71
15	120	127	128	44	57	50	72	72	60	78	63	52	85	85	68
MIN.	82	89	87	44	57	49	65	68	56	70	57	49	77	77	65
MAX.	177	165	178	74	72	60	83	83	68	117	80	63	96	95	75
ART. AV.	128.67	134.40	134.87	57.00	63.75	54.09	76.73	75.47	62.00	85.87	65.47	54.87	87.47	86.80	69.60
VARIANCE	529.52	460.83	563.12	90.53	22.38	10.21	21.92	17.55	9.86	184.12	33.41	12.84	30.41	29.46	7.83

Table 1. Reflection values of soils in bands 7, 3, 2 and in different types of relief.

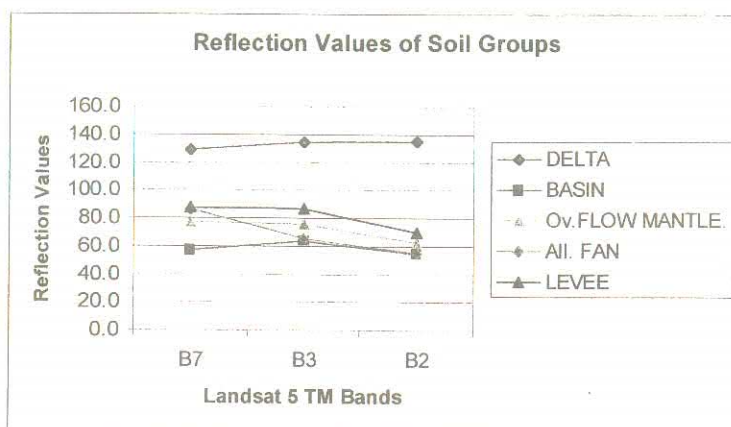


Figure 3. Reflection values of the soils in different relief types.

Cation exchange capacities of soil samples were carried out between 7.34 and 25.68 me/100g. Exchangeable cations were determined as;  $\text{Na}^+$  0.16-9.37 me/100 g;  $\text{K}^+$  0.07-1.51 me/100 g;  $\text{Ca}^{++}+\text{Mg}^{++}$  6.20-17.75 me/100g. According to the results of laboratory analyses,  $\text{Ca}^{++}+\text{Mg}^{++}$  and  $\text{Na}^+$  were found out as dominant cations in the soil samples. Exchangeable anions of soil sample were determined in saturation extract. According to results of laboratory analyses, exchangeable anions were found out as;  $\text{Cl}^-$  14.96-1440.66 me/lt;  $\text{HCO}_3^-$  2.50-15.00 me/lt;  $\text{SO}_4$  2.75 -231.89 me/lt. Reaction (pH) of the soil samples were measured in between 7.50 and 8.11.

## REFERENCES

- Altınbaş Ü., Türk N., Seçmen Ö., Kurucu Y., Bolca M., Cokuysal B., Deibacak S., Turk T. (1999). Reseaches on land use and soil taxonomic units of The west part of Great Meander Basin in Aegean Region by Remote sensing technique. DPT proje No: 96 K 120670, Ege University, Agricultural Faculty, Bornova- Izmir, Turkey.
- Black, C.A. (1965). Methods of Soil Analysis.Part 1-2 American Soc.Agro, Inc., Publisher Madison, Wisconsin, U.S.A.
- Bouyoucos, G. J. (1962). Hydrometer Method Improved for Making Particle Size Analysis of Soil.Agr.Vournal, 54:464-465.
- Jackson, M. L. (1967). Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi.
- Kelley, W. P. (1951). Alkaline Soils. Their Formation, Properties and Reclamation. Reinhold Publishing Corporation, New York, U.S.A.
- Nieuwenhuis E.(1979). Image Interpretation for Soil Surveys. International Institute for Aerospace Survey and Earth Sciences, Enschede, The Netherlands.
- Schlichting, E., Blume H. P. (1966). Bodenkundliches Praktikum.Verlag Paul Parey, Hamburg und Berlin. S.121-125.
- Soil Survey Staff, (1951). Soil Survey Manuel. U.S. Government Printing Office, Washington.
- Rauterberg, E., Kremkus F. (1951). Bestimmung von gesamt Humus und alkalischen Humusstoffen in Boden. Weinheim.
- U.S. Salinity Lab. Staff, (1954). Diagnosis and Improvement of Saline and Alkaline Soils. U.S. Government Handbook No:60, Printing Office, Washington.
- Zinck J. A. (1988). Physiography and Soil. International Institute for Aerospace Survey and Earth Sciences, Enschede, The Netherlands.

# THE RELATIONSHIPS BETWEEN THE EXCHANGEABLE SODIUM RATIO (ESR) AND SODIUM ADSORPTION RATIO (SAR) IN SOME SOILS OF THE AMİK PLAIN

Necat Ağca, Kemal Doğan

Mustafa Kemal University, Faculty of Agriculture, Department of Soil Science  
TR 31040 Antakya-Turkey

## ABSTRACT

The aim of this research has been to determine the relationships between ESR and SAR in some soils of the Amik Plain as affected by some chemical properties of these soils.

pH, EC, soluble sodium, calcium, magnesium, bicarbonate and chloride contents of the soils ranged between 7.37-8.19, 0.506-6.819 mS/cm, 0.33-21.28 me/l, 2.07-25.04 me/l, 0.53-61.88 me/l, 0.34-4.12 me/l and 0.37-34.72 me/l, respectively.

The ESR and SAR values of the soils were in range of 0.0049-0.0611 and 0.22-6.09, respectively. The Gapon coefficients (Kg) of ESR-SAR relationships changed between 0.0056-0.0120. The coefficient of single regression equation which was determined for all data is 0.0090. Coefficients of all regression equations were found to be statistically significant.

The order of alkalization tendency of the layers in the profile of the soils is 50-90 cm > 0-20 cm > 20-50 cm.

## INTRODUCTION

Exchangeable Sodium Ratio (ESR) is determined from exchangeable Sodium (N<sub>ex</sub>) and cation exchange capacity (CEC) (me/100g) by the following relationship:

$$ESR = N_{ex} / (CEC - N_{ex})$$

Sodium Adsorption Ratio (SAR) is, on the other hand, calculated from concentration of cations (me/l) in the saturation extract by the equation:

$$SAR = Na / [(Ca + Mg) / 2]^{1/2} \quad (\text{Harron et al., 1983}).$$

The ESR is significantly correlated to the SAR for many soils (Bower, 1959; Paliwal and Gandhi, 1976; Poonia and Talibudeen, 1977). Thus, once the relationships between ESR and SAR has been determined, ESR can be estimated from this relationship (Bower, 1959). But, ESR-SAR relationship is affected by some soil properties (Poonia and Talibudeen, 1977). Therefore, it is necessary to determine this relationship individually for soils of different regions.

ESR-SAR equation which was derived to investigate relation between composition of exchange and solution phases by Gapon in 1933, assume that there is a linear correlation between similar cations in solution and exchange phases. Afterwards, this equation is reorganized by Richards (1954) as follows.

$$ESR = K_g \times SAR$$

Where, K<sub>g</sub> is Gapon coefficient.

There are many researches on the ESR-SAR relationship. It was evident from the findings of Yeşilsoy (1969), Al Chalabi and Pasricha (1981), Hall and Berg (1983), Guth and Brown (1985), Ağca and Deric (1991), Saltalı (1996) and Walter (1997), that the Gapon selectivity coefficient (K<sub>g</sub>) is not constant but can change in a rather wide range, from 0.0041 to 0.0875.

The aim of this research has been to determine the relationships between ESR and SAR in some soils of the Amik Plain as affected by some chemical properties of these soils. Specifically, a reliable estimate of the ESR from the SAR would be useful for characterization of alkali soils and provide information regarding their reclamation and alkalization tendency.

## MATERIALS and METHODS

The research area is located in Amik plain. The Amik plain, which is one of the most important agricultural areas in Turkey, is situated in Southern Part of the country. The area, in general, has Mediterranean climate, but receives more than the usual precipitation.



In this research, first, two different test areas which can represent plain were selected in the Amik Plain. Each area contained two intersecting lines: A and B lines on the first area and C and D lines on the second area. Then, a total of 63 disturbed soil samples were taken from 23 spots on these four lines at 0-20, 20-50 and 50-90 cm depths in June 1998. The spots were selected at one kilometer intervals.

Soil samples were analysed for pH and electrical conductivity (EC) (in the saturation extract), exchangeable sodium, cation exchange capacity (CEC), organic matter, soluble cations and anions by common methods (Richards, 1954; Rhoades, 1982; Sparks, 1996).

The ESR values were calculated by using exchangeable sodium and CEC values, whereas, calculation of SAR was based on soluble sodium, calcium and magnesium concentrations (Richards, 1954). Then, relationships between ESR and SAR values were examined by linear regression analyses (Jurinak et al., 1984), and reported for individual lines, averages for test areas and as overall average for the region at each soil depth. Furthermore, the ESR equations were calculated on the basis of EC ranges of the soils.

## RESULTS and DISCUSSION

Some Chemical Properties and ESR and SAR values of the Soils were given in Table 1. The pH varied between 7.37-8.19 and EC was in range of 0.506-6.819 mS/cm. Contents of soluble sodium, potassium, calcium and magnesium in the soils were found between 0.33 and 21.28, 0.08 and 0.66, 2.07 and 25.04, and 0.53 and 61.88 me/l, respectively. The range of carbonate, bicarbonate and chloride concentration of the soils were between 0.20-1.40, 0.34-4.12 and 0.37-34.72 me/l, respectively. The soluble sodium, EC, ESR and SAR values, in general, increased and soluble potassium decreased with increasing depth. But, there was not a definite variation in other soil properties with increasing depth. In addition, there was a wide variation of soil properties among spots at each depth.

The ESR values were between 0.0049 and 0.0611 while the SAR values were in range of 0.22-6.09. The lowest ESR and SAR values were found for spot B6 (0-20 cm) and the highest for spot D5 (50-90 cm). The ESR increased in accord with SAR values (Table 1).

The regression equations for ESR-SAR relationships, determined for individual lines, averages for test areas and as overall average for the region at each soil depth and on the basis of EC values of the soils were shown in Table 2. The Gapon coefficients ( $K_g$ ) of ESR-SAR relationships changed from 0.0056 to 0.0120. The lowest  $K_g$  value was found for line B (0-20cm) and the highest for line D (0-20 cm). The coefficient of single regression equation which was determined for all data is 0.0090. The  $K_g$  values obtained from ESR and SAR data in this study are in agreement with those of previous studies.

As shown in Table 2,  $K_g$  values of the soils were different for each line and each depth. This variability may be stemming from differences in soil properties. In fact, ESR-SAR relationship is affected by soil properties such as CEC, organic matter, surface charge density, salt content (Bower, 1959; Paliwal and Gandhi, 1976; Jurinak et al., 1984). In this research,  $K_g$  values, in general, decreased with increasing organic matter content and was higher in surface layers having high organic matter than in sublayer with low organic matter. For example, in the Line B, 0-20 cm depth having the highest organic matter content has the lowest  $K_g$  value. Similar results were reported by other researchers (Poonia and Talibudeen, 1977; Harron et al., 1983; Ağca and Derici, 1991; Saltalı 1996).

The  $K_g$  values which were obtained for four different salinity classes of the soils varied between 0.0080 and 0.0144 (Table 2). According to data in Table 2, it is obvious that  $K_g$  is affected by salinity (EC) and  $K_g$  decreases up to 4.5 mS/cm of EC then increases as the salinity increases. This results are in agreement with the results shown by Harron et al. (1983) and Levy and More (1965) but in disagreement with those of Frenkel and Alperovitch (1984) and Poonia et al. (1984). The inconsistent reaction of  $K_g$  to salinity may be result from mineralogical properties of the soils. Because, Jurinak et al. (1984) indicated that there may be an interaction between clay minerals and salts, and clay mineral-salinity interaction may influence both CEC and cation preference of exchange phases.

Table 1. Some chemical properties and calculated ESR and SAR values of the soils

Spot	Depth (cm)	pH	EC at 25°C (mS/cm)	ESR	SAR	Spot	Depth (cm)	pH	EC at 25°C (mS/cm)	ESR	SAR
Line A						Line C					
A1	0-20	8.15	0.777	0.0063	0.32	C1	0-20	8.08	1.293	0.0156	1.74
	20-50	7.97	0.506	0.0072	0.51		20-50	7.66	4.022	0.0181	1.69
	50-90	7.88	0.567	0.0113	0.59		50-90	7.71	4.138	0.0437	3.74
A2	0-20	7.80	6.795	0.0188	2.30	C2	0-20	8.02	1.578	0.0339	3.51
	20-50	7.62	4.165	0.0116	1.06		20-50	7.93	1.810	0.0333	4.09
	50-90	7.72	2.684	0.0124	1.19		50-90	7.83	3.054	0.0397	3.78
A3	0-20	7.95	1.080	0.0127	0.91	C3	0-20	8.02	0.563	0.0087	0.74
	20-50	7.79	0.768	0.0137	1.48		20-50	7.88	0.751	0.0124	1.39
	50-90	7.74	0.942	0.0074	1.03		50-90	7.86	1.480	0.0201	1.93
A4	0-20	8.00	1.719	0.0317	3.36	C4	0-20	8.06	2.760	0.0108	1.37
	20-50	7.72	4.569	0.0224	2.87		20-50	7.78	4.103	0.0250	2.05
	50-90	7.55	5.398	0.0209	2.41		50-90	7.58	6.819	0.0320	3.65
A5	0-20	7.86	1.737	0.0121	1.15	C5	0-20	8.05	1.812	0.0149	2.31
	20-50	7.53	3.719	0.0156	1.35		20-50	7.82	2.027	0.0234	2.58
	50-90	7.61	4.876	0.0190	1.89		50-90	7.64	4.715	0.0168	1.98
A6	0-20	8.12	2.112	0.0145	1.82	Line D					
	20-50	7.64	3.648	0.0197	1.99	D1	0-20	8.09	1.267	0.0056	0.63
	50-90	7.49	5.296	0.0211	2.41		20-50	7.90	0.591	0.0159	1.34
A7	0-20	7.92	4.549	0.0275	2.76		50-90	7.69	0.649	0.0125	1.35
	20-50	7.47	5.477	0.0220	2.47	D2	0-20	7.89	1.509	0.0069	0.65
	50-90	7.58	6.452	0.0305	2.78		20-50	7.85	1.008	0.0230	2.40
Line B							50-90	7.70	3.533	0.0374	3.03
B1	0-20	7.86	0.898	0.0072	0.59	D3	0-20	8.19	0.937	0.0271	2.31
	20-50	7.88	0.741	0.0103	1.01		20-50	7.69	1.829	0.0319	3.97
	50-90	7.80	0.701	0.0098	1.47		50-90	7.80	4.802	0.0356	4.00
B2	0-20	7.95	1.080	0.0127	0.91	D4	0-20	8.06	2.760	0.0108	1.37
	20-50	7.79	0.768	0.0137	1.48		20-50	7.78	4.103	0.0250	2.05
	50-90	7.74	0.942	0.0074	1.03		50-90	7.58	6.819	0.0320	3.65
B3	0-20	7.86	1.561	0.0112	1.29	D5	0-20	8.01	1.257	0.0114	1.02
	20-50	7.77	1.242	0.0120	1.21		20-50	7.82	2.840	0.0172	1.80
	50-90	7.79	1.669	0.0142	1.41		50-90	7.94	1.626	0.0611	6.09
B4	0-20	7.88	1.548	0.0121	1.51						
	20-50	7.84	3.229	0.0211	2.04						
	50-90	7.37	4.745	0.0190	2.14						
B5	0-20	7.99	0.734	0.0124	0.87						
	20-50	7.90	2.317	0.0179	1.81						
	50-90	7.48	5.092	0.0250	2.06						
B6	0-20	8.01	0.575	0.0049	0.22						
	20-50	7.89	0.550	0.0086	0.37						
	50-90	7.76	0.756	0.0094	0.78						

\*Spots A7 and B2, and Spots C4 and D4 are common on lines A, B and C, D, respectively



Although the relationship between ESR and SAR of soils used in this research are affected by soil properties, it is difficult to isolate the individual effects of these properties on Kg since there were no significant correlations between Kg and individual soil parameters. As indicated also by Ağa and Derici (1991), the differences among Kg values may be result from combined effect of these characteristics.

Most of the regression equations were found to be statistically significant at 0.001 level. This outcome means that regression equations obtained may be used for calculating ESR values from SAR data. But, the use of equations determined at each depth on each line is more useful for sensitive investigations.

Table 2. The regression equations for ESR-SAR relationships of the soils ( $ESR=a+Kg \text{ SAR}$ )

Depth (cm)	A	Kg	r <sup>2</sup>	Depth (cm)	a	Kg	r <sup>2</sup>
<b>Line A</b>				<b>Line C</b>			
0-20	0,0031	0,0081	0,936 **	0-20	-0,0006	0,0090	0,888 *
20-50	0,0048	0,0067	0,944 **	20-50	0,0064	0,0068	0,858 *
50-90	0,0024	0,0086	0,844 **	50-90	-0,0040	0,0114	0,883 *
<b>General</b>	<b>0,0033</b>	<b>0,0079</b>	<b>0,897 **</b>	<b>General</b>	<b>-0,0002</b>	<b>0,0096</b>	<b>0,868 **</b>
<b>Line B</b>				<b>Line D</b>			
0-20	0,0051	0,0056	0,640 *	0-20	-0,0020	0,0120	0,940 **
20-50	0,0040	0,0075	0,899 **	20-50	0,0087	0,0060	0,868 *
50-90	-0,0019	0,0108	0,753 *	50-90	0,0005	0,0097	0,926 **
<b>General</b>	<b>0,0029</b>	<b>0,0080</b>	<b>0,761 **</b>	<b>General</b>	<b>0,0013</b>	<b>0,0094</b>	<b>0,937 **</b>
<b>Lines A and B</b>				<b>Lines C and D</b>			
0-20	0,0032	0,0079	0,922 **	0-20	0,0002	0,0092	0,876 **
20-50	0,0046	0,0069	0,927 **	20-50	0,0075	0,0064	0,857 **
50-90	0,0008	0,0093	0,808 **	50-90	-0,0003	0,0101	0,910 **
<b>General</b>	<b>0,0030</b>	<b>0,0080</b>	<b>0,871 **</b>	<b>General</b>	<b>0,0007</b>	<b>0,0094</b>	<b>0,911 **</b>
<b>Line A, B, C and D</b>				<b>Line A, B, C and D</b>			
Depth (cm)	a	Kg	r <sup>2</sup>	EC mS/cm	a	Kg	r <sup>2</sup>
0-20	0,0021	0,0084	0,889 **	0,5 - 1,5	0,0029	0,0082	0,788**
20-50	0,0050	0,0071	0,903 **	1,5 - 3,0	-0,0009	0,0094	0,958**
50-90	-0,0002	0,0100	0,930 **	3,0 - 4,5	-0,0004	0,0114	0,962**
<b>General</b>	<b>0,0016</b>	<b>0,0090</b>	<b>0,914 **</b>	4,5 - 7,0	0,0030	0,0080	0,800**

\*: Significant at 0.05 level] \*\*: Significant at 0.01 level

Gapar coefficients may be used as indicators of alkalization tendency in soils. Because, at equilibrium between solid and liquid phase of the soils, the ESR values which are dependable criteria for alkalization, depend on firstly Kg values of the equations and to some extent intercept values of equations at any given SAR value. In other words, the higher Kg value shows the higher ESR value in the same soils at any given SAR value (Ağa et al., 1998). Therefore, considering the overall average, the order of alkalization tendency of the soil layers in the profile of the soils is 50-90 cm > 0-20 cm > 20-50 cm. This means that the alkalization will firstly begin at 50-90 cm layer then follow at 0-20 and 20-50 cm layers of the soils, if conditions for alkalization are imposed, although there are no alkalinity problems in these soils yet.



## REFERENCES

- Ağca N., Derici R. (1991). The Relationships Between the Exchangeable Sodium Ratio (ESR) and the Sodium Adsorption Ratio (SAR) on Widespread Soil Series in the Harran Plain. *Turkish J. of Agriculture and Forestry*. 15 (2): 239-247 (in Turkish).
- Ağca N., Aydın M., Derici M.R., Yeşilsoy M.Ş., Erşahin S. (1998). Alkalization Tendency and Infiltration Rate Relationships of Widely Soil Series in Harran Plain, Turkey. *Proceedings of M. Şefik Yeşilsoy International Symposium on Arid Region Soils (21-25 September 1998, Menemen-İzmir-Turkey)*. pp. 114-119.
- Al Chalabi A.S. Pasricha N.S. (1981). Sodium-Calcium Exchange in Some Salt-Affected Soils. *J. Indian Society Soil Science*. 29 (1): 46-49.
- Bower C.A. (1959). Cation Exchange Equilibrium in Soils Affected by Sodium Salts. *Soil Science*. 88: 32- 35.
- Frenkel H., Alperovitch N. (1984). The Effect of Mineral Weathering and Soil Solution Concentration on ESR-SAR Relationships of Arid and Semi-arid Zone Soils from Israel. *Journal of Soil Science*. 35: 367-372.
- Guth D.L, Brown K.W. (1985). A Comparison of the SAR and Vaneslow Equations in Three Soils. *Soil Science*. 140 (5): 356-361.
- Hall A., Berg W.A. (1983). Prediction of the Sodium Hazard in Coal Mine Overburden. *Reclamation and Revegetation Research*. 2: 191-204.
- Harron W.R.A., Webster G. R., Cairns R.,R. (1983). Relationships Between Exchangeable Sodium and Sodium Adsorption Ratio in a Solonchic Soil Association. *Can. J. Soil Sci.* 63: 461-467.
- Jurinak J.J., Amrhein C., Wagenet R.J. (1984). Sodic Hazard: The Effect of SAR and Salinity in Soils and Overburden Materials. *Soil Science*. 137(3): 152-159.
- Levy R., Mor E. (1965). Soluble and Exchangeable Cation Ratios in Some Soils of Israel. *Journal of Soil Science*. 16(2): 290-295.
- Paliwal K.V., Gandhi A.D. (1976). Effect of Salinity, SAR, Ca:Mg Ratio in Irrigation Water and Soil Texture on the Predictability of Exchangeable Sodium Percentage. *Soil Science*. 122: 85-90.
- Poonia S.R., Mehta S.C., Pal R. (1984). The Effects of Electrolyte Concentrations on Calcium-Sodium Exchange Equilibria in Two Soil Samples of India. *Geoderma*. 32:63-70.
- Poonia S.R., Talibudeen O. (1977). Sodium-Calcium Exchange Equilibria in Salt-Affected and Normal Soils. *Journal of Soil Science*. 28: 276-288.
- Rhoades J.D. (1982). Soluble Salts. *Methods of Soil Analysis*. No.9. Part.2 (ed. A.L. Page). American Soc. of Agronomy, Inc. Soil Sci. Society of America, Inc. Madison, Wisconsin USA. P.167-179.
- Richards L.,A. (1954). *Diagnosis and Improvement of Saline and Alkali Soils*. SDA, Handbook 60. 160 p.
- Saltalı K. (1996). A Study on Salt Dynamics and Determination of Tendency for Alkalinization of Tokat- Kazova Soils. *Gaziosmanpaşa University, Graduate School of Natural and Applied Science, Department of Soil Science (Ph D. Thesis)*. 95 p. (in Turkish).
- Sparks D.,L. (1996). *Methods of Soil Analysis*. Part 3. Chemical Methods. SSSA. Madison, Wisconsin, USA.
- Walter F. (1997). Extraction of Forest Tree Volume from Carabas SAR data. *Scandinavian Journal of Forest Research*. 12: 4, 370-374.
- Yeşilsoy, M.Ş. (1969). The Cation Exchange Characteristics of the Soils in the Trakya Region. *Proceedings of 1.,2. and 3. Congres of Soil Science Society of Turkey*. pp. 47-59. (in Turkish).

# SOIL SALINITY MONITORING OF A SELECTED AREA IN THE YÜREĞİR PLAIN, ADANA-TURKEY

Hasan Özcan<sup>1</sup>, Erhan Akça<sup>2</sup>, Selim Kapur<sup>2</sup>, Oğuz Dinç<sup>2</sup>

<sup>1</sup> The Sixth Regional Directorate of State Hydraulic Works, Planning Section, 01330 Seyhan-ADANA/TURKEY.

<sup>2</sup> University of Çukurova, Faculty of Agriculture, Department of Soil Science, 01330 Balcalı-ADANA/TURKEY.

## ABSTRACT

Long term changes in soil salinity of a 10000 ha area of the Yüreğir plain was studied considering irrigation, drainage, soil and topographic properties, using soil salinity data obtained in 1959 and 1979, with recently analysed soils (surface horizon 0-15, 15-30 cm) collected from previously determined soil series.

Results revealed that non-saline, slightly and moderately saline soils were 93% of the study area in 1959, 73 % in 1979, and 72% in 1999. Strongly and very strongly saline areas did not increase in comparison to the 1979 and 1999. The problem area in 1979 has been reclaimed by newly opened drainage canals, whereas areas with no salinity problems, surrounded by the Akyatan lagoon and its overflowed area, reveal increased salinity. The saline areas in the local lowlands have not significantly changed within a 40 year-period due to soil and topographic conditions.

Land covered with natural vegetation exposes increased salinity at the top soil due to the increasing capillarity by roots, whereas parts devoted to agriculture have revealed decrease of salinity at the surface and increase with depth due to increased leaching by tillage.

## INTRODUCTION

It is generally known that soil productivity changes based on its physical and chemical properties. The most important factors effecting soil productivity are soil salinity, alkalinity and ground water levels. Soil salinity and alkalinity are mainly caused by natural and cultural (secondary salinisation) factors. While climate, natural drainage, topographic properties, geologic structure, parent material, distance to the sea are natural factors; unsuitable irrigation methods and water quality, insufficient drainage, poor land management are cultural factors. Saline, saline-alkaline and alkaline soils are usually seen in the hollow and flat topographies in the arid and semi arid climatic conditions. In these areas, the upward movement of high groundwater, waterflood and excess evapotranspiration can cause salt accumulation at the soil surface (Dinç, 1987; Mehanni, 1998; Özcan and Çetin, 1998). The salt caused both by natural and cultural effects on soil can be of chemical, physical and biological origin. Chemical effects are the cation exchanges and the interaction among salts. Whereas the major physical effects are on permeability where a non-permeable subsoil layer can partly or completely prevent salt leaching from soil (Dinç et al., 1990; Smedema and Rycroft, 1983). Biological effects are the changes in osmotic pressure and alteration of protoplasmatic actions in plants (Özgül, 1974; FAO, 1985; Smedema and Rycroft, 1983).

The study area has no outflow to the sea and is composed of alluvial deposits which are more suitable for salinisation. The south section towards the Mediterranean Sea of the Lower Seyhan Plain (ASO), one of the earlier irrigation projects of Turkey, has been highly effected by salinisation. The salt effected soil series are Helvacı, Arıklı, Arpacı, Gemisüre and the dominant salt type is halite (according to Nuns, 1960 and Dinç et al., 1990). Yüzgeç (1985) investigated salt changes in the surface horizons of the Çukurova Region between 1956 and 1984. Results revealed that the strongly saline areas decreased from 16,8 % to 2,1% with irrigation and saline soils from 105639 ha to 60898 ha. Özcan and Çetin (1996) examined maximum soil salinity and alkalinity in a soil profile (within 150 cm) from 1956 to 1979 in the fourth project area of ASO. They pointed out that there had been 2,5 and 1,5 fold increases in saline-alkaline and strongly saline areas respectively, with a 1,5 fold decrease in saline soils. The reasons of these changes were; vicinity leakage owing to upper catchment irrigation, irrigation from drainage canals and the highly saline groundwater. The northern part of the area intended for investigation has been under irrigation since 1960 following the Seyhan dam construction. But, the study area has not had irrigation infrastructure and the drainage canals have



been partly constructed since 1990 as is the usual practice in many similar cases. Thus the aim of the study seeks to evaluate the drainage and irrigation effects on soil salinity and monitoring of changes since 1959 in selected saline areas ( about 10000 ha) of the Yüreğir plain.

## **MATERIALS AND METHODS**

### **MATERIALS**

The study area was decided to represent the ASO fourth project area. Hence, having considered the topographic condition and soil series, about a 10000 ha area with complex soil series was selected for the study. The area is located between the Adana province and Karataş town and surrounded by the YD3 main drainage canal and the Akyatan Lagoon. The Mediterranean climate prevails within annual precipitation of 772,3 mm/year, average temperature of 18,1 °C and total evaporation of 1580,1 mm. From a topographic perspective the area is flat with 0-0,05 % slope. The altitude is 2,5 m in the north, 2 m in the south with some local depressions. The 1/25000 scaled topographic map, land classification report of the Yüreğir plain (TGAE, 1959), land classification report of the Lower Seyhan plain fourth project area (DSİ, 1979) and the detailed soil map and report of the Çukurova Region (Dinç et al., 1990) were the basic materials used in the study area.

### **METHODS**

The salinity classes of the 1959 and 1979 were considered together with the slopes for determining sampling points representing each mapping unit and the previous years' salinity classes. Soil samples were collected from 0-15 and 15-30 cm depths from the identified two hundred sampling points (october-november 1999). The soluble salt and pH analys of the soils were carried out on saturated pastes according to Bower and Wilcox (1965) and Jackson (1967) respectively.

## **RESULTS**

### **Variations On The Salt Levels Over The Years**

The soils studied are on three different physiographic units ( Dinç et al., 1990) of the Yüreğir plain (Figure 1). Helvacı, Arpacı and Oymaklı are the most common soils of the study area. The variations in the soil salinity levels (0-30 cm) of the study area over the years 1959-1999 are shown in Figure 2 and their maps are presented in Figures 3,4 and 5. The non-saline and slightly to moderately saline soil areas were about 93% before the irrigation project started, they decreased primarily to 73% in 1979 when irrigation was intensified at the upper part of the project area and then decreased to 72% in 1999 after constructions of the new main drainage were started. On the other hand the no changes in the strongly and very strongly saline soils between 1979 and 1999 seem to be misleading when Figures 3, 4 and 5 are examined by drawing out the following results;

- Salinity has decreased except in the local depressions after the construction of the drainage canals at the north of the study areas. On the contrary, due to the insufficient outlet and the partly operating pump station even the non-saline areas (areas towards the Akyatan Lagoon and its vicinity ) are determined to have significantly increased in salinity. The salinity level of the water of the Akyatan Lagoon was more than 150 dS/m (strongly saline) due to the lack of water circulation and high groundwater levels in its western part (KHGM, 1997; DSİ, 1979). In addition, at the north of lagoon there is a 3000 ha saline-alkaline weed area with waterlogging developed from surface flow and intensive rainfall, especially in the winter season effecting the south of the area.



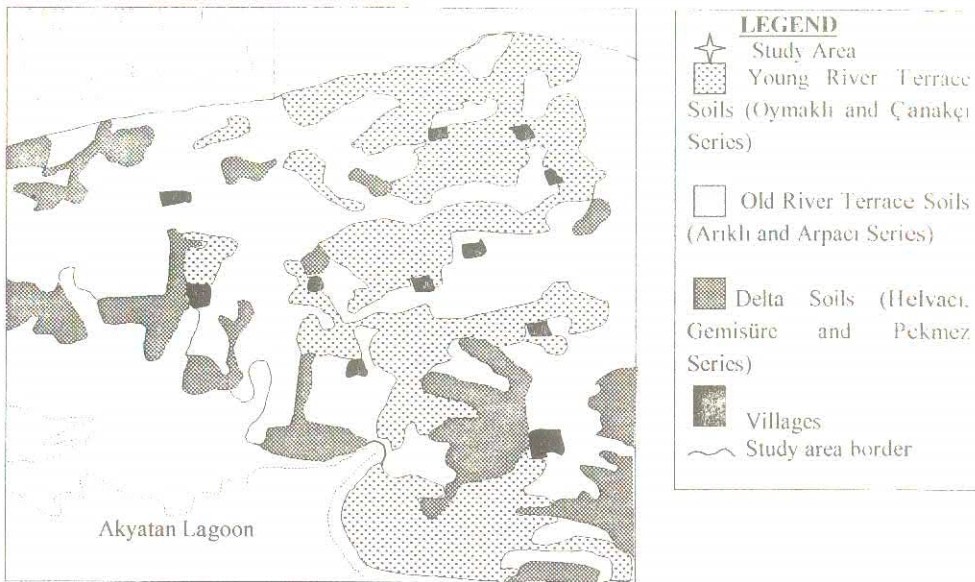


Figure 1. The study area and the soils

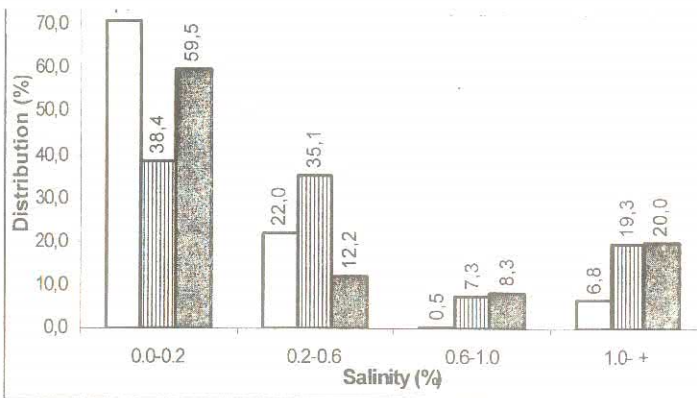


Figure 2. Variation of cumulative values of salinity in 1956, 1977 and 1999

- Due to the low altitude of the southern part of the study area (2m), the bottom level of the open drainage canals is lower than the sea level, thus the south of the study area is effected by the sea aswell.

Figure 1 shows the soils of the test area together with Figure 4 and 5 which show the increase of the strongly and very strongly saline soils in the delta and old terraces. The soil series which exist within these two physiographic units contain more than 50% clay with massive structures in the lower horizons due to low hydraulic conductivity levels.

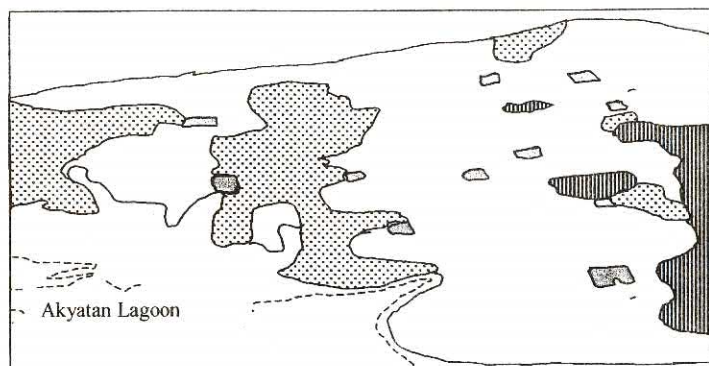


Figure 3. Map of soil salinity levels in 1956

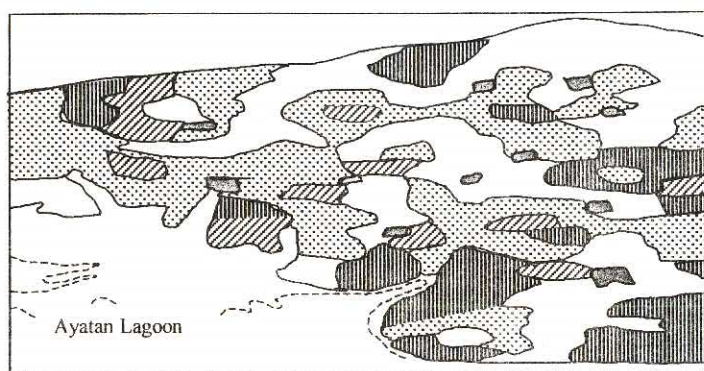


Figure 4. Map of soil salinity levels in 1977

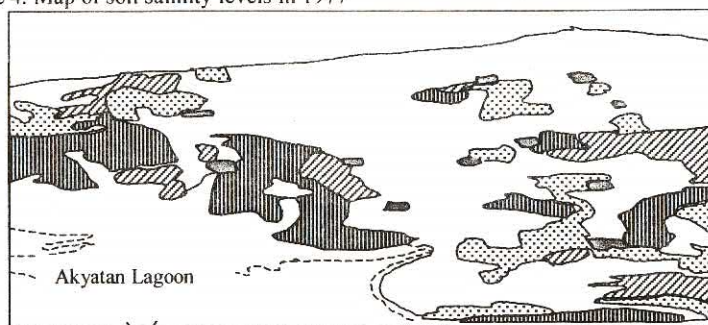
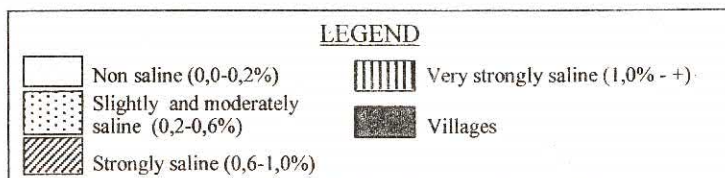


Figure 5. Map of soil salinity levels in 1999



## SALT REMOVAL

The salt movement in the top soils representing different physiographic units (0-15 cm and 15-30 cm) is given in Figure 6. The salinity of 14 out of 147 soil samples have decreased with depth whereas others have increased. Local lowlands and the area covered with natural vegetation expose increase of salinity at the top soil owing to capillarity, whereas parts devoted to agricultural management have effected capillary movement negatively by destruction of micro and macro pores. Destroyed pores cause a decrease in capillarity, inhibiting saline groundwater movement to the surface. Agricultural practices effect salinity of the area in two different ways. First destruction of the pores, second increasing leaching of salt related to crop patterns.

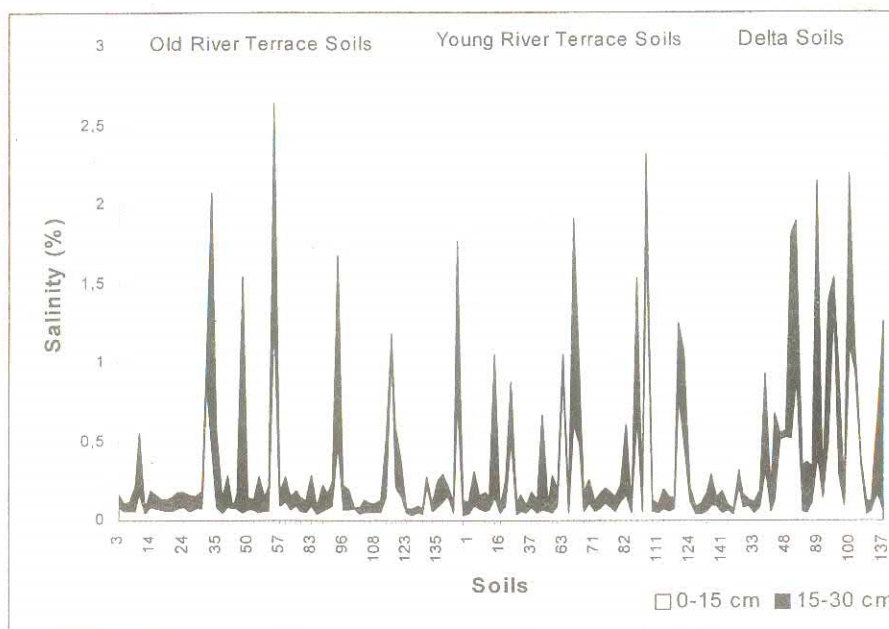


Figure 6. Salt removal in the top soil

## CONCLUSIONS

The following conclusions can be drawn from this study:

1. The annual precipitation ( about 772.3 mm/year) may improve salinity conditions by itself provided sufficient drainage is present.
2. Uncontrolled irrigation practices applied in the upper and some parts of the study area can cause 50 % over irrigation water use (Özcan and Çetin, 1995) with C<sub>2</sub>S<sub>1</sub> quality water containing 0.45-0.50 dS/m salinity (DSI, 1979). Thus applying 1000 mm irrigation water in the area leaves 3 ton/ha/year salt on the soil. This may be another way for increased salinisation under poor drainage conditions allowing insufficient percolation and drainage discharge.
3. High saline groundwater, soil and topographic conditions are more effective than the effects of the sea and the Akyatan Lagoon for salinity development. Especially in the lowland and delta areas very strong salinisation has not changed since 1956.
4. High evaporation rates increased salinisation in the wasteland and bare areas.
5. Absence and/or lack of well maintained drainage networks are the main cause of developing salinity as elsewhere.



## REFERENCES

- Bower, C.A.; Wilcox, L.V., 1965. Soluble Salt Method of Soil Analysis. Methods of Soil Analysis Part 2, Am. Soc. Agron. No:9, Madison, Wilconsin USA, p:933-940.
- Dinç, U., 1987. Türkiye Toprakları Ders Notları. (Basılmamış). Adana.
- Dinç ve ark., 1990. Çukurova Bölgesi Toprakları. Ç.Ü.Z.F. Yardımcı Ders Kitabı, No:26, Ç.Ü.Z.F. Adana.
- DSİ, 1979. Aşağı seyhan Projesi Aşağı Seyhan Ovası IV. Merhale (7YP-8YP) Sahaları Planlama Arazi Tasnif Raporu. DSİ, Ankara.
- FAO, 1985. Guidelines: Land Evaluation For Irrigated Agriculture. FAO Soils Bulletin No. 55, Rome, FAO. 229 pp.
- General Directorate of Rural Services, 1997. Akyatan Lagoon Project. Anonymous.
- Jackson, M.L., 1967. Soil Chemical Analysis. Prentice Hall of India Private Ltd. New Delhi.
- Mehanni, A.H., 1988. The Influence of Depth and Salinity of Watertables on the Salt Levels in the Duplex Red-Brown Earths of Goulburn Valley of Victoria. Australian-Journal of Experimental-Agriculture. V. 28(5), p.593-597. Australia.
- Nunns, F.K., 1956. Work Plans For Soil Survey of the Seyhan Delta Area. TA Project 77-149, USOM/TURKEY.
- Özcan, H.; Çetin, M., 1995. Aşağı Seyhan Ovasında Sulama ve Drenaja Yönelik Problemler ve Çözüm Önerileri. Türkiye Toprak İlmi Derneği, İlhan Akalın Toprak ve Çevre Sempozyumu, Ankara.
- Özcan, H.; Çetin, M., 1996. Land Degradation Induced By High Groundwater Level and Soil Salinity In The IV. Stage Project Area of Yüreğir Plain: A Case Study. 1<sup>ST</sup> International Conference on Land Degradation. Proceedings, p. 93-99, 10-14 June, Adana, Turkey.
- Özcan, H.; Çetin, M., 1998. The Relationship Between Groundwater and Soil Salinity in the Eastren Mediterranean Coastal Region, Turkey. Şefik Yeşilsoy International Symposium on Arid Region Soils. 21-23 September, Izmir-Turkey.
- Özgül, Ş., 1974. Tuzluluk ve Sodiklik. Uluslararası Sulama ve Drenaj Komisyonu Türk Milli Komitesi. Teknik Rehber, 04.02-02. Ankara.
- Smedema, L.K.; Rycroft, D.W., 1983. Land Drainage. Batsford Academic and Educational Ltd. London. 376 pp.
- TGAE, 1959. Yüreğir Ovası arazi Tasnif Raporu. Toprak Etüüd Raporları No:1. Ankara.
- Yüzgeç, A., 1985. Çukurova Bölgesi Tuzlu ve Alkali Topraklarının Oluşumu, Dağılımı ve Özellikleri. Ç.Ü. Fen Bilimleri Enstitüsü. (Master Tezi). Adana.

# EFFECTS OF LEACHING WITH IRRIGATION WATERS IN DIFFERENT SALINITY LEVELS ON CHANGE OF PROFILE SALINITY

Engin Yurtseven<sup>(1)</sup>, Ahmet Öztürk<sup>(1)</sup>, Gökhan Çaycı<sup>(2)</sup>, Mehmet Parlak<sup>(2)</sup>

<sup>(1)</sup> Ankara University Faculty of Agriculture Dept. of Farm Structures and Irrigation, Ankara, Türkiye

<sup>(2)</sup> Ankara University Faculty of Agriculture Dept. of Soil Science, Ankara, Türkiye

## ABSTRACT

In this greenhouse experiment, the effect of irrigation water in different salinity levels were investigated on salinization of silty clay loam soil profile, and leaching applications that one of the practices on salinity management in irrigation as well. The experiment was conducted using the large PVC pots with diameter of 35cm and 65cm in height, cropped with the Hungarian vetch (*Vicia pannonica*, Crantz). The experiment was consisted of two parts and both part designed as a factorial experiment in fully randomized with 4 replications. The treatments of the experiment were 4 irrigation water salinity levels (0.25, 1.5, 3 and 6 dS/m) and 2 irrigation water amount applied (70% and 100% of required water). First part of experiment was without leaching and consisted of 32 pots, and the second part was 80 pots with leaching applications two times during the growing period, first in the middle and the second nearly at the end of the growing period using water in different salinity levels. The profile salinities obtained from the first part of experiment at the end of the growing period were higher in all pots due to the irrigation water salinity levels, and decreased sharply with the leaching water. Using water in different salinity levels on leaching caused the variation on the profile salinities. The higher the leaching water salinity level applied, the lesser the decreasing ratio in the profile salinity variation.

## INTRODUCTION

One of the primary objectives of agriculture is to provide the food needs of human beings. These needs increase as the population increases. The world population is expected to be 6.3 thousand million in 2000 and 8.5 thousand million in 2025 (UN, 1991). Growth in crop production can come from increases in arable land, cropping intensity and yield per unit area of cropped land. Nearly 2/3 of the increase in crop production needed in the developing countries in the next decade must come from increases in average yields (FAO, 1988).

Irrigation has already played a major role in increasing food production over the past fifty years. Expansion in irrigation needs to be 2.25 percent per year in order to meet food needs by the year 2000 (FAO, 1988). However, the present rate of expansion in irrigation has recently slowed to less than 1 percent per year (CAST, 1988). One of the reasons is the fact that much of the suitable land and water supplies available for irrigation have already been developed. Progressively more expensive and less favorable areas and water supplies are left for further expansion.

The problem must resolve firstly that at which level it can be used these less favorable water supplies to avoid soil degradation that cause to decrease of crop yield. To avoid degradation of soils caused by the salinity can successfully cope using with the salinity management practices in irrigated areas. These practices are consisted of a series of factors from climatically to irrigation and drainage management. The most important parameter to be considered, is the leaching application. The salts that accumulate in the root zone throughout the irrigation period can be leached out from the zone only by the leaching water applied weather during the irrigation period or at the end of the period. The success of the application is also depending on the quality of the leaching water used (Yurtseven, 1990; Bilgiç, 1992).

In this experiment, the leaching efficiencies on salinity management in irrigation were investigated in large pots consisting of two parts of experiments with and without leaching applications.

## MATERIAL and METHODS

The experiment was carried out in a glass-covered greenhouse using large PVC pots 35 cm in diameter and 65 cm in height. The soil used have been taken from the experimental site of the Faculty of Agriculture at 0-30 cm profile level and sieved by the No.4 sieve just after become dried. Some physical and chemical properties of the soil are given in Table 1.



Table 1. Some physical and chemical properties of the soil

Saturation %	PH	EC <sup>(1)</sup> DS/m	Calcium carbonate %	Available phosphorous kg/da	Available Potassium kg/da	Organic matter %
41.30	7.32	0.49	8.57	1.74	124.42	0.85
Bulk density g/cm <sup>3</sup>	Field capacity %	Wilting point %	Sand %	Silt %	Clay %	Texture
1.31	16.69	7.87	52.55	22.70	24.75	SCL

<sup>(1)</sup> Measured in the extract obtained from 1:2.5 soil-water solution

In the experiment Hungarian vetch (*Vicia pannonica*, Crantz) was used as a test crop. The seeds were sown on 5<sup>th</sup> April 1999, thinned after two weeks by 15 seedlings per pots, and harvested on 22<sup>nd</sup> June 1999. To ensure the plant nutrient requirement before sowing 15 kg/da P and 4 kg/da N fertilization were done.

The experiment was consisting of two groups of pots. Both groups were consisting of 4 irrigation water salinities ( $T_1=0.25$ ,  $T_2=1.5$ ,  $T_3=3$ , and  $T_4=6$  dS/m) and 2 irrigation water amounts ( $Y_1=70\%$  and  $Y_2=100\%$  of required water) applied. Experimental design was factorial in completely randomized with four replications. In the first group of experiment which was without leaching application there were  $(4 \times 2) \times 4 = 32$  pots. In the second group, however, to find out the effect of leaching on salinity management were conducted totally in 80  $[(4 \times 2) + 12] \times 4$  pots, leaching each pot two times during growing period. First leaching was in the middle of the period and the second nearly at the end of the period using with water in different salinity levels (Table 2).

Table 2. Experimental design scheme of second group of experiment

Treatments <sup>(1)</sup>	Replica- tion	EC <sub>i</sub> <sup>(2)</sup> DS/m	EC <sub>lw</sub> <sup>(2)</sup> dS/m	Treatments <sup>(1)</sup>	Replica- tion	EC <sub>i</sub> <sup>(2)</sup> dS/m	EC <sub>lw</sub> <sup>(2)</sup> dS/m
T <sub>1</sub> Y <sub>1</sub> -1	++++	0.25	0.25	T <sub>4</sub> Y <sub>1</sub> -1	++++	6.0	0.25
T <sub>1</sub> Y <sub>2</sub> -1	++++	0.25	0.25	T <sub>4</sub> Y <sub>1</sub> -2	++++	6.0	1.5
T <sub>2</sub> Y <sub>1</sub> -1	++++	1.5	0.25	T <sub>4</sub> Y <sub>1</sub> -3	++++	6.0	3.0
T <sub>2</sub> Y <sub>1</sub> -2	++++	1.5	1.5	T <sub>4</sub> Y <sub>1</sub> -4	++++	6.0	6.0
T <sub>2</sub> Y <sub>2</sub> -1	++++	1.5	0.25	T <sub>4</sub> Y <sub>2</sub> -1	++++	6.0	0.25
T <sub>2</sub> Y <sub>2</sub> -2	++++	1.5	1.5	T <sub>4</sub> Y <sub>2</sub> -2	++++	6.0	1.5
T <sub>3</sub> Y <sub>1</sub> -1	++++	3.0	0.25	T <sub>4</sub> Y <sub>2</sub> -3	++++	6.0	3.0
T <sub>3</sub> Y <sub>1</sub> -2	++++	3.0	1.5	T <sub>4</sub> Y <sub>2</sub> -4	++++	6.0	6.0
T <sub>3</sub> Y <sub>1</sub> -3	++++	3.0	3.0				
T <sub>3</sub> Y <sub>2</sub> -1	++++	3.0	0.25				
T <sub>3</sub> Y <sub>2</sub> -2	++++	3.0	1.5				
T <sub>3</sub> Y <sub>2</sub> -3	++++	3.0	3.0				

<sup>(1)</sup> The numbers show the leaching water salinity levels (1=0.25, 2=1.5, 3=3, 4=6 dS/m)

<sup>(2)</sup> Electrical conductivity of; i=Irrigation water, and lw=Leaching water.

To obtain the irrigation water salinity levels, sodium chloride (NaCl), calcium chloride (CaCl<sub>2</sub>) and magnesium sulphate (MgSO<sub>4</sub>) salts were used. Since the effects of the Ca<sup>++</sup> and Mg<sup>++</sup> ions on the soil physical properties are supposed the same, the Ca/Mg ratio were chosen 1:1 as additional basis (Poonia and Pal, 1979; Yurtseven, 1990). The Sodium Adsorption Ratio (SAR) of the irrigation water was kept below 1 to avoid the sodium hazard, since the control water SAR ratio was equal to 0.45. So the required salt doses for each water level were calculated using with a BASIC software (Yurtseven, 1990). The results of the salinity analyses of irrigation waters used are given in Table 3.

To determine the required irrigation water amounts for each salinity level used additional pots for each salinity level and measured extracting the drainage water collected from the irrigation water applied. While the 70% of calculated total irrigation water was giving to the Y<sub>1</sub> pots, 100% of the required irrigation water applied to the Y<sub>2</sub> pots. The irrigation times were determined with the observation of the plant phenological status. The leaching fraction, LF, chosen 30% corresponding of the soil saturation percentage, that was nearly 10 liter per pot and leaching were done first on 21<sup>st</sup> May



and second on 18<sup>th</sup> June 1999. During the growing period totally 6 irrigations were done nearly 10 days intervals.

Table 3. Irrigation waters analysis used in experiment

Salinity Levels	pH	EC DS/m	Cations, me/l					Anions, me/l				SAR
			Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>++</sup>	Mg <sup>++</sup>	Total	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>-</sup>	Total	
T <sub>1</sub>	7.11	0.246	0.43	0.07	0.70	1.14	2.34	1.60	0.50	0.24	2.34	0.45
T <sub>2</sub>	7.19	1.532	1.94	0.10	3.76	8.82	14.60	1.90	10.22	2.48	14.60	0.77
T <sub>3</sub>	7.48	3.106	2.91	0.19	9.18	17.84	30.12	2.10	20.50	7.52	30.12	0.79
T <sub>4</sub>	7.71	5.922	6.08	0.30	22.29	29.76	58.43	1.70	40.25	16.48	58.43	1.19

Soil samples were taken from 0-20, 20-40 and 40-60cm of depths to determine the profile salinity. Because it was not possible to take enough soil samples from the pots, to have more extracted water from this less amount of soil samples, the soil salinity measurements were done in the extracts obtained from the 1:2.5 soil-water solutions. The total salinity measurements were done measuring the electrical conductivity values at 25°C (Anonymous, 1954) by the YSI 3200 conductivitemeter. Available phosphorus according to Olsen et al.(1954), soil texture according to Bouyoucos (1951), and the rest of the soil and water analysis were done according to Anonymous (1954).

## RESULTS and DISCUSSION

The profile salinity values obtained from the pots leached with water in different salinity levels are given in Table 4 as the averages of the data obtained from 0-60cm soil profile and throughout tree different times during the growing period. The variation of the profile salinities is also shown in Figure 1. In this figure, the profile salinities obtained from the first part of experiment, which was conducted without leaching, are shown as well. Results obtained from the second part of the experiment show that without leaching applications the profile salinities increased according with the increasing irrigation water salinities. For example, in the 0-60cm profile the average soil salinity at T<sub>1</sub> salinity level was 0.6 dS/m, while at T<sub>4</sub> level was 1.57 dS/m. But, applying the leaching water, soil salinities decreased depending on the leaching water salinities. The higher the leaching water salinity applied, the lesser the decreasing ratio in the profile salinity changes obtained. Using good quality irrigation water for leaching caused to decrease the profile salinities to around initial salinity levels.

Table 4. Average soil salinity values obtained from 0-60cm profiles

Treat-ments	Average soil salinities <sup>(1)</sup>			Treat-ments	Average soil salinities <sup>(1)</sup>		
	1	2	3		1	2	3
T <sub>1</sub> Y <sub>1</sub> -1	0,88	0,74	0,70	T <sub>3</sub> Y <sub>2</sub> -2	1,04	1,22	0,48
T <sub>1</sub> Y <sub>2</sub> -1	0,77	0,74	0,21	T <sub>3</sub> Y <sub>2</sub> -3	1,05	1,06	0,55
T <sub>2</sub> Y <sub>1</sub> -1	0,99	0,68	0,29	T <sub>4</sub> Y <sub>1</sub> -1	1,38	1,28	0,46
T <sub>2</sub> Y <sub>1</sub> -2	0,88	0,92	0,35	T <sub>4</sub> Y <sub>1</sub> -2	1,12	1,28	0,47
T <sub>2</sub> Y <sub>2</sub> -1	0,73	0,98	0,32	T <sub>4</sub> Y <sub>1</sub> -3	1,66	2,04	0,83
T <sub>2</sub> Y <sub>2</sub> -2	0,85	0,86	0,45	T <sub>4</sub> Y <sub>1</sub> -4	1,36	1,57	0,84
T <sub>3</sub> Y <sub>1</sub> -1	0,95	1,09	0,26	T <sub>4</sub> Y <sub>2</sub> -1	1,21	1,71	0,57
T <sub>3</sub> Y <sub>1</sub> -2	1,16	1,25	0,39	T <sub>4</sub> Y <sub>2</sub> -2	1,12	1,55	0,56
T <sub>3</sub> Y <sub>1</sub> -3	0,99	1,22	0,59	T <sub>4</sub> Y <sub>2</sub> -3	1,27	1,65	0,75
T <sub>3</sub> Y <sub>2</sub> -1	0,87	1,26	0,26	T <sub>4</sub> Y <sub>2</sub> -4	1,36	1,84	1,17

<sup>(1)</sup> Average soil salinity values 1=before the first leaching, 2=before the second leaching, 3=at the end of the growing period

The average profile salinity varied during the growing period significantly according to the leaching applications. While increasing the salinities caused by the irrigation water salinities, showed the sharp decrease just after the leaching and met the level considerable lower than the same treatments without leaching. Leaching with the water at 0.25 and 1.5 dS/m salinity levels, the average profile salinities decreased at the beginning salinity levels at the end of the experiment. The 6 dS/m leaching water salinity, however, caused the end period salinity level higher than the initial salinity levels of the soil profile.

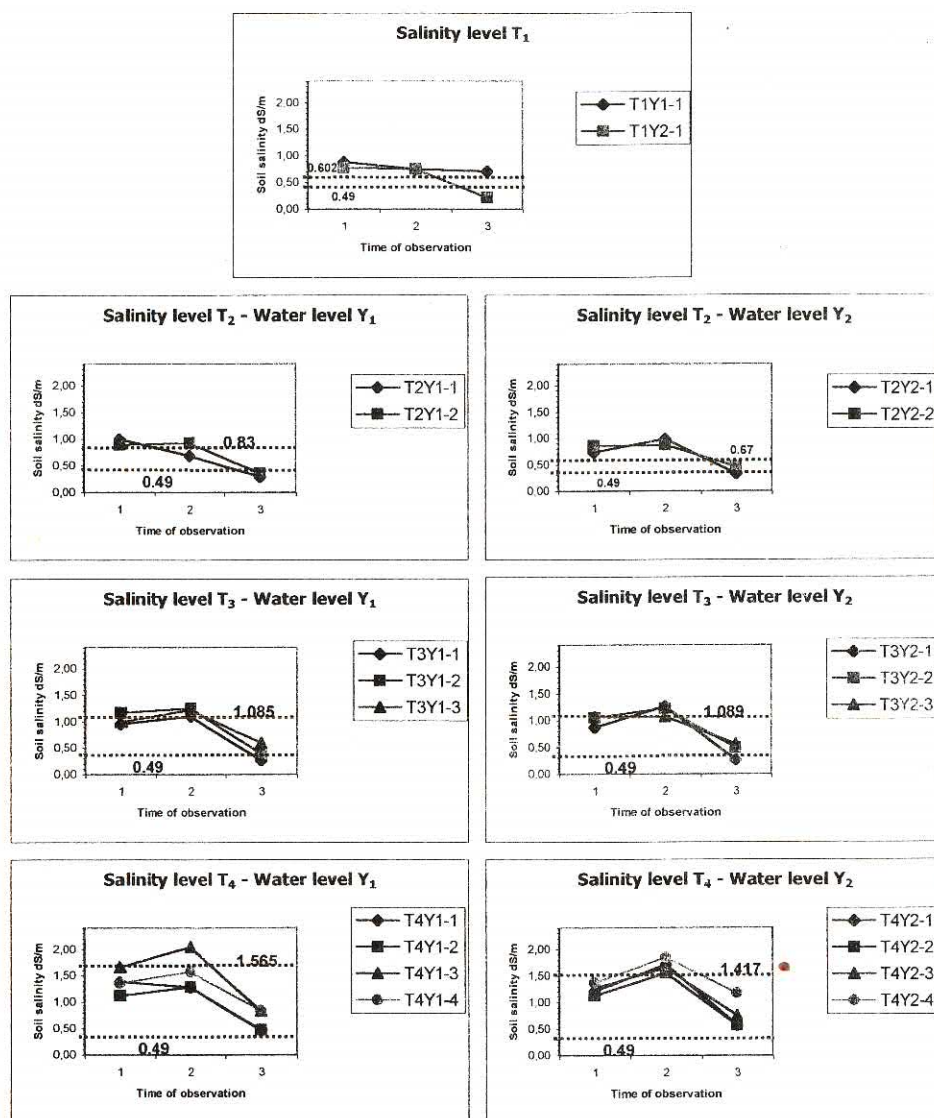


Figure 1. Average soil profile salinities obtained during the growing period. (1=Before the first leaching; 2=Before the second leaching; and 3=At the end of the period. Dashed lines show the soil average salinities obtained without leaching application. Initial soil salinity was 0.49 dS/m.

The irrigation water amounts applied had a little effect to produce the profile salinities of the soil. Although it was not so clear the difference between the salinities of Y<sub>1</sub> level and Y<sub>2</sub> levels without leaching water application, salinities were little bit higher at Y<sub>1</sub>, than Y<sub>2</sub>. This increasing rate nearly was 20% at T<sub>2</sub> salinity level, and 10% at T<sub>4</sub> salinity level.

Examining Figure 2, the effect of leaching and leaching water salinity on the profile salinization can be explain better. In this figure, the profile salinity values obtained from 0-20, 20-40

and 40-60cm of depths of  $T_4$  level both for  $Y_1$  and  $Y_2$  treatments are given in comparison with the salinity values from  $T_1$  salinity level. There is no significant difference between the irrigation water amount treatments relating to the soil profile salinities. But the salinities show a little variation through the soil depth. In general salinities are higher at 0-20 and 40-60cm depths but lower at 20-40cm profile. The salinization of the profile is clearly affected by the salinity level of the leaching water. For the whole profile, obtained salinities at the end of the growing season are higher when used 3 and 6 dS/m leaching water than the others. Beside this, at  $T_4$  level, all the treatments become more saline than  $T_1$  level.

Similar results have been obtained by Yurtseven (1990), Bilgiç (1992), and Yurtseven and Sönmez (1996) during their experiments which have been conducted with different irrigation water salinities and consisting leaching applications in the field or in the pot conditions.

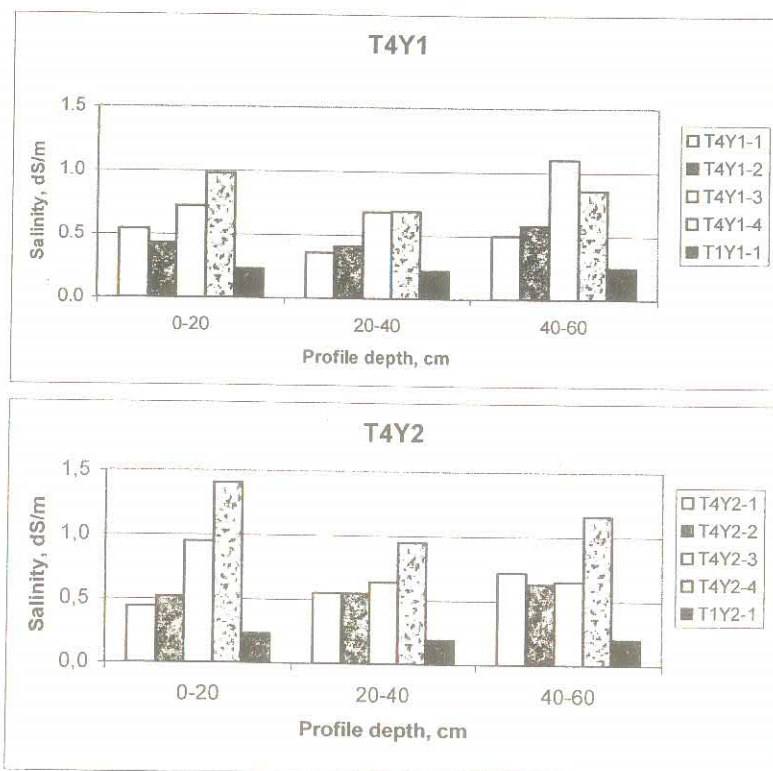


Figure 2. Soil salinities obtained from  $T_4$  salinity level through different profile depths in comparison with the salinities obtained from  $T_1$  level

As a result we can say that, applying leaching water to the root zone of the soil is one of the main practice to keep profile salinity below the harmful level for crop production. Irrigation waters, since they are not pure, increase the profile salinity depending on their quality and amount applied. The higher the salinity of irrigation water applied, the higher the profile salinization obtained at the end of the irrigation period. To leach the salts accumulated in the root zone, good quality water to be applied if available. Otherwise some salts can still remain after the leaching with high saline waters.



## REFERENCES

- Anonymous, 1954. Diagnosis and Improvement of Saline and Alkali Soils. L.A. Richards (Ed.). U.S. Dept. of Agric. Handbook No.60, USA.
- Bilgiç, K., 1992. Saline irrigation practices: Leaching management. In partial fulfillment of the requirements for the Master of Science in Irrigation. ICAMAS (International Center for Advanced Mediterranean Agronomic Studies) Bari, Italy.
- Bouyoucos, G.J., 1951. A calibration of the hydrometer method for making mechanical analysis of soils. Agron. J. 43:434-438.
- CAST, 1988. Effective Use of Water in Irrigated Agriculture. CAST (Council for Agricultural Sciences Technology) Report No.113, Ames, Iowa.
- FAO, 1988. World Agriculture Toward 2000: An FAO Study. N.Alexandratos (Ed.). Bellhaven Press, London, 388pp.
- Olsen, S.R.; C.V. Cole; F.S. Watanable and L.A. Dean, 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate.
- Poonia, S.R. and R. Pal, 1979. The effect of organic manuring and water quality on water transmission parameters and sodication of a sandy loam soil. Agric. Water Manage. 2:163-175.
- Rhoades, J.D.; A. Kandiah and A.M. Mashali, 1992. The Use of Saline Waters for Crop Production. FAO Irrigation and Drainage Paper No.48, 133pp, Rome.
- UN, 1991. World Population Prospects 1990. Population studies No.120, United Nations, New York, 607pp.
- Yurtseven, E., 1990. Değişik kalitedeki sulama sularının soya fasulyesi verimine etkisi. (Doktora) A.Ü. Fen Bilimleri Enstitüsü, Kültürteknik Anabilim Dalı (Basılmamış).
- Yurtseven, E. ve B. Sönmez, 1996. Sulama suyu tuzluluğunun domates verimine ve toprak tuzluluğuna etkisi. Doğa Tr. J. of Agriculture and Forestry, 20(1):27-33.

# MONITORING AND EVALUATION OF *IN SITU* HYDRAULIC CONDUCTIVITY AND GROUNDWATER QUALITY OF THE PILOT AREA IN THE LOWER SEYHAN PLAIN, ADANA, TURKEY

Mahmut Çetin<sup>1</sup>, Hasan Özcan<sup>2</sup>, Fatih Topaloğlu<sup>1</sup>

<sup>1</sup>Department of Agricultural Structures and Irrigation, Faculty of Agriculture, University of Çukurova, 01330 Balcalı-ADANA/TURKEY

<sup>2</sup>The Sixth Regional Directorate of State Hydraulic Works, Planning Section, 01330 Seyhan-ADANA/TURKEY

## ABSTRACT

This study has been conducted in the pilot area of the Lower Seyhan Plain (ASO), Adana, Turkey. The purpose of the study is to monitor and evaluate possible changes of the *in situ* hydraulic conductivity (K, m/d), groundwater (GW) electrical conductivity (EC, dS/m), groundwater depth (GWD, cm) and sodium adsorption ratio [SAR, (meq/l)<sup>0.5</sup>] of GW with regard to soil series and agricultural practices prevailing in the area within two decades between 1980 and 1999. To achieve the aim, the archive data, collected in 1980 for the purposes of drainage planning works by General Directorate of State Hydraulic Works (DSI), and detailed field investigation data gathered by researchers in 1999, have been utilised.

*In situ* hydraulic conductivity values varied, on the average, from 2.57 to 4.11 m/d during the monitoring period. The increase on the average was found insignificant at the 95 % probability level. Change map of K indicated highly variation over the area reflecting the alluvial origin of the study area soils. No relation was found between K and other variables as well as soil types. Average EC values decreased remarkably from 26.1 to 9.6 dS/m within two decades showing a trend towards improvement in favour of agriculture. This improvement in the EC was attributed to drainage development works and irrigation practices having been conducted in the area. Spatial distribution pattern of changes in EC showed that GW EC tended to increase in the depression areas, but to decrease in other places. GWD increased approximately 50 cm in the area. It was concluded that drainage development works contributed to this increase. SAR values of GW remained constant around 26 (meq/l)<sup>0.5</sup>. This result was verified statistically at the level of significance of 5%. Map of changes in SAR showed that no association was available among soil series or K, EC, and GWD.

## INTRODUCTION

Where land, water, and people meet, people invariably manipulate the ecosystem to assure their survival. People's livelihood is threatened when the ecosystem no longer produces enough to meet their needs. While the inhabitants face more and more problems in eking out a living in that harsh environment, the fragile ecosystem is increasingly under pressure. As a result of this pressure, particularly over-exploitation of land and water resources, or use of those resources under unfavourable conditions leads to degradation on the resource base and causes irreversible problems. For example, irrigation developments may conduce to waterlogging, alkalinity and/or salinity, and reduction on soil permeability owing to mismanagement or project faults.

Nevertheless, irrigation is essential in arid and semiarid regions (Boonstra, 1996). A prime requirement for successfully irrigated agriculture is the development and maintenance of a root zone in which the moisture-oxygen-salt balance is favourable for plant growth (Schrevel, 1997; Kelleners and Chudhry, 1998). The balance in question is maintained to a considerable extent by an adequate drainage. Poor irrigation and drainage water management, and unfavourable soil physical characteristics reverse that balance at the expense of creating both environmental problems and land degradation (Kelleners et al., 1996). On the other hand, the transition from dry-land farming to irrigated farming takes a long time and needs special care. In arid and semi-arid regions, a number of examples can be found easily that a lot of irrigation projects have failed and let the farmers down gently because of serious problems, such as aforementioned ones, emerged after irrigation practices.

Therefore, the monitoring and evaluation is an integral part of agricultural practices. The average horizontal hydraulic conductivity, K, of soil profile below the water table (Russo, 1984; Moustafa and Yomota, 1998), groundwater salinity, EC, and sodium adsorption ratio, SAR, (Johnston, 1977; Ayers, 1977; Kelleners and Chudhry, 1998), and groundwater depth, GWD, from soil surface



(Kelleners et al., 1996; Kelleners et al., 1997) were studied with intent to detect causes and effects of drainage and irrigation developments as well as management level in the course of time.

The aim of this study was to determine if there were any changes in the horizontal hydraulic conductivity of soil horizons below a water table, groundwater table depth, groundwater salinity and sodium adsorption ratio data collected in 1980 and 1999, and to show areal extent of any changes over a period of twenty years.

## MATERIALS AND METHODS

### Description of The Study Area

The study area covering 4200 ha of land consists of a part of the *Fourth Stage Irrigation Project Area of the Lower Seyhan Plain (ASO)*, is located in the southern part of Turkey. Typical Mediterranean climate prevails in the area. The annual rainfall varies between 366 and 1365 mm, with an average of 772 mm. Fifty one percent of rainfall falls during the winter season, but only 3% in the summer season. The average annual temperature is about 18.8 °C. Average annual *Class A Pan* evaporation is 1580 mm.

Although no irrigation development works have still existed in the area, but drainage canals, farmers have been using drainage effluent and poor quality deep well water for irrigation practices since 1980's. At the very beginning of 1980's, there was only one main drainage conveyance canal passing through the study area, named YD3 (Figure 1), and carrying out all drainage effluent of irrigated areas located in the northern part of the study area. Step by step, secondary and tertiary lateral drainage canals have been constructed lately in the area. The *Authorities of State Hydraulic Works* state that the command area is planned to be irrigated in the forthcoming years.

Dinç et al. (1990) report that there exist mainly three physiographic units in the study area, namely, young and old river terrace soils, and delta soils. Young and old river terrace soils are dominant in the study area and stretch eastward and northward, respectively. However, delta soils show a patchy pattern (Figure 1). The soil texture is generally clay to silty-clay-loam.

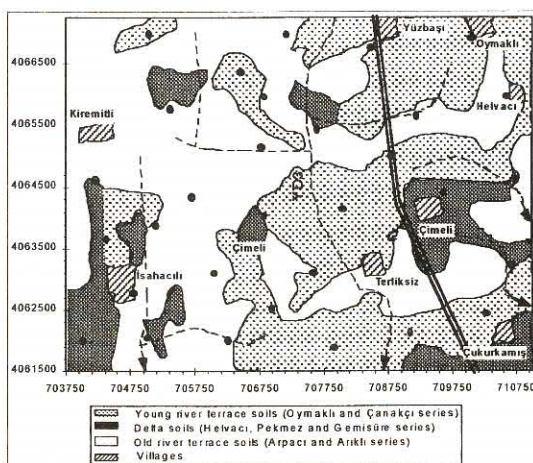


Figure 1. A general layout of the study area, showing distribution of soil types, sampling sites and drainage pattern

### Data Collection, *In Situ* Measurements and Laboratory Analysis

The area was surveyed by the *State Hydraulic Works (DSI)* for the purpose of preparing *planning drainage report* in 1980. The data on *in situ* hydraulic conductivity, depth to water table, groundwater quality, and soil characteristics were collected from 24 sampling sites. The findings were stored in the archive files. In this study, a detailed field survey was conducted in 1999. Data on *in situ* horizontal hydraulic conductivity of soil profile under groundwater table, depth to water table from the soil surface, and groundwater samples for electrical conductivity and sodium adsorption ratio measurements were collected contemporaneously from both just the same sampling sites where DSI staff visited in 1980 and also 9 additional sites.

*In situ* soil hydraulic conductivity (K, m/d) and depth to water table (GWD, cm) measurements were determined through following the procedures given by Boonstra (1996), Oosterbaan and Nijland (1994). Furthermore,  $\text{Ca}^{++} + \text{Mg}^{++}$  and  $\text{Na}^{+}$  analysis for sodium adsorption ratio calculation (SAR,



[meq/l]<sup>0.5</sup>), and electrical conductivity (EC, dS/m) measurements of collected groundwater samples were performed by following the principles presented by USSLS (1954) and Ayers (1977).

### Tests for Stationarity and Mapping of Areal Changes

Descriptive statistics of the two data set obtained within the monitoring period were calculated by following the procedure of Ott (1995). The *F*-test was utilised to test hypothesis which states that two samples are drawn from the populations having equal variances. Through following Montgomery and Runger (1994); Topaloğlu et al. (1999) and Davis (1986), *Student t* test was performed to test hypothesis which states that the mean of the population from which the first sample was sampled in 1980 is the same as the mean of the parent population of the second sample sampled in 1999. Each value of the variates observed in 1980 was subtracted from the ones observed in 1999 and resultant values were mapped to show areal extend of any changes (Davis, 1986) over two decades.

## RESULTS AND DISCUSSIONS

### Statistical Analysis

Descriptive statistics for *in situ* soil hydraulic conductivity (K, m/d), electrical conductivity (EC, dS/m) of groundwater (GW), depth to water table (GWD, cm), and calculated SAR [(meq/l)<sup>0.5</sup>] values of GW were calculated (Table 1). Table 1 shows clearly that mean of K and GWD increased considerably, EC decreased remarkably and SAR remained unchanged between two decades.

Table 1. Descriptive statistics of the data sets observed in 1980 and 1999

Sample statistics	K1980	K1999	EC1980	EC1999	GWD1980	GWD1999	SAR 1980	SAR 1999
Mean, ( $\bar{x}$ )	2.57	4.11	26.1	9.6	103	155	26.14	26.55
Median	2.50	2.07	25.3	7.1	98	151	25.27	32.03
Standard Dev. (S)	0.72	5.24	14.7	8.3	28	33	8.94	14.16
Kurtosis (C <sub>k</sub> )	1.32	6.34	-0.80	0.58	2.20	2.34	0.11	-1.10
Skewness (C <sub>s</sub> )	0.89	2.28	0.08	1.06	1.17	0.95	-0.62	-0.51
Range	2.95	24.39	54.0	32.2	126	162	34.96	46.23
Minimum	1.25	0.20	2.1	0.6	60	100	4.31	0.28
Maximum	4.20	24.59	56.0	32.8	186	262	39.27	46.51
CV	28.02	127.49	56.20	85.60	27.51	21.10	34.20	53.33

Standard deviations increased from 0.72 to 5.24 m/d, from 28 to 33 cm, and from 8.94 to 14.16 (meq/l)<sup>0.5</sup> for K, GWD and SAR, respectively (Table 1). The increase in standard deviations indicates that values are scattered widely about the mean and the tendency for central clustering is weak. This implies that spatial variations do exist in K, GWD and SAR, and also tend to increase in the course of events. The tendency to increasing spatial variations might be ascribed to the drainage development works, transition from dry-land farming to irrigated farming, and other different agricultural practices as well as hydrological changes in the area. Reversely, standard deviation of EC of GW decreased in the course of time, reflecting less spatial variation in EC and the tendency for clustering around the mean.

Coefficient of variation (CV) increased from 28 to 127 %, from 56 to 86 %, from 34 to 53 % for K, EC and SAR, respectively. The increase in CV manifests obviously the fact that the change in S is greater than the change in the mean value (Table 1). However, the reverse of that remark is true for K of GWD.

The changes in variances of data sets collected in 1980 were tested against those of the ones collected in 1999. Test results showed that the changes in variances of all variates, except for GWD, were significant at the level of significance of 5 % (Table 2), reflecting the fact that activities performed in the area during the monitoring period disturbed the homogeneous structure of the variates.

Average K and SAR values appear to have increased over the study area (Table 1). However, this conclusion could not be justified by statistical tests at 95 % probability level (Table 2), verifying that the changes could be ascribed to the inherently random character of the variate. The decrease in the mean of EC and the increase in the mean of GWD were found significant, indicating in plain words that reclamation works could affect efficiently on the phenomena.

Table 2. Test results for equality of variances and means

Statistics	K1980	K1999	EC1980	EC1999	GWD1980	GWD1999	SAR 1980	SAR 1999
<i>F test for equality of variances</i>								
$S^2$	0.72	5.24	14.7	8.3	28	33	8.94	14.16
$df (v=n-1)$		32	23			32		32
$df (v=m-1)$	21			32	23		23	
$F_{calculated}$	53.21		3.16		1.34		2.51	
$F_{critical} (\alpha=0.05)$	2.30	Rejected	2.13	Rejected	2.23	Accepted	2.23	Rejected
<i>Student-t test for equality of means</i>								
$\bar{x}$	2.57	4.11	26.1	9.6	103	155	26.14	26.55
$df (v=n+m-2)$	53		55		55		55	
$t_{calculated}$	-1.37		5.39		-6.3		-0.12	
$t_{critical} (\alpha=0.05)$	2.01	Accepted	2.01	Rejected	2.01	Rejected	2.01	Accepted

### Mapping Areal Extent of Changes

The aforementioned results of classical statistics are far from indicating areal changes over the area. For this reason, data sets for K, EC, GWD and SAR observed in 1980 were subtracted from those observed in 1999. The resultant difference data sets were gridded by the method of *Inverse Distance to a Power 2* and mapped so that a visual comparison could be made. Difference maps for each variable were presented in Figure 2.

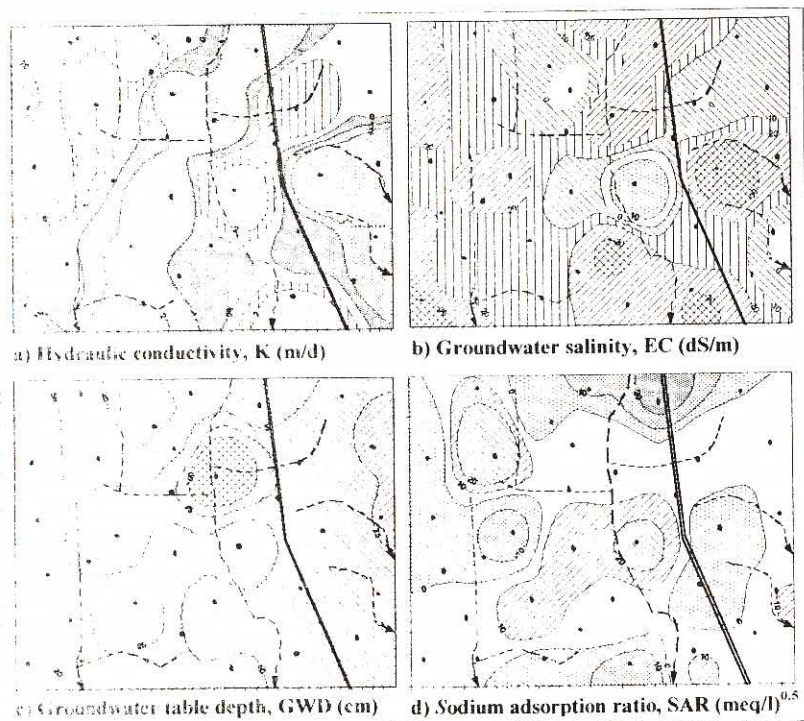


Figure 2. Areal extent of the changes in K, EC, GWD, and SAR between the years 1980 and 1999



Figure 2a shows that K values increased somewhat in the northwest part of the study area. However, it appears that K values decreased along a corridor from north to southwest and in the eastern part of the area. There is no clear evidence that drainage development works and soil types contribute to any decrease or increase in K. This result could be attributed to the alluvium origin of soils. Additionally, no relation was found between K and other variables (Figure 2).

Groundwater electrical conductivity decreased remarkably during the observation period, except for small patchy areas in the middle of the study area (Figure 2b). Inappropriate topography having a relatively small depression is dominant in this part. This decrease in EC could be ascribed to the transition from rain-fed agriculture to irrigated agriculture, construction of lateral drainage canals, and excessive irrigation practices in the fields located in the vicinity of the northern part of the study area. It is remarkable to state that the most decrease in EC emerged in the delta soil types (Figure 1 and 2b).

Over the study area, no relation was found between soil types and GWD increase (Figure 1 and 2c). GWD increased more or less 50 cm, on the average, between the observation period. It is obvious from Figure 2c that GWD responded to construction of lateral drainage canals with very well development in terms of agriculture. This increase in GWD is an indicator of the effectiveness of the drainage canals in controlling the water table. Maximum increase in GWD occurred in the middle of the study area. However, it should be stated clearly that drainage development works could not contribute well enough to increase GWD to a certain level in favour of agriculture. Possible reasons for that could be attributed to the lack of enough open drainage canal density and inappropriate drainage outlet conditions, no pipe drains installation, the problem of side slope stability of open drainage canals stemming from "soupy" material and also siltation due to alluvial character of soils, and sloughing in due to high sodium concentration in soils.

SAR values of GW remained almost stable during the observation period, but showed high variation (Table 1). Although EC of GW decreased remarkably between the years 1980 and 1999, the change in SAR values is generally greater than zero over the area (Figure 2b and 2d). The maximum increase realised in depression areas. No association was detected between soil types and SAR changes. Additionally, it could be concluded that drainage development works had no effect on the average SAR changes in terms of agriculture. The increase in SAR might be attributed to irrigation practices helping the salts leach to the groundwater body.

## ACKNOWLEDGMENT

*This research was partially supported by the Research Fund Office of Rectorate of Çukurova University through a Research Contract ZF.99.14. The Authors would like to thank Mr. Hasan MERT of the Deputy Director of DSL and Mr. Adil AKYATAN of Manager of Planning Section of DSL, Adana, Turkey, for giving us access to data of the Fourth Stage Planning Drainage Report of the Lower Seyhan Plain and for providing us with equipment during field survey.*

## REFERENCES

- Ayers, R. S., 1977. Quality of Water for Irrigation. Journal of the Irrigation and Drainage Division, ASCE, Vol. 103, No. IR 2, Proc. Paper 13010, pp. 135-154.
- Boonstra, J., 1996. Constraints and Opportunities for Integrated Water-Management Models. IIRI Annual Report, The Netherlands, pp. 8-25.
- Davis, J. C., 1986. Statistics and Data Analysis in Geology. John Wiley & Sons, Inc., New York, NY 646 p.
- Diñç, U., Sarı, M., Şenol, S., Kapur, S., Sayın, M., Derici, M.R., Çavuşgil, V., Gök, M., Aydın, M., Ekinci, H., Ağa, N., Schlichting, E., 1990. Çukurova Region Soils. University of Çukurova, Faculty of Agriculture, Publication Number 26, Çukurova University Printing Office, Adana, Turkey (published in Turkish).
- Johnston, W. R., 1977. National Water Quality Goals and Irrigated Agriculture. Journal of the Irrigation and Drainage Division, ASCE, Vol. 103, No. IR 2, Proc. Paper 12988, pp. 109-114.
- Kelleners, T. J., and Chudhry, M. R., 1998. Drainage Water Salinity of Tubewells and Pipe Drains: A Case study from Pakistan. Agricultural Water Management Vol. 37, pp. 41-55.



- Kelleners, T. J., Sharma, R. D., and von Hoffen, R. A., 1997. Salinity of Drainage Water from Pipe Drains in Clay Soils. ILRI Annual Report, The Netherlands, pp. 26-38.
- Kelleners, T. J., von Hoffen, R. A., and Oosterkamp, H. C., 1996. Effluent Salinity of Pipe Drains: Case Studies in the Punjab Province, Pakistan, and the Fayoum Depression, Egypt. ILRI Annual Report, The Netherlands, pp. 34-52.
- Montgomery, D. C., and Runger, G. C., 1994. Applied Statistics and Probability for Engineers. John Wiley & Sons, Inc., New York, 895 p. + Appendices.
- Moustafa, M. M., and Yomota, A., 1998. Spatial Modeling of Soil Properties for Subsurface Drainage Projects. *Journal of Irrigation and Drainage Engineering*, Vol. 124, No. 4, pp. 218-228.
- Oosterbaan, R.J., and Nijland, H. J., 1994. Determining the Saturated Hydraulic Conductivity. In *Drainage Principles and Applications* by H. P. Ritzema (editor-in-chief), ILRI Publication 16, The Netherlands, 1125 p.
- Ott, W. R., 1995. *Environmental Statistics and Data Analysis*. Lewish Publishers, New York, 313 p.
- Russo, D., 1984. A Geostatistical Approach to Solute Transport in Heterogeneous Fields and Its Applications to Salinity Management. *Water Resources Research*, Vol. 20, No. 9, pp. 1260-1270.
- Schrevel, A., 1997. Water, Agent of Change: Transition to Irrigated Farming in the Snip Area, Rajasthan, India. ILRI Annual Report, The Netherlands, pp. 8-25.
- Topaloğlu, F., Yücel, A., Tülücü, K., Çetin, M., 1999. Use of Peak Discharges in Flood Frequency Analysis. *TÜBİTAK Turkish Journal of Agriculture and Forestry* 23 (1999), Supplementary Issue 1, 187-192, (Only abstract in English, original text in Turkish), ANKARA.
- USSLS (U. S. Salinity Laboratory Staff), 1954. *Diagnosis and Improvement of Saline and Alkali Soils*. USDA Handbook 60, U. S. Department of Agriculture, Washington, D.C.

# THE TECHNOLOGICAL AND MINERALOGICAL CHARACTERISTICS OF RAW MATERIALS USED FOR BRICK-TILE INDUSTRY IN KAHRAMANMARAŞ REGION

Kadir Yılmaz<sup>1</sup>, Mehmet Nuri Bodur<sup>2</sup>

<sup>1</sup>Kahramanmaraş Sütçü İmam University, Faculty of Agriculture, Department of Soil Science, Kahramanmaraş-Türkiye

<sup>2</sup>Kahramanmaraş Sütçü İmam University, Faculty of Engineering and Architecture, Department of Civil Engineering, Kahramanmaraş-Türkiye

## ABSTRACT

The brick-tile industry has an important potential in the Kahramanmaraş Region. The raw material for making brick-tile is mostly supplied from fertile soils of the agricultural areas.

The investigation and determination of the physical, chemical, mineralogical and technical properties of the raw material which has already been used by brick-tile industrial factories in research area was aimed to get some results in which about the economical values of that material supplying from the research area. In addition, the other brick-tile industry raw material which is called as Menzelet Clay has no any importance in usage for agricultural purposes and a waste of industrial ash material from any factories have investigated in usage and also compared with the each other.

It was resulted that the waste of industrial ash material was not technological and mineralogical usage for the brick-tile industry. It can be stated that Menzelet Clay material is efficiently used by this industrial proposes. It can be stated that its usefulness will be increased by applying some effective processes such as powdering and grinding of that material.

Therefore, the scarcity and cost of raw material for making brick-tile will be reduced by the using Menzelet Clay as an industrial raw material in this respect. Finally, it is concluded that brick-tile industrial's raw materials must apparently be supplied from the other resource areas which respectively non-agricultural areas.

## INTRODUCTION

The soils that using for raw materials of brick-tile and porcelain manufacture have to be different properties for brick-tile and porcelain manufacture. The raw materials of brick-tile have not coarse materials such as sand. They were formed with precipitate of stream sediments. This materials were prefer by factory owner. This attitude causes lose of fertile soils of the fertile agricultural areas.

After the raw materials of derived non agricultural areas were powdering and grinding, they were used for brick-tile manufacture in Gediz provinces. Although the deriving of raw material was prohibited in the agricultural area, the brick-tile manufacture was not less (Ünver et al., 1987).

The soils of brick-tile manufacture have high level clay ratio. Together, silt have to included at the definite ratio and the unified classification system should be CL. The high level clay may be crack of brick-tile while drying and heating. Its shaping is difficult while mud. The sandy soils have little plastic properties. The sandy soils are scattered in the shaping and have rough surface. After it is furnace, resistance and hardness are very little. The plasticity is very important for blend of soils and its shape keeping. The high level plasticity is unsuitable for brick-tile manufacture. The little plastic clays are absorbed water 20 percent of dry weight when the attached of the hand. The high plastic clays are absorbed water 26-27 percent of dry weight when the attached of the hand (Dizdar, 1991).

The illite and kaolinite clays are the most suitable for brick-tile industry. Because montmorillonite have high shrinking and swelling potential, it is unsuitable for brick-tile industry. So, Vertisols should not be use for brick-tile manufacture.

Because  $\text{CaCO}_3$  was transformed to  $\text{CaCO}_3$  during furnace and letter it was transformed  $\text{Ca(OH)}_2$  and it caused crack and exploded. The  $\text{CaCO}_3$  should be lower level of 25 percent. The carbonate should not be granular. The carbonate should be fine fraction and separated in to material. Because the carbonate is approach sintering and melting degree. The high level carbonate in the soil is make difficulties furnace technology. Because the furnace temperature is also increased for increasing solidity and sintering, the colour is turned to yellow with carbonate effect and destroyed shape of brick-tile. The  $\text{Fe}_2\text{O}_3$  is generally found at the oxide situation and prefer to be 8-10 percent in the soils. The  $\text{Fe}_2\text{O}_3$  is cause increasing of hardness in the end of furnace and decrease of water absorption and



cause red colour of brick-tile. The high level organic matter lessen resistance of brick-tile. Organic matter leave black carbon residue on surface brick-tile. Total salinity which absorbed water and lessen resistance of brick-tile. So, total salinity should be at the lower level of 1.5 percent (Dizdar, 1991).

## **MATERIALS and METHODS**

### **Description of Study Area**

Kahramanmaraş is located in the east Mediterranean of Turkey. It lies between 37° 11' and 38° 36' North, and between 36° 15 and 37° 42' East and covers about 1450 km<sup>2</sup>. The area is generally hilly, and elevation ranges from 450 to 3081 m or higher.

The study area has mainly two climatic region. The climate of northern area has mesic temperature and aridic soil moisture regime. Monthly mean temperature ranges from -0.4 °C in December to 23 °C in July, with mean annual value of 10.3 °C. The average annual precipitation is about 386 mm at Elbistan. The southern area has thermic temperature and xeric soil moisture regime. The total annual precipitation is about 710 mm, most of which occurs in winter, between December and April. The mean annual temperature is 16.5 °C, and monthly mean temperature ranges from 4.5 °C in January to 28 °C in August (Tigem, 1991; Kaya, 1996).

### **Geology of Sampled Area**

The surrounded area is mostly covered by the metamorphic, sedimentary rocks and also some basaltic rocks which are locally outcropped in this region (MTA, 1975). The alluvial materials were deposited and also outcropped in the southern part of Kahramanmaraş, Afşin and Elbistan. The carbonate rocks which were deposited as a limestone during the different time in the mountainous areas. The ophiolitic units were also outcropped in the eastern part of Göksun and Pazarcık villages.

*Paleozoic:* Most of the metamorphic rocks belongs to this period were widespread in the around of Afşin village and also in the southern part of Elbistan village. Permo-Carboniferous rocks also outcropped in the around of Göksun, Afşin and Elbistan villages. These rocks were underlined by the Silurian-Devonian rocks and also old metamorphic rocks (MTA, 1975).

The metamorphic rock units are generally represented by the gabbro, peridotite, serpentine, calc-schist, marble, crystallized limestone, phyllite and also pelitic schist in the Kahramanmaraş Province (DSİ, 1973; Perinçek ve Kozlu, 1984; Türkünal, 1996).

*Mesozoic:* The oldest formations were generally overlain by Eocene limestone. The limestone in upper- Cretaceous age mostly outcropped in the area which is located in between Afşin and Pazarcık-Gölbaşı. Many basaltic flow occurrences aged in the post-Miocene are encountered in the Kahramanmaraş region. Semi-crystalline basal rocks, crystalline schist, green-colored schist, gneiss and amphibolite are also encountered in this area (MTA, 1975).

The conglomerate, sandstone and shale containing various blocks of different lithology and age, unconformably lies over the metamorphic rocks. The widespread occurrences of pillow lavas, radiolarian cherts, pelagic fossiliferous limestone and also tubidites are encountered in the Kahramanmaraş region (Perinçek ve Kozlu, 1984).

*Cenozoic:* The Miocene depression areas in around Kahramanmaraş were filled with very thick and coarse erosional conglomerates during the plio-Quaternary period (MTA, 1975).

Some plio-Quaternary outcrops are preserved as parts of the older alluvial areas. These outcrops are represented by fluvial deposits such as alluvium terrace and channel deposits. The important Quaternary deposits are those of the slope scree around the Berit Mountain, the wide alluvial fan in the north of Derbent village and the alluvial plains of the meandering rivers of Göksun and Ceyhan (Perinçek ve Kozlu 1984) The some sedimentary and metamorphic rock units are represented by, marl, shale, limestone, conglomerate and sandstone which is locally calcarenitic and fossiliferous, in this time period. The flysch with blocks is also represented by conglomerate greenish-gray shale, sandstone and sandy and fine bedded limestone (Perinçek ve Kozlu, 1984).

The andesitic outcrops are found in the north of the Nurhak mountains as intruded into the Andırın limestone and the ophiolitic rock units. Especially basaltic rocks which were formed in the upper Eocene to Neogene are widespread in the Narlı and Kahramanmaraş Central Plains (DSİ, 1973).

### **Physical and Chemical Analyses**

The soil samples were air dried and sieved to remove coarse fragments (>2 mm). PH measurements were made in saturated soil after 4-h equilibration period. Electrical conductivity values were obtained from saturated samples (Richards, 1954). The total carbonate contents were measured



by using scheibler calcimeter (Çaglar, 1949). Organic matter contents were determined by wet oxidation with dichromate (Walkley, 1946). Particle-size distributions in the <2 mm fraction were determined by the hydrometer method (Bouyoucus, 1951).  $\text{Fe}_2\text{O}_3$  were extracted from whole soil samples by the citrate-bicarbonate-dithionite method. The concentrations of extracted  $\text{Fe}_2\text{O}_3$  were determined by Perkin Elmer 3110 atomic absorption spectroscopy (Jackson, 1969).

#### Technological Analyses

The soil samples were sieved to remove coarse fragments (>0.430 mm) for determining of the Atterberg limits. The determinations of Liquid-limits (LL) were based on Sowers criteria (1965). This is the water content, causing it to transform into a viscous that will flow when jarred. It is measured on thoroughly puddle soil material and is expressed on a dry weight basis (110 °C). Plastic Limit (PL) was determined according to Sowers criteria (1965). The plasticity index (PI) is the difference between the plastic limit (PL) and liquid limit (LL) and indicates the water-content range over which the soil has plastic properties. Shrinkage limit (SL) was determined according to Karol criteria (1955). The shrinkage index (SI) is the difference between the plastic limit (PL) and shrinkage limit (SL).

#### Mineralogical Analyses

The soil samples for mineralogical analysis were pre-treated with 1 N NaOAC, adjusted to pH 5, to remove carbonates, and with 30 %  $\text{H}_2\text{O}_2$  to remove organic matter, and with sodium dithionite-citrate-bicarbonate to remove Fe-Si-Al-oxides. The samples were then adjusted to make pH 9.5 with 1 M  $\text{Na}_2\text{CO}_3$  to effect particle dispersion. Sand was separated by wet sieving; clay and silt fractions were separated by Stokes methods. Diffractograms were obtained from Mg-saturated samples, and also from K-saturated samples. X-ray diffraction analyses of the clay fraction (<2  $\mu\text{m}$ ) were scanned from 3 to 13 2 $\theta$  on oriented samples on glass slides with nickel-filtered Cu K $\alpha$  radiation using a Philips X-ray diffractometer (Jackson, 1969). The diffraction intensity of clay minerals were determined with calculating of peak area.

The multiplication factors were obtained by Yılmaz (1990) on Harran Plain and Yılmaz, Sayın (1998) on Çukurova Plain were used to quantitative clay analyses. According to both investigations, the multiplication factors of smectite-palygorskite, smectite-illite and smectite-kaolinite were 3.37, 2.25 and 3.29, respectively.

After organic matter and carbonate were removed In order to determined clay minerals distributions in the soil composition, sand was separated by wet sieving and silt and clay fractions were separated by Stokes methods. The particle size distribution was determined on a dry weight basis (105 °C) (Jackson, 1969). The clay rates in the clay fraction applied to soil composition.

## RESULTS and DISCUSSION

The soils have slightly alkaline reaction, pH 7.96-8.43. Total salinity was found between 0.01 and 0.39 percent.  $\text{CaCO}_3$  rate was found between 2.74 and 27.36 percent. The organic matter contents were found between 1.33 and 3.11 percent in to the soils.  $\text{Fe}_2\text{O}_3$  were found between 1.03 and 2.58 % (Table 1).

According to Dizdar (1991), total salinity should be at the lower level of 1.5 percent and  $\text{CaCO}_3$  should be at the lower level of 25 percent for brick-tile industry. The salinity contents of investigated samples were suitable for brick-tile industry. The carbonate contents of samples were suitable. But the numbered 6 of the sample is an exception. The carbonate content of the numbered 6 of the sample was found at the 27.36 percent. The high carbonate ratio was unsuitable for brick-tile industry. The organic matter with high levels were unsuitable for brick-tile industry. Except sample 9, the organic matter contents of the samples were found at the lower level of 3 percent. The organic matter contents of the investigated samples were suitable for brick-tile industry. The  $\text{Fe}_2\text{O}_3$  of the samples which were wished to be high levels was found about 2.5 percent (Table 1).

In the investigated technological properties of the samples, liquid-limit, plastic limit, plastic index, shrinkage limit and shrinkage index were found between 25.06 and 61.16 percent, between 18.48 and 39.54 percent, between 6.58 and 17.97 percent, between 13.50 and 22.62 percent, between 1.37 and 20.01 percent, respectively (Table 2). The unified classification system of the four samples were found CL and the three samples were found ML and the one sample was found MH and the one sample was found NP. The only samples 6 and 9 have technological problems in the investigated samples (Table 2). The sample that taken from Gavur Gölü has expansive-shrinkage clays was

unsuitable for brick-tile industry. The sample 9 was fossil ash and derived from various factories in the location and it has not plastic property and is unsuitable for brick-tile industry. The technological properties of the samples 1, 2, 3, 4, 5, 7 and 8 were found suitable for brick-tile industry.

In the clay minerals of clay fraction, smectite was found between 2.04 (sample 7) and 19.19 percent (sample 6). Similarly, paligorskite between 19.64 (sample 8) and 39.33 percent (sample 7), illit between 10.99 (sample 6) and 27.83 percent (sample 4), kaolinite between 16.12 (sample 1) and 22.89 percent (sample 6), vermiculate between 5.24 (sample 3) and 29.72 percent (sample 8) (Figure 1), (Table 3).

Smectite of the clay minerals in the soil composition was found between 0.32 (sample 7) and 7.06 percent (sample 6). Similarly, paligorskite between 2.51 (sample 8) and 10.83 percent (sample 6), illit between 1.71 (sample 8) and 9.22 percent (sample 3), kaolinite between 2.69 (sample 7) and 8.44 percent (sample 6), vermiculate between 1.77 (sample 3) and 6.48 percent (sample 6) (Table 4). In the sample 6 the smectite ratio was the highest and also the sample 6 was CH according to unified system of classification so, it supports the previous investigation (Ünver et al., 1987).

Table 1. Physical and Chemical Properties of The Samples

Samples No	PH	Total Salt	CaCO <sub>3</sub>	Organic Matter	Free Fe <sub>2</sub> O <sub>3</sub>	Particle Size Distribution %			Texture
			%			Sand	Silt	Clay	
1	7.96	0.19	4.74	2.36	1.80	39.57	33.02	27.41	CL
2	8.25	0.14	6.75	1.33	2.33	23.78	39.37	36.85	CL
3	8.19	0.10	16.41	2.12	2.58	27.96	29.44	42.60	C
4	8.00	0.01	7.66	1.40	2.07	43.88	34.48	21.64	L
5	8.12	0.22	7.84	1.82	1.95	41.31	34.65	24.04	L
6	8.43	0.38	27.36	1.71	1.03	13.82	47.53	38.65	SiCL
7	8.40	0.02	2.74	1.55	2.19	48.54	35.17	16.29	L
8	8.09	0.08	14.22	1.49	1.24	67.45	27.63	14.92	SL
9	8.38	0.39	5.65	3.11	1.53	51.47	40.92	7.61	SL

Table 2. Technological Properties of The Samples

Samples No	LL	PL	PI	BL	BI	The Unified Classification System
	%					
1	43.65	30.72	12.93	21.14	9.58	ML
2	46.86	28.89	17.97	22.62	6.27	ML
3	48.92	33.87	15.05	15.53	18.34	ML
4	34.51	21.95	12.56	16.77	5.18	CL
5	38.12	23.96	14.16	13.50	10.46	CL
6	61.16	39.54	21.62	19.53	20.01	MH
7	25.06	18.48	6.58	16.44	2.04	CL
8	36.69	23.26	13.43	21.89	1.37	CL
9	Non-Plastic (NP)					

The sand, silt and clay which its organic matter and also CaCO<sub>3</sub> were removed was found between 8.99 and 50.44 percent, between 23.66 and 37.82 percent, between 4.59 and 36.87 percent (Table 4). Although the samples 1, 2, 3, 4, 5 and 6 have suitable particle-size distributions, but also the samples 7, 8 and 9 have unsuitable particle-size distributions for brick-tile industry. The samples not removed CaCO<sub>3</sub> (Table 1) and removed CaCO<sub>3</sub> (Table 4) were compared in order to determinate



particle-size distributions of  $\text{CaCO}_3$ . According to investigation results, The  $\text{CaCO}_3$  of the sample 3 was found as equal in the clay, silt and sand fraction. The  $\text{CaCO}_3$  of sample 6 was found in the silt fraction. The  $\text{CaCO}_3$  of sample 8 was found in the sand fraction. Being fine fraction of  $\text{CaCO}_3$  was important for brick-tile quality (Dizdar, 1991). The  $\text{CaCO}_3$  fractions of the samples 3 and 6 were more suitable than sample 8. Because  $\text{CaCO}_3$  contents of other samples were few, the particle-size distributions of  $\text{CaCO}_3$  were not determined.

There were positive significant correlation between smectite and plastic limit ( $r: 0.960^{***}$ ), between smectite and plastic index ( $r: 0.906^{**}$ ), between smectite and shrinkage limit ( $r: 0.849^{**}$ ), between clay and liquid limit ( $r: 0.849^{**}$ ), between clay and plastic limit ( $r: 0.864^{**}$ ), between liquid limit and plastic limit ( $r: 0.975^{***}$ ), between liquid limit and plastic index ( $r: 0.935^{***}$ ). There were negative significant correlation between sand and liquid limit ( $r: -0.927^{***}$ ), between sand and plastic limit ( $r: -0.895^{**}$ ), between sand and plastic index ( $r: -0.880^{**}$ ). The similar results had been also found by Mitchell (1976), Sayın (1981) and Dizdar (1991).

The sample 8 (Menzelet) which has large reserve and located non-agricultural area is important potential for brick-tile industry and to protect agricultural areas. Menzelet sample is the decomposed clay materials which was widespreading in the investigation area. Menzelet sample was found in the CL groups and has suitable pH, total salinity, carbonate organic matter levels for brick-tile industry. The unsuitable characteristic of Menzelet sample has not suitable particle-size distributions and has high sand fraction level. Menzelet sample which is has widespreading on non-agricultural area and suitable technological and mineralogical properties to brick-tile industry is important to protect agricultural area. Except texture, physical, the chemical and mineralogical

Table 3. Clay Mineralogical Analyses

Samples No	Smectite	Palygorskite	Illite	Kaolinite	Vermiculite	Total
	%					
1	10.66	30.71	22.16	16.12	20.35	100
2	13.27	28.77	21.76	22.17	14.03	100
3	15.41	31.90	27.29	20.16	5.24	100
4	7.26	36.02	27.83	19.87	9.02	100
5	9.98	31.05	24.36	16.86	17.75	100
6	19.19	29.36	10.99	22.89	17.57	100
7	2.04	39.33	25.49	17.03	16.11	100
8	15.07	19.64	13.41	22.16	29.72	100
9	-	-	-	-	-	100

Table 4. The Chemical and Mineralogical Properties of The Samples

Chemical and Mineralogical Properties of The Samples											
Samples No	Total Salt	CaCO <sub>3</sub>	Org. Mat.	Free Fe <sub>2</sub> O <sub>3</sub>	Sand	Silt	Clay Fraction				
							Smectite	Palygorskite	Illite	Kaolinite	Vermiculite
	%										
1	0.19	4.74	2.36	1.80	34.03	30.55	2.81	8.09	5.83	4.24	5.36
2	0.14	6.75	1.33	2.33	17.54	37.82	4.52	9.81	7.42	7.56	4.78
3	0.10	16.41	2.12	2.58	20.30	24.70	5.21	10.78	9.22	6.81	1.77
4	0.01	7.66	1.40	2.07	39.15	29.40	1.47	7.32	5.65	4.04	1.83
5	0.22	7.84	1.82	1.95	34.21	32.23	2.17	6.74	5.29	3.66	3.85
6	0.38	27.36	1.71	1.03	8.99	23.66	7.06	10.83	4.05	8.44	6.48
7	0.02	2.74	1.55	2.19	45.95	31.77	0.32	6.21	4.02	2.69	2.54
8	0.08	14.22	1.49	1.24	45.41	24.78	1.93	2.51	1.71	2.83	3.80
9	0.39	5.65	3.11	1.53	50.44	34.28	Amorphous				



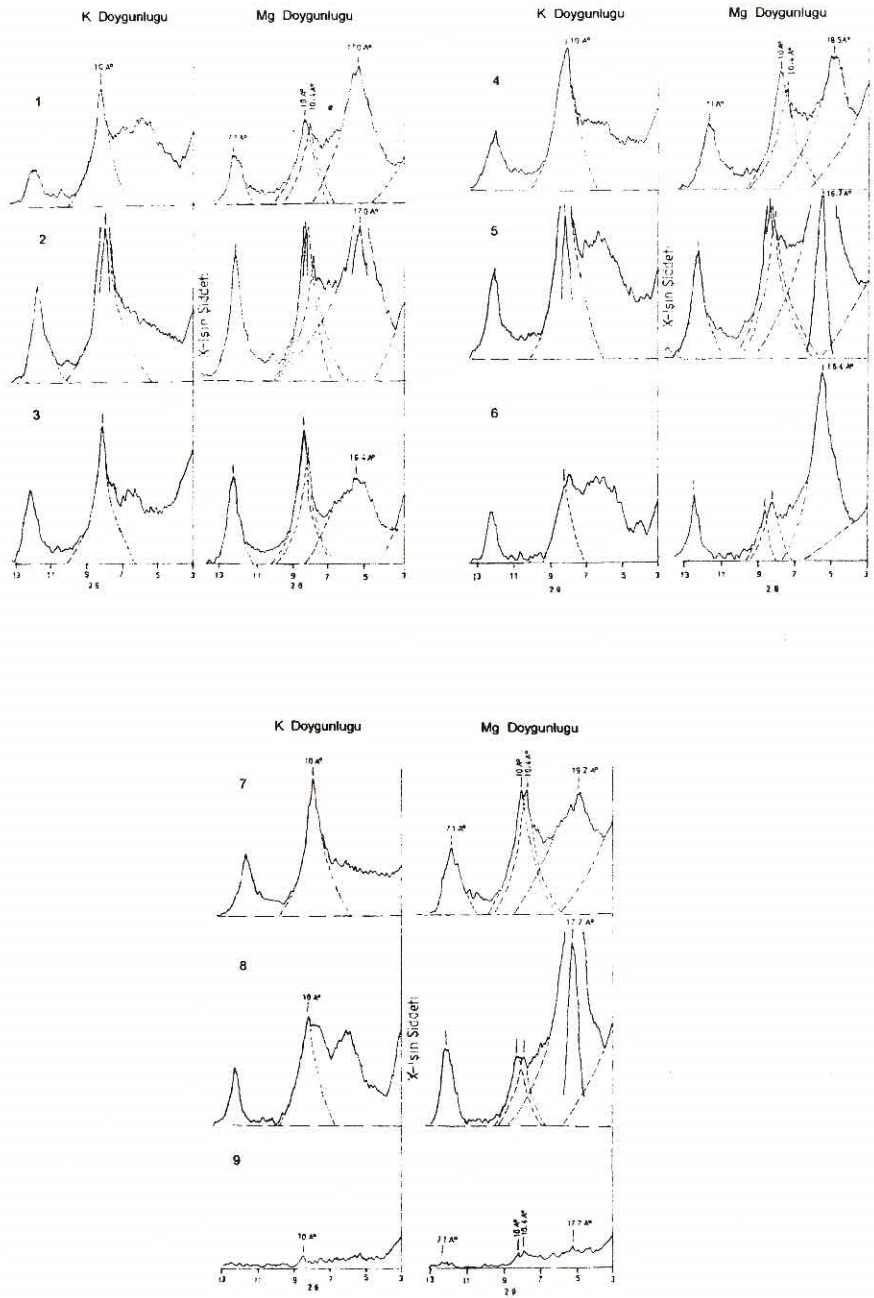


Figure 1. X-ray diffractograms of the clay samples

properties of Menzelet sample were suitable for brick-tile industry. It may be mixed with other soils which have high clay contents. The brick-tile price has been increasing because of the brick-tile factories purchase agricultural areas for brick-tile manufacture. Menzelet sample that is widespreading on non-agricultural area will decrease the cost of brick-tile. It was resulted that the waste of industrial ash material was not suitable for technological and mineralogical properties for the brick-tile industry. It can be stated that Menzelet Clay material is efficiently used by this industrial proposes. On the other hand it can be stated that its usefulness will be increased by applying some effective processes such as powdering and grinding of that material. Therefore, the scarcity and cost of raw material for making brick-tile will be reduced by the using Menzelet Clay as an industrial raw material in this respect. Finally, it is concluded that brick-tile industrial's raw materials must apparently be supplied from the other areas which not agricultural areas productively.

## ACKNOWLEDGEMENTS

We wishes to thank Prof. Dr. Selim KAPUR and Research Ass. Erhan AKÇA

## REFERENCES

- Black C. A., (1965). Methods of soil analysis. Agronomy. no: 9. part: 1 and 2. Ame. Soc. of Agr. Madison. Wisc. 1572 p.
- Bouyoucos G. J., (1951). A Recalibration of the hydrometer method for making mechanical analysis of soils. Agron. Jour. 43. 434-438.
- Çağlar K. Ö., (1949). Toprak bilgisi. A. Ü. Ziraat Fakültesi. Yayın no:10. 230 s. Ankara.
- Dizdar M. Y., (1991). Uygulama için toprak bilgisi. Tarım Orman ve Köyişleri Bakanlığı Köy Hizmetleri Genel Müd. yayınları. Ankara.
- DSİ., (1973). Kahramanmaraş ovaları hidrojeolojik etüt raporu. Yer Altı Suları Dairesi Başkanlığı Ankara.
- Jackson M. L., (1969). Soil chemical analysis. advanced course. 2. nd ed. published by the Author. Univ. of Wisconsin. 8955 Madison. USA.
- Karol R. H., (1955). Engineering properties of soils. Prentice-Hall Inc. New York. USA.
- Kaya F., (1996). Kahramanmaraş İlinin iklim özellikleri (Yüksek lisans tezi). K.S.Ü. Sosyal Bilimler Enstitüsü. Kahramanmaraş. 144 s.
- Köy Hizmetleri Genel Müdürlüğü., (1997). Kahramanmaraş İli arazi varlığı. İl rapor no: 46. Ankara.
- Mitchell J. K., (1976). Fundamentals of soil behaviour. Wiley. New York.
- MTA., (1975). 1/500.000 ölçekli Türkiye jeoloji haritası, Hatay paftası. MTA yayınları. Ankara.
- Perinçek, D., Kozlu, H., (1984). Stratigraphy and structural relations of the units in the Afşin-Elbistan-Doğanşehir region (Eastern Taurus). In Geology of the Taurus Belt ed. By. Tekeli, O., and Göncüoğlu, M.C., International symposium on the geology of the Taurus Belt 1983. 181-198 p. MTA. Ankara.
- Sayın M., (1981). Toprak teknolojisi ders notları. Ç. Ü. Ziraat Fak. Toprak Bölümü. Adana.
- Sowers G. F., (1965). Methods as soil analysis. Part I. American Society of Agronomy Inc. Publisher. Madison. Wis. USA.
- Topraksu., (1973). Ceyhan Havzası Toprakları. Topraksu Genel Müdürlüğü. Yayın no: 285. S: 86. Ankara.
- U. S. Salinity Laboratory Staff., (1954). Diagnosis and improvement of saline and alkali soils (ed. L. A. Richards). USDA Agriculture Handbook No: 60. U. S. Gov. Printing Office. Washington. 160p.
- Ünver İ., Kapur S., Çağrı M. R., Çavuşgil V. S., (1987). Relationships between technological properties and clay minerals of the present and potential raw materials for brick-tile industry at some regions. II: Ulusal Kil Sempozyumu. 203-216. ODTÜ. Ankara.
- Tigem., (1991). Kahramanmaraş Tarım İşletmesi Topraklarının etüt ve haritalanması. Tarım İşletmeleri Genel Müdürlüğü. Yayın no: 11. 54s.
- Türkunal S., (1996). Kahramanmaraş İli enlemi ile Engizek sıradağları arasında kalan bölgenin jeolojisi. TJMO yayını, 31 s. Ankara.
- Yılmaz K., Sayın M., (1998). Çukurova Bölgesi yaygın toprak serilerinde çarpım faktörü yöntemiyle kantitatif kil analizi. KSÜ Fen ve Mühendislik Dergisi 36-46.
- Yılmaz K., (1990). Harran Ovası Topraklarının mineralojik karakterizasyonları (Doktora tezi). Ç. Ü. Fen Bil. Ens., Adana.

# EFFECTS OF DIFFERENT LEAD AND CADMIUM COMPOUNDS ON SOIL CATALASE ENZYME ACTIVITY

Ayten Karaca<sup>1</sup>, Rıdvan Kızılkaya<sup>2</sup>, Koray Haktanır<sup>1</sup>

<sup>1</sup> Soil Science Department, Faculty of Agriculture Ankara University, Ankara

<sup>2</sup> Soil Science Department, Faculty of Agriculture, Ondokuz Mayıs University, Samsun

## ABSTRACT

In this research, the effects of added different lead (Pb) and cadmium (Cd) compounds on the catalase enzyme activity in the coarse-textured soil, fine-textured soil and organic soil were investigated.

Cd and Pb were applied in the forms of cadmium nitrate ( $\text{Cd}(\text{NO}_3)_2$ ), cadmium chloride ( $\text{CdCl}_2$ ), cadmium acetate ( $\text{Cd}(\text{CH}_3\text{COO})_2$ ), and cadmium carbonate ( $\text{CdCO}_3$ ), lead nitrate ( $\text{Pb}(\text{NO}_3)_2$ ), lead chloride ( $\text{PbCl}_2$ ), lead acetate ( $\text{Pb}(\text{CH}_3\text{COO})_2$ ) and lead carbonate ( $\text{PbCO}_3$ ). The samples were kept at 70% field capacity during an incubation period of 60 days at 28 °C.

The effects of Cd and Pb compounds, applied to three different soils, on the catalase activity was found to be significant ( $P < 0.01$ ) depending on time and doses during 60 incubation days. While different Cd components applied to soil decreased the catalase activity, Pb compounds, with the exception of  $\text{PbCl}_2$ , increased the catalase activity.

The highest inhibition effect of Cd compounds on the catalase activity was found in the coarse-textured soil. However, the lowest effects of both Cd and Pb compounds on the catalase activity was found in the organic soil.

## INTRODUCTION

In recent years several reports have been documented the harmful effects of long-term heavy metal contamination of agricultural soils, due to sewage sludge (Karaca et al., 1999, Moreno et al, 1998, 1999), phosphate fertilizer (Williams and David, 1975; Karaca and Haktanır, 1997a) rubbish disposal (Ranby et al., 1978) and fly ash (Natusch, 1978, Karaca and Haktanır, 1997b) application on soil microbial activity at several sites.

In soils, metals may (i) occur as microbiologically inactive forms such as insoluble precipitates, (ii) be adsorbed by clay-sized minerals and (iii) occur as humic metal solid organic complexes (Bruce et al., 1983).

Among the various elements of inorganic origin that are responsible for soil pollution, heavy metals such as Cd and Pb are by far the most important. Once these metals enter the soil, they remain there for long periods of time without being destroyed by the soil microorganisms, whereas molecules of organic origin can be microbially degraded (Blum, 1989).

The effect of heavy metals on soil biological activity has been studied by a number of authors. Doelmann and Haanstra (1984) showed that microbial respiration was reduced in soil contaminated with heavy metals, and Chaney et al. (1978) reported that Cd and Zn lead to a reduction in soil respiration. The inhibiting action of heavy metals on phosphatase activity has been demonstrated (Tyler, 1974; Math and Kovacs, 1980; Doelmann and Haanstra, 1989; Marzadori et al., 1996) and a similar inhibiting action on arylsulfatase has also been reported by Al-Khafaji and Tabatabai, 1979. The influence of various trace metals on soil urease activity has been studied (Tabatabai, 1977; Doelmann and Haanstra, 1986). Other parameters, such as the ratio between the C of the biomass and the organic C in the soil due to the presence of heavy metals (Chander and Brookes, 1991, 1992).

A quick way to obtained information on the biological activity of soil microorganisms can be by the measure of soil catalase and dehydrogenase activities. They are very sensitive to heavy metals (Naplekova and Bulavko, 1983; Perez and Gonzalez, 1987; Wilke, 1991) and can be used as a simple toxicity test (Rogers and Li, 1985).

The objective of this study was to investigate the effects of various compounds of Pb and Cd on soil catalase activity in different soil type.



## MATERIALS and METHODS

### Soil and Experimental Procedure

The fine-textured soil was a clay loam and the coarse-textured soil was a silty loam, taken from the experiment field of agriculture faculty of Ankara University. The organic soil was a peat and taken from Bolu-Yenicag peat soil. The soils were collected from the top 20 cm of soil. Soil samples were air dried, sieved (2 mm), and stored. It were obtained pH of soil at 1:2.5 soil water suspension according to Richards (1954), organic material by using modified Walkley-Black Method (Jackson, 1962), grain size distribution by Bouyoucos (1951), CEC was determined according to methods given in Black (1965), total nitrogen was assessed using the Kjeldahl method, as specified by Bremner (1965).

Soil samples were extracted for available Pb and Cd in DTPA solution (0.005M DTPA+0.005M CaCl<sub>2</sub>+0.1M TEA (triethanolamine) pH 7.3), (Lindsay and Norvell, 1978). The soil samples were digested in aqua regia (Loon and Lichwa, 1973) to determine the total Pb, and Cd. All the solutions of Pb and Cd were analyzed by atomic absorption spectrophotometer (AAS) with flame or graphite furnace when required.

### Incubation experiment

Cd and Pb nitrate, chloride, acetate, and carbonate were added to the 250 g soil samples at concentrations of 0, 250, 750, and 1500 mgkg<sup>-1</sup> and mixed. The mixtures, three replicates of each treatment, were placed in pots and kept at temperature of 28°C. The water content of the soil was adjusted to 70 % of field capacity. Throughout the two months, water losses exceeding 10% of the initial values were compensated for by addition of distilled water.

## RESULTS and DISCUSSION

### Physical and Chemical Characteristics of Soils

The soils were divided into three groups, based on soil texture. Some important physico-chemical characteristics of soil are shown in Table 1.

Table 1. Selected physico-chemical properties of soil used in the study.

Soil	Sand	Silt	Clay	pH	OM	N	CEC	TotPb	TotCd	AvPb	AvCd
Fine	26.97	44.34	28.69	7.8	1.78	0.12	32.7	19.50	1.42	2.05	0.05
Coarse	65.76	19.50	15.07	7.8	2.50	1.25	18.9	8.75	1.12	0.50	0.07
Organ.	-	-	-	5.9	110	1.91	116	29.25	1.75	0.10	0.12

Cd and Pb expressed as mg kg<sup>-1</sup>/g dry soil; sand, silt, clay, organic matter; N expressed as % and CEC expressed as Cmolkg<sup>-1</sup>. Fine: the fine-textured soil; coarse: the coarse-textured soil; Organ.: organic soil; OM: organic matter; N: total nitrogen; CEC: cation exchangeable capacity; TotPb: total Pb; TotCd: total Cd; AvPb: available Pb; AvCd: available Cd.

### Effects of Various Cd Compounds on Soil Catalase Activity

The effects of four different Cd compounds, applied in concentrations of 0, 250, 750, and 1500 mgkg<sup>-1</sup> to the three different soil types, on soil catalase activity are showed in Table 2.

During incubation, addition of Cd in the presence of four different compounds had different effects on soil catalase activity in all soils ( $P < 0.01$ ). In the presence of Cd, catalase activity was most elevated in the fine-textured soil and at its lowest value in the organic soil. It was discovered that all the different Cd compounds caused significant reduction in catalase activity in the fine-textured soil with incubation periods. When the 60 day incubation period was taken as the base time, the degree of inhibition of the catalase activity of the various Cd compounds was found to be;

Cd nitrate (74.2 %) > Cd carbonate (53.8 %) > Cd acetate (40.2 %) > Cd chloride (27.9 %) for the fine-textured soil, while the order for the coarse-textured soil was Cd chloride (74.2 %) > Cd carbonate (72.6 %) > Cd acetate (53.6%) > Cd nitrate (51.6 %).

Added Cd chloride had a greater effect on the catalase activity in the coarse-textured soil than in the fine-textured soil, due to the difference in soil type, variations in the amount of organic matter and CEC.

In organic soils, it was discovered that the effects of the various Cd compounds were not as clear as in the other soil types, and that Cd nitrate, Cd chloride, and Cd acetate inhibited the catalase activity in the ratio 9.6%, 11.6%, and 6.5%, respectively. Because of the buffering properties of the organic soil, it can be assumed that the toxic effect of different amounts of the Cd compounds was less evident than in the fine and the coarse-textured soils.

Linear regression analysis showed that the effects of each of the parameters (incubation period, soil type, doses, and compound) were significant in their influence on the inhibiting of the catalase activity. Further, it was found that the order of significance was incubation period\*\*>soil type\*\*>compounds\*\*>doses<sup>ns</sup> (\*= $P < 0.01$ , ns= not significant). When the effects of the different Cd compounds were compared it was found that they differed significantly. As an average of all soils, the effects of Cd compounds in inhibiting the catalase activity varied in the order; Cd chloride > Cd nitrate > Cd acetate > Cd carbonate. It was found that Cd chloride was the most effective in inhibiting the catalase activity.

Table 2. Effects of different compounds of Cd and Pb on the catalase activity in three different soils (mg O<sub>2</sub> 5g topak<sup>-1</sup>).

The catalase Compound s	Inc.	Coarse-textured Soil				Fine-textured Soil				Organic Soil			
		0	250	750	1500	0	250	750	1500	0	250	750	1500
Pb(NO <sub>3</sub> ) <sub>2</sub>	1.	59.0	110.0	125.9	127.0	76.1	140.6	157.8	129.8	42.4	47.9	47.0	42.0
	10.	55.3	94.0	97.0	111.6	81.4	186.0	132.8	174.0	41.0	38.5	39.3	41.0
	30.	50.9	94.7	105.0	109.0	78.4	137.0	147.3	148.9	39.7	38.3	39.3	42.1
	60.	47.0	52.0	57.0	70.0	64.0	73.1	89.7	98.5	37.7	39.0	37.0	39.7
Pb(CH <sub>3</sub> COO) <sub>2</sub>	1.	60.3	112.0	125.7	149.7	69.0	127.1	153.2	178.0	43.7	46.5	48.1	48.0
	10.	56.7	102.0	113.0	136.0	67.0	188.2	176.3	208.0	42.0	46.0	48.0	42.5
	30.	50.0	100.0	109.0	125.0	74.3	99.1	105.3	106.3	39.0	42.0	45.7	45.7
	60.	48.9	76.0	89.0	85.0	61.0	65.1	69.4	73.7	38.9	42.3	40.7	42.4
PbCl <sub>2</sub>	1.	60.0	69.0	72.0	72.5	72.0	77.0	89.0	85.0	44.3	44.0	42.0	42.0
	10.	57.3	50.4	49.0	35.0	79.8	73.0	79.4	82.1	42.7	44.9	44.3	40.0
	30.	53.7	25.7	25.0	13.0	66.5	62.1	59.6	56.7	40.0	40.0	43.0	40.7
	60.	50.9	20.9	20.0	6.5	62.0	50.3	44.1	40.0	37.4	39.3	39.9	39.0
PbCO <sub>3</sub>	1.	59.1	75.4	79.3	87.5	74.5	78.4	77.5	67.0	40.0	40.0	39.4	39.7
	10.	56.5	76.0	79.9	90.4	77.1	75.0	65.0	63.5	42.0	44.1	45.7	49.6
	30.	55.0	75.0	87.5	94.1	70.4	88.1	105.9	117.5	39.7	40.0	40.7	40.0
	60.	49.0	73.0	76.0	79.4	59.0	63.5	60.4	54.1	37.4	39.5	36.4	39.0
Cd(NO <sub>3</sub> ) <sub>2</sub>	1.	59.0	59.7	67.0	73.0	76.6	70.3	92.4	79.3	45.0	43.0	43.1	39.0
	10.	57.5	56.0	50.0	40.3	76.1	128.3	110.9	73.8	41.0	42.0	40.0	36.7
	30.	55.1	52.0	37.0	21.0	78.6	28.8	22.1	31.0	39.6	39.1	35.0	35.0
	60.	47.0	37.6	20.5	10.1	74.0	20.1	20.1	17.0	37.0	37.1	33.2	30.0
Cd(CH <sub>3</sub> COO) <sub>2</sub>	1.	56.0	79.0	67.0	63.6	69.0	142.5	107.5	89.8	43.0	47.3	47.0	45.0
	10.	50.1	73.0	62.0	60.0	74.0	136.1	99.1	63.6	40.7	40.0	43.0	45.0
	30.	48.3	45.0	32.0	30.0	63.9	50.3	37.2	39.9	38.1	37.0	40.0	40.0
	60.	44.0	37.0	13.0	11.3	50.7	39.0	31.0	21.0	36.0	35.4	34.6	31.0
CdCl <sub>2</sub>	1.	57.9	52.0	47.0	47.0	73.6	73.0	69.0	64.2	41.5	47.0	49.7	59.0
	10.	56.5	43.4	36.5	20.4	86.1	70.0	66.4	50.1	40.4	46.0	44.0	44.0
	30.	54.0	40.2	13.6	7.4	67.9	64.1	56.0	34.5	40.0	39.1	37.0	33.0
	60.	45.0	23.1	9.7	1.0	55.0	50.0	40.0	29.0	37.0	34.0	34.1	30.0
CdCO <sub>3</sub>	1.	58.0	76.7	82.0	90.0	71.2	202.9	162.5	112.3	41.0	45.0	47.0	49.0
	10.	52.1	55.4	59.7	73.0	76.6	90.3	134.6	91.5	40.2	40.2	51.3	57.0
	30.	50.0	32.0	20.0	13.0	69.5	33.6	28.1	41.2	39.7	39.7	43.1	40.7
	60.	45.0	19.0	11.0	7.0	54.8	33.0	23.7	19.3	37.0	37.0	37.9	38.0

0, 250, 750, 1500 doses of each compounds as expressed mg kg<sup>-1</sup>, inc.; incubation time (day).



As a result of the path analysis, it was determined that the significant factors were acting independently of each other.

Incubation period	-0.3147 path coefficient, 100%
Soil Type	0.0560 path coefficient, 100%
Application doses	-0.3655 path coefficient, 100%
Cd compounds	-0.2194 path coefficient, 100%.

Our data suggest that the reaction of the catalase activity to application of various Cd compounds depends on the soil type and on the particular compound and amount used.

Cd has been referred to as an essential element for some soil microorganisms (e.g. *Psalliotia*) and trace amounts stimulate microbial growth (Wollum, 1973).

Perez and Gonzalez (1987) found that the increase of Cd did not affect the catalase activity significantly. They said that the concentration of Cd in their study was high and besides, active catalase can persist in extracellular state adsorbed on soil colloids.

Bond et al. (1976) showed that the addition of 10ppm Cd stimulated soil respiration initially and at lower level (0.01ppm) the period of stimulation was of longer duration. However, Bitton et al. (1986) have shown that 1.8 ppm Cd inhibited the dehydrogenase activity of 50% of the bacterial population.

### Effects of Various Pb Compounds on Soil Catalase Activity

The effects of four different Pb compounds, applied in concentrations of 0, 250, 750, and 1500 mgkg<sup>-1</sup> to the three different soil types, on soil catalase activity are shown in Table 2.

In each soil, the catalase activity showed different sensitivity to the Pb additions in different compounds ( $P < 0.01$ ). In the presence of Pb, the catalase activity was most elevated in the fine-textured soil and at its lowest value in the organic soil.

In the fine-textured soil, the catalase activity increased by the addition of Pb acetate and Pb nitrate during the incubation period ( $P < 0.01$ ). However, Pb chloride inhibited the catalase activity by 27.7% for all incubation periods, while Pb carbonate inhibited the catalase activity at the beginning of the incubation period. It increased the activity at the end of the incubation time ( $P < 0.01$ ).

In the coarse-textured soil, Pb in the presence of Pb carbonate, Pb acetate, and Pb nitrate increased the catalase activity during the incubation period ( $P < 0.01$ ). However, Pb chloride inhibited the catalase activity by 69% during the incubation period ( $P < 0.01$ ).

In the organic soil, which has a high CEC, addition on Pb in the presence of four different compounds did not effect on the catalase activity significantly. Because of the organic matter fraction of the soil has a strong capacity for Pb ions (Hildebrand and Blum, 1974), it can be assumed that the toxic effect of different amounts of the lead compounds in the organic soil was less evident than in the fine and the coarse-textured soils.

Linear regression analysis showed that the effects of each of the parameters (incubation period, soil type, doses, and compound) were significant in their influence on the inhibiting of the catalase activity. Further, it was found that the order of significance was incubation period\*\*>soil type\*\*>compounds\*\*>doses<sup>ns</sup> (\*= $P < 0.01$ , ns= not significant). As a result of the path analysis, the same results were determined as Cd.

When the effects of the different Pb compounds were compared it was found that Pb nitrate and Pb acetate increased the catalase activity. Since lead acetate is readily soluble, its effect can be equated with that of free Pb ions. However, acetate and nitrate effects on the catalase activity were the least toxic, this is probably explained by the anionic effect of the C and N source for some of the microorganisms.

These proposals are supported by the finding of Perez and Gonzalez (1987), who found similar effect of Pb acetate on the catalase activity.

Naplekova and Bulavko (1983) also found that the addition of Pb acetate increased the catalase activity in the Chernozem soil and inhibited it in the Sod-Podzolic soil.

Pb chloride decreased the activity. Added Pb chloride had a greater effect on the catalase activity in the coarse-textured soil than in the fine-textured soil, due to the difference in soil type, variations in the amount of organic matter and CEC. The concentration of free Pb ions is considerably decreased by clay minerals such as montmorillonite, illite and kaolinite. The adsorption of Pb to these



minerals is 2-3 times as strong as that of other divalent cations such as Ca and Cd (Bittell and Miller, 1974). Pb chloride has no inhibitory effect on the catalase activity in the organic soil and that inhibition may be caused by more soluble forms of Pb, which may be hard to define since after addition Pb chloride is immediately bound (adsorbed and chelated), or converted to compounds such as Pb phosphate, Pb carbonate or Pb oxide (Ter Haar, 1971).

This results are supported by finding Doelmann and Haanstra, (1979) who reported that Pb chloride seriously inhibited the respiration in sandy soil, but it's effect was only small in clay soil and did not effect in peat soil.

## CONCLUSIONS

The type of inhibition or activation of the soil catalase activity by heavy metals (Cd and Pb) was studied. In each soil, the catalase activity showed different sensitivity to the Cd and Pb additions in different compounds. While different Cd components applied to soil decreased the catalase activity, Pb compounds, with the exception of PbCl<sub>2</sub>, increased the catalase activity.

The results obtained showed that the catalase activity depends on the Cd and Pb contents in the soil. Activity changed according to the type of Cd and Pb compounds applied to the soil, the amount and solubility of the compounds and the soil group.

## REFERENCES

- Al-Khafaji, A.A., Tabatabai, M.A. (1979). Effects of trace elements on arylsulphatase activity in soils. *Soil Science*. 127: 129-133.
- Beck, T.H. (1971). Die Messung der Katalasen Aktivität von Böden. *Z. Pflanzenernähr. Sodenk.* 130: 68-81.
- Bittell, J.E., Miller, R.J. (1974). Lead, Cadmium and Calcium Selectivity Coefficients on a Montmorillonite, illite and kaolinite. *J. of Environ. Qual.* 3: 250-252.
- Bitton, G., Khafif, T., Chataigner, N., Bastide, J., Coste, C.M. (1986). A Direct INT-Dehydrogenase Assay for Assessing Chemical Toxicity. *Toxicity. Assessment*. 1: 1-12.
- Black, C.A. (ed.). (1965). Methods of soil analysis, parts 1 and 2. *Agronomy*. 9: 552-562. Am. Soc. Agron., Madison, WI.
- Blum, W.E.H. (1989). Soil pollution by heavy metals: causes, processes, impacts and need for future actions: In: Proceedings of third meeting. Steering Committee for the conservation and management of the environment and natural habitats (CDPE), Strasbourg.
- Bond, H., Lightart, B., Shimabuku, R., Russel, L. (1976). Some Effects of Cd on Coniferous Forest Soil and Litter Microcosms. *Soil. Sci.* 121: 278-287.
- Bouyoucos, G.J. (1951). A Calibration of the Hydrometer for Making Mechanical Analysis of Soils. *Agronomy Journal* 43: 9.
- Bremner, J.M. (1965). Total Nitrogen. In *Methods of Soil Analysis 2*; (C.A. Black, Ed.). American Society of Agronomy, Madison, Wis., 1145-1178.
- Chander, K., Brookes, P.C. (1991). Effects of heavy metals from past applications of sewage sludge on microbial biomass and organic matter accumulation in a sandy loam and silty loam UK soil. *Soil Biol. Biochem.* 23: 927-932.
- Chander, K., Brookes, P.C. (1992). Effects of Zn, Cu, and Ni in sewage sludge on microbial biomass in a sandy loam. *Soil Biol. Biochem.* 25: 1231-1239.
- Chaney, W.R., Kelly, J.M., Strickland, R.C. (1978). Influence of Cd and Zn on carbon dioxide evolution from litter and soil from a black forest. *J. Environ. Qual.* 7: 115-119.
- Doelman, P., Haanstra, L. (1979). Effect of Lead on Soil Respiration and Dehydrogenase Activity. *Soil Biol. Biochem.* 11: 475-479.
- Doelman, P., Haanstra, L. (1984). Short-term and long-term effects of Cd, Cr, Cu, Ni, Pb, and Zn on microbial respiration in relation to abiotic soil factors. *Plant and Soil*. 79: 317-321.
- Doelman, P., Haanstra, L. (1986). Short and long-term effects of heavy metals on urease activity in soils. *Biol. Fertil. Soils*. 2: 213-218.

- Doelman, P., Haanstra, L. (1989). Short-term and long-term effects of heavy metals on phosphatase activity in soils. An ecological dose-response model approach. *Biol. Fertil. Soils*. 8: 235-241.
- Haar Ter, G.J. (1971). Composition of Airborne Lead Particles. *Nature, Lond.* 232: 553-554.
- Jackson, M.L. (1962). *Soil Chemical Analysis*. Prentice Hall Inc. Eng. Cliffs. U.S.A..
- Karaca, A., Haktanir, K. (1997a). Determination of Cd contents of phosphate fertilizers and raw phosphates. *Turkish J. of Agriculture and Forestry*. 21 (4): 327-334.
- Karaca, A., Haktanir, K. (1997b). Effects of Afsin-Elbistan power plant emission on the physical, chemical, and biological properties of nearby soils. Ph. D. Thesis (in press).
- Karaca, A., Naseby, N.C., Lynch, J. (1999). Effect of Cd contamination with sewage sludge and phosphatase fertiliser amendments on soil enzyme activities, available Cd and other ion contents of soil. *Soil Biology and Biochemistry* (in press).
- Lighthart, B., Baham, J., Volk, V.V. (1983). Microbial Respiration and Chemical Speciation in Metal Amended Soils", *J. Environ. Qual.*, 12(4): 543-548.
- Lindsay, W.L., Norwell, W.A. (1978). Development of a DTPA Soil Test for Zn, Fe, Mn and Cu. *Soil Sci. Soc. Am. J.* 42: 421-428.
- Loon, J.C., Lichwa, J. (1973). A study of the atomic absorption determination of some important heavy metals in fertilizers and domestic sewage plant sludges. *Environ. Lett.* 4: 1-18.
- Marzadori, C., Ciavatta, C., Montecchio, D. Gessa, G. (1996). Effects of lead pollution on different soil enzyme activities. *Biol. Fertil. Soils*. 22: 53-58.
- Math, P., Kovacs, G. (1980). Effects of Mn and Zn on the activity of phosphate in soil. 1. Phosphatase activity of a calcareous chernozem soil under maize. *Agrokem. Talajtan.* 29: 441-446.
- Moreno J.L., Garcia C. Hernandez T. (1998) Changes in organic matter and enzyme activity of an agricultural soil amended with metal-contaminated sewage sludge compost. *Communications in Soil Science and Plant Analysis*. 29: 2247-2262.
- Moreno J.L., Hernandez T. Garcia C. (1999) Effects of cadmium-contaminated sewage sludge compost on dynamics of organic matter and microbial activity in an arid soil. *Biology and Fertility of Soils*. 28: 230-237.
- Naplekova, N.N., Bulavko, G.I. (1983). Enzyme Activity of Soils Polluted by Lead Compounds. *Soviet Soil Sci.* 15: 33-38.
- Natusch, D.F.S. (1978). Potentially Carcinogenic Species Emitted to the Atmosphere by Fossil Fueled Power Plants. *Enviro. Health Perspect.* 22: 79-80.
- Perez-Mateos, M., Gonzalez-Carcedo, S. (1987). Effect of Cadmium and Lead on Soil Enzyme Activity. *Rev. Ecol. Biol. Sol.* 1: 11-18.
- Ranby, B., Albertson, A.C., Jansson, S.L. (1978). Effects of growing crops in plastic stabilized or pigmented with Cd compounds: preliminary results of pot experiments with spring wheat. *Ambio.* 7: 172-174.
- Richards, L.A., ed. (1954). *Diagnosis and Improvement of Saline and Alkali Soils*. U.S.D.A. Handbook 60.
- Rogers, J.E., Li, S.W. (1985). Effect of Metals and Other Inorganic Ions on Soil Microbial Activity: Soil Dehydrogenase Assay as a Simple Toxicity Test. *Bull. Environ. Contam. Toxicol.* 34: 858-865.
- Tabatabai, M.A. (1977). Effects of trace elements on urease activity in soils. *Soil Biol. Biochem.* 9: 9-13.
- Tyler, G. (1974). Heavy Metal Pollution and Soil Enzymatic Activity. *Plant and Soil*, 41: 303-311.
- Williams, C.H. David, D. J. (1975). The Effects of Superphosphate on Cd of Soils and Plants. *Aust. J. Soil Res.*, 11: 43-56,
- Wilke, B.M. (1991). Effects of Single and Successive Additions of Cd, Ni and Zn on Carbon Dioxide Evolution and Dehydrogenase Activity in a Sandy Luvisol. *Biol. Fertil. Soils*. 11: 34-37,
- Wollum, A.G. (1973). Immobilization of Cd by Soil Microorganisms. *Environ. Health Perspect.* 4: 103.



# EFFECT OF EDTA ON THE EXTRACTABILITY OF ZINC, CADMIUM, AND NICKEL IN SOILS

Ayten Karaca, O. Can Turgay, Sevinç Arcak

Soil Science Department, Faculty of Agriculture, Ankara University, Ankara

## ABSTRACT

Ethylenediaminetetraacetic acid (EDTA), are persistent in the environment. The presence of EDTA in soil may alter the mobility and transport of Zn, Cd, and Ni in soils because of the formation of water soluble chelates, thus increasing the potential for metal pollution of natural waters. Mobility of metals is related to their extractability. To investigate metal extractability affected by EDTA, Zn, Cd, and Ni were added to 2 different type of soil samples (the fine-textured soil and the coarse-textured soil) at rates of 75, 1.5, and 4 mg kg<sup>-1</sup>, respectively. Both natural and metal-amended soils were treated with Na<sub>2</sub>EDTA at rates of 0, 0.1, and 0.2 mg kg<sup>-1</sup>. After 6 months of incubation, soil samples were extracted with 0.1N HCl, DTPA (diethylenetriamine-pentaacetic acid) and 1 M MgNO<sub>3</sub>, the latter of which extracts the exchangeable form of metals.

Results showed that Zn in all extraction increased with increasing rates of EDTA in the natural and metal-amended soils. In the natural soils, Ni in HCl extraction significantly increased with adding EDTA in the coarse-textured soils. In the metal-amended soils, Ni in all extraction increased with increasing rates of EDTA. In the natural soils, the presence of EDTA did not greatly affect extractibility of Cd in all soils. In the metal-amended soils, Cd in all extraction increased with EDTA in the fine-textured soil. The presence of EDTA did not affect extractibility of Cd in the coarse-textured soils.

## INTRODUCTION

Synthetic chelating agents such as Ethylenediaminetetraacetic acid (EDTA) have been used in the past to decontaminate nuclear reactors and other material (Ayers, 1970; Piccolo, et al, 1986). EDTA is a powerful hexadentate chelating ligand. It is widely utilized for industrial purposes (e.g. metal treatment, photography, pharmaceutical products, industrial cleaning, textile, paper etc.), (Kari et al., 1995) when it is necessary to inactivate undesirable metal ions that could cause problems. It is estimated that approximately 20% of the total EDTA production are used in detergents and cleaning products (AIS, 1987). EDTA is not a phosphate substitute. The purpose of the EDTA content in laundry detergents is the stabilization of the perborate bleach, and there for it is used only in low levels (Alder et al., 1990). In agriculture, EDTA complexes have been used for about 30 years as commercial soil amendments to improve micronutrient availability (Li and Shuman, 1996). The behavior of chelating agents in plants was described by Wallace et al, (1974). Attempts have been made to develop theoretical models from which the complexation of heavy metals by various chelates can be predicted and explained (Lindsay et al, 1967; Lindsay and Norvell, 1969; Halverson and Lindsay, 1977). EDTA forms highly stable water soluble complexes with a wide range of radionuclide and metal ions. It is persistent in the environment because it is resistant to decomposition by radiation (Kari et al., 1995) and rather slowly biodegradable in soil (Means et al. 1980, Bolton et al. 1993).

Bolton et al. (1993) showed that only 15% of EDTA added to soil was degraded after 5 months, indicating that it could affect metals for a significant period of time. They also found that EDTA was not mineralized more rapidly or to a great extent in the surface soil than in the subsurface sediments. These results contrast with previous studies in which surface soils and organic C enriched soils had grater rates and amounts of EDTA (Tiedje, 1975, 1977).

It is likely that chelate structure and/or the liability of the metal-chelate complex determine the resistance of the complex to mineralization. Albasel and Collenle (1985) and Yu and Klarup (1994) found that EDTA increased the yields in spite of the fact that it increases the soluble fraction of Fe, Zn, Mn, and Cu in soil.



DTPA and 0.1N HCl extraction procedures are commonly employed to estimate the plant-available forms of micronutrients in soil. They are used equally to determine available forms of heavy metals such as Cd and Ni (Roca and Pomares, 1991). Shuman (1985) used 1M  $\text{Mg}(\text{NO}_3)_2$  the exchangeable fraction of metals in soil. This solution extracted the most labile form of metals in soil without disturbing other fractions.

The presence of EDTA in soil may alter the mobility and transport of Zn, Cd, and Ni in soils because of the formation of water soluble chelates, thus increasing the potential for metal pollution of natural waters. Mobility of metals is related to their extractability.

The aim of the experiment described here was to study the influence of EDTA on the extractability of Zn, Cd, and Ni in both natural and metal-amended soils.

## **MATERIALS and METHODS**

### **Soil and Experimental Procedure**

Two top-soils were taken from the experiment field of agriculture faculty of Ankara University. Soil samples were collected from the A horizon (0-20 cm) in uncultivated areas. Soil samples were air dried, sieved (2 mm), and stored. It were obtained pH of soil at 1:2.5 soil water suspension according to Richards (1954), organic material by using modified Walkley-Black Method (Jackson, 1958), grain size distribution by Bouyoucos (1951), and cation exchange capacity (CEC) was determined according to methods given in Black (1965).

A solution containing soluble salts of Zn, Cd, and Ni were added a portion of each soil to investigate the extractability of metals in soils. The metals were applied in the form of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  for Zn,  $\text{CdCH}_3\text{COOH}$  for Cd, and  $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  for Ni at rates of 75, 1.5, and 4.5  $\text{mg kg}^{-1}$  soil for Zn, Cd, and Ni, respectively. An aqueous  $\text{Na}_2\text{EDTA}$  solution was applied at three rates (0, 0.1, 0.2  $\text{mg kg}^{-1}$  soil) to 300 g of natural or metal-amended soil samples. After being mixed well, each sample was split into three 100-g replications and put into plastic pots. The pots were placed in the greenhouse and the water content of the soil was adjusted to 70% of field capacity. Throughout the six months, water losses exceeding 10% of the initial values were compensated for by addition of distilled water.

### **Soil Extraction**

Six months after the treatments were initiated, the soils were air-dried, ground and sieved through a 2-mm sieve. Both incubated and original soil samples were extracted for Zn, Cd, and Ni using the 0.1N HCl (Nelson et al, 1959), DTPA (0.005M DTPA+0.005M  $\text{CaCl}_2$ +0.1M TEA (triethanolamine) pH 7.3), (Lindsay and Norvell, 1978), and 1 M  $\text{Mg}(\text{NO}_3)_2$  (pH 7) (Shuman, 1985) solutions. The soil samples without treatments were digested in aqua regia (Loon and Lichwa, 1973) to determine the total Zn, Cd, and Ni. All the solutions of Zn, Cd, and Ni were analyzed by atomic absorption spectrophotometry (AAS) with flame or graphite furnace when required.

Minitab and Mstat computer programs were used for statistical analyses.

## **RESULTS and DISCUSSION**

### **Physical and Chemical Characteristics of Soils**

The soils were divided into two groups, based on soil texture. Averages of the clay percentage, organic matter content, pH, and CEC are 28.69 %, 1.78 %, 7.8, and 32.70  $\text{Cmol kg}^{-1}$  for the fine-textured soil, and compared with 15.07 %, 2.5 %, 7.8, and 18.99  $\text{Cmol kg}^{-1}$  for the coarse-textured soil. The fine-textured soil probably had greater adsorption capacity for metals than did the coarse-textured soil because of the amount of colloidal surface area.

Higher total metal concentrations were found in the fine-textured soils than in the coarse-textured soil (Table 1). Compared with the total metal concentration, the proportion of metal concentrations in the HCl, DTPA, and  $\text{Mg}(\text{NO}_3)_2$  extractions was relatively low in the fine-textured soil, suggesting that these metals in the fine-textured soils were less extractable in the natural soil profile. No significant relationship was found between either HCl, DTPA or

Mg(NO<sub>3</sub>)<sub>2</sub> extractions and total concentration of any metal, indicating that metal extractability did not depend on the total metal contents.

Table 1. Total and HCl, DTPA, and Mg(NO<sub>3</sub>)<sub>2</sub> extractable metal concentrations in soils

Soil	Total content			HCl			DTPA			Mg(NO <sub>3</sub> ) <sub>2</sub>		
	Zn	Cd	Ni	Zn	Cd	Ni	Zn	Cd	Ni	Zn	Cd	Ni
Fine	136.75	1.42	102.50	1.10	0.15	1.05	0.33	0.05	0.28	0.35	0.40	0.90
Coarse	79.50	1.10	90.50	2.20	0.05	1.00	1.50	0.07	0.59	0.49	0.10	1.00

Fine: the fine-textured soil; coarse: the coarse-textured soil, Zn, Cd, and Ni expressed as mg kg<sup>-1</sup>/g dry soil.

#### Effect of EDTA on the Extractability of Zn

Extractable Zn concentration increased with increasing amounts of EDTA in both natural and metal-amended soils (Table 2). There was significant difference between rate of 0.2 mgkg<sup>-1</sup> EDTA and zero EDTA rate, and between 0.1 mgkg<sup>-1</sup> EDTA and the zero EDTA (P<0.05). The increase of Zn in the extractions with adding EDTA demonstrated that the presence of EDTA in soil elevated the extractability of this metal, probably because of an increase in metal solubility by forming soluble metal chelates.

In the fine-textured soil, some treatments of EDTA did not show significant increases in the Mg(NO<sub>3</sub>)<sub>2</sub> extractable Zn in the natural soil. The highest Zn concentrations were obtained with 0.1 N HCl and the lowest with Mg(NO<sub>3</sub>)<sub>2</sub>. DTPA extracted less Zn than 0.1 N HCl which found in other study (Brown et al, 1971).

The extractable Zn was higher in the coarse-texture soil than in the fine-textured soil. Evidence of the importance of soil texture is hard to find in the literature. A high clay content is assumed to result in stronger adsorption and less plant uptake. Hansen and Tjell (1983) found that fine-textured soils reduce levels in soil solution and/or plant uptake. The adsorption of Zn by the soil can be influenced by the clay, CEC, organic matter and soil pH (Shuman, 1975).

The results of the correlation of three extractants showed that 0.1N HCl, DTPA; and Mg(NO<sub>3</sub>)<sub>2</sub> extractions were in agreement in all soils (Table 3). This proposals are supported by finding of Li and Shuman (1996).

#### Effect of EDTA on the Extractability of Cd

The presence of EDTA did not greatly affect on the extractability of Cd in the natural soils. There was usually a significant difference between rate of 0.2 mgkg<sup>-1</sup> EDTA and zero EDTA rate. However, there were fewer instances of statistical significance between 0.1 mgkg<sup>-1</sup> EDTA and 0.2 mgkg<sup>-1</sup> EDTA and between 0.1 mgkg<sup>-1</sup> EDTA and the zero EDTA (Table 2).

In the metal-amended soils, Cd in all extraction increased with EDTA in the fine-textured soil (P<0.05). The presence of EDTA did not affect extractability of Cd in the coarse-textured soil. The HCl extractable Cd in the metal-amended soils was more than 50% of the total Cd (Table 1). The higher extractability with this extractant suggested Cd is a relatively mobile element (King, 1988).

In the natural soil, extractable Cd was higher in the coarse-texture soil than in the fine-textured soil due to its high CEC and complexing ability. John (1974) found that as CEC increased, Cd bonding strength increased.

Haas and Horowitz (1986) studied the adsorption of Cd to kaolinite in the presence of EDTA. They showed that EDTA had a negative effect on sorption of Cd. They attributed the latter to formation of an adsorbed organic layer on the clay surface and concluded that the effect of an organic ligand on Cd sorption varied with the nature of the metal-ligand and ligand-clay interactions.

Thus, the strength of the Cd-ligand complex may be one of several parameters controlling the adsorption process. As the strength of the Cd-ligand bond increases, the ability of the added organic ligand to effectively compete for Cd also increases. Increased metal sorption may occur either by direct complexation of the metal or by the of a soil-ligand metal complex (Naidu and Harter, 1998).

Elliott and Denney (1982) determined that EDTA had an inhibitory effect on the binding of Cd to whole soils. Similar results were reported by Fuji (1978).

The results of the correlation of three extractants showed that 0.1N HCl, DTPA, and  $Mg(NO_3)_2$  extractions were in agreement in all soils (Table 3). This contradicts the results of Li and Shuman (1996), who reported that there was not a good correlation between  $Mg(NO_3)_2$  extractable Cd and either Mehlich-1 or DTPA extractants in both natural and metal-amended soils.

Table 2. Metal concentrations in DTPA, HCL, and  $Mg(NO_3)_2$  extractants in the soil treated by EDTA.

EDTA	NATURAL SOILS			METAL AMENDED SOILS		
	DTPA	HCl	$Mg(NO_3)_2$	DTPA	HCl	$Mg(NO_3)_2$
mg kg <sup>-1</sup>						
mg kg <sup>-1</sup>						
Zn in the fine- textured soils						
0.0	1.59 <sup>C</sup>	2.07 <sup>C</sup>	0.33 <sup>B</sup>	20.41 <sup>C</sup>	29.06 <sup>C</sup>	7.98 <sup>C</sup>
0.1	2.88 <sup>B</sup>	6.29 <sup>B</sup>	0.42 <sup>B</sup>	28.48 <sup>B</sup>	31.66 <sup>B</sup>	10.60 <sup>B</sup>
0.2	3.36 <sup>A</sup>	7.57 <sup>A</sup>	1.47 <sup>A</sup>	30.02 <sup>A</sup>	39.96 <sup>A</sup>	13.06 <sup>A</sup>
Zn in the coarse- textured soils						
0.0	2.45 <sup>C</sup>	3.06 <sup>C</sup>	0.43 <sup>C</sup>	26.74 <sup>C</sup>	41.39 <sup>C</sup>	10.04 <sup>C</sup>
0.1	4.68 <sup>B</sup>	7.41 <sup>B</sup>	0.73 <sup>B</sup>	35.50 <sup>B</sup>	47.86 <sup>B</sup>	13.72 <sup>B</sup>
0.2	5.59 <sup>A</sup>	8.77 <sup>A</sup>	2.29 <sup>A</sup>	39.38 <sup>A</sup>	54.84 <sup>A</sup>	17.35 <sup>A</sup>
Cd in the fine- textured soils						
0.0	0.01 <sup>B</sup>	0.03 <sup>B</sup>	0.09 <sup>C</sup>	0.25 <sup>C</sup>	0.76 <sup>C</sup>	0.17 <sup>C</sup>
0.1	0.03 <sup>A</sup>	0.04 <sup>B</sup>	0.19 <sup>A</sup>	0.37 <sup>B</sup>	2.64 <sup>B</sup>	0.36 <sup>B</sup>
0.2	0.03 <sup>A</sup>	0.06 <sup>A</sup>	0.17 <sup>B</sup>	0.47 <sup>A</sup>	2.73 <sup>A</sup>	0.39 <sup>A</sup>
Cd in the coarse - textured soils						
0.0	0.02 <sup>B</sup>	0.04 <sup>C</sup>	0.28 <sup>B</sup>	0.28 <sup>B</sup>	0.73 <sup>C</sup>	0.19 <sup>B</sup>
0.1	0.03 <sup>B</sup>	0.06 <sup>B</sup>	0.42 <sup>A</sup>	0.31 <sup>A</sup>	1.90 <sup>B</sup>	0.38 <sup>A</sup>
0.2	0.05 <sup>A</sup>	0.09 <sup>A</sup>	0.46 <sup>A</sup>	0.32 <sup>A</sup>	2.23 <sup>A</sup>	0.40 <sup>A</sup>
Ni in the fine- textured soils						
0.0	0.35 <sup>B</sup>	0.15 <sup>B</sup>	0.40 <sup>B</sup>	0.57 <sup>C</sup>	1.21 <sup>A</sup>	0.53 <sup>C</sup>
0.1	0.77 <sup>A</sup>	0.40 <sup>A</sup>	0.68 <sup>A</sup>	1.91 <sup>B</sup>	3.12 <sup>B</sup>	1.20 <sup>B</sup>
0.2	0.96 <sup>A</sup>	0.60 <sup>A</sup>	0.93 <sup>A</sup>	3.07 <sup>A</sup>	5.53 <sup>A</sup>	2.23 <sup>A</sup>
Ni in the coarse - textured soils						
0.0	0.25 <sup>B</sup>	0.30 <sup>C</sup>	0.34 <sup>A</sup>	0.81 <sup>C</sup>	0.60 <sup>C</sup>	0.43 <sup>C</sup>
0.1	0.47 <sup>AB</sup>	0.88 <sup>B</sup>	0.50 <sup>A</sup>	1.98 <sup>B</sup>	2.22 <sup>B</sup>	1.08 <sup>B</sup>
0.2	0.76 <sup>A</sup>	1.40 <sup>A</sup>	0.57 <sup>A</sup>	2.17 <sup>A</sup>	4.51 <sup>A</sup>	1.43 <sup>A</sup>

LSD<sub>0.05</sub>; Zn= 0.213, Cd=0.013, Ni= 0.030  
Ni= 0.036

LSD<sub>0.05</sub>; Zn= 0.213, Cd=0.03,

\* Significant differences between EDTA doses for each method at P<0.05 level indicated by different letters. Values followed by the same latter within an element and extraction are not significantly different at the level, according to LSD<sub>0.05</sub> tests.



Table 3. Pearson correlation coefficients between extractant methods for metals.

Relationship	Natural soils			Metal amended soils		
	Zn	Cd	Ni	Zn	Cd	Ni
DTPA-HCl	0.936*	0.890*	0.259 <sup>Ns</sup>	0.971*	0.909*	0.936*
DTPA-Mg(NO <sub>3</sub> ) <sub>2</sub>	0.798*	0.692*	0.745*	0.861*	0.637*	0.870*
HCl-Mg(NO <sub>3</sub> ) <sub>2</sub>	0.773*	0.679*	0.351 <sup>Ns</sup>	0.814*	0.840*	0.896*

\*: Significant at the 0.05 probability levels, respectively.

Ns: Not significant at the 0.05 probability level.

### Effect of EDTA on the Extractability of Ni

In the natural soils, Ni in all extraction increased with increasing rates of EDTA in the coarse-textured soils (Table 2). There was usually a significant difference between rate of 0.2 mgkg<sup>-1</sup> EDTA and zero EDTA rate in the HCl and DTPA extractions ( $P < 0.05$ ). However, no statistical analyses were performed on the extractability of Ni in Mg(NO<sub>3</sub>)<sub>2</sub> extraction. The presence of EDTA affect on the extratability of Ni in the fine-textured soil. There was a significant difference between rate of 0.2 mgkg<sup>-1</sup> EDTA and zero EDTA rate. However, there was no significant difference between rate of 0.2 mgkg<sup>-1</sup> EDTA and 0.1 mgkg<sup>-1</sup> EDTA rate.

In the metal-amended soils, the presence of EDTA significantly increased Ni in all extractions in both fine and coarse-textured soils ( $P < 0.05$ ).

The results of the correlation of three extractants showed that DTPA and Mg(NO<sub>3</sub>)<sub>2</sub> extractions were in agreement in the natural soils (Table 3). However, there were no significant correlations between DTPA and HCl and between HCl and Mg(NO<sub>3</sub>)<sub>2</sub> extractants. In the metal-amended soils, HCl, DTPA, and Mg(NO<sub>3</sub>)<sub>2</sub> extractions were in agreement. This proposals are supported by finding of Li and Shuman (1996).

### CONCLUSIONS

The complexation of metals with EDTA reduced the activities of the free metallic ions in the soil solution, and, therefore, decreased toxicity of metals to plants. Adding EDTA increased the metal solubility, and raised the concentration of total cations in the soil solution. Therefore, EDTA in natural soils frequently enhanced the availability of micronutrients.

The extractable Zn and Cd were higher in the coarse-texture soil than in the fine-textured soil. The adsorption of Zn and Cd by the soil can be influenced by the clay and CEC.

The Mg(NO<sub>3</sub>)<sub>2</sub> extractant was equivalent to HCl and DTPA in estimating the extractability of Zn, Cd, in all soils, but was less effective for Ni in the natural soils.

### REFERENCES

- AIS (Association International de la Savonnerie et de la Detergence, Bruxelles-Task Force). (1987). An assessment of the implication of the use of EDTA in detergent products.
- Albasel, N., Collenie, A. (1985). Heavy metals uptake from contaminated soils as affected by peat, lime and chelates. *Soil Sci. Soc. Am. J.* 49: 386-390.
- Alder, A.C., Siegrist, H., Gujer, W., Giger, W. (1990). Behavior of NTA and EDTA in biological waste-water treatment. *Water Res.* 24: 733-742.
- Ayers, J.A. (1970). Decontamination of nuclear reactors and equipment. The Ronald Press Company, New York.
- Black, C.A. (ed.). (1965). Methods of soil analysis, parts 1 and 2. *Agronomy*. 9: 552-562. Am. Soc. Agron., Madison, WI.

- Bolton, Jr.H., Li, S.W., Workmen, D.J., Girvin, D.C. (1993). Biodegradation of synthetic chelates in subsurface sediments from the southeast coastal plain. *J.Environ.Qual.* 10: 125-132.
- Bouyoucos, G.J., (1951) .A recalibration of the hydrometer for making mechanical analysis of soils, *Agronomy J.* 43: 434-43.
- Brown, A.L., Quick, J., Eddings, J.L. (1971). A comparison of analytical methods for soil zinc. *Soil Sci. Soc. Am. Proc.* 35: 105-107.
- Elliott, H.A., Denney, J.M. (1982). Effect of EDTA on the binding of Cd. *J. of Environ. Qual.* 11: 658-661.
- Fujii, R. (1978). The complexing and adsorption of Cd in soils in the presence of EDTA and NTA. M.S. Thesis. University of California at Davis.
- Haas, C.N., Horowitz, N.D. (1986). Adsorption of Cd to kaolinite in the presence of organic material. *Water Air Soil Pollution.* 27:131-140.
- Halvorson, A.D., Lindsay, W.L. (1977). The critical Zn concentration of corn and the nonadsorption of chelated zinc. *Soil Sci.Soc.Am.J.* 41: 531-534.
- Hansen, J.A. Tjell, J.C. (1983). In R.D. Davis, G. Hucker and P. l'Hermite (eds), *Environmental effects of organic and inorganic contaminants in sewage sludge*, D.Reidel Publ. Co., Dordrecht, Holland, p. 91. .
- Jackson, M.L., (1958). *Soil chemical analysis*. New Jersey, Prentice hall.Inc.498.
- John, M.K. (1971). Influence of soil characteristics on adsorption and desorption of Cd. *Environ. Lett.* 2: 173-179.
- Kari, F.G., Hilger, S., Canonica, S. (1995). Determination of the reaction quantum yield for the photochemical degradation of Fe (III)-EDTA in surface waters. *Environ. Sci. Technol.* 29: 1008-1017.
- King, L.D. (1988). Retention of metals by several soils the southeastern United States. *J.Environ.Qual.* 17: 239-246.
- Li, Z. Shuman, L.M., (1996). Extractability of Zinc, cadmium, and nickel in soils amended with EDTA. *Soil Science*, 161(4): 226-232.
- Lindsay, W.L., Hodgson, J.F., Norvell, W.A. (1967). The physicochemical equilibrium of metal chelates in soils and their influence on the availability of micro nutrient cations. *Trans. J. Meet. Comm. 2, 4 Int. Soc. Soil Science.* 305.
- Lindsay, W.L., Norvell, W.A. (1969). Equilibrium relationships of Zn, Fe, Ca, and H with EDTA and DTPA in soils. *Soil Sci. Soc. Am. Proc.* 33: 62-68.
- Lindsay, W.L., Norvell, W.A. (1978). Development of a DTPA soil test for Zn, Fe, Mn, and Cu. *Soil Sci.Soc.Am.J.*42: 421-428.
- Loon, J.C., Lichwa, J. (1973). A study of the atomic absorption determination of some important heavy metals in fertilizers and domestic sewage plant sludge. *Environ. Lett.*4: 1-18.
- Means, J.L., Kucak, T., Crear, D.A. (1980). Relative degradation rates of NTA, EDTA, and DTPA and environmental implications. *Environ.Pollut.Series B.* 1: 45-60.
- Naidu, R., Harter, R.D. (1998). Effect of different ligands on Cd sorption by and extractability from soils. *Soil Sci. Soc. Am. J.* 62: 644-650.
- Nelson, J.L., Boawn, L.C., Viets, F.G. (1959). A method for Zinc status of soils using acid-extractable zinc and titratable alkalinity values. *Soil Science.* 88: 275-283.
- Piciulo, P.L., Adams, J.W., Davis, M.S., Milian, LiW., Anderson, C.I. (1986). Release of organic chelating agents from solidified decontamination wastes. NUREG/CR-4709, BNL-NUREG-52014. National Tech. Inf. Service, Springfield, V.A.
- Richards, L.A., (1954).Diagnosis and improvement of saline and alkali soils. *U.S.D.A. Handbook* 60.
- Roca, J., Pomares, F. (1991). Prediction of available by heavy metals by six chemical extractants in a sewage sludge-amended soil. *Commun.Soil Sci. Plant Anal.* 22: 2119-2136.

- Shuman, L.M. (1975). The effect of soil properties on Zn adsorption by soils. *Soil Sci. Soc. Am. Proc.* 39: 454-458.
- Shuman, L.M. (1985). Fractionation method for soil micro elements. *Soil Science*. 140: 11-22.
- Tiedje, J.M. (1977). Influence of environmental parameters on EDTA biodegradation in soils and sediments. *J. Envir. Quality*, 6: 21-26.
- Tiedje, J.M. (1975). Microbial degradation of EDTA in soils and sediments. *Appl. Environ. Microbiol.* 30: 327-329.
- Yu, J., Klarup, D. (1994). Extraction kinetics of copper, zinc, iron, and manganese from contaminated sediment using disodium ethylenediaminetetraacetate. *Water Air Soil Pollution*. 75: 205-225.
- Wallace, A., Muller, R.T., Cha, J.W., Alexander, G.V. (1974). Soil pH, excess lime and chelating agent on micronutrients in soybeans and bush beans. *Agronomy J.* 66: 698-700.



# SEASONAL CHANGES IN SOIL MICROBIAL BIOMASS AND ENZYME ACTIVITY IN ARABLE AND GRASSLAND SOILS

Hatice Sevim Uçkan\*, Nur Okur\*\*

\*Department of Soil Science, Faculty of Agriculture, Uludağ University, Görükle-BURSA

\*\*Department of Soil Science, Faculty of Agriculture, Ege University, Bornova-İZMİR

## ABSTRACT

Seasonal changes in soil moisture, soil temperature and C input from crop roots, rhizosphere products and crop residues can have a large effect on soil microbial biomass and its activity. The objective of this study was to quantify the seasonal changes in soil microbial biomass and the enzyme activity in soils under cultivation and grassland soils. Soil samples were taken at two different times (May and September, 1998). Five soils under cereal, five soils under vegetable and five grassland soils were selected for the study. All samples belonged to Alluvial Great Soil Group of Bursa Plain.

Significant differences were found between soil sampling periods for microbial biomass, mineralizable C and protease activity. Microbial biomass C in September compared to May averaged 52.5, 68.7 and 18.2 % greater under cereal, vegetable and pasture soils, respectively. Mineralizable C was higher in soils under cereal and vegetable in September, possibly due to more flows of C and N to soils. Dehydrogenase activity was similar in two different sampling periods. In May, more favourable weather conditions (moisture and temperature) and fertilization increased soil protease activity.

## INTRODUCTION

Soil microbial biomass, a living part of soil organic matter, is an agent of transformation for added and native organic matter and acts as a labile reservoir for plant-available N, P, and S (Jenkinson and Ladd, 1981). The activity of the microbial biomass is commonly used to characterize the microbiological status of a soil (Nannipieri et al., 1990), and to determine the effects of cultivation (Beyer et al., 1991; Anderson and Domsch, 1993), field management (Perott et al., 1992), or contamination (Chander and Brookes, 1993) on soil microorganisms.

Soil physicochemical characteristics influence the level of biomass and the activity of microorganisms. Seasonal changes in soil moisture, soil temperature and C input from crop roots, rhizosphere products (i.e. root exudates, mucilage, sloughed cells, etc.), and crop residues can have a large effect on soil microbial biomass and its activity (Ross, 1987), which in turn, affect the ability of soil to supply nutrients to plants through soil organic matter turnover (Bonde and Roswall, 1987). Microbial biomass has been reported to vary seasonally in European soils (Patra et al., 1990). Singh et al. (1989) have also reported a seasonal variation in the microbial C, N and P in forests and savanna. Generally, a negative relationship between soil moisture content and microbial biomass was reported by Ross (1987) for New Zealand soils under tussock grassland and introduced pasture. Short-term fluctuations of moisture and temperature conditions have been shown to influence the amount of microbial biomass carbon (MacGill et al., 1986). Soil organic carbon levels, too, have been reported to be governed by climatic conditions (Jenny, 1980). Limited data, however, exist on the magnitude of seasonal changes in soil microbial biomass and enzyme activity in different agricultural ecosystems. In this study, the amounts of soil microbial biomass and enzyme activity in soils under cultivation were determined at May when crop root and residue additions were minimal and at September when crop residues were maximal. In addition, the same microbiological indices are also compared to those of grassland soils.

## MATERIAL and METHODS

**Sampling sites of soils:** Fifteen Alluvial soil samples in the Northwest Anatolia, Bursa were sampled in May and September 1998. Annual temperature and rainfall averages 14.8 °C and 68.5 mm, respectively. Table 1 shows the crops and the characteristics of soils. Sand content of soils ranged from 17.12 to 53.84 %, clay from 22.00 to 42.16 % and silt from 20.00 to 50.00 %. Soil reaction (pH) was between 7.43 and 8.46, soil organic C content 0.52 and 1.71 % and the ratio soil organic C:total N 5.0 and 7.9.

Table 1. The crops and some physicochemical properties of soils

Soil sites	Soil particle size (%)			pH (H <sub>2</sub> O)	Org.C %	N <sub>t</sub> %	C:N
	Sand	Clay	Silt				
Cereal							
Barley	41.28	26.72	32.00	8.08	1.05	0.140	7.5
Maize	36.00	22.00	42.00	7.43	0.52	0.080	6.5
Oats	18.56	31.44	50.00	8.46	0.67	0.110	6.1
Wheat	34.56	25.44	40.00	7.98	1.03	0.130	7.9
Wheat	18.56	41.44	40.00	8.26	0.84	0.140	6.0
Vegetable							
Cucumber	17.84	42.16	42.00	8.20	1.12	0.180	6.2
Squash	25.12	30.88	44.00	8.15	1.03	0.180	5.7
Tomato	17.12	32.88	50.00	8.31	0.86	0.170	5.0
Aubergine	19.84	38.16	42.00	8.43	0.70	0.130	5.4
Green pepper	23.84	32.16	44.00	8.14	0.56	0.110	5.1
Pasture							
Alfalfa	21.12	34.88	44.00	7.65	1.52	0.240	6.3
Vetch	23.28	34.72	42.00	8.05	1.71	0.220	7.8
Alfaalfa	27.12	26.88	46.00	7.93	0.84	0.140	6.0
Alfaalfa	53.84	26.16	20.00	7.73	0.75	0.110	6.8
Vetch	22.56	31.44	46.00	8.28	0.93	0.140	6.6

**Soil analysis:** The collected soils were sieved (4 mm) and stored at 4 C° until needed. Subsamples for the determination of physicochemical parameters were air dried and sieved (2 mm) before analysis. Organic C was determined as described by Walkley and Black (1934) and, total N by Bremner (1960). Other physicochemical analysis were determined according to the standard methods.

**Measurement of microbial biomass:** Microbial biomass C was determined by substrate-induced respiration method (Anderson and Domsch, 1978): Moist soil samples (100 g) were amended with glucose (400 mg), and the pattern of respiration response was recorded for 4 h. By a conversion factor, values were converted to mg biomass-C.

**Mineralizable C:** Mineralizable C was estimated from the quantity of CO<sub>2</sub>-C mineralized from soil during a 7-d incubation at 27 C° (Isermeyer, 1952).

**Dehydrogenase activity:** Dehydrogenase activity was determined according to the method of Thalmann (1967), in which TTC (2, 3, 5-triphenyl tetrazolium chloride) serves as a terminal acceptor of protons and electrons from organic compounds being oxidized.

**Protease activity:** Protease activity was assayed by the method of Ladd and Buttler (1972). This procedure involves the determination of aromatic amino acids released during the incubation period by using casein as substrate.

## RESULTS AND DISCUSSION

### Microbial Biomass and Mineralizable C

Microbial biomass C, mineralizable C and microbial biomass C: organic C (MBC:C) ratio are given Table 2. Soil microbial biomass C and mineralizable C increased significantly at 1 % level from the first sampling date (May) to the second sampling date (September) in all soils (Table 3). Microbial biomass C in September compared to May averaged 52.5, 68.7 and 18.2 % greater under cereal, vegetable and pasture soils, respectively. Since microbial biomass is generally correlated with the level of soil organic matter and is influenced by climatic variables, its solely measurement can not show whether a specific cropping or tillage is gaining or losing organic matter. In order to elucidate the changes in organic matter equilibrium, emphasis has been placed on the proportion of total organic C within the microbial biomass (Wu and Brookes, 1988; Anderson and Domsch, 1989). Using this



concept, organic matter equilibrium functions have been provided for the ratio of biomass C to total organic C in a wide range of crop rotations (Anderson and Domsch, 1989) and macroclimates (Insam et al., 1989). In this study, the ratio of microbial biomass C to total organic C of soils are given Table 2. MBC:OC ratio of every two sampling period differed significantly at 1 % level (Table 3). The ratio ranged from 5.3 to 9.9 in May while from 8.4 to 85.0 in September for all soil samples.

Table 2. Values of microbial biomass C and mineralizable C and MBC:OC ratio of soils.

Soil Sites	Mic. Biomass C (mg C 100 g <sup>-1</sup> soil)		Mineralizable C (mg CO <sub>2</sub> -C 100 g <sup>-1</sup> soil)		MBC:OC* (%)	
	May 98	Sep 98	May 98	Sep 98	May 98	Sep98
<b>Cereal</b>						
Barley	103.82	134.32	31.47	60.35	9.9	15.4
Maize	45.99	115.29	14.67	56.96	8.8	57.6
Oats	61.33	142.18	45.13	76.40	9.1	35.5
Wheat	64.27	83.58	30.09	26.05	6.2	28.8
Wheat	77.99	63.81	55.92	21.39	9.3	8.4
<b>Vegetable</b>						
Cucumber	59.94	142.75	45.78	32.63	5.3	39.6
Squash	93.67	88.74	47.05	34.80	9.1	13.0
Tomato	67.63	125.37	37.35	35.92	7.9	13.5
Aubergine	66.94	129.01	37.34	39.84	9.6	22.6
G. pepper	55.28	92.13	23.16	65.20	9.9	24.9
<b>Pasture</b>						
Alfalfa	127.95	132.44	50.59	26.89	8.4	9.9
Vetch	128.65	120.32	47.77	38.01	7.5	16.7
Alfalfa	59.87	80.61	19.42	18.41	7.1	25.2
Alfalfa	40.09	110.60	10.90	20.05	5.4	85.0
Vetch	77.07	68.12	43.27	36.38	8.3	11.9

\*: Microbial biomass C: Total organic C

Table 3. Differences between microbiological indices in different sampling periods (at 1 % level)

Microbial biomass C (mg C 100 g <sup>-1</sup> soil)	May 98	75.36 b	LSD: 0.265
	Sep. 98	108.61 a	
Mineralizable C (mg CO <sub>2</sub> -C 100 g <sup>-1</sup> soil)	May 98	35.99 b	LSD: 0.360
	Sep. 98	39.99 a	
MBSC:OC (%)	May 98	8.06 b	LSD: 0.255
	Sep. 98	27.2 a	

These results showed that organic matter residues added to soils in September allows a more efficient organic matter utilization per unit biomass as compared to soils taken in May which is lesser in organic matter. When plant groups are compared, MBC:OC ratio of arable soils was higher than the pasture soils. The fact that two or more crops have been growing in arable soils caused a higher chemical diversity of organic matter input and the microorganisms which are endowed with a more economic metabolism are favoured with time (Anderson and Domsch, 1990).



Seasonal changes in the mineralizable C reflected the availability of easily-decomposable substrates. Mineralizable C was higher in soils under cereal and vegetable in September, possibly due to more flows of C and N to soils. C input from crop roots, rhizosphere products and crop residues can have a large effect on mineralizable C and N in soils. Robertson et al (1994) states a more flows of C and N in soils under sorghum than under green panic.

### Enzyme Activities

A knowledge of the spectrum of enzymatic activities of a soil is important since it will indicate the potential of the soil to permit the basic biochemical processes necessary for maintaining soil fertility. Dehydrogenase and protease activities were determined in the study soils and the results obtained are given in Table 4. No differences are found between the two sampling periods of dehydrogenase activity (Table 5). Dehydrogenases are considered to play an essential role in the initial stages of the oxidation of soil organic matter by transferring hydrogen and electrons from substrates to acceptors (Ross, 1971). Comparing plant groups, a higher dehydrogenase activity of pasture soils were found than the arable soils. There is a negative correlation between the dehydrogenase activity and the soil aerating conditions. In pasture soils where soil tillage is not applied, O<sub>2</sub> input to soil is lesser compared to arable soils. Therefore, pasture soils contain lesser O<sub>2</sub> than arable soils. The deficit aeration conditions in the pasture soils might explain the high dehydrogenase activity.

Table 4. Dehydrogenase and protease activities of soils

Soil Sites	Dehydrogenase Activity ( $\mu\text{g TPF g}^{-1}$ soil)		Protease Activity ( $\mu\text{g Tyrosin g}^{-1}$ soil 2h <sup>-1</sup> )	
	May 98	Sep 98	May 98	Sep 98
Cereal	359.50	360.64	148.40	120.73
Barley	78.81	96.53	81.16	32.88
Maize	291.08	298.18	140.04	115.82
Oats	239.43	243.46	117.90	39.28
Wheat	284.97	284.85	114.60	17.20
Vegetable				
Cucumber	301.74	327.23	135.83	109.48
Squash	410.87	492.04	129.80	60.32
Tomato	261.07	275.76	121.39	44.26
Aubergine	167.57	168.43	124.90	88.18
G. pepper	139.20	148.85	57.77	24.55
Pasture				
Alfalfa	860.01	881.18	367.96	87.32
Vetch	576.70	314.33	284.17	45.48
Alfalfa	238.62	274.62	53.66	34.19
Alfalfa	240.22	281.36	92.69	31.19
Vetch	201.22	216.06	138.84	170.07

Table 5. Differences between enzyme activities in different sampling periods  
(at 1 % level)

Dehydrogenase Activity ( $\mu\text{g TPF g}^{-1}$ soil)	May 98	310.90 a	LSD: 0.035
	Sep. 98	310.06 a	
Protease Activity ( $\mu\text{g Tyrosin g}^{-1}$ soil 2h <sup>-1</sup> )	May 98	140.80 a	LSD: 0.280
	Sep. 98	68.06 b	

Significant differences were found between the two sampling periods of protease activity (Table 5). The values of protease involved in the N cycle were higher in soil samples which were taken in May 98. Soil proteases are rate-limiting enzymes in the N mineralization process of soils (Ladd and Paul, 1973) and negatively affected by aridity (Schinner et al., 1995). In May, more favourable weather conditions (moisture and temperature) and fertilization increased soil protease activity. Comparing plant groups, protease activity of pasture soils was higher than arable soils. The fact that soil is covered with alfalfa and vetch during all the year, probably, increased protease activity of pasture soils.

#### Relationships between microbial parameters and some soil properties

Although there was no relationship between soil organic C and microbial C, a significant correlation was found between soil organic C and the ratio of microbial biomass C to soil organic C (Table 6). Anderson and Domsch (1989) stated that the ratio of soil biomass C to organic C ratio is a good indicator of changes in microbial performance caused by environmental conditions. The structure and distribution of C in soil affect biological activity and probably the microbial biomass. Organic C and total N were highly correlated with dehydrogenase and protease activities of soils. Addition of N fertilizer or organic fertilizer to soils increased the microbial enzymatic activity.

Table 6. Relationships between microbial parameters and some soil properties

	C <sub>org</sub>	C <sub>mic</sub>	MBC:OC	Min. C	DHG	Protease	N <sub>t</sub>
C <sub>org</sub>	-	ns	-0.659**	ns	0.682**	0.709*	0.806**
C <sub>mic</sub>	ns	-	0.775**	ns	ns	ns	ns
C <sub>mic</sub> to C <sub>org</sub> ratio	-0.659**	0.775**	-	ns	ns	ns	-0.423*
Min. C	ns	ns	ns	-	ns	ns	ns
Dehydrogenase	0.682**	ns	ns	ns	-	0.564**	0.792**
Protease	0.709**	ns	ns	ns	0.564**	-	0.602**
Total N	0.806**	ns	-0.423*	ns	0.792**	0.602**	-

ns: Not significant

#### REFERENCES

- Anderson, J.P.E. and Domsch, K.H. (1978). A physiological method for the quantitative measurement of microbial biomass in soils. *Soil Biol. Biochem.* 10 : 215-221.
- Anderson, T.H. and Domsch, K.H. (1989). Ratios of microbial biomass carbon to total organic carbon in arable soils. *Soil Biol. Biochem.* 21: 417-479.
- Anderson, T.H., Domsch, K.H. (1993) The metabolic quotient for CO<sub>2</sub> (qCO<sub>2</sub>) as a specific activity parameter to assess the effects of environmental conditions, such as pH, on the microbial biomass of forest soils. *Soil Biology & Biochemistry* 25:393-395.
- Beyer, L., Blume, H.P., Peters, M. (1991). Biological activity and organic matter transformations in typical soils of Schleswig-Holstein. *Geoderma* 49:273-284.
- Bonde, T.A. and Rosswall, T. (1987). Seasonal variation of potentially mineralizable nitrogen in four cropping systems. *Soil Science Society of America Journal* 51, 1508-1514.
- Bremner, J.M. (1960). Determination of nitrogen in soil by the Kjeldahl method. *Journal of Agricultural Sciences* 55, 11-13.
- Chander, K. Brookes, P.C. (1993) Residual effects of zinc, copper and nickel in sewage sludge on microbial biomass in a sandy loam. *Soil Biology & Biochemistry* 25:1231-1239.
- Insam, H., Parkinson, D. and Domsch, K.H. 1989. Influence of macroclimate on soil microbial biomass. *Soil Biol. Biochem.* Vol. 21. No. 2, 211-221.
- Isermeyer, H., (1952). Eine einfache methode zur bestimmung der karbonate im boden. *Z.Pflanzenern. Düng. Bodenkde.*

- Jenkinson, D.S., Ladd, J.N. (1981) Microbial biomass in soil measurement and turnover. In *Soil Biochemistry* (E.A. Paul and J.N. Ladd, eds.) Vol 5, 415-471. Marcell Decker, New York.
- Jenny, H. (1980) *The Soil Resource*. Springer, New York.
- Ladd, J.N., Butler, J.H.A., (1972). Short-term assay of soil proteolytic enzyme activities using proteins and dipeptide derivatives as substrates. *Soil Biology & Biochemistry* 4:19-39.
- Ladd, J.N., Paul, E.A. (1973) Change in enzymatic activity and distribution of acid-soluble, amino acid-nitrogen in soil during nitrogen immobilization and mineralization. *Soil Biology & Biochemistry* 5:825-840.
- McGill, W.B., Cannon, K.R., Robertson, J.A. and Cook, F.D. (1986). Dynamics of soil microbial biomass and water soluble organic C in Breton L after 50 years of cropping the two rotations. *Canadian Journal of Soil Science* 66, 1-19.
- Nannipieri, P., Grego, S., Ceccanti, B. (1990) Ecological significance of the biological activity in soil. *Soil Biochem* 6:293-355.
- Patra, D.D., Brookes, P.C., Coleman, K., Jenkinson, D.S. (1990) Seasonal changes of soil microbial biomass in an arable and a grassland soil which have been under uniform management for many years. *Soil Biology & Biochemistry* 8, 249-253.
- Perrott, K.W., Sarathchandra, S.U., Dow, B.W. (1992). Seasonal and fertilizer effects on the organic cycle and microbial biomass in a hill country soil under pasture. *Aust. J. Soil Res.* 30:383-394.
- Robertson, F.A., Saffigna, P.G., Myers, R.J.K. (1994) Dynamics of carbon and nitrogen in a long-term cropping system and permanent pasture system (Queensland). *Australian Journal of Agricultural Research* 45(1):211-221.
- Ross, D.J. (1971) Some factors influencing the estimation of dehydrogenase activities of some soils under pasture. *Soil Biology & Biochemistry* 3, 97-110.
- Ross, D.J. (1987). Soil microbial biomass estimated by the fumigation-incubation procedure : seasonal fluctuation and influence of soil moisture content. *Soil Biology & Biochemistry* 19, 397-404.
- Schinner, F., Öhlinger, R., Kandeler, E., Margesin, R. (1995). *Methods in Soil Biology*. Springer-Verlag Berlin Heidelberg New York.
- Singh, J.S., Raghubanshi, A.S., Singh, R.S., Srivastava, S.C. (1989) Microbial biomass acts as a source of plant nutrients in dry tropical forest and savanna. *Nature (London)* 338: 499-500.
- Thalman, A., (1967). Zur methodik der bestimmung der dehydrogenaseaktivitaet im boden mittels Triphenyltetrazoliumchlorid (TTC). *Landwirtsch. Forsch.* 21:249-258.
- Walkley, A. and Black, I.B. (1934). An examination of the Degtjareff method for determining soil organic matter a proposed modification of the chromic acid titration method. *Soil Science* 37, 29-38.
- Wu, J. and Brookes, P.C. (1988). Microbial biomass and organic matter relationships in arable soils. *J. Sci. Food Agric.* 45 : 138-139.



# SITUATION OF DESERTIFICATION IN TURKEY AND STRUGGLE CARRIED OUT AGAINST DESERTIFICATION IN KARAPINAR WIND EROSION CONTROL AREA

Mevlüt Demiryürek  
Köy Hizmetleri Konya Araştırma Enstitüsü, Konya

## ABSTRACT

The project area covers 13.000 hectares which is sub-divided to different areas taking into consideration the nature of problems and the types of measures to be taken. The problem areas of Karapınar covers 4.300 hectares of shifting dunes, 4.000 hectares of dune shadows, 3.200 hectares of flat land very sensitive to erosion and 1.500 hectares of basaltic rocks. In this project, dimensions and methods, the most economic means of prevention, were determined through a series of researches. Construction of red-screens to decrease wind speed which causes the sand dunes move is included in the first phase of prevention works. In the second phase, spaces between the screens were grassed with perennial and drought resistant plant. Afforestation, the third phase, included planting locally adapted large and needle-leaved trees. The third-phased practices implemented in the problem area prevented the continuous movement sand dunes.

- Strip farming system counter to dominant to wind direction at 40-60 m. width on the area of 2.000 hectares (1.000 hectares cultivated, 1.000 hectares fallowed) gave satisfactory in controlling sand.

- Construction of red-screens (at 1.m height and 8-10m at width) on the sand dune area of 4.300 hectares to decrease wind speed stabilised the sand dunes and spaces between the screens should be grassed with perennial and drought resistant plant.

- Afforestation should include planting locally adapted large and needle-leaved trees. The third-phased practices implemented in the problem area prevented the continuous movement sand dunes.

- For meadow amelioration bare areas should be planted to cultivated and locally adopted plants and mixed grass seeds should be sown by drills on areas where natural vegetation has been removed. Overgrazing was the one of the main reasons of wind erosion.

## INTRODUCTION

Turkey has a total land area of 78 million ha, of which around 28 million ha is used for arable farming. Large area of the arable land deteriorated due to the erosion by wind, because it is characterised with a fragile soil, lower precipitation, and erosive wind. Due to signs of soil erosion by wind are currently visible across the country's farmland, woodland and rangeland.

In Turkey wind erosion is a detrimental problem especially in southern part of central Anatolia, which is the driest zone of the country, and in Kars province in the East. However, it also occurs in coastal areas. 466.000 hectares of land are subject to wind erosion varying from slight to excessive, and approximately 70 % of this area are within the boundaries of Konya Province.

The soils in the area subjected to wind erosion, are alluvial, colluvial, sierozem and regosol that have a texture of light sandy loam on upper layers and heavy clay on lower layers. They are rich in lime and potash and poor in organic materials and phosphorus.

Destruction of natural cover when the land was put in cultivation or by overgrazing exposed it to wind. To protect the land, we must provide a substitute for this cover. Exposure of soil of wind for even short periods may result in severe erosion. Maintenance or apply adequate measures, therefore, becomes the primary goal of all wind erosion control efforts.

To set up a significantly based soil conservation strategies, for arable land in Central Anatolia, and to reduce susceptibility of land to wind erosion and mitigate its effect when does occur, we need to develop appropriate management for controlling wind erosion and assessing on-site and off-site damage and choice for adaptive measures that combat land degradation.

## MATERIAL

Karapınar sub-province, which is situated on Konya -Adana highway, is at a distance of 95 km to Konya. It covers an area of 4315 square kilometers. It is bounded on the north and west by Konya plain, on the east by Karacadağ and on the south by Andıklı, Küçük Kartan and Büyük Kartan Hills.

The area consists of alluvial, colluvial, sicorezem and regosol soils which have a texture of light sandy loam on upper layers and of heavy clay on lower layers. They are rich in lime and potash and poor in organic materials and phosphorous. Of the total arable land, roughly 296.900 hectares, 103.000 hectares are subject to wind erosion damages of different type and different grades.

Climate of the region can be defined as semi-arid continental. The summers are dry and have warm day-temperatures, followed by cool nights. The winters are usually cold with an verge of twenty day a year in which the soils are covered with snow. Greatest amount of snow falls in January and February. Average annual precipitation in the project area is about 270 to 280 mm, about 40% falls in winter. During the growing season rainfall normally amounts to only 90 to 120 mm and is not enough for crops, that are not irrigated. It tends to reduce the yield of small grain crops in dry farming system and the harvest is about one or more earlier than that one of the same crops in irrigated areas. The average precipitation from July through September totals only about 10 mm.

Heavy rainshowers occur a few times a year. Occasionally more than 20 mm falls in one day, often within a few hours. Snowfall is normally light and snow periods total about from 10 to 16 days a year. Hailstorms, local in nature, are not rare and occur mainly in spring time. Sometimes they may cause damage to certain crops.

The annual precipitation of the places near the mountains, which surround the Great Konya basin is generally higher ( Nigde = 357 mm, Konya= 315 mm, Karaman= 361 mm ), than in the central part of basin ( Karapınar 275 mm ).

Because the Erosion Camp area is at fairly high elevation and because the sky is dominantly clear and the air is dry, the daily range in temperature is great. Its average about 10 C° in winter and about 15 C° in summer. Average temperature is 11 C°. In winter the nights are cold. The average monthly lowest temperature ranges from about - 2 to about - 5 C° in night. In time the temperature is falls below - 20 C° or lower. The average frost-free period extends from the middle of May to October. In summer the temperature is often between 30 and 35 C° and is occasionally above 35 C°.

The dominant winds are commonly from south-western corner, mainly from south, south-west and rise to dust storms that are disagreeable and destructive. Stormy days are common and wind attains speeds of 20 to 25 m/sec or more.

Principally because of dry air and warm summer day, the evaporation rate is relatively high. Evaporation from free water surface averages 1189 mm in Konya annually. The average relative humidity between about 40 % in summer to 80 % in winter.

## METHOD

- Strip farming system counter to dominant to wind direction at different width ( 40.m, 50 .m, 60 .m, 70 .m, 80. m, 90. m and 100 .m) was applied on the area of 2.000 hectares, 1.000 hectares cultivated, 1.000 hectares fallowed.

- Construction of red-screens (at 1.m height and 8-10m at width) on the area of 4.300 hectares to stabilize the sand dunes and to decrease wind speed which causes the sand dunes move is included in the first phase of prevention works.

- In the second phase, spaces between the screens were grassed with perennial and drought resistant plant.

- Afforestation, the third phase, included planting locally adapted large and needle-leaved trees. The third-phased practices implemented in the problem area prevented the continuous movement sand dunes.

- Seeds of four species plants such as Tapir (*Marrubium parviflorum*), Geven (*Astragalus micracophalus*), Yandak (*Alhagi camalorum*) and Püren (*Artemisia* sp.) which were survived during the prevention work was sampled, produced and then propagated for meadow amelioration.

- Grazing under control was held on the flat land very sensitive to wind erosion.



## DISCUSSION

Wind erosion in the project area occurred in three stages: wearing away, conveying and accumulating. It is largely attributable to natural agencies such as climate, vegetative cover and soil as well as to human factors such as the adoption of improper farming system, crop rotation, inappropriate land use, unsuitable machinery and equipment, over-grazing and using some species of grasses as fuel.

4.000 hectare of area was small dunes which were formed by the accumulation of wind drifted materials. Within the project area, there are some 140 species of flora. Some drought- resistance varieties, such as speedwell, milkvetch, ground ivy, wheat, grass and thistle are capable to hold sands and materials carried by wind thus causing the formation of small dunes. Researches reveal that excellent grasslands and meadow once flourished here, but they were reduced to almost nothing due to overgrazing, using some grass species as fuel and the destruction meadow. When the erosion problem revealed, only four species plant such as Tapir ( *Marrubium parviflorum* ), Geven ( *Astragalus micracophalus* ), Yandak ( *Alhagi camalorum* ) and Püren ( *Artemisia* sp.) survived. Seeds of this four species plants which were survived during the prevention work was sampled, produced and then propagated on the pasture area.

The process of wind erosion considerably effected by the wind and the suitability of the soil property to erosion. In general when the speed of wind is over 14 km/hour, soil movement is started thereby resulting in wearing away of Karapınar land. The eroded land move either by leaping or dragging or as suspended in the air while they are conveyed by the wind. When they accumulate where they meet an impediment or when the speed of wind is reduced. This situation brought about the shifting dunes ( roughly 4.300 ha.) individually or in chains. Some dunes reach 150 m at width, 240 m at length and 41 m at height. They have a gradient of 5 to 17 % on the direction of wind and 20 to 48 % on the other side. They are of crescent shape. Reed-screens were constructed on this area and grass and tree plantation among these red- screens were started.

Both dry and irrigated farming practices should be applied on the areas of sand dunes and small sand hills subject to wind erosion like Karapınar. Dry farming practices included rangeland improvement which was implemented in two ways,

1. Bare areas among the small dunes were planted to cultivated crops for meadow amelioration without damaging the natural vegetation,
2. Mixed grass seeds were sown by drills on areas where natural vegetation has been removed.

In areas where field crops farming under dry conditions was not possible, vineyards and almond orchards were established.

Wind erosion prevention works have great interest both in the country and the abroad. Native and foreign visitors to Karapınar, especially those who are professionally interested in the works, have highly appreciated the results achieved in the area. In fact wind erosion control works are being implemented in many countries, but what is really remarkably in our success is to make use of the most economic methods and shortest time to a desert land into a fertile arable land. One of the most important factors was water supply in this project. Since the area was deficient of adequate surface water resources, irrigation water was supplied from ground water resources. Reeds, grass, seeds, nurselings, and machinery and equipment necessary for project implementation were supplied locally. We have extended the limits of our responsibilities to involve the farmer living in the vicinity to the project area; they have learned to apply modern farming techniques, e.g. use of underground water for irrigation, adoption of new kinds of crop, fertilisation etc. Profit obtained has recovered the expenses in a short time and gave way to increase in come.

## REFERENCES

- Abalı, İ. 1980. Karapınar yöresinde nadas-hububat tarım yönteminde uygulanacak toprak işleme ve ekim aletleri .konya bölge topraksu araştırma enstitüsü yayınları ,genel yayın no 70, rapor no 56 Konya.
- Abalı,İ .1981. " Orta anadolu'da rüzgar erozyonunu önleyici ekim nöbetinin toprak kaybına etkisi " Konya bölge müdürlüğü topraksu araştırma enstitüsü yayınları- konya.
- Abalı,İ. 1993. Akhisar civarındaki rüzgar erozyonu etkisi altındaki arazilerde toprak özellikleri ile erozyon arasındaki ilişkileri ve rüzgar erozyon denklemi faktörlerinin hesaplanması (doktora )



- Taysun,A., Doğan . O, Örnez. O Ve Çanga,M .1986 . Orta anadolu bölgesinde rüzgar erozyonu oluşumu ve alınacak önlemler rehberi. Köy Hizmetleri Genel Müdürlüğü Genel Yayın no : 54, rehber no: 9 ankara.
- Akalan,İ.1965. Rüzgar erozyonu ve korunma çareleri. a.ü.ziraat fakültesi yaylığı- ankara.
- Bagnold,R.A.1943. The physics of blown desert dunes.william marrow and co. newyork.
- Bisal,F. Ve J.Hscih 1966. Influence of moisture on erodibility of soil by wind soil sci.102
- Carrekar,J.R.1966. Wind Erosion In The Southeast.Jour..Soil And Water Conservation.21 ( 3 ): 86-88
- Chepil,W.S.1950. I-Properties of soil which influence wind erosion, II- aggregate structure and indeks of erodibility soil sci.69-403-414.
- Chepil,W.S.1953. Factors that influence clod structure and erodibility of soil by wind.i.soil texture.soil sci.75
- Chepil,W.S. N. P.Woodruff .1953. The physics of wind erosion and its control advances in agron.15.
- Chepil,W.S.1954. Factors that influence clod structure and erodibility of soil by wind.ii.calcium carbonate and decomposed organic matter.
- Chepil,W.S. N. P.Woodruff .1954. Estimations of wind erodibility of field surfaces. soil and water conservation journal.6 : 257-265,285.
- Chepil,W.S.1955. Factors that influence clod structure and erodibility of soil by wind. iv. sand,silt and clay .soil sci.80.
- Chepil,W.S.1958. Soil conditions that influence wind erosion. u.s.d.a. tech. bul.no. no.1185.washington d.c.
- Çelebi .H.1971. Konya karapınar proje sahası topraklarında rüzgar erozyonu ile ilgili araştırmalar. atatürk üniversitesi ziraat fakültesi .cilt .2, sayı .2.erzurum.
- Çelebi .H.1973. Ulaş devlet üretme çiftliği arazisinin rüzgar erozyon yönünden planlanması. Atatürk üniversitesi ziraat fak. 2. dergisi, cilt .4, sayı 2.erzurum.
- Çelebi .H.1981.İğdır Devlet üretme çiftliği arazisinde rüzgar erozyonuna ilişkin araştırmalar. atatürk üniversitesi yayınları no: 578, ziraat fakültesi yayınları no: 262 araştırma serisi no: 173 erzurum.
- Eriş,S.1963. İç anadolu karapınar çevresindeki kum reliefi hakkında istanbul üniversitesi coğrafya dergisi.istanbul.
- Gillette, D.A..Blifford,J.R.I.H Fenster, C.R.1972. Measurements of aerosol size distributions and vertical fluxes of aerosols on land subject to wind erosion.j.applied.meteor, 11: 977-987.
- Gillette, D.A.1977. Fine particule emissions due to wind erosion. transact.asae,20:890-897.
- Hacen,L.J, E.L.Skidmore Ve J.D. Dickarson .1972. Designing narrow strip barrier system to control wind erosion . reprinted from the journal of soil and water conservation. november-december .volume. 27. number.6
- Lyles ,J., N,F Schmeidler, N.P.Woodruff 1973. Stubble requirements in field strips to trap windblown soil u.s. department of agriculture, agricultural research publication 164.
- Lyles ,J.,1975. possible effects of wind erosion on soil productivity. j.soil water cons. 36 : 279 – 282.
- Özdoğan, N.1976. Rüzgar erozyonu ve rüzgar erozyonu sahalarında alınacak tedbirler. topraksu genel müdürlüğü yayınları no: 306- ankara
- Richard ,L.Ob, 1954.Diagnosis and improvement of saline and alkali soils.u.s.dep.of . agr. handbook 60.
- Sevim, Z. A.İstanbuluoğlu. 1985. Kars-aralık 'taki toprakların rüzgar erozyonuna ilişkin özellikleri. atatürk üniversitesi çevre sorunları araştırma merkezi.erzurum.
- Soil Survey Staff, 1954. Soil survey manuel.u.s department agricultere handbook. no: u.s. goverment print.
- Taysun,A, İ.Abalı, M.Yakar.1983. Rüzgar erozyon denklemi ile ilgili olarak Türkiyede yapılabilecek çalışmalar.köy hizmetleri menemen araştırma enstitüsü .menemen
- Taysun,A,1984. Rüzgar erozyonu araştırmalarında kullanılabilecek rüzgar tüneli tipleri. e.ü.ziraat fak. bornova.
- Taysun,A, 1987. Rüzgar erozyonuna etki eden faktörler ( toprak bünyesi ve kuru agregatlar. d.ü.ziraat fak..şanlıurfa
- Taysun,A, 1989. Toprak ve su korunumu .e:ü.ziraat fak. toprak böl.bornova

- Topçu, H.1979.Orta anadolu'da anız örtülü tarım sisteminde rüzgar erozyonunu önleyici şerit genişliği . konya bölge topraksu araştırma enstitüsü müdürlüğü yayınları genel yayın no: 62 , rapor serisi no: 48 .konya
- Topçu,H, İ.Abali. 1979. Karapınar rüzgar erozyon alanlarında uygun nadas zamanı ve derinliğinin nem korunumu ve buğday verimine etkisi. konya bölge topraksu araştırma üdürlüğü yayınları genel yayın no: 68, rapor seri no:54 .konya.
- Topraksu.19725. Toprak istatistik bülteni. köy işleri ve kooperatifler bakanlığı topraksu genel müdürlüğü.ankara
- Tüzüner ,A. 1990 . Toprak ve su analiz laboratuvarları el kitabı .ankara.
- U.S.Salinity.Lab.Staff.1954. Diagnosis and improvement of saline and alkali soils. goverment print. office ,washington.
- Ülgen,N.; M, Ateşalp, 1972. Toprakta organik madde tayini. toprak ve gübre araştırma enstitüsü, yayın no: 23, ankara.
- Woodruff,N.P; F.H.Siddoway 1965. A wind erosion equation soil sci. soc. amer. proc. 29 ( 5 )
- Zing,A.W. 1950. Evaluation of the field surfaces with a portable wind tunnel. soil sci. soc. amer. proc. 15: 11-17

# EFFECT OF INDUSTRIAL SEWAGE SLUDGE APPLIED TO SOIL

Burcu Tasatar<sup>1</sup>, Koray Haktanır<sup>1</sup>,

<sup>1</sup>Soil Science Department, Faculty of Agriculture, Ankara University, Ankara

## ABSTRACT

In this research, DUSA (Industrial Yarn Manufacturing) and SEKA (Paper and Cellulose Production) manufacturing (both are located in İzmit) Wastewater Treatment Plant sludge samples were used. And, these sludges' physical, chemical, and biological effects on agricultural soil, taken from İzmit Alikahya village were search. For this purpose, soil-sludge mixtures moisturized up to 70% of their water absorption capacity (maximum 0.5 % evaporation permitted) were prepared and kept at 28 °C for the period of five months. Waste sludge applied (control, 20, 40, 80, 160 t ha<sup>-1</sup>) soil samples were analyzed at 10 different incubation periods to determine nitrogen mineralization (NH<sub>4</sub><sup>+</sup>-N and NO<sub>3</sub><sup>-</sup>-N), soil respiration (CO<sub>2</sub> evolution), and urease enzyme activity. The physical and chemical properties of soil and sludges were analyzed before and after the mixing to find out if particular sludge sample at given rate had changed soils' physical and chemical properties. Then, positive changes were doubled checked to determine correct sludge dosage. Finally, all results were compared with statistical methods. Finding of the research have shown that in both soil-sludge mixtures, depending on sludge dosage rate, there were increase in organic matter, available phosphorus, electrical conductivity (EC) and cation exchange capacity (CEC); decrease in pH value; and, no noticeable change in other physical and chemical properties of soil-sludge mixtures. SEKA sludge sample was more effective than DUSA's sludge in total nitrogen. But, DUSA's sample was more effective in pH drop and in the increase of density, organic matter, electrical conductivity, available phosphorus and total phosphorus content. Urease enzyme activity, one of the soil's biological properties, increased with sludge application rate and decreased with incubation time was more for SEKA sludge than DUSA. However, the amount of CO<sub>2</sub> decreased in both sludge, but SEKA sludge had more CO<sub>2</sub> evolution. When incubation period ended, there was rapid mineralization observed in both sludge samples. The amount of NH<sub>4</sub><sup>+</sup>-N has increased with the dosage rate, and nitrification was strongly affected by incubation period (p<0.01).

## INTRODUCTION

Disposal of municipal sewage sludge and effluents has recently received much publicity because of the increasing amounts of these wastes produce by urban and industrial activities. Due to growing concern over disposal of sewage sludge in the oceans and the high cost of incineration, land application and land filling are becoming more common. Currently about 60% of the sewage sludge produced in the U.K., amounting to 18 million tones annually is applied to agricultural soils as organic manure (Chander and Brookes, 1991). The application of dried sewage sludge and sludge effluents to agricultural land is becoming a wide spread practice because of the high content of organic and inorganic N, P and other plant nutrients in such sludges. Soil enzymes play an important role in the mineralization of organic substances and making nutrient ions available. Due to the reactions of urease and phosphates NH<sub>4</sub><sup>+</sup> and PO<sub>4</sub><sup>-</sup> are made available to plants from organic substances in soils. (Reddy et al.1987). The percentages of sludge C and N mineralized in soil vary with the sludge type applied to the soil, as well as with the amount and the composition of the organic matter in the sludges (Hattori, 1988).

Epstein et al. (1976) showed that laboratory incubations of soil with high rates of sewage sludge could cause an increase in cation exchange capacity (CEC). Respiration rate is the most widely used index of soil microbial activity. Enzyme assays in conjunction with respiration rate measurements can provide a clearer picture of the overall soil microbial population and its activity (Stroo and Jencks, 1985).

The purpose of this research is to determine the effect of two different sewage sludges on soil nitrogen mineralization (NH<sub>4</sub><sup>+</sup>-N and NO<sub>3</sub><sup>-</sup>-N), CO<sub>2</sub> evolution, and urease enzyme activities in soil after 140 days incubation period. The physical and chemical properties of soil and sludges were analyzed before and after the mixing to find out if particular sludge sample at given rate had changed soils' physical and chemical properties.



## MATERIALS AND METHODS

### Soil and Sludge Description:

The soil used was from Izmit-Alikahya Village (0-20 cm depth) . Sewage sludges from DUSA (Industrial Yarn Manufacturing) and SEKA (Paper and Cellulose Production) manufacturing plants' (both are located in Izmit) wastewater treatment plants.

### Experimental Design:

The soil sample and sludge samples were stored on ice in transit, and sieved ( $<2\text{mm}$ ) and stored at  $4^{\circ}\text{C}$  for no longer than 1 week before assay of  $\text{NH}_4^{+}\text{-N}$  and  $\text{NO}_3^{-}\text{-N}$  at the beginning. The soil sample 400  $\text{cm}^3$  volume plastic pots were filled with 200 g of soil. Both sludge were air -dried and then added to the pots containing 200 g. soil at 5 rates equivalent to 0, 20, 40, 80, and 160  $\text{t ha}^{-1}$  on a volume ( $107^{\circ}\text{C}$ , oven dry) basis and soil and sludge in each pot were mixed well. No chemical fertilizer was added with these treatments. The incubation experiment was conducted using a randomized block design with 3 replications (3 pots) per treatment. Finally ground ( $<2\text{mm}$ ) sludge was thoroughly mixed with sieved ( $<2\text{mm}$ ) soil. The pots were placed in an incubator at  $28^{\circ}\text{C}$ . Throughout the incubation period, water losses exceeding 10% of the initial values were compensated for by addition of distilled water.

### Sampling and Analysis:

Samples were taken at 1, 7, 14, 28, 42, 56, 70, 105, and 140 days of the incubation period for the following analyses. For each sample, pH and electrical conductivity (EC) were measured in a 1:2.5 water extract (Richards, 1954); organic material by using modified Walkley-Black Method (Jackson, 1962); grain size distribution by Bouyoucos (1951); soil cation exchange capacity (CEC) was determined by saturation with ammonium acetate at pH 7 (Chapman, 1965); total phosphorus was determined by the Vanado Molybdate method (Kacar, 1996); the soil was extracted with 60% of  $\text{HClO}_4$  and the extract assayed for available phosphorus (atomic emission spectrophotometer) (Kacar,1990). The soil samples was analyzed for concentrations of water soluble  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$  using EDTA titration method,  $\text{Na}^{+}$ ,  $\text{K}^{+}$  using flame photometer,  $\text{CO}_3^{-2}$ ,  $\text{HCO}_3^{-}$  using 0.01  $\text{H}_2\text{SO}_4$ ,  $\text{Cl}^{-}$  using the titration with 0.01 N  $\text{AgNO}_3$ , and  $\text{SO}_4^{-2}$  using calculation method (Richards,1954). The soil was extracted with 1 N  $\text{NH}_4\text{OAc}$ , pH 8.2; and extract assayed for  $\text{Na}^{+}$  and  $\text{K}^{+}$ (flame photometer) and Ca and Mg (titration with 0.01 N EDTA) (Borekci, 1991). Total nitrogen was assessed using the Kjeldahl method, as specified by Bremner (1965). For  $\text{NH}_4^{+}\text{-N}$  and  $\text{NO}_3^{-}\text{-N}$ , moist soil was placed in 150 ml Erlenmeyer flasks with 100ml of 2M KCl. Flasks were placed on a rotary shaker for 30 min and contents filtered through whatman filter paper No. 42. Soil extracts were used for the measurement of  $\text{NH}_4^{+}\text{-N}$  and  $\text{NO}_3^{-}\text{-N}$  by steam distillation using MgO and Devarda's alloy (Bremner, 1965).  $\text{CO}_2$  evolution was determined according to the method of Isermayer (1952), Urease enzyme activity was measured by Hoffman and Teicher Method (1957). Seka and Dusa plants' sludges physical and chemical properties were determined like soil sample as you see above.

Statistical analyses were evaluated by ANOVA and differences among the groups were separated by LSD (Duncan's multiple range test,  $P<0.01$ ).

## RESULTS and DISCUSSION

### Some Physical and Chemical Properties of Soil-Sludge Mixtures

The physical and chemical characteristics of the sludges and soil are shown in Table 1. Some physical and chemical properties of soil amended with Dusa and Seka sludges changed after 140 days of incubation period. Table 2 presents the changes in pH, EC, CEC, total and available phosphate, organic matter, organic carbon, total nitrogen, and C/N rate. The changes are calculated as the difference between the measured parameter for before treatments were applied and after 140 days treatments were applied. In both sludges used in the present study was approximately neutral, so in the soil, pH was decreased by the highest Dusa sludge treatment and Seka's 20, 40 treatments.

Table 1. Selected physical and chemical properties of the soil and sewage sludge samples

Sample	pH (1:2.5)	EC dSm <sup>-1</sup>	CaCO <sub>3</sub> %	O.M. %	O.C. %	N %	C/N	NH <sub>4</sub> <sup>+</sup> -N mgkg <sup>-1</sup>	NO <sub>3</sub> <sup>-</sup> -N mgkg <sup>-1</sup>	Total P mgkg <sup>-1</sup>	Available P mgkg <sup>-1</sup>
Soil	7.91	1.02	1.46	13.99	6.99	0.74	9.37	181.6	150.6	2605	293.25
DUSA	7.27	2.54	0.147	48.77	24.38	1.14	21.38	927.66	401	301.1	181.6
SEKA	7.1	10.91	1.46	68.33	34.16	3.26	10.47	2120	905.66	2600.3	433.46

Sample	CEC cmol kg <sup>-1</sup>	Exchangeable Na <sup>+</sup>	K <sup>+</sup>	Cations Ca <sup>++</sup> +Mg	Sand	Silt	Clay	Texture % Class
Soil	34.62	0.58	7.51	26.52	28.4	29.2	42.4	C
DUSA	179.03	4.31	2.13	172.26				
SEKA	51.91	6.86	5.52	39.53				

Exchangable cations as expressed me 100 g<sup>-1</sup>; O.M., organic matter; CEC, cation exchange capacity; O.C., organic carbon; N, total nitrogen

In Seka sludge applied pots pH was measured between 7.60 to 7.65 and Dusa sludge applied pots pH was measured between 6.81 to 7.77. EC increased with sludge additions for both sludge because of the higher salt content of both sludges. Sewage sludges increased CEC in each sludge soil mixures after incubation period. Increasing CEC was evident for soil that had been incubated in the laboratory, especially in the 15 to 30-cm depth samples. This is probably due to the slight increase in organic carbon (Cavallaro et al.1993). Epstein et al. (1976) reported that sewage sludge increased CEC as estimated by the sum of exchangeable cations or "effective CEC." After 140 days of incubation period available P was high at the beginning of the incubation period. Increasing P availability has been associated with sewage sludge and other organic amendments (Barbarick and Workman 1987; McCoy et al. 1986). Organic matter content significantly ( $p<0.01$ ) increased with application of the highest dosage of Dusa sludge compare to Seka sludge. There is no significant difference in total nitrogen content after incubation period.

Table 2. Some physical and chemical properties of soil amended with Dusa and Seka sludges changed differently depending on dosage after 140 days of incubation period.

	PH (1:2.5)	EC dSm <sup>-1</sup>	CEC cmol kg <sup>-1</sup>	Total P mgkg <sup>-1</sup>	AvailableP mgkg <sup>-1</sup>	O.M. (%)	O.C. (%)	N (%)	C/N
Dusa <sub>0</sub>	7.770A	1.510D	36.85B	2636B	302.5C	11.99B	6.000B	0.6100A	10.14A
Dusa <sub>20</sub>	7.520B	1.610D	26.88D	1843C	373.7B	10.91B	5.460B	0.5200A	10.55A
Dusa <sub>40</sub>	7.480B	2.210C	30.32C	2637B	299.7C	11.38B	5.690B	0.6300A	9.080A
Dusa <sub>80</sub>	6.810C	2.940B	36.02B	2901A	356.1B	11.22B	5.610B	0.5600A	10.09A
Dusa <sub>160</sub>	7.450B	4.460A	52.76A	2447B	453.9A	15.75A	7.870A	0.6800A	11.65A
Seka <sub>0</sub>	7.630A	1.620A	37.03B	2753A	299.9C	11.50A	5.75A	0.6700B	10.84A
Seka <sub>20</sub>	7.600A	1.810A	26.76C	1606B	379.5A	10.88B	5.440B	0.5700B	9.740A
Seka <sub>40</sub>	7.600A	1.630A	38.80B	1318C	285.3C	9.620C	4.810B	1.0500A	4.630B
Seka <sub>80</sub>	7.650A	1.920A	37.08B	1671B	331.8B	8.880C	4.440B	1.0400A	4.340B
Seka <sub>160</sub>	7.610A	1.690A	43.24A	1769B	282.2C	11.99A	5.995A	0.6000B	3.210B
1.SD=	0.1964	0.4641	2.826	200.5	31.68	2.137	1.114	0.1553	2.922

O.M., organic matter; CEC, cation exchange capacity; O.C., organic carbon; N, total nitrogen . Significant differences between doses at  $P<0.01$  level indicated by different letters. 0, control; 20, 40, 80, and 160, doses of each sewage sludge as expressed t ha<sup>-1</sup>



### Some Biological Properties of Soil-Sludge Mixtures

Enzyme activities are generally considered to be a more direct expression of soil biological activity or of the activities of specific processes of nutrient cycling and organic matter turnover, than measurements of microbial numbers (Hattori, 1988). The changes in the activities of urease enzyme in the soil amended with Dusa and Seka sludges at 5 rates equivalent to 0, 20, 40, 80, and 160 t ha<sup>-1</sup> are shown in Table 3. Table 3 shows that soil urease activity was significantly ( $p < 0.01$ ) changed after application of different doses of two sewage sludges during incubation period. Urease enzyme activity in soil amended with Seka sludge. Before sludge application soil urease enzyme activity was found 16.97 mg N 100 g<sup>-1</sup>. Urease enzyme activity changed in soil amended with Seka sludge between 17.51 to 35.45 mg N 100 g<sup>-1</sup> in the first day of incubation period. In Dusa sludge, urease activity changed between 27.33 to 54.30 mg N 100 g<sup>-1</sup> depend on the application doses in the first day. Soil urease enzyme activity values decreased to 23.83 to 19.60 mg N 100 g<sup>-1</sup> in Dusa sludge and 15.29 to 18.57 mg N 100 g<sup>-1</sup> in Seka sludge depend on the sludge application doses and incubation time during the incubation period. These values was found significantly ( $p < 0.01$ ) important according to variance analysis. Hoffman and Hofmann (1966) classified soil urease activity levels low ( $>8$ ), normal (between 8-16), and high (16<). Dusa sludge effected on soil urease enzyme activity more than Seka sludge in 160 t ha<sup>-1</sup> dosage rate in first, 7, 28, 42, and 56 days of incubation. This result was found significantly ( $p < 0.01$ ) important depend on variance analysis. Dusa and Seka sludges effected soil urease enzyme activity differently. In all treatments sludge rates increased urease enzyme activity but urease enzyme activity decreased depend on incubation period in amended soil with both sludges.

Table 3. Change of the urease enzyme activity in amended soil with two different sewage sludge during the incubation period.

Inc. Time	Dusa <sub>0</sub>	Dusa <sub>20</sub>	Dusa <sub>40</sub>	Dusa <sub>80</sub>	Dusa <sub>160</sub>	Seka <sub>0</sub>	Seka <sub>20</sub>	Seka <sub>40</sub>	Seka <sub>80</sub>	Seka <sub>160</sub>
1 <sup>st</sup>	27.33D	38.98C	44.88B	54.30A	56.47A	17.51C	19.79C	27.21B	30.07B	35.45A
7 <sup>th</sup>	23.84C	32.77B	36.72B	44.35A	44.13A	15.29C	20.41B	23.23B	22.45B	32.34A
14 <sup>th</sup>	19.44B	20.94B	22.18B	24.89B	31.11A	13.63C	20.61B	22.10B	20.68B	28.56A
28 <sup>th</sup>	18.69B	19.24B	20.87B	23.67B	32.28A	15.98C	19.71B	20.92AB	22.59A	25.21A
42 <sup>nd</sup>	21.99B	22.47B	22.24B	24.90B	31.37A	15.00B	22.63A	22.62A	23.76A	25.55A
56 <sup>th</sup>	21.97C	21.34C	23.35C	27.01A	31.43A	14.82B	20.21A	18.68AB	17.11B	22.84A
70 <sup>th</sup>	18.35B	18.75B	19.88B	20.65B	24.67A	12.55B	16.11B	17.44AB	18.33A	24.32A
105 <sup>th</sup>	17.06	19.94A	19.04A	21.10A	21.90A	13.11B	16.04A	16.35A	18.24A	21.47A
140 <sup>th</sup>	15.89A	17.44A	16.70A	17.84A	19.60A	11.04B	11.07B	15.00AB	17.37A	18.57A

LSD=5.106

+. Significant differences between doses for each sludge horizontally at  $P < 0.01$  level indicated by different letters. Urease expressed as mgN/100 g soil<sup>-1</sup>. Inc. Time, incubation time (day); 0, control; 20, 40, 80, and 160, doses of each sewage sludge as expressed t ha<sup>-1</sup>

Before sludge application, CO<sub>2</sub> evolution was found 3.15 mg CO<sub>2</sub>/100 g 24 hour in soil. In the first day of the incubation period CO<sub>2</sub> evolution was found between 2.04 to 6.47 mg CO<sub>2</sub>/100 g.24 hour in soil amended with Dusa sludge and between 2.98 to 6.40 mg CO<sub>2</sub>/100 g.24 hour in soil amended with Seka sludge. CO<sub>2</sub> evolution increased until 7<sup>th</sup> day of incubation period depend on sludge dosage increase. Following incubation times, CO<sub>2</sub> evolution decreased in soil amended with both Dusa and Seka sludges depend on doses and incubation period. CO<sub>2</sub> evolution that is a result of soil microbial activity and soil organic matter decomposition decreased depend on application doses and increasing time. CO<sub>2</sub> evolution decreases especially in higher rates doses during incubation period this shows inhibition of general-purpose microorganisms in soil (Diaz-Burgos et al.,1993). In all treatments Seka sludge increased CO<sub>2</sub> evolution more than Dusa sludge and this was found significantly ( $p < 0.01$ ) important as a result of variance analysis.



Table 4. CO<sub>2</sub> evolution depend on incubation period and sludge doses

Inc. Time	Dusa <sub>0</sub>	Dusa <sub>20</sub>	Dusa <sub>40</sub>	Dusa <sub>80</sub>	Dusa <sub>160</sub>	Seka <sub>0</sub>	Seka <sub>20</sub>	Seka <sub>40</sub>	Seka <sub>80</sub>	Seka <sub>160</sub>
1 <sup>st</sup>	3.34C	2.17D	2.04D	5.04B	16.47A	3.00B	2.98B	3.17B	6.40A	6.24A
7 <sup>th</sup>	3.54C	4.10C	7.87B	7.37B	9.24A	3.67D	5.70C	8.14B	9.20AB	9.37A
14 <sup>th</sup>	3.00C	2.17C	4.44B	8.50A	7.87A	3.00C	5.17B	5.94B	8.00A	9.00A
28 <sup>th</sup>	2.10B	2.63B	4.30A	4.93A	4.16A	3.60B	2.66B	5.43A	6.23A	6.10A
42 <sup>nd</sup>	3.94AB	4.54A	3.84AB	2.34C	3.17BC	1.74B	2.17B	5.34A	5.34A	6.34A
56 <sup>th</sup>	0.73B	1.60AB	1.20B	1.74AB	2.70A	0.74D	2.30C	4.27B	4.47AB	5.54A
70 <sup>th</sup>	0.21A	0.35A	0.93A	0.97A	0.94A	0.77C	0.89C	2.59B	2.45B	4.40A
105 <sup>th</sup>	0.31A	0.46A	0.82A	1.03A	0.97A	0.52C	0.99BC	1.89B	2.08B	3.37A
140 <sup>th</sup>	0.13A	0.36A	0.50A	0.85A	0.96A	0.09B	1.0AB	1.09AB	1.67A	1.95A

LSD=1.071

+ Significant differences between doses for each sludge horizontally at  $P<0.01$  level indicated by different letters. CO<sub>2</sub> expressed as mg CO<sub>2</sub> 100 g 24 h<sup>-1</sup>. Inc. Time, incubation time (day); 0, control; 20, 40, 80, and 160, doses of each sewage sludge as expressed t ha<sup>-1</sup>. Significant differences between doses at  $P<0.01$  level indicated by different letters.

The changes in the amount of NH<sub>4</sub><sup>+</sup>-N in the soil amended with Dusa and Seka sludges at 5 rates equivalent to 0, 20, 40, 80, and 160 t ha<sup>-1</sup> are shown in Table 5. First day of the incubation, the amount of NH<sub>4</sub><sup>+</sup>-N was found between 160.53 to 270.67 mg kg<sup>-1</sup> in soil amended with Dusa sludge and between 164.97 to 206.50 mg kg<sup>-1</sup> in soil amended with Seka sludge. The amount of NH<sub>4</sub><sup>+</sup>-N decreased depend on the time but it is increased depend on the increasing sludge application doses. In the research, between amonification and time and doses were found significant ( $p<0.01$ ) relations. Sozudogru et al. (1996), was found quicker amonification in the first and second weeks of incubation and than amonification decreased step by step during incubation period. At the end of the incubation period all left NH<sub>4</sub><sup>+</sup>-N (mg kg<sup>-1</sup>) amounts approached each other. (Dusa sludge 33.33-46.33 mg kg<sup>-1</sup>, Seka sludge 42.70-50.23 mg kg<sup>-1</sup>). Quick mineralization can explain with higher Nitrate content (3.26%) and narrow C/N rate (10.47) in the soil amended with Dusa sludge. Slow mineralization can explain with lower Nitrate content (1.14%) and wider C/N rate (21.38) in the soil amended with Seka sludge. There is no different effects of both sludges was found over soil's NH<sub>4</sub><sup>+</sup>-N content except 160 t ha<sup>-1</sup> application rate. Dusa sludge showed higher mineralization than Seka sludge in the 160 t ha<sup>-1</sup> application rate.

The first day of the incubation, the amount of NO<sub>3</sub><sup>-</sup>-N was found between 203.50 to 285.00 mg kg<sup>-1</sup> in soil amended with Dusa sludge and between 140.30 to 247.60 mg kg<sup>-1</sup> in soil amended with Seka sludge. In soil samples amended with Dusa sludge, nitrification increased the highest level and was observed significant differences between doses in six weeks that is following amonification. Table 6 shows that NO<sub>3</sub><sup>-</sup>-N amount was significantly ( $p<0.01$ ) changed depend on dosage rates and incubation period. In soil samples amended with Seka sludge, NH<sub>4</sub><sup>+</sup>-N and NO<sub>3</sub><sup>-</sup>-N amounts were found lower than Dusa's samples but there is more homogeneity in mineralization dispersion. Sozudogru et al. (1996) was found similar results in their incubation research.

In all treatments Dusa sludge significantly ( $p<0.01$ ) showed higher nitrification rate than Seka sludge. Seka and Dusa sludges effected amended soil positively. Dusa sludges had higher plant nutrient matter than Seka sludges. When Dusa sludge was applied to soil it increased soil biological activity rapidly. Both sludges can use as a soil improver or soil fertilizer without any inhibition in the soil if their metal content and trace element content were known.

Table 5.  $\text{NH}_4\text{-N}$  amount depend on incubation period and sludge application doses in experimental soil.

Inc. Time	Dusa <sub>0</sub>	Dusa <sub>20</sub>	Dusa <sub>40</sub>	Dusa <sub>80</sub>	Dusa <sub>160</sub>	Seka <sub>0</sub>	Seka <sub>20</sub>	Seka <sub>40</sub>	Seka <sub>80</sub>	Seka <sub>160</sub>
1 <sup>st</sup>	171.97C	160.53C	174.77C	222.37B	270.67A	164.97D	167.30B	196.23A	206.50A	192.70A
7 <sup>th</sup>	142.57C	159.83C	156.57BC	182.03B	253.17A	142.10A	150.50A	153.67A	139.77A	48.40A
14 <sup>th</sup>	138.00C	143.03B	185.73A	146.53B	170.57A	151.67A	161.70A	151.33A	139.30A	34.40A
28 <sup>th</sup>	154.00B	154.47B	160.07B	164.87B	211.17A	167.53A	156.80A	156.33A	153.30A	150.97A
42 <sup>nd</sup>	124.13B	153.07A	160.77A	140.93A	156.10A	132.10A	141.40A	133.70A	142.60A	134.30A
56 <sup>th</sup>	51.90A	142.80A	135.80A	134.17A	166.37A	44.30A	144.90A	142.10A	156.80A	154.20A
70 <sup>th</sup>	141.17A	80.63B	86.87B	71.70B	121.70A	77.47A	78.87A	79.10A	87.50A	84.13A
105 <sup>th</sup>	120.00A	1176.00B	79.67B	71.33B	110.67A	64.50A	73.03A	66.83A	59.70A	52.67A
140 <sup>th</sup>	44.00A	33.33A	42.00A	35.33A	46.33A	42.70A	42.70A	50.23A	49.03A	43.40A

LSD=29.60

+ Significant differences between doses for each sludge horizontally at  $P<0.01$  level indicated by different letters

$\text{NH}_4\text{-N}$  expressed as  $\text{mg kg}^{-1}$ . Inc. Time, incubation time (day); 0, control; 20, 40, 80, and 160, doses of each sewage sludge as expressed  $\text{t ha}^{-1}$ .

Table 6.  $\text{NO}_3\text{-N}$  amount depend on incubation period and sludge application doses in experimental soil.

Inc. Time	Dusa <sub>0</sub>	Dusa <sub>20</sub>	Dusa <sub>40</sub>	Dusa <sub>80</sub>	Dusa <sub>160</sub>	Seka <sub>0</sub>	Seka <sub>20</sub>	Seka <sub>40</sub>	Seka <sub>80</sub>	Seka <sub>160</sub>
1 <sup>st</sup>	230.80B	220.00B	240.30B	273.50A	285.00A	203.50B	199.70B	140.30C	235.70A	247.60A
7 <sup>th</sup>	203.60D	305.00C	340.90B	418.60A	444.70A	222.90C	229.10C	220.50C	274.40B	326.40A
14 <sup>th</sup>	232.90E	336.30D	413.00C	544.40B	594.50A	258.10B	250.10B	220.80C	287.90A	299.30A
28 <sup>th</sup>	267.60E	365.40D	593.30B	499.30C	812.20A	299.60A	265.80C	282.10B	279.80B	314.80A
42 <sup>nd</sup>	267.40E	406.70D	505.60C	666.60B	868.70A	294.00C	287.50D	319.00B	343.90A	362.10A
56 <sup>th</sup>	240.20D	266.20C	1312.20B	287.50B	362.10A	275.10E	408.80C	465.70B	513.60A	308.20A
70 <sup>th</sup>	348.10D	395.20B	474.20A	421.90B	380.70C	259.60	216.50C	264.30B	339.40A	322.60A
105 <sup>th</sup>	379.70A	402.90B	407.00A	387.00A	357.30B	292.00A	217.00B	222.00B	279.70A	275.70A
140 <sup>th</sup>	328.30B	309.00B	361.00A	378.0A	318.70B	310.70B	265.70C	316.00B	321.70B	355.30A

LSD=29.60

+ Significant differences between doses for each sludge horizontally at  $P<0.01$  level indicated by different letters.  $\text{NO}_3\text{-N}$  expressed as  $\text{mg kg}^{-1}$ . Inc. Time, incubation time (day); 0, control; 20, 40, 80, and 160, doses of each sewage sludge as expressed  $\text{t ha}^{-1}$ .

**ACKNOWLEDGEMENTS:** This PhD thesis has been supported by TUBITAK through contract No: TOGTAG-1472.

## REFERENCES

- Barbarick, K. A., S.M. Workman. (1987). Ammonium bicarbonate-DTPA and DTPA extractions of sewage sludge amended soils. *J. Environ. Qual.* 16:125-130.
- Bouyoucus, G.O.A. (1951). Recalibration of the hydrometer method for making mechanical analysis of soils. *Agronomy Journal*, 43, 434-438.

- Börekçi, M. (1991). Türkiye topraklarında katyon değişim kapasitesi ile değişebilir katyonların tayininde uygulanacak metodlar, T.C. Tarım ve Köyişleri Bakanlığı, Köy Hizmetleri Genel Müdürlüğü, Toprak ve Gübre Araştırma Enstitüsü Müdürlüğü, 174, Ankara, 37-40.
- Bremner, J.M. (1965). Methods of soil analysis, Part 2, Chemical and Microbiological Properties, Ed. C.A. Black, Amer. Soc. of Agron. Inc. Pub. Agron. Series No:9, Madison, Wisconsin, USA.
- Cavallaro, N., N. Padilla, J. Villarrubia, (1993). Sewage sludge effects on chemical properties of acid soils. *Soil Science*, 156, 2, 63-70.
- Chapman, H.D. (1965). Methods of soil analysis Part 2. Chemical microbiological properties. Ed. C.A. Black. Amer. Soc. Of Agron. Inc. Publ. Agron. Series no: 9, Medison, Wis, USA.
- Chander, K., P.C. Brookes. 1991. Effects of heavy metals from past applications of sewage sludge on microbial biomass and organic matter accumulation in a sandy loam and silty loam U.K. soil. *Soil Biol. Biochem.* Vol. 23, No. 10: 927-932.
- De Boodt, M., O. Verdonck, I. Cappaert. (1973). Method of measuring the water release curve of organic substrates. *Proceeding Symposium Artificial Media in Horticulture*. 2054-2062.
- Díaz-Burgos, A., B. Ceccanti, A. Polo. (1993). Monitoring biochemical activity during sewage sludge composting. *Biology and Fertility of Soils*. 16: 145-150.
- Epstein, E., J.M. Taylor, R.L. Chaney. (1976). Effect of sewage sludge and sludge compost applied to soil on some soil chemical properties. *J. Environ. Qual.* 5: 423-426.
- Hattori, H. (1988). Microbial activities in soil amended with sewage sludge. *Soil. Sci. Plant Nutr.* 34(2): 221-232.
- Hoffman, G.G., K. Teicher. (1957). Das enzyme system unserer kultur boden 7, *Proteçsan* 11. *Zeitschrift Für Pflanzenernährung und bodenkunde*, 77(122), Bonn.
- Hofmann, E., G.G. Hoffman. (1966). Die bestimmung der biologischen tatigkeit in boden mit enzymmethoden. Reprinted from *advance in Enzymology and related subject of Biochemistry*, 28, p: 365-390.
- Isermayer, H. (1952). Eine einfache methode zur bestimmung der boden atmung und karbonate in boden. 2. *Pflanzenernaehrung, Düngung und Bodenkunde*, 56, 26-8.
- Jackson, M.L. *Soil chemical analysis*. Prentice-Hall Inc. New York, (1962).
- Kacar, B. (1990). Gübre Analizleri. Ank. Üniv. Ziraat Fak. Eğitim Araş. Gel. Vakfı Yay. Ankara Üni. Basımevi, ANKARA.
- Kacar, B. (1996). Bitki ve toprağın kimyasal analizleri. Ank. Üniv. Ziraat Fak. Eğitim Araş. Gelş. Vakfı Yay. No:3. A.Ü. Basımevi, ANKARA, 223-225.
- Mc Coy, J.L., L.J. Sikora, R.R. Weil. (1986). Plant availability of phosphorus in sewage sludge compost. *J. Environ. Qual.* 15: 403-409.
- Öztan, B., H. Ülgen, N. (1961) Saturasyon macununda ve ekstraktında tuz tayinleri. *Toprak ve Gübre Araştırma Ens. Müdürlüğü Yayınları, Teknik yayın No:7*, Ankara.
- Reddy, G.B., A. Faza, R. Bennett, (1987). Activity of enzymes in rhizosphere and nonrhizosphere soils amended with sludge, *Soil Biol. Biochem.*, 19, 2: 203-205.
- Richards L.A. (1949), Methods of measuring soil moisture tension. *Soil Sci.*, 68-95-112.
- Richards, L.A. (1954), Diagnosis and improvement of saline and alkaline soils. U.S. Dept. Agr. Handbook, No. 60, p: 110-118.
- Sözüdoğru, S., A. Karaca, K. Haktanır, (1996). Tavuk gübresinin azot mineralizasyonu ve üreaz aktivitesi üzerine etkisi. Ank. Üni. Ziraat Fak. Bilimsel Araştırma ve İncelemeler: 798, Ankara.
- Stroo, H.F., E.M. Jencks. (1985). Effect of Sewage Sludge on Microbial Activity in an Old, Abandoned Mineral soil. *J. Environ. Qual.*, V. 14, 3: 301-304.



# DIFFERENT INDICES IN SOIL BIOLOGICAL ACTIVITIES; MEASUREMENTS OF SOIL MICROBIAL BIOMASS CARBON, NITROGEN AND NRN

Oguz Can Turgay, Akira Haraguchi

Department of Environmental Science, Faculty of Science, Niigata University, Igarashi, 2-8050,  
Niigata, 950-2181, JAPAN

## SUMMARY

The measurement of soil microbial biomass (SMB) is one of the most reliable procedures commonly used for a better comprehension of the nutrient cycle in soil. We used several SMB indices to monitor microbial pool in a wider scale in soil. The objectives of this study were to (i) quantify biomass C, N, ( $B_C$ ,  $B_N$ ) and also Ninhydrin Reactive Nitrogen ( $B_{NRN}$ ), which is a fraction consisted of mainly  $NH_4^+$  N and amino groups (amino acids, proteins and peptides etc.) included by microorganisms and (ii) to test the reliability of these parameters by comparing with soil properties in an andosol soil under different managements. The soil samples were collected from three agricultural plots, under different management in Muramatsu Experimental Station and from neighboring forest site (pine) in Niigata Prefecture, Japan. Following soil fumigation with ethanol free chloroform, a group of samples was extracted with 0.5 M  $K_2SO_4$  and extractable NRN, C, total N,  $NH_4^+$  N were determined in fumigated and unfumigated  $K_2SO_4$  extracts. All SMB values were calculated according to the chloroform-fumigation extraction (CFE) procedure. Biomass parameters showed no remarkable difference between manure and slurry-amended plots. However, marked differences in all soil biomass values were observed among adjacent agricultural and forest ecosystems, in the same climatic environment related with the management. The results, overall, showed that SMB measurements were effective on the determination of microbial pool and were well accorded with soil characteristics.

## INTRODUCTION

Soil organic matter is known to represent the primary origin of energy for microorganisms and can be divided into several fractions that vary in turnover time from hours to thousands of years. The active fraction of organic matter consisted of amino acids, groups of proteins and carbohydrates, represents small, but dynamic portion of the huge and slowly changing background of stabile organic matter. This labile pool is readily available for microbial use and is mostly stored by soil microorganisms. A portion of such kind of organic substances can be quantified as an indicator of actual amount of microbial populations. Thus, there has been increasing interest to definite measurements of the soil microbial biomass and several methods have been attempted to improve more accurate and useful procedure for microbial biomass measurements over the last two decades. Among these methods, Chloroform Fumigation Extraction (CFE) method (Vance et al, 1987) has been more commonly used due to its simplicity and applicability for wide group of soils. This technique is theoretically based on the quantitative extraction of a particular compound, found in all components of the microbial community but in no other constituents of soil. Furthermore, various organic forms such as soluble free sugars, carbohydrates and proteins can be measured in the same extracts (DeLuca and Keeney, 1993b; DeLuca, 1998; Joergensen et al, 1996). However, there are not so many works regarding the determination of particular organic forms in SMB. Ninhydrin, which is a reagent forming a purple complex with varying molecules comprising  $\alpha$ -amino nitrogen and with ammonium and other compounds with free  $\alpha$ -amino groups such as amino acids, peptides and proteins (Moore and Stein 1948) has been lately used as a simple and reliable parameter in microbial biomass determinations (Joergensen and Brookes 1990). In the present study, we assayed ninhydrin reactive compounds to evaluate SMB pool in a wider scale. Our aims were to quantify microbial biomass and also NRN under different soil and test the reliability of these parameters by comparing each other and soil parameters.

## MATERIALS and METHODS

The arable soils (0-10 cm) were sampled from 3 soil plots of Muramatsu Experimental Station, which is located in central Niigata (139° 11 E, 37° 41 N), and from a forest site, near the station in May 1999. The soil type was Andosol which has highly good soil structure, porosity, water holding

capacity, permeability, and which is rich in allophanes and humus containing humified black colored humic substances. Recent crop pattern was watermelon in two of the arable plots, which had been amended with slurry and manure previously. In these plots, soil sampling was made after harvest, before following cultivation. The third plot was a 10-years-old fruit garden, planted with apricot trees. Forest sample was collected after removal of the litter layer from the same depth with arable plots. Each site was sampled 10 times with 50x50 mm soil cores. The samples then bulked and large pieces of plant materials were picked up before pretreatments. All samples were passed through a sieve (2 mm), adjusted to a WHC of 40%, pre-incubated at 25 °C a week and stored at 4 °C before analysis. Soil pH was measured in H<sub>2</sub>O and KCl with a soil to solution ratio of 1:2.5. Soil organic C and N were determined C-N Analyzer (Sumigraph NC-90A).

All SMB parameters were measured by the fumigation-extraction procedure according to Vance et al. (1987) and the extracts were stored at -20 °C prior to analysis.

*Ninhydrin Reactive Nitrogen* determination in soil extracts was carried out as indicated by Joergensen and Brookes (1990). Following addition of ninhydrin solution, reaction was measured colorimetrically at 570 nm.

*Extractable total N* was tested by total persulfate oxidation procedure based on the oxidation of total N to NO<sub>3</sub>-N in an alkali at elevated temperature by using persulfate as described by Cabrera and Beare (1993); Total N, which had been oxidized to NO<sub>3</sub>-N, was reduced to NO<sub>2</sub><sup>-</sup> N within copperized cadmium reduction unit. NO<sub>2</sub><sup>-</sup> N was then measured according to modified Gries Ilosvay method (Keeney and Nelson, 1982).

*Extractable NH<sub>4</sub>* in soil extracts was determined colorimetrically, similar to the original indophenol blue procedure (Alef and Nannipieri, 1995).

*Extractable C* in soil extracts was measured with automated carbon analyzer (SHIMADZU, TOC 5000 model), accelerating and simplifying the organic C determination by using combustion, oxidation and infrared ray absorption processes (Wu et al, 1990; Shibara and Inubushi 1995).

#### Soil microbial biomass calculations

*Biomass C* ( $B_C$ ) was calculated as indicated by (Wu et al, 1990),  $B_C = E_C: k_{EC}$  where  $E_C$ : (extractable C in fumigated soil extracts) – (extractable C in non-fumigated soil extracts) and  $k_{EC}$ : 0.45 (extractable part of microbial C after fumigation)

*Biomass-N* was calculated according to Jenkinson (1988). ( $B_N$ ) =  $E_N: k_{EN}$ , where  $E_N$ : (total N, determined in fumigated extracts) – (total N, determined in non-fumigated soil extracts) and  $k_{EN}$ : 0.45 (extractable part of microbial N after fumigation)

*Biomass ninhydrin reactive N*, ( $B_{NRN}$ ) and extractable NH<sub>4</sub><sup>+</sup>-N ( $E_{NH4}$ ) were calculated based on the same principle of the FE method  $B_{NRN}$  = (ninhydrin-N in extracts of fumigated soils) – (ninhydrin-N in extracts of non-fumigated soils) and  $E_{NH4}$  = (NH<sub>4</sub><sup>+</sup>-N in extracts of fumigated soils) – (NH<sub>4</sub><sup>+</sup>-N in extracts of non-fumigated soils) (Joergensen and Brooke, 1990).

*α-amino N*, which represents amino acids, proteins and peptides included by microorganisms, was calculated from the difference ( $B_{NRN}$  and  $E_{NH4}$ ) as indicated by Joergensen and Brooke (1990). With the exception of NRN values obtained from five replicate measurements, the results presented are arithmetic means of three replicate measurements and expressed on an oven dry basis (24h at 105 °C). Statistical analyses (simple linear regression and Pearson covariance test) were calculated by MINITAB.

Table 1. Description of the top soils in the sites.

Soil Site	Soil texture	Cultivation	Applied Years	pH (H <sub>2</sub> O)	Organic C (mg g <sup>-1</sup> )	Total N (mg g <sup>-1</sup> )	C/N
1 (crop)	SiC	Watermelon <sup>*</sup>	1	6.0	55.6	3.5	16.0
2 (crop)	SiC	Watermelon <sup>††</sup>	1	5.9	56.2	3.6	15.7
3 (fruit garden)	SiC	Apricot	10	6.8	69.3	4.9	14.1
4 (forest)	SiC	Pine	u	5.0	111.3	6.2	18.0

SiC: silty clay. \*: slurry-amended watermelon plot. ††: manure-amended watermelon plot. u: unknown

#### RESULTS AND DISCUSSION

The soil properties (Table 1) and extractable fractions of the soil biomass measured by different techniques are shown for each site (Table 2). The forest soil showed the highest values for all



extractable biomass materials, 836 mg C, 82.9 mg N and 138.2 mg NRN kg<sup>-1</sup> soil, followed by fruit garden soil, 474 mg C, 45.6 mg N and 117.8 mg NRN kg<sup>-1</sup> soil respectively. Slurry and manure amended plot appeared to have same amount of extractable N values, 14.8 mg N, 22 mg NRN kg<sup>-1</sup> soil as a mean of both plots. However, extractable C in manure amended plot was slightly higher than that in slurry amended plot. The results indicated that extractable SMB components ( $E_C$ ,  $E_N$ ,  $B_{NRN}$ ) were significantly correlated with soil organic C, total N and also with each other (Table 4). Soil pH and C:N ratios did not show reasonable correlation with biomass parameters. C:N ratios were not significantly different between cultivated soils (15.3 as an average of cultivated soils and 18.0 for forest soil) which suggests that C and N are in an identical balance in cultivated soils. However, it is clear that three systems are fundamentally different in management. Therefore, C:N ratios does not reflect the status of internal C and N cycle on microbial biomass efficiently.

Table 2. Extractable microbial C, N, NRN and NH<sub>4</sub><sup>+</sup> N of soils.

Soil	Extractable C (mg kg <sup>-1</sup> )		Extractable N (mg kg <sup>-1</sup> )		Extractable NRN (mg kg <sup>-1</sup> )		Extractable NH <sub>4</sub> <sup>+</sup> N (mg kg <sup>-1</sup> )						
Sites	Fumigated	Control	E <sub>C</sub> <sup>a</sup>	Fumigated	Control	E <sub>N</sub> <sup>b</sup>	Fumigated	Control	B <sub>NRN</sub> <sup>c</sup>	Fumigated	Control	E <sub>NH<sub>4</sub></sub> <sup>d</sup>	A/N <sup>e</sup>
Watermelon <sup>+</sup>	387 ± 6.08 <sup>f</sup>	152 ± 2.03	235	37.8 ± 0.57	22.7 ± 2.04	15.1	33.8 ± 0.972	11.4 ± 0.87	22.4	27.2 ± 0.000	23.7 ± 0.503	3.5	18.8
Watermelon <sup>+</sup>	422 ± 13.29	153 ± 0.81	269	37.5 ± 0.21	22.9 ± 1.227	14.5	34.1 ± 0.106	12.5 ± 0.184	21.6	21.2 ± 0.400	17.7 ± 0.833	3.5	18.1
Apricot	581 ± 14.68	106 ± 4.13	474	94.4 ± 0.33	48.8 ± 2.16	45.6	138.6 ± 2.07	20.8 ± 0.692	117.8	46.6 ± 0.120	22.1 ± 0.300	24.5	93.3
Pine	1200 ± 8.1	364 ± 13.5	836	119.6 ± 0.35	36.6 ± 5.75	82.9	188.1 ± 4.07	49.9 ± 2.02	138.2	59.8 ± 0.306	28.1 ± 0.100	31.7	106.5

<sup>a</sup>  $E_C$  = {(amount of organic C extracted from fumigated soil) - (amount of organic C extracted from (unfumigated) soil)}.

<sup>b</sup>  $E_N$  = {(amount of organic N extracted from fumigated soil) - (amount of organic N extracted from (unfumigated) soil)}.

<sup>c</sup>  $B_{NRN}$  = {(amount of NRN extracted from fumigated soil) - (amount of NRN extracted from unfumigated soil)}.

<sup>d</sup>  $E_{NH_4}$  = {(amount of NH<sub>4</sub><sup>+</sup> N extracted from fumigated soil) - (amount of NH<sub>4</sub><sup>+</sup> N extracted from unfumigated soil)}

<sup>e</sup>  $\alpha$ -A. N =  $\alpha$  amino nitrogen {( $E_{NRN}$  -  $E_{NH_4}$ )}

<sup>f</sup> Mean ± standard error.

### Comparison of microbial biomass under different managements

A particular proportion of the soil organic matter input is readily utilized by the organisms, such that the biomass C generally comprises only 1-5% of the soil organic carbon in soil (Jenkinson and Ladd, 1981; Sparling, 1985; Smith and Paul, 1990). The results found in our study suggest that microbial C was approximately 1% of soil organic matter in cropped plots, which have been managed under intensive crop rotation (corn, potato, bean, leek, sunflower, and also watermelon) since 1987, comparatively lower than fruit garden (1.51%) and forest soil (1.66%) (Table 3). Probably, this is because of the cultivation, causing significant disturbance to soil organisms. Active biomass pool in cropped plots apparently regulated by agricultural practices, which alter nutrient input and output frequently. Comparing with these plots, fruit garden and forest soils have much larger biomass C, N and NRN contents due to the facts that the main source of organic input to the biomass in natural ecosystems is from plant material, consisting of roots, leaf, stem litter and actual biomass pool does not alter apart from the fluctuational effects of seasonal changes. Fruit garden has been apricot-planted plot for more than 10 years, means much less cultivation disturbing natural biomass and providing a relatively stable nutrient flow which is similar to that in forest ecosystem. In grassland and arable soils, the microbial biomass contains an average 3.1% of total N, ranging from 0.5% to 6.6% (Joergensen and Mueller, 1996).

Table 3. Soil microbial biomass and its ratio to soil organic C and total N.

Soil sites	Biomass C <sup>b</sup> (mg.kg <sup>-1</sup> )	Rate in organic C <sup>c</sup> (%)	Biomass N <sup>d</sup> (mg.kg <sup>-1</sup> )	Rate in total N (%)	$B_{NRN}$ <sup>e</sup> (mg.kg <sup>-1</sup> )	Rate in total N (%)
Watermelon <sup>+</sup>	522	0.94	33.6	0.98	22.4	0.64
Watermelon <sup>+</sup>	597	1.06	32.3	0.90	21.6	0.60
Apricot	1054	1.51	101.4	2.07	117.8	2.40
Pine	1859	1.66	184.3	2.98	138.2	2.25

<sup>b</sup> Biomass C =  $E_C / k_{EC}$  ( $k_{EC}$  = 0.45, Wu et al, 1990) <sup>c</sup> Biomass-N =  $E_N / k_{EN}$  ( $k_{EN}$  = 0.45 Jenkinson, 1988).

<sup>d</sup>  $B_{NRN}$  = (ninydrin-N in extracts of fumigated soil) - (ninydrin-N in extracts of non-fumigated soil) (Joergensen and Brookes, 1990).

We observed identical inclination in biomass N as a function of total soil N in all soil sites (0.94% for intensively cultivated soils, 2.07% for fruit garden soil and 2.98% for forest soil).  $B_{NRN}$



values and their ratios in total N, ranging between 0.64% and 2.23% (Table 3), were also in agreement with biomass C % and biomass N%. Ninhydrin reactive compounds represent certain cytoplasmic products of microorganisms which are mainly amino acids and  $\text{NH}_4^+$  N. Besides, it reacts with free  $\alpha$ -amino groups consisting of amino acids, peptides and proteins (Moore and Stein, 1948). The substrates such as amino acids and carbohydrates, which form a temporary pool reflecting microbial activity and the delicate balance between degradation and synthesis of organic materials, have been used as a measure of organic matter quality (Stevenson 1982; Arshad et al, 1990). We, therefore, measured microbial  $\text{NH}_4^+$  N separately to calculate the fraction of  $\alpha$ -amino N (see biomass calculations), and obtain a sensitive parameter.  $\text{NH}_4^+$  N contents of non-fumigated soils, which were taken as soil  $\text{NH}_4^+$  N, ranged from 17.7 to 28.1  $\text{mg kg}^{-1}$  soil and did not show good correlation with soil and biomass parameters. In contrast to soil  $\text{NH}_4^+$  N, the fraction of  $\alpha$ -amino N widely ranged from 18.8 to 106.5  $\text{mg kg}^{-1}$  (Table 2) and was significantly correlated with organic C, total N and also biomass parameters (Table 4) which suggests that organic N is mostly accumulated by microbial biomass as proteins, peptides, amino acids etc. and microorganisms are highly competitive for N in the ecosystems where an available C source is not restricted (Jackson et al 1989; Schimel et al 1989).

Table 4. Matrix of correlation coefficients.

Parameters	$E_N$	$E_C$	$E_{NRN}$	$\alpha$ -amino N	$\text{NH}_4^+$ N
Organic C	0.96****	0.97****	0.82***	0.81***	0.80*
Total N	0.98****	0.97****	0.94****	0.94****	0.74*
C/N	0.52	0.58*	0.20	0.18	0.63*
$E_N$		0.99****	0.93****	0.92****	0.79*
$E_C$			0.90****	0.89****	0.77*
$E_{NRN}$				1.0****	0.66*
$\alpha$ -amino N					0.68*

\*correlation coefficients. \* P  $\geq 0.05$ ; \*\*\* P  $\leq 0.001$ ; \*\*\*\* P  $\leq 0.0001$  n=12

## CONCLUSION

It is well understood that cultivation accelerates decomposition of organic matter and results in lower levels of microbial biomass. However, there is no much information regarding organic matter quality and if it is influenced by cultivation. Specific or total determinations of amino acids and carbohydrates are highly reasonable alternatives to evaluate organic matter quality and provide a comparison of microbial N content but represents a limited fraction of total biomass N. Thus, we tested biomass C, and N in addition to NRN and  $\alpha$ -amino N measurements to evaluate the actual size of the microbial pool under different managements. We concluded that NRN was significantly correlated with biomass C, and N and can be used as a reliable biomass parameter monitoring amino acid pool within a wide extent in soil.

**Acknowledgments.** We would like to thank Mr. Akihiro Furubayashi, Faculty of Agriculture, Niigata University, and also Seiichi Nohara, NIES, Tsukuba for their technical assistance.

## REFERENCES

- Alef, K. and Nannipieri, P. 1995. Methods in Applied Soil Microbiology and Biochemistry. Soil nitrogen. Academic Press Limited. 24-28 Oval Road, London NW1. 7DX. pp 79-87
- Arshad, M.A., Schnitzer, M., Angers, D.A. and Ripeester, J.A., 1990. Effects of till vs no-till on the quality of soil organic matter. Soil Biol. Biochem. 22, 595-599
- Cabrera, M.R., and Beare, M.H. 1993. Alkaline persulphate oxidation for determining total nitrogen in microbial biomass extracts. Soil Sci. Soc. Am. J. 57, 1007-1012
- DeLuca, T.H., and Keeney, D.R., 1993b. Soluble anthrone reactive carbon in soils; effect of carbon and nitrogen amendments. Soil Sci. Soc. Am. J. 57, 1296-1300
- DeLuca, T.H., 1998. Relationship of 0.5 M  $\text{K}_2\text{SO}_4$  extractable anthrone reactive carbon to indices of microbial activity in forest soils. Soil Biol Biochem. 30, 1293-1299
- Jackson, L.E., Schimel, J.P. and Firestone, M.K. 1989. Short-term partitioning of ammonium and nitrate between plants and microbes in an annual grassland. Soil Biol. Biochem. 21, 409-415
- Jenkinson, D.S. and Ladd, J.M. 1981. Microbial biomass in soil: measurement and turnover. In: Soil Biochemistry, vol 5 Paul E.A., Ladd J.N (eds). Dekker, New York, pp. 415-471
- Jenkinson, D.S. 1988. The determination of microbial biomass C and nitrogen in soil. In: Advances in

- nitrogen cycling in agricultural ecosystems. Wilson JR (ed) CAB International, Wallingford, 368-386
- Joergensen, R.G. and Brookes, P.C. 1990. Ninhydrin reactive nitrogen measurements of microbial biomass in 0.5 M K<sub>2</sub>SO<sub>4</sub> soil extracts. *Soil Biol. Biochem.* 22, 1023-1027
- Joergensen R.G. and Mueller, T. 1996. The fumigation-extraction method to estimate soil microbial biomass: calibration of the k<sub>EN</sub> value. *Soil Biol. Biochem.* 28,33-37
- Joergensen, R.G., Mueller, T., and Volkmar, W. 1996. Total carbohydrates of the soil microbial biomass in 0.5 M K<sub>2</sub>SO<sub>4</sub> soil extracts. *Soil Biol. Biochem.* 28, 1147-1153
- Keeney, D.R., and Nelson, M.H. 1982. Nitrogen-inorganic forms In; *Methods of soil analysis, part 2, chemical and microbiological methods* page AL, Miller DR, Keeney Dr (eds). *Agronomy* 9(2), ASA, SSSA, Madison, WI, 643-698
- Moore, S. and Stein, W.H. 1948. Photometric ninhydrin method for use in chromatography of amino acids. *J Biol. Chem.* 243: 6281-6283
- Schimel, J.P., Jackson, L.E. and Firestone, M.K. 1989. Spatial and temporal effects on plant microbial competition for inorganic nitrogen in a California annual grassland. *Soil Biol. Biochem.* 21, 1059-1066.
- Shibara, F. and Inubushi, K. 1995: Measurement of microbial biomass C and N in paddy soils by the fumigation-extraction method. *Jpn. J. Soil Sci. Plant Nutr.*, 41-(4), 681-689
- Smith, L.J. and Paul, E.A. 1990. The significance of soil microbial biomass estimations. *Soil Biochemistry*, vol 6 Bollag J.M, Stotzky G (eds). Marcel Dekker, New York, pp. 357-396
- Sparling, G.P. 1985. The soil biomass. In: *Soil Organic Matter and Biological Activity*. Vaughan O, Malcolm RE (eds). Martinus Nijhoff / Dr W Junk, Dordrecht, Boston, Lancaster, p. 223
- Stevenson, F.J. 1982. *Humus chemistry*. John Wiley and Sons, New York.
- Vance, E.D., Brookes, P.C. and Jenkinson, D.S. (1987b). An extraction method for measuring soil microbial biomass. *Soil. Biol. Biochem.* 19, 703-707
- Wu, J., Joergensen, R.G., Pommerening, B., Chaussod, R. and Brookes, P.C. 1990. Measurement of soil microbial biomass-an automated procedure. *Soil Biol. Biochem.* 22, 1167-1169.

# BITTER GOURD (*MOMORDICA CHARANTIA* L.) GROWING IN GÖDÖLLŐ REGION HUNGARY

Bela Berenyi, Csilla Kleinheincz  
Szent István University, Faculty of Agriculture and Environmental Sciences in Gödöllő  
Department of Tropical and Subtropical Agriculture  
H-2103 Gödöllő, P.O.Box 303. HUNGARY

## ABSTRACT

The *Momordica charantia* L. is nowadays a significant vegetable and herb in the South-Asian countries. The authors have examined the possibilities of the growing of the bitter gourd under the climatic and soil conditions of Gödöllő. In the test the authors determined the sowing time and the methods of cultivation and harvesting of the bitter gourd, an alternative vegetable.

## INTRODUCTION

Pálvölgyi-Szedák (1996) have summarised the expected effects of climatic change in Hungary by the year 2030. Their conclusions are the following: the warming up in the period between April-September won't be higher than 3 °C and the probability, that it will be less than 1.2 °C, is 50%. This means 10-40% less clouds in the summer, and 30-90 mm less rainfall in the summer period, causing a higher frequency and degree of droughts.

The warming up in winter will be 0.2-5 °C with a probability of 90%, most likely it will be 0.6-3.4 °C.

They assumed that the rainfall in the winter period will be higher, and it will fall as rain due to milder climates.

The humidity of the soil will not increase as the evaporation in the warmer period between October and March will compensate the effect of the increased rainfall.

The length and phase of seasons will change significantly; the short spring with unsettled weather will be followed by a longer summer period, with only slightly higher mean temperature than it is today. Autumn will begin later and last longer with an "Indian summer", and the mild winter will frost from January until March. The climate will be "Mediterraneanised" and similar to the cities of Belgrade and Ljubljana.

This assumption was revised by Mátyás (1996) who compared the future climate of Hungary to the steppe climate of the Anatolian Highlands as the continental character dominates both areas being surrounded by chains of high mountains.

In the south-part of Hungary where climate is mainly continental with mediterranean influence in historical time fig (*Ficus carica* L.) and pomegranate (*Punica granatum* L.) were introduced.

In 1980 the ground nut (*Arachis hypogaea* L.) chick pea (*Cicer arietinum* L.) lady finger or bahmia (*Abelmoschus esculentus* (L.) Moench) kiwi fruit (*Actinidia chinensis* Planch and *A. arguta* Miq.) were newly introduced for mass production in Hungary. In 1983 for decoration banana was introduced and propagated with the method of meristeme propagation by Mericlon on the base of the suggestion of the author.

Since the climate of Hungary is changing the introduction of new vegetable varieties that take advantage of the warm and dry conditions is advisable. The production of bitter gourd (*Momordica charantia* L.) could cover the demand of the neighbouring countries, mainly Austria and Germany.

## MATERIAL AND METHODS

Most relevant information were established on the fields tests at the Experimental Station of Horticulture of the Faculty of Agriculture and Environmental Sciences in Gödöllő Szent István University.

The experimental site had a brown forest soil with a mechanical composition of adobe and sand. Its ability to retain water was (FC%) 22-23 vol.% in the ploughed layer and 13-15 vol.% in



deeper layers. The value of useful water content decreases with depth from 15-16 vol.% to 8-10 vol.% (I. Helyes and Gy. Varga, 1990). The average precipitation is 564 mm a year.

Bitter gourd is sown in the Spring but it also can be planted. It may be planted on the tropics in the Autumn. The time of planting affects the appearance of male and female flowers through the changes in the length of the day. The vegetation period is between 2-4 months.

Bitter gourd can be grown either on trellis or without it. On the experimental site a 170 cm high trellis was used. Seedlings were planted 50 cm from each other.

Seeds were sown in two groups, on 9<sup>th</sup> of June, 1999 and on 5<sup>th</sup> of July. Germination occurred after five days.

## RESULTS AND DISCUSSION

Bitter gourd is an important vegetable in several countries. The fruit is cut into pieces before cooking and soaked in water to wash out the bitter components. The young sprouts and leaves are also used.

The fruit is rich in vitamins, it contains mainly A B1, B2 and C-vitamin, the latter can be even 100 mg in 100 g of fruit. The fruit also contains several minerals (Ca 137.69 mg/100 g fresh fruit, Mg 119.92 mg/100g) (Yuwai, Rao, Kaluwin, Jones and Rivett, 1991). It is thought to be a good iron source but the iron content is only due to the high iron content of the tropical soils. The levels of trace minerals are low (Cu 3.54 mg/100g, Fe 5.97 mg/100g, Zn 3.53 mg/100g). The fruit contains 93.2 % water. Fatty acids give 0.76 % of the dry matter with  $\alpha$ -eleostearic as the leading fatty acid in bitter gourd. The amino-acid analysis of the bitter gourd has shown that the fruit contains almost every essential amino-acid in the right proportion except lysine, cystine and methionine.

As a herb it can be used in different forms. The root has a contractive effect, the fruit is used as a remedy for catarrh, flux and cough. The juice is drunk as a remedy for chronic colitis and bacillary dysentery (Perry, 1980). The fruit reduces the blood-sugar level.

The plants were given additional irrigation but they seemed to endure the effects of drought as well. The flowering was not disturbed by the drought. The plants were grown without additional fertiliser. Twice hoeing was necessary against the weeds. Only aphids appeared at the end of the vegetation period, but it seems likely that in case of production on larger areas other pests and diseases may appear.

Although cold reduced the growing rate of the fruits, the plant itself endured cool conditions until the beginning of October, no chronic changes could be seen on the leaves. However, it should not be left on the field in October because it will be blighted by frost.

## RESULTS

1. The flowering and fruit-growing of the plant was not affected by the length of the day, therefore production in polyethylene or glass greenhouse is possible in Hungary.
2. The rate and appearance of male and female flowers should be examined further, and the effect of pruning on the yield should be experimented.
3. From this year on hybrids will be tested. In the future the authors are planning to modify the cultivation methods of the bitter gourd to make the production more economical in Hungary.

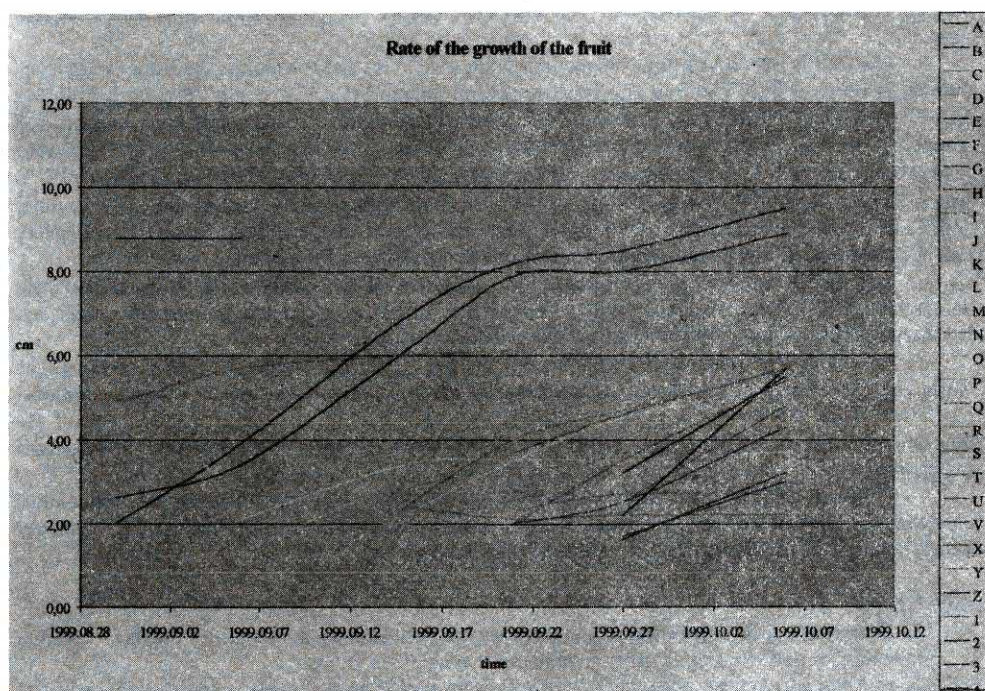
## REFERENCES

- Abusalcha, Dutta O.P.(1994): Performance of bittergourd (*Momordica charantia* L.) under different training systems. *Indian Journal of Agricultural Sciences*. 64/7 479-481 pp.
- Berényi, Béla(1998): Introduction of new species of plants to Hungarian Agriculture. Published in *International Symposium on arid region soil*. Turkey 654-660.
- Hodossi, S.(1983): Fontos trópusi kabakos zöldségnövény a chayote és a keserűtök. *Kertgazdaság*. XV/2. 33-36.
- Kuri E Yuwai, Koyyalamudi Sundar Rao, Chalapan Kaluwin, Gwyn P.Jones, Donald E. Riwett(1991): Chemical Composition of *Momordica charantia* L. Fruits. *J. Agric. Food Chem.* 39: 1762-1763.
- S.Mendlinger, S. Huyskens, A. Benzioni, M. Ventura(1992): Optimization of agrotechniques for cultivating *Momordica charantia* L. (karela). *Journal of Horticultural Science* 67/2: 259-264.

Rasco O. A., Castillo S. P.(1990): Flowering patterns and vine pruning effects in bittergourd (*Momordica charantia* L. L.) varieties „Sta. Rita” and „Makiling”.*The Philippine Agriculturist*. 73/3-4: 311-322.

Varga, Gy., Helyes, L., Dimény, J., Somos, A. (1996): The marks of drought on different vegetable crops under the Hungarian ecological conditions. *1<sup>st</sup> Egypt-Hung. Hort. Conf.* 2.

## APPENDICES





# A MODEL CONCERNING TO THE YIELD LOSS OF MAIZE FROM WEED DENSITY OR DRY BIOMASS

Stefka Alexieva, Ivanka Stoimenova

"N. Poushkarov" Institute of Soil Science and Agroecology, 7 Shosse Bankya Str., 1080 Sofia,  
Bulgaria

## ABSTRACT

Three years (1994-1996) field experiment with maize and natural infestation with different biological weed species was conducted on Pelic Vertisols in West Bulgaria (near Sofia). Three variants of N, P fertilization were realized with non-treated and treated by atrazine + nicosulfurone. The differences in the weed density and dry weed biomass accumulated at the non-treated and treated variants were used in the suggested by us mathematical model to determine the competition between maize and mixed type of weed infestation. The model allowed to determine with satisfactory accuracy the yield losses due to the weeds density or dry weed biomass accumulated.

## INTRODUCTION

Crop responses to weed competition are difficult to predict, particularly in non-irrigated crop production systems (Hahn *et al.*, 1995; Lindquist *et al.*, 1996). In recent years, much emphasis has been placed on the development of simple, empirically derived regression models that equate eventual crop yield loss with some measurable characteristic of a weed population early in the growing season. Typically, descriptive models of crop: weed competition are valid only for the conditions from which they were developed (Weaver, 1996). Even in the basic case of one weed species competing with a particular crop, the instability of empirical yield loss models between sites and among years at the same site have confounded the usefulness of this approach (Kropff *et al.*, 1984; Cousens *et al.*, 1988; Lindquist *et al.*, 1996). In addition to the impact of growing season weather factors that influence the interactions between specific crop and weed combinations include crop and weed densities, relative times of emergence and edaphic characteristics (Firbank *et al.*, 1990; Kropff & Spitters, 1991; Wilson *et al.*, 1995). Such models can be used to integrate and to assess the relative importance of the multiple influences on competition. They may also give insight as to why specific responses are evident in the field only in certain years and locations, while providing a powerful tool for quantifying the longterm behaviour of specific crop: weed competition models are often based on existing ecophysiological models for plant growth (Weaver, 1996). Kiniry *et al.*, (1992) developed the ALMANAC model to provide a practical, easily adopted tool for simulating competition in mixed plant communities. ALMANAC requires a relatively small number of species - specific plant parameters and is considered of intermediate complexity (Debake *et al.*, 1997). When early maize growth was not compromised by water stress, the maize canopy overtopped the *A. theophrasti* canopy, relegating the latter to a subordinate position. Generally, when early season precipitation exceeded 100 mm, predicted loss was low (McDonaldt & Riha, 1999).

In this paper, the dynamics of competition between maize and *A. retroflexus*, *C. album*, *E. crus-galli*, *S. glauca*, *C. bursa pastoris* is studied in order to determine which are the critical phases of maize development as affected by the weeds in relation to N, P application. The following aspects were studied? (1) Does mixture of weeds lead to yield losses of maize in the different regime of N, P application? (2) Which aspect of climate is responsible for structuring the maize response to weeds competition? (3) If climate data can be used to improve our capacity to rationalize pre-and post-emergence weed control decisions?

## MATERIAL AND METHODS

A field experiment was carried out during the period 1994-1996, in Sofia district on pelic vertisols. The content of humus was in soil depth 0-28 cm - 3.43% and 3.65% in depth 28-60 cm. The available total N and P in the layer 0-28 cm were 0.23% and 0.082%, in the layer 28-60 cm the total N



and P are 0.145% and 0.082% respectively. The previous crop was *Triticum aestivum* L. harvested for grain. Three years monoculture of maize randomized in four replications with plot size 200 m<sup>2</sup>. The following scheme was used: Factor A - treated with N, P fertilizers; a<sub>1</sub> - N<sub>0</sub>P<sub>0</sub>; a<sub>2</sub> - N<sub>50</sub>P<sub>40</sub>; a<sub>3</sub> - N<sub>70</sub>P<sub>60</sub>; Factor B - weed control; b<sub>1</sub> - hand - weeding; b<sub>2</sub> - atrazine 1500 g a.i. ha<sup>-1</sup> + nicosulfurone 480g a.i. ha<sup>-1</sup>. The atrazine was applied pre-emergence of the maize for selective control of broad-leaved weeds and nicosulfurone was applied of 3-5 leaves of maize and 1-3 leaves of grass weeds. The hand-weeding of the control and herbicide treatments was made in the growth stage "7-9 leaf". In all trial treatments according to the factors A and B, weed spp. and weed dry biomass was determined as number m<sup>-2</sup> and g m<sup>-2</sup>. The dry weight was obtained after 54 hours drying at 80°C.

The maize field was not irrigated; phosphorus fertilize was applied during the main soil ploughing in the autumn and nitrogen fertilizer was applied with the last presowing cultivation. The crop was sown between May 5 and 10. Maize density was 47000 plants ha<sup>-1</sup> spaced 70 cm between the rows.

The results from the experiment that we made during the period 1994-1996 are presented in table 1. The real yield loss  $\epsilon$  are calculated as follows:

$$\epsilon = \left( 1 - \frac{Y_1}{Y_2} \right) 100 [\%] \quad (1)$$

Table 1. Input data from real yield loss, weed's density and dry weed's biomass from the field experiments

Variant	Dry weed's biomass, g m <sup>-2</sup>	ΔA=A <sub>1</sub> -A <sub>2</sub> , g m <sup>-2</sup>	Weed's density, n m <sup>-2</sup>	ΔD=D <sub>1</sub> -D <sub>2</sub> , n m <sup>-2</sup>	Observed yield, kg ha <sup>-1</sup>	Real yield loss ε, %
1994						
N <sub>0</sub> P <sub>0</sub> +c <sub>2</sub>	A <sub>2</sub> =49	23	D <sub>2</sub> =39	60	Y <sub>2</sub> =5840	4.7
N <sub>0</sub> P <sub>0</sub> +c <sub>1</sub>	A <sub>1</sub> =72		D <sub>1</sub> =99		Y <sub>1</sub> =5580	
N <sub>5</sub> P <sub>4</sub> +c <sub>2</sub>	A <sub>2</sub> =54	30	D <sub>2</sub> =54	62	Y <sub>2</sub> =6000	5.1
N <sub>5</sub> P <sub>4</sub> +c <sub>1</sub>	A <sub>1</sub> =84		D <sub>1</sub> =116		Y <sub>1</sub> =5710	
N <sub>7</sub> P <sub>5</sub> +c <sub>2</sub>	A <sub>2</sub> =64	30	D <sub>2</sub> =62	65	Y <sub>2</sub> =6190	6.2
N <sub>7</sub> P <sub>5</sub> +c <sub>1</sub>	A <sub>1</sub> =94		D <sub>1</sub> =127		Y <sub>1</sub> =5830	
1995						
N <sub>0</sub> P <sub>0</sub> +c <sub>2</sub>	A <sub>2</sub> =17	23	D <sub>2</sub> =42	33	Y <sub>2</sub> =4980	0.4
N <sub>0</sub> P <sub>0</sub> +c <sub>1</sub>	A <sub>1</sub> =40		D <sub>1</sub> =75		Y <sub>1</sub> =4960	
N <sub>5</sub> P <sub>4</sub> +c <sub>2</sub>	A <sub>2</sub> =10	39	D <sub>2</sub> =33	42	Y <sub>2</sub> =4990	0.2
N <sub>5</sub> P <sub>4</sub> +c <sub>1</sub>	A <sub>1</sub> =49		D <sub>1</sub> =75		Y <sub>1</sub> =5000	
N <sub>7</sub> P <sub>5</sub> +c <sub>2</sub>	A <sub>2</sub> =18	55	D <sub>2</sub> =45	39	Y <sub>2</sub> =5060	0.8
N <sub>7</sub> P <sub>5</sub> +c <sub>1</sub>	A <sub>1</sub> =73		D <sub>1</sub> =84		Y <sub>1</sub> =5020	
1996						
N <sub>0</sub> P <sub>0</sub> +c <sub>2</sub>	A <sub>2</sub> =0	58	D <sub>2</sub> =0	133	Y <sub>2</sub> =5480	15.6
N <sub>0</sub> P <sub>0</sub> +c <sub>1</sub>	A <sub>1</sub> =58		D <sub>1</sub> =133		Y <sub>1</sub> =4740	
N <sub>5</sub> P <sub>4</sub> +c <sub>2</sub>	A <sub>2</sub> =0	99	D <sub>2</sub> =0	135	Y <sub>2</sub> =5800	12.8
N <sub>5</sub> P <sub>4</sub> +c <sub>1</sub>	A <sub>1</sub> =99		D <sub>1</sub> =135		Y <sub>1</sub> =5140	
N <sub>7</sub> P <sub>5</sub> +c <sub>2</sub>	A <sub>2</sub> =0	107	D <sub>2</sub> =0	138	Y <sub>2</sub> =6190	13.0
N <sub>7</sub> P <sub>5</sub> +c <sub>1</sub>	A <sub>1</sub> =107		D <sub>1</sub> =138		Y <sub>1</sub> =5480	
C <sub>1</sub> – without herbicides; c <sub>2</sub> – atrazine 1500 g a.i. ha <sup>-1</sup> + nicosulfurone 480 g a.i. ha <sup>-1</sup>						

#### Description of the mathematical model

The mathematical interpretation of the dependence between  $\epsilon$  and  $\Delta A$  (respectively  $\Delta D$ ) is based on the following premises:

1. The functional relationship between the depended quantity is analyzed for years with approximately equal climate conditions for a culture (in our case the period 1994 and 1996); during 1995 when the

sum of the precipitation's is above 100 mm/m<sup>2</sup>, then it is necessary to introduce a correction coefficient, definition of limit values of that climate factor.

2. The dependence between  $\varepsilon$  and  $\Delta A$  (or  $\Delta D$ ) according to the data from table 1, it is possible to approximate precisely using a parabola of the type  $Y = a \cdot X^2$  (the branch in area +x, +y is valid), here the depended quantity  $Y$  is identified with  $\Delta A$  (or  $\Delta D$ );  $X$  – with  $\varepsilon$  and the independent parameter in this function “a” is the quantity –  $1/\Delta_1^2$  (or  $1/D_1^2$ ).

3. The graphic description of the parabola is presented in fig.1.

There is an analogy between the geometrical place of the parabola points and the experiment data for  $\varepsilon$ ,  $\Delta A$  (or

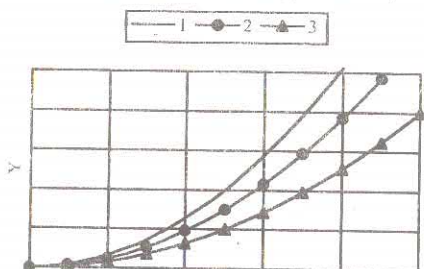


Fig.1

$$1 \rightarrow Y = \frac{X^2}{(A_1')^2}$$

$$2 \rightarrow Y = \frac{X^2}{(A_1'')^2}$$

$$3 \rightarrow Y = \frac{X^2}{(A_1''')^2}$$

$$A_1' < A_1'' < A_1''', D_1' < D_1'' < D_1'''$$

$\Delta D$ ); and  $A_1$  ( $D_1$ ) – so with increasing of  $\Delta A$  (or  $\Delta D$ ) and  $A_1$  ( $D_1$ ) the parabola branch “is opening” and the values of  $X$  increasing, respectively the losses  $\varepsilon$  increase. These three premises define the following relation between the losses  $\varepsilon_A$  and the quantity dry weed's biomass  $A$

$$\varepsilon_A = M \frac{\sqrt{\Delta A}}{A_1} 100 [\%] \quad (2)$$

and the degree on weed density  $D$

$$\varepsilon_D = M \frac{\sqrt{\Delta D}}{D_1} 100 [\%] \quad (3)$$

The coefficient  $M$  reflects the climate conditions and has the following values:

- When the sum the precipitation for the period  $< 100 \text{ mm/m}^2$  –  $M=1$ ;
- When the sum the precipitation for the period  $> 100 \text{ mm/m}^2$  –  $M=0.1$ .

The expression (2) and (3) give the mathematical interpretation of the dependence between the yield losses in [%] from the degree of weed density or the dry weed's biomass. The results from the calculated values of  $\varepsilon_A$  and  $\varepsilon_D$  compared with the real yield losses  $\varepsilon$  are presented in table 2.

## DISCUSSION

The degree of infestation and the quantities of the weed dry biomass in the control variant depended on the level of mineral fertilization (Table 1). During the three year period of investigation these two parameters were highest in the variants with the highest norms of fertilization and their values were lower in the variants without fertilization. During the period “sowing - 7-9 leaf” the highest degree of infestation showed *Amaranthus retroflexus* L. in hand weeding variant. The obtained participation part (in percent) of *A. retroflexus* in the total degree of weed infestation varied from 43.1 to 65.2, depending on the norms of mineral fertilization and precipitation.

The weed seeds quantity in the soil bank, soil type and precipitation in the first 20-30 days after the pre-emergence treatment influenced generally on the soil herbicides effect. The treatment with atrazine 1500 g a.i. ha<sup>-1</sup> pre-emergence +nicosulfurone 480 g a.i. ha<sup>-1</sup> in phase “3-5 leaf” of maize combination killed all annual weeds in the applied 3 variants of N, P fertilization in 1996.



Table 2. Calculated maize yield losses according to the dependencies (2) and (3)

Years	Real yield loss $\varepsilon$ (from table 1), %	Predicted yield loss $\varepsilon_A$ from biomass, %	Predicted yield loss $\varepsilon_D$ from density, %
1994	4.7	6.7	7.8
	5.1	6.5	6.8
	6.2	5.8	6.4
1995	0.4	1.2	0.8
	0.2	1.3	0.9
	0.8	1.0	0.7
1996	15.6	13.1	8.7
	12.8	10.1	8.6
	13.0	9.7	8.5

This effect was due to the optimal water content (75-80% from FC) in the period "sowing -7-9<sup>th</sup> leaf" of the maize (36 days) and relatively low precipitation (49,2 mm) in the same period. The larger precipitation (122.8 mm) in the same period of 1995 significantly decreased the herbicides mix effect. As a result the herbicides moved on and under the soil surface, weeds survived (in different percentage) in all of the variants of treatments. The differences of the soil herbicides effect in the beginning of the crop vegetation allowed us to determine the competition between the maize and weeds as a difference between the non-treated and treated variants.

The best weed control was observed in treatments with the highest application of mineral fertilization and that control was less in variants without mineral fertilization (Table 1). In 1996 when the precipitation was 49.2 mm in combination with high effective temperature sum (ETS), was observed the highest weed control in all of the treatments. The herbicide application influenced strongly of the dry weed biomass quantity in comparison to the infestation degree.

The differences in the weed density and the dry weed biomes accumulated in the non-treated and treated variants were used in the suggested by us mathematical model to determine the competition between maize and mixed weed interactions. The object of the model was the mixed type of weed infestation, because usually the crop infestation was with different weed species. The data of the non-treated and herbicide-treated 3 variants of N, P fertilization were the base of the model. The model allowed to determine with satisfactory accuracy the yield reduction due to the weeds density or the dry weed biomes. The lower differences between real measured and predicted yield losses may be due to the decreased crop: weed competition for water in the year with more precipitation (1995). In favorable early season weather allowed maize to dominate the weed mixed canopy and maize crop did not incur substantial yield losses regardless the weed density or dry biomes. This prediction in consistence with other studies that have documented the importance of water in early season growth for structuring the competitive relationship between crop and weed population. When early maize growth was not compromised by water stress, the maize canopy overtopped the weed mix infestation, relegating a latter subordinate position. These analyze support the field observation that maize yield response to *A. theophrasti* density is inherently variable in rained environments (Hahn *et al.*, 1995; Lindquist *et al.*, 1996; McDonald & Riha, 1999). Excluding the precipitation in early maize growth season, mathematical models of yield losses (e.g. density or dry biomass dependence) are unable to capture the variation in maize response to mixed weed type competition. In this study the mathematical models predicted lower differences between real founded and predicted yield losses  $\pm 1\%$ . The predicted yield losses differed more from the real once in the dryer 1996, when the competition for water between crop and weeds probably increased. Conversely, when early maize growth was compromised by water stress, the mixed weed population was highly competitive with maize and correlated with maize yield losses. In unfavorable early season weather, the mathematical models allowed to determine with satisfactory accuracy the yield reduction. The real and predicted yield losses reached  $\pm 7\%$  when was used weeds density and  $\pm 3.5\%$  when was used dry weeds biomass.



## REFERENCES

- Cousens R, Firbank LG, Mortimer AM & Smith RGR (1988) Variability in the relationship between crop yield and weed density for winter wheat and *Bromus sterilis*. *Journal of Applied Ecology* 25: 1033-1044.
- Debaeke P, Caussanel JP, Kiniry JR, Kafiz B & Mondragon G (1997) Modelling crop, weed interactions in wheat with ALMANAC. *Weed Research* 37: 325-341.
- Firbank LG, Cousens R, Mortimer AM & Smith RGR (1990) Effects of soil type on crop yield-weed density relationships between winter wheat and *Bromus sterilis*. *Journal of Applied Ecology* 27: 308-318.
- Hahn RR, Degni JG & Mt Pleasant J (1995) Leaf cover measurement for velvetleaf thresholds in field corn. In: *Proceedings Northeast Weed Science Society*, 49: 94. BOSTON.
- Kiniry JR, Williams JR, Gaddman PW & Debaeke P (1992) A general, process-oriented model for two competing plant species. *Transactions of the ASAE* 35: 801-810.
- Kropff MJ & Spitters CJT (1993) A simple model of crop loss by weed competition from early observations on relative leaf area of the weeds. *Weed Research* 31: 97-105.
- Kropff MJ, Vossen FJH, Spitters CJT & De Groot W (1984) Competition between a maize crop and a natural population of *Echinochloa crus-galli* (L.). *Netherlands Journal of Agricultural Science* 32: 324-327.
- Lindquist JL, Mortensen DA, Clay SA et al. (1996) Stability of corn (*Zea mays*) - velvetleaf (*Abutilon theophrasti*) interference relationships. *Weed Science* 44: 309-313.
- Mc Donald AJ & Riha SJ (1999) Model of crop: competition applied to maize: *Abutilon theophrasti* interactions. II. Assessing the impact of climate: implications for economic thresholds. *Weed Research* 39: 371-381.
- Weaver SE (1996) Simulation of crop-weed competition: models and their applications. *Phytoprotection* 77: 3-11.
- Wilson BJ, Wright KJ, Brian P, Clements M & Stephens E (1996) Predicting the competitive effects of weed and crop density on weed biomass, weed seed production and crop yield in wheat. *Weed Research* 35: 265-278.

# A RESEARCH ON USING DIFFERENT GROWING MEDIUMS FOR SEEDLINGS

Tuncay Demirer<sup>(1)</sup>, Canan Öztokat Kuzucu<sup>(2)</sup>

<sup>(1)</sup> Çanakkale Onsekiz Mart University, Department of Soil Science, 17100-Çanakkale

<sup>(2)</sup> Çanakkale Onsekiz Mart University, Department of Horticulture, 17100-Çanakkale

## ABSTRACT

This research has been carried out to increase the production of cos lettuce, cucumber and tomato under unheated high tunnels with plastic covers at the research farm of Çanakkale Onsekiz Mart University.

This research was applied to split plot design with 4 replications and included 3 plants, 35 subjects and also 420 seedling bags. Seedling compost was composed of peat, pumice, perlite, organic fertilizer and rice husks. This composition was mixed in the ratios of 1/4+3/4, 2/4+2/4, 3/4+1/4 respectively.

The following parameters were determined: germination period, the period for development of 4-6 leaves, the height of seedlings and the number of leaves, were determined. The results were evaluated by analysis of variance and compared with Duncan test. The best results were obtained by using the combinations of peat, perlite and pumice.

## INTRODUCTION

In Turkey 18 944 345 tons of vegetable was produced from 785 212 000 da. 1 491 390 tons of this production is leaf vegetables (249 000 ton lettuce), 16 101 00 is fruit bearing vegetables (7 250 000 ton tomato and 1 250 000 ton cucumber) (Anon., 1995).

Because of its climate, geography, easy transportation possibilities and industrial structure, Çanakkale is a city in which intensive farming has been done. Crop production continues on 353 589 ha and vegetable crops cover 16 359 ha. In these areas lettuce (104 ha), tomato (7 616 ha) and cucumber (476 ha) are commonly grown.

In plant production maximum yield is possible as long as sub and upper soil conditions are convenient. Upper soil (controlled mediums) (greenhouses) conditions can be controlled more easily for sub soil conditions (planting medium) it is more important to contain sufficient water, mineral matter, oxygen and cleanliness from insects, diseases and weed seeds (Şeniz and Boztok, 1974).

In plant production, especially in vegetable crop production direct seed planting or seedling plantings are possible. Seedling enables early harvest, saving money from time, energy and seed, and getting healthy plants (Şeniz, 1984). Using high quality seedlings are necessary to guarantee high yields and for this compost is an important input.

A good quality compost must have sufficient drainage, ventilation and tampon capacity, absorb water and nutrient elements, be naturally neutral (6.5-7.5), sterile, clean from insects and diseases, easily found and cheap, show no salinity problem and be also ready to use physically and chemically (Alan, 1990; Demirer et al., 1998; Demirer, 1998; Güzel, 1999). For this reason beside peat and organic fertilizer, which are the most important ingredients of the compost, perlite, pumice and rice husks were also used completely or in different proportions to contribute to cucumber, tomato and lettuce farming for table and industrial consumption in Çanakkale.

## MATERIAL and METHOD

The research was carried out in the unheated plastic high tunnel at the research farm of Çanakkale Onsekiz Mart University.

Tests plants were Colono cv. (lettuce), Urbana cv. (tomato), Maraton (cucumber) while peat, pumice, perlite, rice husks and organic fertilizers were used as seedling compost. During the research 138 mg N/L, 58 mg P/L, 112 mg K/L solutions were used as fertilizers.

Research was designed according to split plot design with 4 replications including 3 plants, 35 subjects and also 420 seedling bags.

Seedling composts were mixed in the ratios of 1/4+3/4, 2/4+2/4, 3/4+1/4 and complete forms. Organic materials were disinfected with methylbromite and after ventilating 2 days filled into 16x16.5 cm size black polyethylene bags. In filling the bags, 1 cm margin was left from the top edge of the

bags and the composts were pressed slightly (Şeniz, 1984; Varış, 1991). Bags having rice husks and husk mixtures were added N (ammonium nitrate) (10% of husk weight) in order to regulate the C:N ratio. To all bags 1 cm long drainage splits (2 cm from the bottom) were opened at 4 different places (Varış, 1991). Each bag was watered one-day before planting and 3 seeds, which had been soaked in distilled water for 3-4 hours, were planted. After covering the seeds with the compost and pressing slightly, they were watered again (100cc/bag). After germination the healthy seedlings were retained but the others removed. Seedling bags were placed with 15-20 cm intervals on raised soil in the greenhouse to prevent them etiolate (Şeniz, 1984). The greenhouse was kept at 20°C by airing. Watering was done early in the morning with solutions, which were prepared before and kept at 15°C with a dose of 150 ml/bag/day. The solutions were controlled frequently to keep the pH in neutral limits.

The parameters of germination period, period for development of 4-6 leaves, seedling height and leaf numbers were determined. The results were evaluated by analysis of variance and compared with Duncan test.

## FINDINGS and DISCUSSION

The results of the analysis of variance and Duncan grouping of the research data were shown in Table 1-2.

The medium and the medium-plant interaction were found to be statistically significant ( $p<0.01$ ) for germination and the time for reaching the 4-6 leaves stage. For seedling height and the number of leaves, however, medium, plant and their interactions were found to be statistically significant ( $p<0.01$ ) factors.

In the research we have observed no germination at number 32 and 34 subjects in all replications so that none of the parameters was evaluated. The same problem was also observed in some replications that had high organic fertilizer and rice husks. The existence of high levels of proteins and other N compounds which eventually convert to ammonia and nitrate in organic materials and spoiled texture resulted in the lengthened emergence time and also seedling deaths (Güzel, 1999).

Germination time began from 6 days at peat, perlite and pumice mixtures but extended to 12 days at mixtures (2/4 or 3/4) that had higher organic materials (Table 1). Research results are parallel some researchers who state that if temperature and soil textures are convenient, germination will occur between 7-15 days (Şeniz and Boztok, 1974; Şeniz, 1984). When the germination time was reviewed with respect to the plant type, cucumbers germinated and emerged in 7 days, tomatoes and lettuces in 8 days (Table 1).

Time of reaching 4-6 leaves stages changed between 20-25 days from planting. This duration was 20 days at peat, perlite, pumice and their mixtures with each other but was longer to 25 days at rice husks and organic fertilizer mixtures with each other and with other inorganic materials (Table 1). This 5 days extension could be explained with low water holding and permeability but high air capacity (Şeniz and Boztok, 1974; Şeniz, 1984; Güzel, 1999).

Seedling height changed between 7.40 and 16 cm according to the medium material, 9.29 and 12.81 according to plant.

Leaf number changed between 4 and 8 according to medium material. According to plants leaf number was determined 7.35 for lettuce, 5.67 for tomato and 5.76 for cucumber (Table 1). If the subject was considered took up for interactions, germination time was found between 4 and 13-14 days; and reaching 4-6 leaves stage changed between 19-20 days. This duration was observed to be shorter in peat, perlite and pumice mixtures but longer in organic fertilizer and rice husks. Seedling heights changed between 6.5-18 for tomato, 5.8-13 cm for lettuce and 5.9-17 cm for cucumbers. These values were determined high in peat mixtures but low at rice husks and organic fertilizer mixtures. Leaf numbers were determined as 4-8 for tomato, 4-12 for lettuce and 4-9 for cucumber but no relations were found with medium materials.



Table 1. Analysis of Variance and Duncan Grouping

Subjects Medium (A)	Germination time (day)	4-6 leaves stage (day)	Seedling height (cm)	Leaf number (number)
1. 4/4 Peat	6.08 i	20.42 h-i	16.00 a	6.67 b-c
2. 4/4 Pumice	6.58 f-i	20.83 g-i	11.37 j-m	6.00 e-g
3. 4/4 Perlite	6.50 f-i	21.42 d-i	8.17 s	4.67 h
4. 4/4 Rice husk	7.33 d-i	21.83 c-i	10.10 n-p	4.58 h
5. 4/4 O. Fertilizer	7.33 d-i	21.25 e-i	7.40 s	4.68 h
6. 1/4 Peat+3/4 Pum	6.08 i	21.58 d-i	14.07 b-c	6.67 b-e
7. 2/4 Peat+2/4 Pum	6.33 g-i	20.42 h-i	14.43 b-d	8.00 a
8. 3/4 Peat+1/4 Pum	6.25 h-i	20.42 h-i	13.23 e-g	7.67 ab
9. 1/4 Peat +3/4 Per	6.92 e-i	21.17 e-i	14.60 ac	7.33 ab
10. 2/4 Peat+3/4 Per	6.42 f-i	20.92 f-i	12.70 g-h	6.67 b-e
11. 3/4 Peat+1/4 Per	6.00 i	20.00 i	13.40 d-g	7.33 a-c
12. 1/4 Peat+3/4 Husk	8.67 b-h	21.92 c-i	12.57 g-i	7.33 a-c
13. 2/4 Peat+2/4 Husk	7.83 c-i	22.33 b-h	15.27 ab	6.67 b-e
14. 3/4 Peat+1/4 Husk	6.75 f-i	21.83 c-i	10.90 k-o	4.67 h
15. 1/4 Peat+3/4 O.Fert.	8.00 b-i	23.33 a-e	12.77 f-h	7.00 a-d
16. 2/4 Peat+2/4 O.Fert.	8.75 b-g	22.58 a-h	10.93 k-n	5.67 f-g
17. 3/4 Peat+1/4 O.Fert.	7.67 c-i	24.00 a-c	10.07 o-p	6.67 c-e
18. 1/4 Pum+3/4 Per	6.17 i	23.33 a-e	10.87 k-o	6.67 c-e
19. 2/4 Pum+2/4 Per	6.83 e-i	21.75 c-i	10.67 m-o	6.00 e-g
20. 3/4 Pum+1/4 Per	6.25 h-i	20.75 g-i	11.42 j-m	6.67 c-e
21. 1/4 Pum+3/4 Husk	10.83 ab	23.08 a-f	10.13 n-p	6.33 d-f
22. 2/4 Pum+2/4 Husk	7.33 d-i	24.58 ab	13.78 c-f	6.00 e-g
23. 3/4 Pum+1/4 Husk	9.33 a-e	21.92 c-i	9.60 ö-r	4.67 h
24. 1/4 Pum+3/4 O.Fert	8.42 b-i	22.33 b-h	10.42 n-ö	5.42 f-h
25. 2/4 Pum+2/4 O.Fert	7.00 e-i	23.58 a-d	9.13 r	5.67 f-g
26. 3/4 Pum+1/4 O.Fert	9.58 a-d	23.67 a-d	9.04 r	5.33 f-h
27. 1/4 Per+3/4 Husk	7.83 c-i	23.33 a-e	10.20 n-p	5.67 f-g
28. 2/4 Per+2/4 Husk	7.25 d-i	24.58 ab	11.70 h-k	6.17 d-g
29. 3/4 Per+1/4 Husk	8.25 b-i	25.00 a	10.80 l-o	8.00 a
30. 1/4 Per+3/4 O.Fert	7.50 d-i	21.42 d-i	12.10 h-j	5.67 f-g
31. 2/4 Per+2/4 O.Fert	8.83 b-f	23.67 a-d	9.50 p-r	6.00 e-g
32. 3/4 Per+1/4 O.Fert.	0.00	0.00	0.00	0.00
33. 1/4Husk+3/4 O.Fert	0.00	0.00	0.00	0.00
34. 2/4Husk+2/4 O.Fert	10.33 a-c	24.00 a-g	11.53 j-l	8.00 a
35. 3/4Husk+1/4 O.Fert	12.67 a	23.00 d-k	8.20 s	6.00 e-g
Significance degree	**	**	**	**
Plant (B)	Germination time (day)	4-6 leaves stage (day)	Seedling height (cm)	Leaf number (number)
1. Tmatoes	7.85	22.25	12.18 a	5.67 b
2. Lettuce	7.91	22.45	9.29 b	7.35 a
3. Cucumber	7.33	22.24	12.81 a	5.76 b
Significance degree	n.s.	n.s.	**	**

\*\*,p &lt;0.01

Table 2. Analysis of Variance and Duncan Grouping of Interactions (AxB)

Subjects	Germination time (day)			4-6 Leaves stage (day)			Seedling height (cm)			Leaf number (number)		
	AXB <sub>1</sub>	AXB <sub>2</sub>	AXB <sub>3</sub>	AXB <sub>1</sub>	AXB <sub>2</sub>	AXB <sub>3</sub>	AXB <sub>1</sub>	AXB <sub>2</sub>	AXB <sub>3</sub>	AXB <sub>1</sub>	AXB <sub>2</sub>	AXB <sub>3</sub>
1. 4/4 Peat	6.00 f-g	6.25 d	6.00 c	20.00 d-e	21.25 c-f	20.00 g-h	18.00 a	13.00 ab	17.00 a	7.00 ab	8.00 d	5.00 de
2. 4/4 Pumice	6.00 f-g	7.00 cd	6.75 c	20.00 d-e	21.00 b-f	21.00 d-h	13.50 d-g	8.60 m	12.00 f-h	5.00 cd	8.00 de	5.00 de
3. 4/4 Perlite	6.00 f-g	7.50 b-d	6.00 c	22.75 a-e	21.50 b-f	20.00 g-h	7.90 m-o	6.10 o	10.50 h-j	4.00 d	4.00 h	6.00 b-d
4. 4/4 Rice husk	8.00 e-g	8.00 b-d	6.00 c	22.00 b-e	22.25 b-f	21.25 d-h	10.38 j-l	9.90 f-j	10.00 j	5.50 b-d	4.25 h	4.00 e
5. 4/4 O. Fertilizer	8.00 e-g	8.00 b-d	6.00 c	21.00 c-e	22.00 b-f	20.75 e-h	7.30 o	6.90 n-o	8.00 k	5.00 cd	4.00 h	5.00 de
6. 1/4 Peat+3/4 Pumice	6.00 f-g	6.00 d	6.25 c	20.00 de	22.75 a-d	21.00 d-h	15.50 a-c	11.20 b-f	14.50 b-d	6.00 a-c	8.00 de	6.00 cd
7. 1/4 Peat+2/4 Pumice	6.00 f-g	6.50 d	6.50 c	20.00 de	20.75 d-f	20.50 f-h	15.50 bc	13.30 o	15.50 b-d	6.00 a-c	11.00 ab	7.00 a-c
8. 3/4 Peat+1/4 Pumice	6.00 f-g	6.25 d	6.50 c	20.00 de	20.75 d-f	20.50 f-h	14.00 c-f	12.20 a-d	13.50 i-f	7.00 ab	12.00 a	4.00 e
9. 1/4 Peat+3/4 Perlite	8.75 b-d	7.00 cd	6.25 c	20.00 e	22.50 a-e	20.25 g-h	16.00 ab	12.30 a-c	15.50 a-e	5.00 cd	10.00 a-c	7.00 a-c
10. 2/4 Peat+1/4 Perlite	6.00 g	6.00 d	6.00 c	20.00 e	20.00 f	20.00 g-h	15.50 bc	10.30 e-h	15.40 a-c	6.00 bc	8.00 de	6.00 cd
11. 3/4 Peat+1/4 Perlite	9.75 a-e	10.25 a-c	8.75 b-g	21.25 c-e	24.50 a-c	20.00 h	11.00 h-k	10.20 f-h	16.50 a	5.00 cd	11.00 ab	6.00 cd
12. 1/2 Peat+3/4 R. husk	8.75 b-g	6.00 d	6.75 a-c	24.25 a-c	21.00 d-f	21.75 e-h	18.00 a	11.30 a-f	16.50 a	8.00 a	6.00 f-g	6.00 cd
13. 2/4 Peat+2/4 R. husk	7.00 e-g	6.00 d	7.75 c	21.50 b-e	21.00 d-f	20.00 a-h	9.50 km	8.60 i-m	16.60 b-d	5.00 cd	5.00 gh	4.00 e
15. 1/2 Peat+3/4 R. husk	8.75 b-g	7.25 cd	8.00 bc	23.50 a-d	21.50 b-f	25.00 a-c	12.50 f-h	10.60 e-g	15.20 a-c	6.00 bc	9.00 cd	6.00 cd
16. 2/4 Peat+2/4 R. husk	10.75 a-d	9.00 b-d	6.50 c	23.00 a-e	22.00 b-f	22.75 a-h	13.50 d-g	9.30 g-k	10.00 j	6.00 bc	7.00 e-f	4.00 e
17. 3/4 Peat+1/4 R. husk	8.00 e-g	7.00 cd	8.00 bc	25.00 ab	24.00 a-d	23.00 a-h	13.40 d-g	6.20 o	10.60 h-j	6.00 bc	9.00 cd	5.00 de
18. 1/4 Pumice+3/4 Per	6.25 e-g	6.00 d	6.25 c	23.00 a-e	24.75 ab	22.25 b-h	12.50 f-h	12.10 a-e	8.00 k	6.00 bc	10.00 a-c	4.00 e
19. 2/4 Pumice+2/4 Per	7.25 d-g	7.25 cd	6.00 c	21.50 b-e	23.75 a-d	20.00 h	9.00 i-n	10.00 f-j	13.00 d-g	5.00 cd	8.00 de	5.00 de
20. 3/4 Pumice+1/4 Per	6.75 e-g	6.00 d	6.00 c	21.00 c-e	21.25 c-f	20.00 h	11.28 h-j	9.00 g-k	14.00 c-e	6.00 bc	7.00 e-f	6.00 cd
21. 1/4 Pumice+3/4 R. husk	6.50 e-g	14.00 a	12.00 ab	22.25 b-e	24.00 a-d	23.00 a-h	12.00 g-i	6.90 n-o	11.50 g-l	6.00 bc	6.00 cd	6.00 cd
22. 2/4 Pumice+2/4 R. husk	7.75 e-g	7.75 b-d	6.50 c	26.00 a	24.25 a-d	23.50 a-g	15.00 b-d	10.35 d-h	16.00 ab	6.00 bc	6.00 fg	6.00 cd
23. 3/4 Pumice+1/4 R. husk	9.00 b-g	11.00 ab	8.00 bc	23.50 a-d	20.00 e-f	22.25 b-h	13.50 d-g	6.30 o	9.00 k	4.00 d	6.00 fg	4.00 e
24. 1/4 Pumice+3/4 O. Fert.	8.75 e-g	8.00 b-d	8.50 a-e	21.50 b-e	22.25 b-f	23.25 a-h	10.50 i-l	8.75 h-l	12.00 f-h	5.00 cd	5.25 gh	6.00 cd
25. 2/4 Pumice+2/4 O. Fert.	7.00 e-g	9.00 b-d	6.00 c	31.00 c-e	23.75 a-f	26.00 a	14.30 b-e	7.20 i-o	5.90 l	6.00 bc	6.00 fg	5.00 de
26. 3/4 Pumice+1/4 O. Fert.	11.50 a-c	9.00 b-d	8.25 bc	23.50 a-d	23.00 a-e	24.50 a-d	10.00 i-l	9.13 g-k	8.00 k	6.00 bc	6.00 fg	5.00 de
27. 1/4 Per+3/4 R. husk	7.00 e-g	8.75 b-d	7.75 c	23.50 a-d	24.25 a-d	22.25 b-h	8.00 m-o	7.10 m-o	15.50 a-c	6.00 bc	5.00 gh	4.00 e
28. 2/4 Per+2/4 R. husk	6.25 e-g	7.50 b-d	8.00 bc	23.75 a-c	24.25 a-d	25.75 a-b	13.00 e-g	9.50 g-k	12.60 e-g	5.50 bd	7.00 e-f	6.00 cd
29. 3/4 Per+1/4 R. husk	7.75 e-g	8.00 b-d	9.00 a-c	25.00 ab	24.00 a-d	26.00 a	9.00 i-n	10.00 f-j	13.40 d-f	4.00 d	12.00 a	8.00 ab
30. 1/4 Per+3/4 O. Fert.	7.75 d-g	8.00 b-d	6.75 c	22.50 c-e	19.00 f	22.75 a-h	12.00 g-i	8.80 h-k	15.50 a-c	6.00 bc	5.00 gh	6.00 cd
31. 2/4 Per+2/4 O. Fert.	9.50 a-f	9.00 b-d	8.00 c	24.00 a-c	22.00 b-f	25.00 a-c	7.50 n-o	8.40 i-n	12.60 e-g	4.00 d	6.00 fg	8.00 ab
32. 3/4 Per+1/4 O. Fert.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33. 1/4 R. Husk+3/4 O. Fert.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34. 2/4 R. husk+2/4 O. Fert.	13.00 ab	9.00 b-d	9.00 a-c	25.00 ab	23.00 a-e	24.00 a-e	12.00 g-i	9.10 g-k	13.50 d-f	8.00 a	7.00 e-f	9.00 a
35. 3/4 R. husk+1/4 O. Fert.	14.00 a	11.00 ab	13.00 a	23.00 e	22.00 b-f	24.00 a-e	6.50 o	5.80 o	12.30 f-g	4.00 d	5.00 gh	9.00 a
Significance degree	**	**	**	**	**	**	**	**	**	**	**	**

\*\*, p&lt;0.01

## DISCUSSION

Using 100% organic materials in seedling growing causes toxicity because of decomposition and ammoniaification. For this reason, using completely decomposed sterile inorganic materials mixed with the high quality organic matters and having good texture, airing and water holding capacities leads to better seedlings and higher germination ratios. The best results were obtained from peat+pumice, peat+perlite or perlite+pumice combinations so that these combinations were found to be advisable.

## REFERENCES

- Alan R., (1990). Serada kullanılan bazı yetiştirme ortamları ve özellikleri. Türkiye V. Seracılık Sempozyumu. İZMİR.
- Anonymous, (1995). Tarımsal yapı ve üretim. DİE Yayınları. ANKARA.
- Anonymous, (1999). T. O. ve K. İ. B. Tarım il müdürlüğü. Yayınlanmamış Tarım İstatistikleri Raporu. ÇANAKKALE.
- Demirer T. (1998). Tarım ve değişik oranlarda karışık ortamların sabit bakım şartlarında marulda verim ve kaliteye etkisi. Ç.O.M.Ü. Ziraat Fakültesi Araştırma Raporları (Basılmamış), ÇANAKKALE.
- Demirer T., Müftüoğlu N. M., Öztokat C. (1998). Toprak, dere kumu, perlit, pomza taşı ve odun talaşında yetiştirilen hıyar bitkisinin verim ve kalite kriterlerinin karşılaştırılması. Ege Bölgesi I. Tarım Kongresi. 7-11 Eylül. AYDIN.
- Güzel N. (1999). Süs bitkileri gübrelemesi. Ç. Ü. Ziraat Fakültesi Ders Kitabı No: 113 ADANA.
- Şeniz V. (1984). Sebzeçilikte fide yetiştiriciliği ve sorunları. Atatürk Bahçe Kültürleri Araştırma Enstitüsü. Yayın No: 60. YALOVA.
- Şeniz V. Boztok K. (1974). Tohum ekim kasaları ve fide yetiştirme saksıları için hazırlanan farklı harçların, sera domates bitkilerinin gelişmesi, verim ve ekenciliği üzerine etkileri. Ege Üniversitesi Ziraat Fakültesi Dergisi 11 (3): 535 – 555
- Varış S. (1991) Topraksız kültür ve ülkemiz seralarının, dünü, bugünü ve yarını. Salat Haberler, 76-3
- Yurtsever N. (1984). Deneysel istatistik metotları, T. O. ve K. İ. B. Köy Hizmetler Genel Müdürlüğü, Toprak ve Gübre Araştırma Enstitüsü Yayınları, Genel Yayın No: 121, ANKARA



# DETERMINATION OF NUTRIENT STATUS IN HAZELNUT LEAVES SAMPLED FROM TERME AND UNYE REGIONS

Ayhan Horuz, Ahmet Korkmaz

Ondokuz Mayıs University, Agronomy, Department of Soil Science, Samsun-Turkey

## ABSTRACT

This survey study was carried out in Terme and Unye regions in order to determine the macro and micro nutrient status in hazelnut leaves. Hazelnut is one of the most important agricultural crops, especially in the Eastern Black Sea Region of Turkey. Hazelnut leaves were sampled from twenty one orchards in Terme and thirty orchards in Unye. N, P, K, Ca, Mg, Fe, Mn, Zn and Cu analysis were done in the hazelnut leaf samples. The maximum, minimum and mean values for mentioned plant nutrients were presented in this study.

## INTRODUCTION

Analyzing the leaf samples is one of the most useful methods for determination of the plant nutrition requirements. The plant analysis give a benefit to prevent the plant nutritional disorders, especially in fruit trees. Since determination of nutrient requirements in fruit trees takes much more time when comparing with annual plants. Therefore, determining the nutrient status in hazelnut orchards and carrying out the fertility and productiving of these lands are very important in planning of the fertilizer programs. Determining nutrient status of plants sampled in a large survey study and comparing the results with some certain criteria provide to carry out the fertility potential of hazelnut plant. In this case, sufficient and deficient areas can be determined according to nutrient status in hazelnut plants.

The aim of this study was to determine macro nutrient status of the hazelnut plants in Terme and Unye regions beside micro nutrient status, which has an important effect on quality properties in hazelnut, and to investigate the relationships among them.

## MATERIALS and METHODS

Total 153 hazelnut samples, from 21 orchards in Terme and 30 orchards in Unye were sampled from the youngest shoots with 3 replications in 1995 according to Ibrikçi et al. (1994).

The leaf samples were washed with distilled water, dried and ground in a mill. The samples of the ground leaves were digested in concentrated nitric and perchloric acid (4:1-HNO<sub>3</sub>:HClO<sub>4</sub>) and analyzed for P colorimetrically by Kacar (1972), and for Ca, Mg, K, Fe, Mn, Zn and Cu by AAS. Also the ground sampled were used for determining total nitrogen by the Kjeldahl method (Kacar 1984).

Statistical analysis of the results were done using TARIS package program and evaluated according to Tosun (1990).

## RESULTS and DISCUSSION

In this survey study N, P, K, Ca, Mg, Fe, Mn, Zn and Cu contents of hazelnut plants in Terme and Unye and their relationship each others were investigated. For total 153 leaf samples from 51 different hazelnut orchards representing these regions, the maximum, minimum, mean, and standard deviation values for the nutrient contents of hazelnut leaves are given in Table 1. The results of the leaf analysis were investigated according to the limit levels in the previous works about hazelnut nutrition and soil analysis results. These results were evaluated with respect to the most suitable values for Black Sea Region.

The hazelnut plant nutrient status in Terme and Unye regions were classified according to the limit levels and given in Table 2.

Table 1. The maximum, minimum, mean and standard deviation values for the nutrient contents of hazelnut leaves in Terme and Unye.

Site name		N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
		%					ppm			
Terme	Min.	1.39	0.11	0.32	1.22	0.19	221.20	96.90	11.80	3.25
	Max.	2.90	0.27	0.93	3.47	0.50	1241.14	1291.51	121.60	12.43
	Mean	2.27	0.18	0.60	2.09	0.31	505.09	481.01	25.06	5.69
	Sd.	0.33	0.04	0.14	0.55	0.07	237.34	331.07	15.20	1.82
Unye	Min.	1.46	0.09	0.26	1.20	0.16	140.33	44.28	6.44	2.69
	Max.	3.54	0.27	0.78	3.24	1.56	1770.92	4822.46	69.64	20.23
	Mean	2.32	0.16	0.53	2.25	0.27	420.88	854.72	27.35	6.64
	Sd.	0.44	0.04	0.12	0.48	0.15	331.76	875.84	11.15	2.85

Table 2. Classification of the hazelnut plant nutrition in 63 samples of Terme and 90 samples of Unye according to N, P, K, Ca, Mg, Fe, Mn, Zn and Cu contents.

Nutrient Elements	Limit Levels	Classification	Terme		Unye	
			Samp. Numb.	%	Samp. Numb.	%
N, %	< 2.50	Low	53	84.13	62	68.89
	2.50-3.50	Sufficient	10	15.87	27	30.00
	>3.50	High	-	-	1	1.11
P, %	<0.15	Low	12	19.05	43	47.78
	0.15-0.40	Sufficient	51	80.95	47	52.22
	>0.40	High	-	-	-	-
K, %	<0.4	Severe deficient	6	9.52	14	15.55
	0.4-0.6	Deficient	20	31.75	48	53.33
	0.6-0.8	Medium	34	53.97	28	31.12
	>0.8	Optimum	3	4.76	-	-
Ca, %	<0.6	Low	-	-	-	-
	0.6-2.50	Sufficient	47	74.60	64	71.11
	>2.5	High	16	25.40	26	28.89
Mg, %	<0.20	Low	2	3.18	12	13.33
	0.20-0.35	Medium	47	74.60	74	82.23
	>0.35	High	14	22.22	4	4.44
Fe, ppm	<50	Low	-	-	-	-
	50-400	Sufficient	28	44.44	61	67.78
	>400	High	35	55.56	29	32.22
Mn, ppm	<25	Low	-	-	-	-
	25-800	Sufficient	52	82.54	59	65.56
	>800	High	11	17.46	31	34.44
Zn, ppm	<23	Low	32	50.79	34	37.78
	23-50	Sufficient	30	47.62	55	61.11
	>50	High	1	1.59	1	1.11
Cu, ppm	<6	Low	42	66.67	38	42.22
	6-12	Sufficient	20	31.75	49	54.45
	>12	High	1	1.58	3	3.33

## Macro Elements

### Nitrogen

Total N contents in the hazelnut leaves varied from 1.39 % to 2.90 % with an average of 2.27 % and standard deviation of 0.33 in Terme, and also varied from 1.46 % to 3.54 %, with an average of 2.32 % and standard deviation of 0.44 in Unye (Table 1).

When total nitrogen analysis results were evaluated according to Ibrikçi et al. (1994), nitrogen levels in the leaf samples were found to be 84.14 % low, 15.87 % sufficient in Terme, and found to be 68.89 % low, 30.00 % sufficient and 1.11 % high in Unye (Table 2).

Nitrogen is an important element for plant nutrition (Romisonda et al., 1983). Sufficient N levels were reported to be 2.30 % - 2.50 % by Painter (1963), 2.50 % by Molne (1976), 2.60 % by Romisonda et al. (1983), 2.20 %-2.50 % by Chaplin (1981). Organic matter content, clay type and its quantity in the region soils influence the nitrogen contents in soils and nitrogen levels in hazelnut leaves.

In Terme, it was found that N contents in the leaf samples showed significant positive correlation with P content ( $r=0.324^{**}$ ) and significant negative correlation with Ca content ( $r=-0.398^{**}$ ). Beyhan et al. (1996) and Aydin et al. (1997) reported that there is a synergistic relationship between N and P. Attributing to Simpson (1986), Aktaş (1994) found that there was a synergistic effect of nitrogen and phosphorus fertilizers on potato yield. N contents in the leaf samples in Unye showed negative correlation with Ca ( $r=-0.288^{*}$ ) and Fe ( $r=-0.250^{*}$ ) contents. The similar results were also obtained in palaz hazelnut variety by Beyhan et al. (1996) and in pistachio plant by Uzunharman (1995).

### Phosphorus

P contents in the hazelnut leaves varied from 0.11 % and 0.27 % with an average of 0.18 % and standard deviation of 0.04 in Terme, and also varied from 0.09 % to 0.27 %, with an average of 0.16 % and standard deviation of 0.04 in Unye (Table 1).

When phosphorus analysis results were evaluated according to Ibrikçi et al. (1994), phosphorus levels in the leaf samples were found to be 19.05 % low, 80.95 % sufficient in Terme, and found to be 47.78 % low and 52.22 % sufficient in Unye (Table 2).

Phosphorus plays an useful role in insemination and formation of fruit although hazelnut shows minimum response with the increasing dosage of this element (Painter, 1963; Molne 1976; Baron et al. 1985, Tous et al. 1987). Sufficient P contents for hazelnut leaves stated to be 0.13 % - 0.60 % by Chaplin (1981), 0.11 % by Lopez- Acevedo (1983), 0.18 % by Molne (1976), 0.14 %- 0.16 % by Painter (1963). Genç (1969), in his study, found that sufficient P amount in hazelnut leaves was 0.15 % P contents in plants are influenced by form of P existing in soil, soil pH and absorption ratio by plants. In our study, P contents were found to be low in the soils had low pH. Therefore P contents in the plants were also found to be low.

Except N, P contents of the samples in Terme did not show any correlation statistically with the other elements. There was a significant positive correlation between P and K contents of the leaf samples ( $r=0.426^{*}$ ) in Unye.

### Potassium

Potassium contents in the hazelnut leaves varied from 0.32 % to 0.93 % with an average of 0.60 % and standard deviation of 0.14 in Terme, and also varied from 0.26 % to 0.78 %, with an average of 0.53 % and standard deviation of 0.12 in Unye (Table 1).

When total potassium analysis results were evaluated according to Baron et al. (1985), potassium levels in the leaf samples were found to be 9.52 % severe deficient, 31.75 % deficient, 53.97 % medium, 4.76 % optimum in Terme, and found to be 15.55 % severe deficient, 53.33 % deficient and 31.12 % medium in Unye (Table 2).

K plays an important role in increasing of the production quality and the grain size because of increasing assimilation of N in leaves (Painter and Hammer, 1962). Sufficient K amount in hazelnut leaves were informed to be between 0.90 % and 1.00 % by Painter (1963), 0.95 % By Molne (1976), 0.80 % - 3.00% by Chaplin (1981) and 0.80 % by Kowalenko (1982). Genç (1969) reported that it was between 0.60 % and 0.70 %.

The K contents in the leaf samples showed significant negative correlation with Mg contents ( $r=-0.276^{*}$ ) and Mn contents ( $r=-0.282$ ) in Terme, and also positive correlation with Ca contents ( $r=0.240^{*}$ ) in Unye. Aktaş (1994) stated that there was an anthogotistic correlation between K and Mg.



### Calcium

Calcium contents in the hazelnut leaves varied from 1.22 % to 3.47 % with an average of 2.09 % and standard deviation of 0.55 in Terme, and also varied from 1.20 % to 3.24 %, with an average of 2.25 % and standard deviation of 0.48 in Unye (Table 1).

When calcium analysis results were evaluated according to Chaplin (1981), calcium levels in the leaf samples were found to be 74.60 % sufficient and 25.40 % high in Terme, and found to be 71.11 % sufficient, 28.89 % high in Unye (Table 2).

The limit levels for Ca were reported as 1.35 % - 1.50 % by Painter (1963), 1.10 % by Molne (1976), 0.60 % - 2.50 % by Chaplin (1981) and 1.44 % by Kowalenko (1982). Ca which is an important nutrient element in fruit composition is necessary for a good increase in size and development of fruit Molne (1976).

It was obtained that there was a significant positive correlation between Ca and Fe contents ( $r=0.244^*$ ). The similar results were also obtained by Uzunharman (1995).

### Magnesium

Magnesium contents in the hazelnut leaves varied from 0.19 % to 0.50 % with an average of 0.31 % and standard deviation of 0.07 in Terme, and also varied from 0.16 % to 1.56 %, with an average of 0.27 % and standard deviation of 0.15 in Unye (Table 1).

When calcium analysis results were evaluated according to Painter (1963), magnesium levels in the leaf samples were found to be 3.18 % low, 74.60 % sufficient and 22.22 % high in Terme, and found to be 13.33 % low, 82.23 % sufficient and 4.44 % high in Unye (Table 2).

The sufficient Mg amounts in hazelnut plant were reported as between 0.20 % and 0.35 % by Painter (1963), 0.20 % by Molne (1976), 0.24 - 1.00 % by Chaplin (1981) and 0.24 - 0.31 by Kowalenko (1984).

It was found that there was a significant positive correlation between Mg contents and Fe contents ( $r=0.465^{**}$ ) in Terme region. Also, Uzunharman (1995) found the similar relationship.

### Micro Elements

#### Iron

Iron contents in the hazelnut leaves varied from 221.20 ppm to 1241.14 ppm with an average of 505.09 ppm and standard deviation of 237.34 in Terme, and also varied from 140.33 ppm to 1770.92 ppm, with an average of 420.88 ppm and standard deviation of 331.76 in Unye (Table 1).

When iron analysis results were evaluated according to Chaplin (1981), iron levels in the leaf samples were found to be 44.44 % sufficient and 55.56 % high in Terme, and found to be 67.78 % sufficient, 32.22 % high in Unye (Table 2).

Iron exists in component of some proteins in chain of fotosentes. That fotosentetic activity falls with a decrease in available Fe amount (Marschner 1986; Dejong 1982). It was informed that sufficient Fe contents in hazelnut plants are 180 ppm by Molne (1976), 167 ppm by Lopez-Acevedo (1983).

Fe contents in the leaf samples of hazelnut plant showed significant negative correlation with Mn contents ( $r=-0.312^*$ ) in Terme region. Aktaş (1981) reported that Fe application to soil decreased Mn contents of plants. A positive correlation between Fe and Cu contents ( $r=0.423^{**}$ ) was found in the leaf samples in Unye region.

#### Manganese

Manganese contents in the hazelnut leaves varied from 96.90 ppm to 1297.51 ppm with an average of 481.01 ppm and standard deviation of 331.07 in Terme, and also varied from 44.28 ppm to 4822.46 ppm, with an average of 854.72 ppm and standard deviation of 875.84 in Unye (Table 1).

When manganese analysis results were evaluated according to Chaplin (1981), calcium levels in the leaf samples were found to be 82.54 % sufficient and 17.46 % high in Terme, and found to be 65.56 % sufficient, 34.44 % high in Unye (Table 2).

Sufficient Mn levels for hazelnut plant were reported as 250 ppm by Molne (1976) and Romisonda et al. (1983), 157ppm By Lopez-Acevedo (1983), 25-100 ppm by Ibriki et al. (1994). In

the low pH conditions in soils, availability of Mn for plants is higher because of increasing solubility of Mn in low pH conditions Aydemir (1985). But, excess Mn in soil can have a toxic effect for plants. Mn ion in soils decreases hundred times for increasing each pH unit Lindsay (1972). Therefore, in high pH conditions, Mn availability will not be adequate for plant requirement. According to the experimental results by Page (1962), increments in pH increase the production of Mn-organic matter complex. These complex have a decrease effect in Mn availability. Mn deficiency is seen in the soils which have high pH levels and high organic matter contents (Aydemir, 1985).

### Zinc

Zinc contents in the hazelnut leaves varied from 11.80 ppm to 121.60 ppm with an average of 25.06 ppm and standard deviation of 15.20 in Terme, and also varied from 6.44 ppm to 69.64 ppm, with an average of 27.35 ppm and standard deviation of 11.15 in Unye (Table 1).

When Zinc analysis results were evaluated according to Painter (1983), zinc levels in the leaf samples were found to be 50.79 % low, 47.62 % sufficient and 1.59 % high in Terme, and found to be 37.78 % low, 61.11 % sufficient and 1.11 % high in Unye (Table 2).

Sufficient limit levels for Zn were determined as 19 - 20 ppm by Kowalenko (1982), 15-80 ppm by Chaplin (1981).

### Copper

Copper contents in the hazelnut leaves varied from 3.25 ppm to 12.43 ppm with an average of 5.69 ppm and standard deviation of 1.82 in Terme, and also varied from 2.69 ppm to 20.23 ppm, with an average of 6.64 ppm and standard deviation of 2.84 in Unye (Table 1).

When copper analysis results were evaluated according to İbrikçi et al. (1994), copper levels in the leaf samples were found to be 66.67 % low, 31.75 % sufficient and 1.58 % high in Terme, and found to be 42.22 % low, 54.45 % sufficient and 3.33 % high in Unye (Table 2).

Sufficient Cu levels for hazelnut plant were stated as 40 ppm by Molne (1976), 2 - 50 ppm by Chaplin (1981), 7 - 10 ppm by Kowalenko (1982). İbrikçi et al. (1994) also found 6 - 12 ppm for sufficient Cu level in the hazelnut leaves.

### REFERENCES

- Aktaş M., (1981). Demir Gübrelemesinin Soya Fasulyesi Bitkisinin Fosfor, Çinko, Mangan ve Bakır Kapsamı Üzerine Etkisi. A.Ü. Zir. Fak. Yıllığı 31, S: 49-57.
- Aktaş M., (1994). Bitki Besleme ve Toprak Verimliliği. A.Ü. Ziraat Fak. Yayın No:1361, Ders Kitabı:395, Ankara.
- Aydemir O., (1985). Bitki Besleme ve Toprak Verimliliği. A.Ü. Ziraat Fak. S. 1-286 Erzurum.
- Aydın, I., Uzun F. Ve Sürücü A., (1997). Asit Reaksiyonlu Toprakta Kireç, Azot ve Fosfor Uygulamasının Macar fıgında Mineral Element İçeriğine Etkisi. Turkish Jr. Of Agric. And Forestry, 21 (3), 281-288.
- Baron L.C., Riggert C. and Stebbins R.L., (1985). Groving Hazelnut in Oregon. Ed. Oregon State University Extension Service, 20 p.
- Beyhan, N., Sürücü A., Korkmaz A. ve Demir T., (1996). Farklı Azot Dozlarının Palaz Fındık Çeşidinde Yapraklardaki Besin Element Düzeylerine Etkisi. Fındık ve Diğer Sert Kabuklu Meyveler Sempozyumu. OMÜ. Ziraat Fak. Samsun S: 68-76.
- Chaplin M.H., (1981). Intervalos Criticos de Nutrientes en Avellano. Refered as Personal Communication in Lopez-Acevedo
- Dejong T.M., (1982). Leaf Nitrogen Cotents and CO<sub>2</sub> Assimilation in Peach. J. Amer. Soc. Hort. Sci. 107 (6), S: 955-959.
- Genç, Ç., (1969). Fındık Gübrelemesi. Tarım Bakanlığı Ziraat İşleri Gen. Müd. Yayınları A-134, Dizerkonca Matbaası. İstanbul.
- İbrikçi, H., Gülüt K.Y. ve Güzel N., (1994). Gübrelemede Bitki Analiz Teknikleri. Ç.Ü. Ziraat Fak. Genel Yayın No: 95 Ders Kitapları Yayın No: 8 S. 1-75 Adana
- Kacar, B., (1972). Bitki ve Toprağın Kimyasal Analizleri 2. Bitki Analizleri Ankara Üniv. Zir.Fak. Yayınları No:453, S. 1-646 Ankara.
- Kacar, B., (1984). Bitki Besleme Uygulama Klavuzu. A.Ü. Zir. Fak. Yay: 900 Uygulama

Klavuzları:214, S. 1-140 Ankara

Kowalenko, C.G., (1982). Soesenal Effects on Leaf Nutriend Concentrations of Filbert Canadiad Journal of Soil Sceience G.2.1 (209-211).

Lindsay, W.L., (1972). Inorganic phase equilibria of micronutrients in soils. In J.J. Mortveds et al., ed Micronutrients in Agriculture, soil Sci. Soc. Inc p. 41-57, Madison, Winsconsin USA.

Lopez-Acevedo, M., (1983). Estudio de la Fertilizacion del Avellano Mediante Diagnostico Foliar. Memoria Correspondiente al Convenion entre la Diputacion de Tarragona y la Universidat Politecnica de Barcelona.

Marschner H., (1986). Mineral Nutrition in Higher Plants. Acedemic Press, 674 pp.

Molne R., (1976). Observaciones Para Una Racionalizaion y Economia en el Abonado de los avellanos. I Congreso International de Almendra y Avellana. Memoria , Reus, Spain: 191-210.

Page, E.R., (1962). Studies in soil and plant manganese. Plant and Soil. 16:247-257.

Painter, J.H. and H.E. Hammer, (1962). Effect of Differential Applications of Nitrogen K, Mg,Bor and Phosphorus on Their Concentration in Leaves of Filbert Trees. Proc. Amer. Soc. Hort. Sci. Vol. 80:315-326.

Painter, J.H., (1963). A Recent Leaf Analysis Service Development of Importance to Nut Growers in Oregon. Nut Growers Assoc. Washington Proc. 496-8.

Romisondo P., Manzo P. And Tombesi A., (1983). Scelta delle Cultivar. Aspetti della Tecnica Colyurale e Loro Riflessi Sulla Cualita delle Produzioni. Atti del Cunvegno Internazionale sul Nocciuolo. Avellino (Italia) 395-405.

Stebbins, R.L., (1969). The concept of Plant Analysis and How To Take A Leaf Somple.Fr. 118 Reused June 1969.

Tosun, F., (1990). Tarımda Uygulamalı İstatistiksel Metodları, O.M.Ü. Zir. Fak., Samsun.

Tous J., Rovira M. and Plana J., (1987). Cultivo del Avellano. Fruticultura Profeccional, No: 11:115-123.

Uzunharman A., (1995). Şanlıurfa Yöresinde Antep Fıstığı (Pitacia vera L.) Yetiştirilen Toprakların Bazı Fiziksel ve Kimyasal Özellikleri İle Antep Fıstığı Bitkisinin Kimi Besin Maddesi İçerikleri. Yüksek Lisans Tezi, A.Ü. fen Bilimleri Enstitüsü, Ankara.



# DETERMINATION OF MALNUTRITION OF ACACIA YÜZÜNCÜ YIL CAMPUS AREA

Füsün Gülser<sup>(1)</sup>, Nalan Türkoğlu<sup>(2)</sup>, R. İlknur Gazioğlu<sup>(2)</sup>

<sup>(1)</sup> University Of Yüzüncü Yıl, Faculty Of Agriculture, Department Of Soil Science, 65080 Van-Turkey

<sup>(2)</sup> University of Yüzüncü Yıl, Faculty of Agriculture, Department of Horticulture, 65080 Van-Turkey

## ABSTRACT

Growing capability acacia isn't enough the other plants in the soil of Y.Y. Campus area. Therefore, the results of afforestation studies aren't satisfied. It is aimed that determination of relationships in between malnutrition of acacia and soil characteristics in this study.

Acacia trees 10-12 years old, were used as experimental plants. Tree length, corolla width, dry leaf weight, leaf surface area and amounts of some macro and micro nutrients of leaf were determined. Furthermore, some characteristics of soil samples in which trees are grown were analysed.

Correlation analysis were applied in these data. Soil and plant relationship connected with malnutrition were determined.

As a conclusion, research area soil was found inadequate for nitrogen and available phosphorus content. Furthermore, It was determined that iron and zinc contents of some soil samples were in critical levels. In addition to, nitrogen and phosphorus contents of leaves samples obtained from trees at the plot areas were found at low levels. Besides, it was established that vegetative growth of these trees were weak, as well.

## INTRODUCTION

It is very important to choose the best tree species in afforestation according to the soil and climate requirement of each tree species. *Robinia pseudoacacia* L. (False Acer), used in afforestation in the campus area of the University of Yüzüncü Yıl-Van, is a species which belongs to Leguminosae family, this species is very abundant in Turkey (Seçmen et al, 1995). It has roots which undergo very deeply and spread around widely. As all leguminosae there are mycorrhizas which fix free nitrogen in root tips of False Acer (Aşın and Özkan, 1993). It has no special climatic requirements. It can be grown successfully even in areas with cold winter and dry summer. It is grown best in the river beds and refilled lands. It can be grown in shallow soil and it is tolerant to salinity. It is grown in all kinds of soil included dry, poor, and medium heavy ones (Ürgenç, 1992).

According to the Atay's study, it is among the successful species in afforestation of sandy beach areas. False Acer gives very successful results in country landscape arrangements in narrow streets of cities and green areas because it is resistant to air pollution, grows fast and loosely, allows light penetration, stays long in inflorescence, has nice yellow leaves in autumn and grows in salty and alkaline soils (Orçun, 1975).

The soil of campus area is alkaline, rich with clay and lime and poor with organic matter and zinc (Karaçal and Çimrin, 1997). This causes retardation in vegetative growth of False Acer as well as other plant species. For this reason, the expected results may not be obtained in afforestation.

In this study, it is aimed to determine the nutrition and growth problems of False Acacia related to soil character in order to help the afforestation studies.

## MATERIALS and METHODS

The campus area of the University of Y.Y. is 10 km northwest of the city of Van. The land of campus area contains Neojen marns, once under Lake Van at Kuvartner Times and later appeared from the lake terraces (Kempe and Degens 1978).

The campus area has a temperate climatic characteristic with humid and low temperature and rare limitation in water according to Thronthwaite climatic classification (Anonymous, 1971).

The limiting factor of plant growth beside the precipitation is soil in the campus area which has the lowest precipitation in the Lake Van region. Generally, the natural vegetation of this campus area has kserofit plants in step formation (Behçet and Altan, 1994). In the study, soil samples from 20,40,60,80 and 100 cm depth were taken by screw from eight different places in the campus afforestation area. Due to the obstacles from hard layers in soil, in some cases, samples could not be taken from same depths.

According to Kacar (1994) in soil samples analyses of pH, salinity, lime, organic matter, P, K, Ca, Mg, Fe, Cu, Zn, Mn were done by method of Jackson (1958), saturation conductivimeter (Richard, 1954), calcimeter (Allison and Moodie, 1965), modified Walkley Black method, sodiumbicarbonate method (Knudsen et al, 1982), 1N ammonium acetate extraction solution (Thomas,1982), DTPA method (Lindsay and Norwell, 1978) respectively.

In the study 10-12 years old False Acer trees were used. In all areas leaf samples from eighth trees were taken from in each direction on the trees, dried and grinded. In the grinded leaf samples N was analysed by Kjeldahl method, P was spectrophotometric method. K, Ca,Mg, Fe, Cu, Zn and Mn were by atomic absorption device according to Kacar (1984) respectively. Correlation analyses of the obtained results were done by SAS computer programme (Anonymous 1988). Tree height and crown diameter were measured by planimeter. The leaves were dried in drying oven at 65°C until constant weight. Then dried leaves were weighted by sensitive scale.

## DISCUSSION

It was shown the results of analysis of soil samples obtained from different places in Campus area on Table 1.

Table 1. Some physical and chemical properties of soil samples obtained from plot area.

Plot Area	Depth (cm)	Texture	PH	Salt (%)	Lime (%)	O.M. (%)	P (ppm)	K (ppm)	Ca (ppm)	Mgp (ppm)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
A	0-20	Sandy	7.72	0.01	6.81	0.12	5.51	380	2700	480	1.62	2.61	1.74	13.7
B	0-20	Sandy	7.72	0.017	2.69	0.12	4.6	420	2600	1060	1.45	2.64	0.64	10.04
B	20-40	Sandy	7.76	0.025	12.19	0.35	7.0	420	2800	3500	2.55	3.65	1.60	12.0
B	40-60	Loamy	7.83	0.019	9.66	0.06	3.82	430	2800	440	7.64	3.47	0.93	10.4
B	60-80	Loamy	7.74	0.026	10.61	0.06	3.01	430	2700	410	2.91	3.09	0.93	15.8
B	80-100	Sandy	7.86	0.017	9.66	0.29	5.51	400	300	410	5.66	4.19	0.45	10.86
C	0-20	Sandy	7.81	0.016	8.40	0.41	3.82	310	2500	570	4.37	2.46	2.08	16.37
C	20-40	Loamy	7.61	0.033	1.74	0.06	3.01	260	3000	350	4.73	2.17	0.69	12.79
C	40-60	Loamy	7.68	0.025	16.32	0.29	1.51	260	2900	520	3.64	2.04	0.78	9.76
C	60-80	Loamy	7.75	0.021	15.36	0.06	1.51	250	2700	520	6.39	2.11	0.78	11.50
C	80-100	Loamy	7.61	0.033	1.74	0.06	0.76	670	2500	710	1.98	2.69	2.65	16.00
D	0-20	Sandy	7.89	0.010	15.36	0.06	3.01	150	2500	500	4.74	1.94	1.93	10.59
D	20-40	Sandy	7.87	0.010	14.73	0.06	1.51	150	2500	460	1.25	2.08	1.98	10.68
D	40-60	Loamy	7.91	0.017	5.86	0.06	3.01	190	2600	1200	2.91	2.74	1.55	10.50
D	60-80	Loamy	7.81	0.016	8.40	0.06	1.51	270	2300	330	2.17	2.80	0.74	8.11
E	0-20	Sandy	7.71	0.013	7.45	0.06	3.82	330	2600	710	6.76	4.50	0.50	8.11
E	20-40	Loamy	7.80	0.020	3.96	0.12	4.61	330	2600	780	1.80	2.20	1.41	13.89
E	40-60	Loamy	7.80	0.033	10.93	0.12	4.60	330	2600	470	2.90	3.72	1.26	10.59
F	0-20	Loamy	8.30	0.040	16.63	0.41	0.76	210	2600	1100	3.45	2.36	1.36	10.86
F	20-40	Loamy	8.11	0.040	19.33	0.06	1.51	220	2500	1010	7.50	2.55	1.84	10.31
F	40-60	Loamy	8.22	0.040	20.60	0.46	1.51	270	2500	1240	1.25	1.53	2.60	14.62
G	0-20	Loamy	7.74	0.038	7.76	0.06	0.76	180	2400	340	6.73	2.49	0.31	9.21
G	20-40	Loamy	7.87	0.038	22.02	0.29	0.76	150	2600	550	7.64	2.96	1.45	12.79
H	0-20	Loamy	7.73	0.028	8.71	0.12	3.01	390	3000	670	2.72	2.55	1.26	15.91
H	20-40	Loamy	7.97	0.044	2.06	0.12	3.04	300	2200	510	7.45	3.02	0.78	16.0

According to limit values given, (Kellog, 1952), the soil samples were found low alkaline (7.4-7.8) and med alkaline (7.9-8.4). It was found that the soil samples were nonsalty (< 0.15) according to limit values given in the paper ( Anonymous, 1971). To limit values (Anonymous, 1971), about lime content, the soil is as follows; limy (1-5), med limy (5-15) and more limy (15-25). It was found that organic matter contents of the soil samples were very few, according to reported (Anonymous, 1971)



limit values. It was found that the available phosphorus contents of soil were inadequate (<5) and med-levels to reported by Güner (1968). The potassium contents of the soil samples, except Dand G areas, were found adequate and high level (>200) on all profiles to reported values (Fawzi and Fouly, 1980). It was determined that cooper and manganese contents of the soil were adequate to limit values reported by Viets and Lindsay (1973). Iron contents of the some soil samples were lower than 4.5 ppm and inadequate. It was found that zinc contents were inadequate (<0.5) and critical levels (0.5-1.0) in some soil samples, as well. The averages of the nutrients of the leaf samples from 10 trees randomly choosen at the each plot area were shown Table 2.

Table 2. The averages of the contents of some macro and micro nutrients of the leaf samples.\*

Plot Area	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)
A	1.50	0.16	1.19	1.04	0.60	640	54	201	79
B	1.29	0.17	0.93	0.87	0.48	762	57	117	38
C	1.34	0.15	0.86	1.33	0.56	725	49	172	42
D	1.45	0.13	0.83	1.37	0.60	419	40	150	54
E	1.30	0.13	0.89	0.86	0.56	656	29	127	74
F	1.45	0.16	1.68	1.53	0.77	492	41	369	62
G	1.44	0.19	1.54	1.59	0.96	483	37	228	77
H	1.49	0.18	1.10	1.05	0.82	530	50	274	66

\*The values are the averages of ten replications.

This properties established on the soil samples were seen similar with the study of Gülser (1992) and Karaçal and Çimrin (1997). As the averages were considered it was found that N and P contents of the leaf samples were inadequate at the whole plot area to given (Jones et al., 1991) limit values. Similarly, potassium and calcium levels were found inadequate (<1.23 and <1.54) at the F and G samples areas. It was found that magnesssium content was inadequate at the B area (<0.36). Fe, Cu, Zn and Mn contents of the leaves on the whole areas were adequate and were > 22.4 ppm, >13ppm, >1.13 ppm and >33ppm respectively.

The values of the length of the trees, width of the crown, the leaf surface area and weight of the dry leaf were shown on Table 3.

Table 3. Some properties of the trees obtained leaf samples.\*

Plot Area	Length of Tree (m)	Crown Width (m)	L. Surface Area (cm <sup>2</sup> )	Dry Leaf Weight (g)
A	3.0	2.3	5.3	1.1
B	2.8	1.8	6.3	0.7
C	2.9	1.6	7.6	0.9
D	3.6	2.6	9.2	1.0
E	3.5	2.8	7.4	1.0
F	3.0	1.7	8.6	1.5
G	4.2	2.3	6.1	0.8
H	2.9	1.6	7.2	0.8

\*The values are the averages of ten replications.

The crown width and length of the trees were between 1.6-2.8 m and 2.8-4.2 respectively. The trees were shown weak growth therefore the crown width and length of the tree 10 m and 5-25 m respectively, as reported on the papers (Ürgenç 1998; Tanrıverdi, 1987; Odabaş, 1989). According to the result of the performed correlation analyses, linear correlation coefficient values between the leaf and soil properties were shown on Table 4.



Table 4. Linear correlation coefficients between leaf and soil properties.

	pH	Salt	Lime	OM	P	K	Ca	Mg	Fe	Cu	Zn	Mn	L.N	L.P	L.K	L.Ca	L.Mg	L.Fe	L.Cu	L.Mn
Salt	0.48***																			
Lime	0.54***	0.27*																		
OM	0.68***	0.41***	0.67***																	
P	-0.35**	-0.56***	-0.45***	-0.17																
K	-0.44***	-0.24*	-0.54***	-0.22	0.50***															
Ca	-0.35***	-0.15	-0.15	-0.07	0.40***	0.33**														
Mg	0.33	0.23	-0.01	0.31**	0.22	0.12	0.35**													
Fe	0.08	0.37**	-0.05	-0.05	-0.25*	-0.33**	-0.07	-0.03												
Cu	-0.26*	-0.05	-0.21	-0.17	0.46***	0.29*	0.13	0.002	0.35**											
Zn	0.35**	-0.04	0.35**	0.45***	0.001	0.17	-0.05	0.063	-0.55***	-0.40***										
Mn	0.03	0.21	-0.17	0.14	0.16	0.46***	0.49***	0.12	-0.24*	-0.16	0.44***	-0.07								
L.N	0.05	0.035	0.04	-0.04	-0.01	-0.14	-0.11	-0.25*	-0.14	-0.11	-0.03	0.15	0.08							
L.P	-0.04	0.003	-0.02	-0.08	0.02	0.10	0.28	-0.21	0.03	0.06	0.01	0.09	0.09	0.18						
L.K	0.25*	0.32**	0.32**	0.41***	-0.15	-0.17	-0.18	-0.07	0.15	0.06	0.21	0.09	0.09	0.18	0.07					
L.Ca	0.03	-0.15	0.09	-0.09	0.10	-0.16	-0.10	-0.06	-0.13	-0.11	0.13	0.08	-0.12	0.01	0.07	0.42**				
L.Mg	0.12	0.32**	0.14	0.03	-0.25*	-0.21	-0.09	-0.12	0.24	-0.05	-0.10	-0.05	0.11	0.15	0.42**	-0.01				
L.Fe	-0.23	-0.13	-0.07	-0.01	0.26*	0.31	0.24	0.25	-0.11	0.19	0.05	0.18	-0.01	-0.09	-0.12	-0.30	-0.29			
L.Cu	0.08	-0.23	0.05	0.04	0.21	-0.06	0.18	-0.03	0.12	0.06	-0.002	-0.06	0.10	-0.14	0.09	-0.06	0.11	-0.03		
L.Mn	0.37**	0.28*	0.33	0.34	-0.26*	-0.18	-0.01	0.05	-0.04	-0.28	0.24*	0.14	0.07	0.13	0.46	0.39	0.43**	-0.18	-0.02	
L.Zn	0.002	-0.08	0.03	0.03	0.10	-0.08	0.07	-0.20	-0.08	-0.11	0.07	-0.02	-0.01	0.14	0.20	-0.14	0.17	-0.12	0.14	0.15

It was found positive correlation between pH level on soil samples and K and Mg values of leaf samples on the level of 5% and 1% respectively. It was found important positive correlations between salt level on soil and K and Mg content of the leaf on the level of 1% and between salt level and leaf Mn level on the level of 5%. Important positive correlations were found between in lime content of the soil samples and leaf K level ( $P<0.01$ ) It was found positive important ( $P<0.05$ ) correlations between phosphorus on soil and Mg and Fe level on the leaves. It was found important negative correlations between phosphorus on the soil and mangan level of the leaf at the level of 5%. It was determined important positive correlations between K level of the soil and Fe content of the leaf ( $P<0.05$ ). Important negative correlations between Mg level on the soil and nitrogen level of the leaf were found at the level of 5 %. Negative correlations between manganese content of the leaf and cooper content of the soil, positive correlations, between zinc content of the soil and manganese content of the leaf were found ( $P<0.05$ ).

To find out malnutrition of the trees, the correlations before mentioned were found unadequate. Similarly, Johansson (1978) reported that leaf analyses supply knows that soil analyses can not reveal, and it should be considered the effect of complicated interactions between nutrients. It was found important negative correlations between pH level of the soil and soil P, Ca and K levels ( $P<0.01$  and  $P<0.001$ ). Similarly, negative correlations between lime and P, Ca and K levels.

Therefore, it should be considered that high pH level and lime level effect negatively uptaking of P, K and Ca. Phosphorus content was determined also unadequate according to soil analyses, may have effected negatively plant growth.

Soil of the research area are very poor about organic matters because of this area has unmaturing and noncultivar young soil. This case, may be the cause of negative factor for plant growth.

Aktaş (1995) revealed that growth range and vegetative growth period decreased on plants with deficient nitrogen and posphorus levels.

Unsufficient rainfall may be the cause to fail on the afforestation in this area.

As a conclusion, to success on afforestation, nitrogen and phosphorus fertilization together with irrigation, may be advised.

When critical iron and zinc levels on the soil were noticed, to prevent further deficiency, these elements can add to soil

## REFERENCES

- Aktaş, M., 1995. Bitki Besleme ve Toprak Verimliliği A.Ü. Ziraat Fakültesi Yayınları, 1501, Ankara.
- Anonymous, 1971. Van Gölü Havzası Toprakları, Tarım Orman ve Köy İşleri Bakanlığı, Toprak-Su
- Anonymous, 1988. Pc SAS User's Guide: Statistics. SAS Inst. Inc. Cary. NC.
- Aşın, R., Özkan, C., 1993. Tohumlu Bitkiler (Spermatophyta) Odunsu Taksonlar. K.T.Ü. Orman Fakültesi Yayınları, 19, Trabzon
- Behçet, L., Altan, Y., 1994. Van, Erçek, Turna ve Bostaniçi Göllerinin Sucul Florası Tr.J. of Botany, 18, 91-98.
- Fawzi, A.F.A. and M.M.El-Fouly, 1980. Soil and Leaf Analysis of Kin Different Areas in Egypt. Genel Müd. Yayınları, 28, Köy İşleri Bakanlığı Yayınları, 197, Raporlar serisi, 67 Ankara.
- Gülser, F., 1992 – Van Gölü Havzası Büyük Toprak Gruplarının Verimlilik Durumları. Yüksek Lisans Tezi.
- Güner, U., 1968. İzmir Bölgesi Tarla Topraklarının Fosfor ve Potasyum İhtiyaçlarını Belirlemeye yarayan Bazı Kimyasal Laboratuvar Metodlarının Neubauer Metodu ve Mukayesesine Dair Araştırmalar. Doktora Tezi. Ege Üniv. Ziraat Fak. Yayınları, 13 Bornova.
- Johansson, J., 1978. Acta Agriculture Scandinavica 28 (1978). Effect of Nutrient Levels on Growth, Flowering and Leaf Nutrient Content of Greenhouse Roses.
- Kacar, B., 1984. Bitki Besleme Uygulama Kılavuzu. A.Ü.Ziraat Fakültesi Yayınları, 900, Ankara.
- Kacar, B., 1994. Bitki ve Toprağın Kimyasal Analizleri III. Toprak Analizleri. Ankara Üniversitesi, Ziraat Fakültesi, Eğitim Araştırma ve Geliştirme Vakfı Yayınları, 3 Ankara
- Karaçal, İ., Çimrin, M., 1997. Y.Y.Ü. Kampus Alanı Toprak Profillerinin Zn Durumu ve Bu Elementin Bazı Toprak Özellikleri ile İlişkileri. Ulusal Çinko Kongresi 12-16 Mayıs 1997. Anadolu Tarımsal Araştırma Enstitüsü, Eskişehir.
- Kellog, C.E, 1952. Our Garden Soils. The Macmillan Company, Newyork.
- Kempe, S., Degens, E.T., 1978. The geology of Lake Van M.T.A. Yayınları, 169.

- Odabaşı, A., 1989. Park ve Bahçe Ss Bitkileri TAV Yayınları, 18. Yalova.
- Orun, E., 1975. Dendroloji II. Ege niversitesi, Ziraat Fakltesi Yayınları, 26, Bornova,
- Semen, . Gemici, Y., Grk, G., Bekat, L., Leblebici E., 1995. Tohumlu Bitkiler Sistematigi Ege niv. Fen Fakltesi Kitaplar Serisi, No:116, İzmir.
- Tanrıverdi, F., 1987. Peyzaj Mimarlığı Bahe Sanatının Temel İlkeleri ve Uygulama Metodları. A.. Yayınları, 643, Erzurum.
- rge, S., 1992, Aa ve Ss Bitkileri Fidanlık Yetiřtirme Teknięi. İ..Orman Fakltesi Yayınları,418. İstanbul.
- rge, S., 1998. Aalandırma Teknikleri. İ. . Orman Fakltesi Yayınları, 441, İstanbul.
- Vites, F.G.and W.L.Lindsay, 1973. Testing Soils for Zinc, Cooper, Manganese and Iron, Editr: L.M.Walshand J.Beaton. Soil Sci. Soc. of Amer. Inc. Medison Visconsin, U.S.A



# EFFECTS OF DIFFERENT GROWING MEDIA AND APPLICATION OF VARIOUS NITROGEN AND PHOSPHORUS DOSES ON THE NUTRIENT UPTAKE OF PEPPER SEEDLING

Füsun Gülser<sup>(1)</sup>, Önder Türkmen<sup>(2)</sup>, Fikret Yaşar<sup>(2)</sup>, Turgay Kabay<sup>(2)</sup>

<sup>(1)</sup> University Of Yüzüncü Yıl, Faculty Of Agriculture, Department Of Soil Science, 65080 Van-Turkey

<sup>(2)</sup> University of Yüzüncü Yıl, Faculty of Agriculture, Department of Horticulture, 65080 Van-Turkey

## ABSTRACT

The mixtures of different materials such as torf + soil + banyard manure, pumice + soil + barnyard manure, and torf were used as seedling growing media. A pepper cultivar, Kandil, was used as an experimental plant. 0 g/m<sup>3</sup>, 540 g/m<sup>3</sup>, 1080 g/m<sup>3</sup>, 1620 g/m<sup>3</sup> nitrogen as ammonium sulphate and 0 g/m<sup>3</sup>, 1380 g/m<sup>3</sup>, 2760 g/m<sup>3</sup>, 4140 g/m<sup>3</sup> P<sub>2</sub>O<sub>5</sub> as diammoniumphosphate were applied to the growing media. Furthermore, constant dose of ammonium sulphate (420 gm<sup>3</sup>) was added to the growing media. The amounts of some macro (N, P, K, Ca, Mg) and micro (Fe, Cu, Zn, Mn) elements were determined in pepper seedlings. It was found that M<sub>1</sub> (torf) and M<sub>2</sub> (torf: garden soil: barnyard manure) growing media had more positive effect on the nutrient uptake of pepper seedlings because of their high level of cation exchange capacity, water holding capacity and organic matter content.

## INTRODUCTION

The growing healthy and the best quality seedlings is an important issue in vegetable production. This is possible with the using suitable variety and growing media and the being in the suitable climatic conditions. The important factors which must be in growing media are the being economical and the obtaining suitable chemical and physical characteristics. The mixture of growing media can be changed according to the vegetable species and growing region. The nutrient which will be also added into growing media are changed according to the growing mixture and vegetable species.

The most abundant nutrients which are used in growing media are N, P and K. Especially N is a vital nutrient in plant growth because the most part of the plant dry matter consists of nitrogenous compounds (Çolakoğlu and Pekcan, 1990). In addition, P and K are very important nutrients like N. Especially the P uptake of plants decreases in low temperatures and insufficient light conditions (Şeniz, 1984). The optimum temperature can not be obtained at seedling growing structures in protected cultivation in early spring. Enough phosphorus in growing media promotes root development (Kacar, 1984). The nutrient composition of pepper seedling were examined with various N and P doses on easily obtained growing media in Turkey. At the end of the study, the most suitable growing media with suitable N and P doses were determined.

## MATERIALS and METHODS

This study was conducted according to factorial experimental design with three replication in the greenhouse of the Horticulture Department of Agriculture Faculty of Yüzüncü Yıl University in 1997. Kandil pepper cultivar was used in this study.

The main subjects are seedling growing media and different nitrogen and phosphorus dose mixtures: Torf (M<sub>1</sub>), (1:1:1) of torf + garden soil+barnyard manure (M<sub>2</sub>), (1:1:1) of sand+ garden soil+barnyard manure (M<sub>3</sub>) and (1:1:1) of pumice + garden soil + barnyard manure (M<sub>4</sub>) were used as seedling growing media.

Constant dose of 420 g nitrogen as ammonium sulphate were added into 1m<sup>3</sup> growing media. Furthermore 0,540, 1080, 1620g N and 0, 1380, 2760, 4140 g P<sub>2</sub>O<sub>5</sub> as diammonium phosphate were applied in to 1m<sup>3</sup> growing media. Some physical and chemical properties of growing media were given in Table 1.

Table 1. Some physical and chemical properties of growing media.

Media	Moisture (%)	CEC (me/100g)	pH	Salt (%)	Lime (%)	P (ppm)	K (ppm)	Org. Matter	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
M <sub>1</sub>	47	47.41	8.2	0.13	3.6	2.8	120	3.72	9.0	1.12	4.75	10.62
M <sub>2</sub>	23	31.13	8.2	0.14	4.9	12.7	246	3.02	9.3	1.76	7.34	12.78
M <sub>3</sub>	16	14.15	8.3	0.07	11.5	13.2	237	0.12	54.3	2.00	5.67	19.80
M <sub>4</sub>	19	36.79	8.3	0.10	6.8	23.0	280	1.86	72.8	4.80	5.11	25.20

According to the analyses results, the capacity of exchangeable cations and water holding capacity of M<sub>1</sub> and M<sub>2</sub> media were found higher than those of the other media. pH values of all growing media were determined as medium alkaline (7.9-8.4) according to the given limit values (Kellog, 1959). All growing media were found nonsalty (<0.15) according to given limit values (Lindsay and Norwell, 1969). Lime content of M<sub>3</sub> and M<sub>4</sub> media were determined as medium level (5-15). M<sub>1</sub> and M<sub>2</sub> growing media had more lime (1-5) according to reported limit values (Lindsay and Norwell, 1969).

P levels were determined as low level (<5) in M<sub>1</sub> medium and high level (>10) in the other media according to given limit values (Güner, 1969).

Organic matter contents of M<sub>1</sub> and M<sub>2</sub> media were found as high level (>3). Organic matter levels were determined as the lowest (<1) and low (1-19), respectively in M<sub>3</sub> and M<sub>4</sub> growing media according to reported limit values by Lindsay and Norwell (1969). K content of torf growing medium was found as low (<150). K levels of the other media were found as adequate (200-300) according to reported limit values (Fawzi and Fouly, 1980). Fe, Cu, Zn, Mn levels were found adequate in all of the growing media according to given limit values (Viets and Lindsay, 1973).

Pepper seedlings were harvested eight weeks after the seed sowing. Levels of some nutrients were analysed in dried and grinded seedling samples according to following methods reported by Kacar (1984).

N content were determined by Kjeldahl Method. P level were analysed by spectrophotometric method. K, Ca, Mg, Fe, Cu Zn and Mn levels were determined by atomic absorption spectrophotometry.

## DISCUSSION

The effects of different growing media and doses on nutrient uptake of seedlings were in Table 2 and 3.

Table 2. Effect of different growing media on the nutrient uptake of seedlings.

Media	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
M1	1.70 D	0.26 B	0.64 A	0.38 A	0.39 A	241 A	12 D	134 C	74 B
M2	2.33 A	0.36 A	0.61 B	0.33 B	0.36 B	150 C	15 C	156 B	80 A
M3	2.10 B	0.37 A	0.60 B	0.25 C	0.36 B	141 D	19 B	173 A	50 D
M4	1.98 C	0.21 C	0.62 AB	0.33B	0.35B	195 B	20 A	92 D	59 C

Table 3. Effect of different nitrogen and phosphorus doses on the nutrient uptake of seedlings.

Doses	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
NoPo	1.89 C	0.30 B	0.58 C	0.34 A	0.36 AB	189 B	20 A	154 A	69 A
N1P1	1.90 C	0.32 A	0.60 BC	0.30 B	0.35 B	171 C	14 D	138 C	61 C
N2P2	2.07 B	0.30 B	0.67 A	0.31 B	0.35 B	194 A	17 B	144 B	69 A
N3P3	2.16 A	0.27 C	0.62 B	0.34 A	0.38 A	173 C	15 C	118 D	65 B

F values obtained in performed variance analysis of different growing media and doses were shown in Table 4.



Table 4. F values obtained in variance analysis.

	Sd	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn
N P	3	256.7***	20.4***	21.8***	18.4***	2.7n.s.	89.3***	313.12***	2803.7***	18.7***
M	3	983.3***	279.8***	4.7*	122.9***	7.3**	1517.9***	6084.1***	14657.7**	219.9***
N P x M	9	67.1***	26.9***	2.9*	57.8***	6.0***	452.3***	3291.2***	2007.9***	181.6***
Error	16									

ns.:nonsignificant \*:significant at P:0.05 \*\*: significant at P:0.01 \*\*\*:significant at P:0.001

Average nitrogen content of the seedlings was found as % 2.33 in  $M_1$  growing medium. It was determined that this value is significantly higher than those of the other growing media. Average nitrogen contents of seedlings were also found significantly different in the various nitrogen and phosphorus applications. The highest average nitrogen value was obtained in  $N_3 P_3$  dose as % 2.16. Nitrogen value in the same growing medium was found significantly different ( $P < 0.001$ ) from others. These differences usually occurred as increasment. The highest nitrogen value was obtained in  $M_2$  growing medium with  $N_3 P_3$  dose. Jones et al. (1991) reported the inadequate value of nitrogen contents for mature young pepper leaves as %3.0-3.5. According to these values, it may be thought that nitrogen contents of seedlings are inadequate.

Average phosphorus contents of seedlings were found significantly higher ( $P < 0.001$ ) in  $M_2$  and  $M_3$  growing media as %0.36 and %0.37, respectively. According to fertilizer doses, average phosphorus content obtained in  $N_1 P_1$  application was found significantly higher ( $P < 0.001$ ) than other doses as % 0.32. Available phosphorus contents of seedlings were decreased in  $M_1$ ,  $M_3$  and  $M_4$  growing media by the application of  $N_1 P_1$  dose. However, decreasment in phosphorus contents of seedlings in  $M_2$  growing medium was determined by the application of  $N_2 P_2$  dose. According to reported (Jones et al., 1991) limit values, phosphorus contents of seedlings were usually found insufficient levels (%0.22-0.70).

The highest average potassium content was obtained in  $M_1$  growing medium as % 0.64. This value was found significantly higher ( $P < 0.05$ ) than those of the other growing media. Differences ( $P < 0.001$ ) among doses were determined significantly important. Average potassium content (%0.67) obtained in  $N_2 P_2$  dose was found higher than those of the other growing media. The highest average potassium value was found in  $M_1$  growing media with  $N_2 P_2$  application as % 0.71. Potassium content of seedlings usually decreased with the increasment of nitrogen and phosphorus doses more than  $N_2 P_2$  dose and it was found insufficient with respect to given (Jones et al., 1991) values.

Various growing media were found significantly different ( $P < 0.001$ ) for calcium content. Average calcium content obtained in  $M_1$  growing medium was higher than those of the other growing media as % 0.38. Differences ( $P < 0.001$ ) were also found among various doses. The highest values were obtained in  $N_0 P_0$  and  $N_3 P_3$  applications as % 0.34. The highest calcium contents was found in  $M_2$  growing medium with  $N_3 P_3$  application as %0.47. It was determined that calcium contents were insufficient (<%1.30) with respect to reported values (Jones et al., 1991).

Average magnesium content of medium were found significantly higher ( $P < 0.01$ ) than those of the other media as % 0.39. Various nitrogen and phosphorus doses were not found significantly different for magnesium content of seedlings. Average magnesium value obtained in  $N_3 P_3$  application was determined higher than those of the other growing media. However, this difference was not significantly important. Magnesium values were found sufficient enough (%0.3-1.0) in all of the applications and growing media according to reported values by Jones et al (1991).

Average iron content of seedlings was obtained significantly higher ( $P < 0.001$ ) than those of the other media as 241 ppm in  $M_1$  media. Fertilizer doses were found significantly different ( $P < 0.001$ ). The highest iron value was obtained in  $N_2 P_2$  applicatios as 194 ppm. The highest iron value was determined in  $M_1$  growing media with  $N_3 P_3$  application as 242 ppm. Iron contents of seedlings decreased with the increasement in nitrogen and phosphorus doses except  $M_1$  growing medium. Available iron contents were determined as sufficient with respect to given (Jones et al., 1991) value (60-300 ppm) in all of the growing media and doses.

All growing media were found significantly different ( $P < 0.001$ ) for average seedling copper contents. Average copper content obtained in  $M_4$  growing medium was found higher than those of the other media as 20 ppm. Significant differences among doses were also found for copper content. Average copper value obtained in  $N_0 P_0$  application was detected higher than those of the other



applications as 20 ppm. Copper values in all of the growing media and applications were found sufficient enough according to the reported (Jones et al., 1991) values (6-25 ppm).

Average zinc content in  $M_3$  media was obtained significantly higher ( $P<0.001$ ) than those of the other growing media as 173 ppm. Significant differences among the doses were also found for zinc content. Average zinc value obtained in  $N_0P_0$  application was determined higher than those of the other applications as 154 ppm. The highest zinc value was obtained in  $M_3$  growing media with  $N_0P_0$  application as 216 ppm. Available zinc contents of seedlings were found sufficient enough with respect to given values (20-200 ppm) by Jones et al (1991).

Differences ( $P<0.001$ ) among growing media were detected for seedling manganese contents. Average manganese value obtained in  $M_2$  growing media was found higher than those of the other growing media as 80 ppm. Differences ( $P<0.001$ ) were also found among the other fertilizer doses for manganese content. The manganese values obtained in  $N_0P_0$  and  $N_2P_2$  applications were found higher than those of the other applications as 69 ppm. The highest manganese value was found in  $M_2$  growing media with  $N_3P_3$  application as 101 ppm. Manganese contents of seedlings were detected sufficient enough with respect to given (Jones et al., 1991) values (50-250 ppm).

That low available K, Ca and Mg contents of seedlings in  $M_2, M_3$  and  $M_4$  growing media with respect to those of  $M_1$  growing media can be explained with the leaching factor (Ergene, 1987) which is more effective in these growing media with low water holding capacity compared to  $M_1$  growing media.

Mn, Cu and Zn contents usually decreased with the increasement in N and P doses. Therefore, there were antagonistic relationship among nutrients. In this study  $N_3P_3$  dose were found less effective on the uptake of nutrients than those of the other applications. This can be explained with Mitscherlich theory (Aktaş, 1995).  $M_1$  and  $M_2$  media had positive effect on the uptake of nutrients of seedling samples with the respect to those of the other media. High level of cation exchange capacity, the water holding capacity and organic matter of these media may have positive effect on the seedling growth.

Similarly, Gülser et al. (1998) reported that  $M_1$  and  $M_2$  growing media had more positive effect on the seedling growth than those of the other media.

## REFERENCES

- Aktaş, M., 1995. Bitki Besleme ve Toprak Verimliliği A.Ü. Ziraat Fakültesi Yayınları, 1501, Ankara.
- Çolakoğlu, H., Pekcan T., 1990. Damlama Sulama Sistemi ile Gübrelemenin Serada Domates Bitkileri Gelişmesi ve Besin Maddesi Alımına Etkisi. Türkiye 5. Seracılık Sempozyumu. Ege Ü. Ziraat Fakültesi, Bahçe Bitkileri Bölümü ve Tarım, Orman ve Köy İşleri Bakanlığı Proje ve Uygulama Genel Müdürlüğü, 17-18-19 Ekim 1990, 131-138 s. İzmir
- Ergene, A., 1987. Toprak Biliminin Esasları Atatürk Üniversitesi Ziraat Fakültesi Yayınları, s (635). Erzurum.
- Fawzi, A.F.A. and M.M.El-Fauly, 1980. Soil and Leaf Analysis of Kin Different Areas in Egypt.
- Gülser, F., Türkmen, Ö., Kabay, T., 1998. The Effects of Different Growth Conditions and Application of Various Nitrogen and Phosphorus Doses on the Seed Germination and Quality of Pepper Seedling. M.Şefik Yeşilsoy International Symposium on Arid Region Soil International Agrohydrology. p(689-695). İzmir.
- Güner, U., 1968. İzmir Bölgesi Tarla Topraklarının Fosfor ve Potasyum İhtiyaçlarını Belirlemeye Yarayan Bazı Kimyasal Laboratuvar Metodlarının Neubauer Metodu ve Mukayesesine Dair Araştırmalar. Doktora Tezi. Ege Üniv. Ziraat Fak. Yayınları, 13 Bornova.
- Jones, J.R., J.B., Wolf, B., Mills, H.A., 1991. Plant Analysis Handbook, Micro Macro Publishing, Inc.
- Kacar, B., 1984 a. Bitki Besleme. A.Ü. Ziraat Fakültesi Yayınları, 899, Ankara.
- Kacar, B., 1984 b. Bitki Besleme Uygulama Kılavuzu. A.Ü. Ziraat Fakültesi Yayınları, 900, Ankara.
- Kellog, C.E., 1952. Our Garden Soils. The Macmillan Company, Newyork.
- Lindsay, W.L., Norwell, W.A., 1969. Development of a DTPA Micronutrient Soil Test. Soil Sci. Am. Proc. 35: 600-602.
- Research and Training Center. 21-24 September, 1998. İzmir, Turkey.
- Şeniz, V., 1984. Sebzeçilikte Fide Yetiştiriciliği ve Sorunları. Tarımsal Araştırmaları Destekleme ve Geliştirme Vakfı, Yayınları, 19, Yalova, 97-98-99 s.
- Vites, F.G. and W.L. Lindsay, 1973. Testing Soils for Zinc, Cooper, Manganese and Iron, Editör: L.M. Walshand J. Beaton. Soil Sci. Soc. of Amer. Inc. Madison Wisconsin, U.S.A.

# EFFECTS OF NITROGEN AND PHOSPHORUS DOSES ON NUTRIENT UPTAKE OF TOMATO SEEDLINGS

Önder Türkmen<sup>(1)</sup>, Füsün Gülsel<sup>(2)</sup>, Turgay Kabay<sup>(1)</sup>

<sup>(1)</sup> University of Yüzüncü Yıl, Faculty of Agriculture, Department of Horticulture, 65080 Van-Turkey

<sup>(2)</sup> University of Yüzüncü Yıl, Faculty of Agriculture, Department of Soil Science, 65080 Van-Turkey

## ABSTRACT

The mixture of garden soil, sand and barnyard manure was used as growing medium in equal amounts. According to the results of soil analysis pH value of the growing medium was detected as low alkaline. Lime content of the growing medium was found as medium level. Texture of the growing medium was determined as loamy. Amounts of nitrogen and organic matter were found at the low level. Phosphorus and potassium contents of the growing medium were found at the high and enough levels, respectively. The growing medium was found as nonsalty. 0g/m<sup>3</sup>, 400 g/m<sup>3</sup>, 800 g/m<sup>3</sup>, 1200 g/m<sup>3</sup>, and 1600 g/m<sup>3</sup> of nitrogen and 0g/m<sup>3</sup>, 600 g/m<sup>3</sup>, 1200 g/m<sup>3</sup> and 1800 g/m<sup>3</sup> of P<sub>2</sub>O<sub>5</sub> were applied into the growing medium as chemical fertilizers. Amounts of some macro (N, P, K, Ca, Mg) and micro (Fe, Cu, Zn, Mn) nutrients of tomato seedling were analysed.

At the end of the study, it was seen that N doses had no effect on P uptake of seedlings. However, P uptake was enhanced by increased P doses. N and P doses had significant effect on some macro and micro elements. Joint application of N (1600 g/m<sup>3</sup>) and P (1800 g/m<sup>3</sup> P<sub>2</sub>O<sub>5</sub>) gave the most positive results on tomato seedlings.

## INTRODUCTION

The most important issue in succesful vegetable production is to grow strong and healthy seedlings. Seedling medium can be prepared with different mixtures. Even with suitable growing medium mixture and ecological conditions, the seedlings sometimes grows weakly. The seedlings are not able to take essential nutrients for some causes. For this reason, seedling growing medium must be balanced for mixtures. There is strong relationship between seedling nutrient uptake and seedling growth. Therefore, fertilization is as important as environmental factors.

Among the most essential plant nutrients, nitrogen and phosphorus come first. Nitrogen has a vital importance on the plant growth because the most part of the plant dry matter consists of nitrogenous compounds. Seedlings with adequate nitrogen have dark color and strong vegetative growth (Kacar, 1984). Phosphorus must be abundant enough in growing medium because phosphorus uptake of plants is decreased under low temperatures and insufficient light conditions. In the shortage of phosphorus, the seedlings become dark colored and the root growth is affected negatively Aktaş (1995).

Phosphorus affects inflorence especially in tomatoes (Akıllı and Biner, 1977). There are quite different references on the application amount of fertilizers as the seedling nutrients. Wacquant at al. propose 218 g of N and 211 g of P<sub>2</sub>O<sub>5</sub> for 1m<sup>3</sup> medium (Şeniz, 1984). The changes in the nutrient content according to the different N and P doses were investigated as an indicator of seedling quality. Amount of nutrients and optimum nitrogen and phosphorus doses for the tomato seedlings were examined in this study.

## MATERIALS and METHODS

This study was carried out according to the factorial experimental design with three replications in the greenhouse of the Horticulture Department of Agriculture Faculty of the University of Yüzüncü Yıl. Different nitrogen and phosphorus doses were studied. The mixtures of garden soil, barnyard manure, and sand were used as seedling growing medium. According to the soil analyses, experimental soil was found as loamy, with low alkaline, nonsalty, moderate limy, and with insufficient organic matter and sufficient P, K, Ca, Mg, Fe, Cu, Zn and Mn. Furthermore, 0,400, 800,1200, 1600g/m<sup>3</sup> N and 0,600, 1200 and 1800 g/m<sup>3</sup> P<sub>2</sub>O<sub>5</sub> were applied into 1m<sup>3</sup> growing media as ammonium nitrate and diammonium phosphate, respectively. Nitrogen amount in diammonium phosphate was taken into consideration in the calculation of N doses. Tomato seedlings were harvested at the transplanting stage (7 weeks after the seed sowing). Seedlings were washed, dried and grinded. Total N of grinded plant samples was measured by Kjeldahl method; phosphorus was



measured by vanadomolibdo yellow color method; Ca, Mg, Fe, Cu, Zn and Mn were measured by atomic absorption spectrophotometer (Kacar, 1984).

## DISCUSSION

The effects of different N and P doses on the nutrient uptake were shown in Table 1 and 2.

Table 1. The effect of different N doses on the nutrient uptake.

	N(%)	P(%)	K(%)	Ca(%)	Mg(%)	Zn(ppm)	Mn(ppm)
N <sub>0</sub>	1.80 D	0.30 A	4.23 AB	1.30 C	1.03 B	62.6 A	110.8 BC
N <sub>1</sub>	3.18 A	0.31 A	4.11 AB	1.58 B	1.30 A	57.7 A	116.5 AB
N <sub>2</sub>	2.15 CD	0.34 A	3.61 B	1.73 A	1.31 A	56.2 A	105.9 BC
N <sub>3</sub>	2.76 AB	0.37 A	4.53 A	1.71 A	1.22 AB	55.4 A	98.4 C
N <sub>4</sub>	2.55 BC	0.33 A	4.47 A	1.78 A	1.37 A	64.7 A	128.8 A

Table 2. The effect of different P doses on the nutrient uptake.

	N (%)	P(%)	K(%)	Ca(%)	Mg(%)	Zn(ppm)	Mn(ppm)
P <sub>0</sub>	2.52 A	0.24 C	4.69 A	1.62 AB	1.46 A	66.6 A	115.7 A
P <sub>1</sub>	2.29 A	0.33 B	3.63 B	1.54 B	1.31 AB	59.6 AB	105.5 B
P <sub>2</sub>	2.66 A	0.33 B	4.17 AB	1.59 B	1.23 BC	54.3 B	114.9 A
P <sub>3</sub>	2.45 A	0.42 A	4.32 AB	1.71 A	1.03 C	57.0 AB	117.3 A

F values obtained in performed variance analyses were shown in Table 3.

Table 3. F values obtained in variance analyses.

	Sd.	N	P	K	Ca	Mg	Zn	Mn
P	3	1.10 n.s.	5.70 **	2.86 n.s.	3.71*	5.30**	1.76 n.s.	3.32*
N	4	10.9***	0.66 n.s.	1.63 n.s.	22.3***	2.36 n.s.	0.88 n.s.	5.75***
PxN	12	1.22 n.s.	1.77 n.s.	3.83***	6.12***	2.00 n.s.	1.03 n.s.	2.96**
Error	39							

ns.: nonsignificant \*significant at P:0.05 \*\*significant at P: 0.01 \*\*\*significant at P:0.001

The effect of different nitrogen doses on tomato seedlings was found significantly ( $p < 0.001$ ) important. Average nitrogen amount of N<sub>1</sub> dose was higher than the other N doses. Increased phosphorus doses had no effect on N uptake.

Increased nitrogen doses had no significant effect on phosphorus uptake. However, phosphorus uptake of tomato seedling was enhanced by increased phosphorus doses. Seedlings had the significantly ( $p < 0.01$ ) highest (% 0.42) phosphorus uptake by P<sub>3</sub> dose.

K amount of seedlings was not affected significantly by increased N or P doses. N<sub>2</sub>P<sub>2</sub> dose gave the lowest K level.

Ca amount of seedlings was increased significantly ( $P < 0.001$ ) by increased N doses. No and N<sub>1</sub> doses gave lower values than the other doses as 1.30 and 1.58, respectively.

P doses also affected Ca uptake. Ca uptake of seedlings was higher at P<sub>3</sub> dose than P<sub>1</sub> and P<sub>2</sub> doses. Although Mg uptake at N<sub>4</sub> dose was higher than that of N<sub>0</sub>, Mg amount of tomato seedlings was not affected significantly by N doses.

Mg uptake of tomato seedlings was ( $P < 0.01$ ) decreased significantly by increased P doses. Mg uptake at P<sub>0</sub> dose was higher than P<sub>2</sub> and P<sub>3</sub> doses.

Zn uptake of tomato seedlings was not affected significantly by increased N and P doses.

Mn uptake of tomato seedlings was increased significantly ( $P < 0.001$ ) by N doses. Mn uptake at N<sub>4</sub> dose (129 ppm) was higher than N<sub>0</sub>, N<sub>2</sub> and N<sub>3</sub> doses.

Mn uptake at P<sub>1</sub> doses (105 ppm) was significantly ( $p < 0.05$ ) lower than the other doses. Increasing N and P doses usually increased nutrient uptake.

The effects of interactions between in N and P doses were not found significantly on the uptake of nitrogen, phosphorus, magnesium and zinc. The interaction effects of N and P doses were detected significantly ( $P < 0.001$ ) different on the uptake of calcium, potassium. The uptake of manganese of seedlings were affected significantly ( $P < 0.01$ ) from by interaction of N and P doses.



Joint application of N and P fertilizer is more effective and there is a synergism (Aktaş 1995) between them.

Kabay (1999) stated that 1600g/m<sup>3</sup> N and 1800g/m<sup>3</sup> P<sub>2</sub>O<sub>5</sub> doses and their interactions gave more positive results on tomato seed germination and seedlings quality.

Nutrient amounts of N<sub>4</sub> (1600g/m<sup>3</sup>N) and P<sub>3</sub> (1800g/m<sup>3</sup> P<sub>2</sub>O<sub>5</sub>) were detected high in tomato seedlings

## REFERENCES

- Akıllı, M., Biner, B., 1997. Fide Yetiştiriciliği. Akdeniz Üniversitesi Ziraat Fakültesi Dergisi.10(1):404-406. Antalya.
- Aktaş, M., 1995. Bitki Besleme ve Toprak Verimliliği. A.Ü. Ziraat Fakültesi Yayınları,1501,Ankara.
- Kabay, T., 1999. Domateste Tohum Çimlenme ve Fide Kalitesi Üzerine Değişen Azot ve Fosfor Dozlarının Etkileri (Yüksek Lisans Tezi, Basılmamış). Y.Y.Ü., Fen Bilimleri Enstitüsü. Van.
- Kacar, B., 1984 a. Bitki Besleme. A.Ü.Ziraat Fakültesi Yayınları, 899, Ankara.
- Kacar, B., 1984 b. Bitki Besleme Uygulama Kılavuzu. A.Ü.Ziraat Fakültesi Yayınları, 900, Ankara.
- Şeniz, V., 1984. Sebzeçilikte Fide Yetiştiriciliği ve Sorunları. Tarımsal Araştırmaları Destekleme ve Geliştirme Vakfı Yayınları, 19, Yalova, 97-98-99 s.

# EFFECT OF N, P AND K APPLICATION on Zn UPTAKE OF TOMATO

Nizamettin Ataoğlu, Yıldırım Sezen  
Atatürk University, Agriculture Faculty, Soil Department In Turkey

## ABSTRACT

The objective of this study was determine the effects of N, P and K applied at different rates on Zn uptake of tomato crop under greenhouse condition .Twenty ppm Zn was applied to each of 72 soil pots at the beginning of the study. The experiment was designed with four nitrogen ( $N_0=0$ ,  $N_1=6$ ,  $N_2=12$ ,  $N_3=18$  kg/da), three phosphorus ( $P_0=0$ ,  $P_1=6$ ,  $P_2=12$  kg/da), and two potassium ( $K_0=0$ ,  $K_1=6$  kg/da) rates. In regard to the type and the amounts of fertilisers, Zn uptake of tomato crop was evaluated. According to the results, N application encouraged Zn uptake while  $P_2O_5$  application had adverse effect. However,  $K_2O$  application had no effect on Zn uptake.

## INTRODUCTION

Directly or indirectly life is always dependent on plants which are used primarily for food, along with their use as raw material and energy source in industry. Zn feeding level of the living beings is mainly related to the Zn uptake level of the plants used as food. In case of Zn insufficiency in the soil, and Zn uptake limitations by some soil, climate or other applications, first of all, plant production is limited in amount and this, in turn, brings about Zn feeding disorders on the other living beings.

One of the factors affecting the relations of soluble activity between solid and liquid phases of the soil is minerals. Of those minerals including Zinc, Blende ( $ZnS$ ), Simitsonit ( $ZnCO_3$ ), Kalamın ( $Zn_2SiO_4 \cdot H_2O$ ), Franklinit ( $Zn(FeO_2)_2$ ), and Willemin ( $ZnCO_3$ ) exist to be primer minerals are connected to soil compounds.

Zn is strictly adsorbed by clay minerals and organic matter to be  $Zn^{++}$ ,  $ZnOH^+$ , and it precipitates to be silicate in alkaline soils (Kaçar, 1995). Zn has different solubility values and its forms in the soil are also different. Zn exists in the soil to be; (I) Ionic in the soil solutions or compounds in organic form, (II) connected to varying points of reactive soil composites, (III) complicated with organic matter, (IV) oxidised by Fe, Al, Mn oxide or hydro-oxides, (V) allocated in primer and seconder minerals (Jenne, 1997).

In plants with Zn deficiency, protein concentrations go down sharply and this results in a decrease of amino-acids and amides amounts in dry matter content of the plant (Çakmak et al., 1989). Olsen (1972) found that phosphorus fertilisation at high rates caused an increase in Zn deficiency in case useful Zn amount to be used by the plants was low.

Youngdahl et al., (1977) stated that high amounts of phosphorus increased pectate fractions of the root cell walls and soluble Zn amount in ethanol. They also stated that connecting to cell walls by increasing rates of phosphorus, Zn transportation to green parts of the plant went down.

Patra et al., (1982) found that an application of Zn to soil in amounts of 0 and 100  $\mu g/g$  increased P and Zn content of the plant while same amounts of P application increased P and Fe content with a decrease in Zn, Cu and Mn content.

It is stated that about half of the soils of the country is poor of Zn. This causes to be Zn deficiency in the plants which, in turn, results in low production and some health problems in animals and human beings fed up with these plants. It is reported that some problems occur because of Zn deficiency. such as slower growing process, dwarfness, lateness in recovery of injuries, lack of taste sense, hypogondism, dermatological problems, unwillingness to eat, disorders in the mechanism of adaptation to darkness, etc. Aksoy (1974) stated that Zn deficiency often occurred not only the Zn deficiency in the soil but in some cases, it is directly related to the concentration of other plant nutrient elements in the soil, and that phosphorus applied to soil more than needed lowered the useful Zn amounts.

In this study, the effect of N, P and K fertilisers applied to tomato crop at different rates, on Zn content was examined.

## MATERIAL AND METHOD

Soil used in this study was collected from 0-20 cm depth in accordance with the study objectives in the farmland at Agricultural Faculty Atatürk Universty in Erzurum. Some physical and chemical soil properties such as texture, soluble salt content, soil moisture, field capacity, wilting point, pH, organic matter content,  $\text{CaCO}_3$ , cation exchange capacity (CEC), exchangeable cations (Ca, Mg, K, Na), total N, nitrogen of ammonium and nitrate, available P, and Fe, Mn, Zn and Cu were determined (Bayraklı, 1987; Demiralay, 1993).

Each pot was filled up with 2 kg soil passed through 4 mm sieve. Tomato crop was planted to the pots after they had four leaves in the seedbed where sown. The experiment was designed in according to the randomised factorial experiment design with the factors of four different type of fertilisers  $\text{N}=0, 6, 12, 18 \text{ kg N/da}$   $\text{P}=0, 6, 12 \text{ kg P}_2\text{O}_5/\text{da}$  and  $\text{K}=0, 6 \text{ kg K}_2\text{O/da}$  rates and 20 ppm Zn to each pot, and with three replications ( $4 \times 3 \times 2 \times 3 = 72$ ), under greenhouse conditions. Nitrogen, phosphate and potassium rates used in the experiment were allocated with the ammonium sulphate ( $\text{N}=21\%$ ), triple super phosphate (44-46%  $\text{P}_2\text{O}_5$ ) and potassium sulphate (50%  $\text{K}_2\text{O}$ ) fertilisers, respectively. Also, each pot was applied 20 ppm Zn ( $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ ). Half of the nitrogen was applied with sowing and the rest was applied one month after planting. Plant growth was observed phenologically and irrigation needs of the plants were covered with pure water. Plants were harvested and dried of  $68^\circ\text{C}$  till constant weight and they were weighed, and dry matter amounts were determined. Amount of plant nutriment elements N, P, K, Fe, Mn, Zn and Cu in plant samples were determined (Bayraklı, 1987).

## RESULTS AND DISCUSSION

Some physical and chemical properties of soil used in this study were given in Table 1. Soil texture was loam (Demiralay, 1993), pH was nötr (Ergene, 1995); organic matter content was medium,  $\text{CaCO}_3$  content was low (Anon., 1982) and CEC was 25.18 me/100 g, an exchangeable Na was 0.25 me Na/100g. Available micro element contents of the soil sample were determined to be Fe: 3.3 ppm, Mn: 4.9ppm, Zn: 1.7 ppm and Cu: 1.6 ppm. It was found that the soil was poor of available nitrogen (Aydin and Sezen, 1995) and total nitrogen was only 0.13 %.

Table 1: Some physical and chemical properties of soil studied.

Moisture, (%)	3.83	Texture	Loam	$\text{NH}_4\text{-N}$ (%)	0.003	Mn, ppm	4.90
Field Cap. (%)	24	Sand (%)	49.71	$\text{NO}_3\text{-N}$ (%)	0.002	Zn, ppm	1.70
Wilting point (%)	14	Silt (%)	29.71	Ca+Mg me/100g	20.05	Cu, ppm	1.60
Soluble salts, (%)	0.013	Clay (%)	20.57	K, me/100g	2.8	Available P	
pH (1: 2.5)	7.10	$\text{CaCO}_3$ , (%)	1.09	Na, me/100g	0.25	$\text{P}_2\text{O}_5$ kg/da	10.6
Org. matter, (%)	2.14	Total N (%)	0.13	Fe, ppm	3.30	CEC, me/100g	24.18

The effect of nitrogen, phosphorus and potassium fertilisers on Zn uptake of tomato crop was given in Table 2. As seen from Table 2, the effect of fertiliser rates on Zn uptake was different. It was clear to conclude that nitrogen increased Zn uptake while phosphorus had adverse effect. Moreover, potassium had no effect on Zn uptake.

Table 2 showed that depending on nitrogen application Zn content of the green parts of the tomato plant increased.  $\text{N}_3$  and  $\text{N}_0$  rates yielded the highest and lowest Zn contents, respectively. As compared to  $\text{N}_0$  rates, these increases were 79 %, 123 % and 144 % for  $\text{N}_1$ ,  $\text{N}_2$  and  $\text{N}_3$  rates, respectively while 61 %, 77 % and 52 % for  $\text{N}_1$ ,  $\text{N}_2$  and  $\text{N}_3$  rates in root parts. With an increase in Zn content by increased N rates even there was a decrease in Zn content for  $\text{N}_3$  rates, an increase in Zn content was also recorded. The effect of the P application on Zn content of the green parts was found to be a decrease of 1.2 % and 29 % for  $\text{P}_1$  and  $\text{P}_2$  rates respectively when compared to  $\text{P}_0$  rate. On the other hand, in root parts this decrease was recorded to be % 24 and 18 % for  $\text{P}_1$  and  $\text{P}_2$  rates respectively. Zn content of green parts of tomato plants increased by K-application as compared to  $\text{K}_0$  rates, but this increase was not statistically significant at  $p < 0.01$ .



Table 2. The effect of nitrogen, phosphorus and potassium fertilisers application on Zn content of root and other parts of the experimental plants.

Fertilizer Rates			Zn content of the green parts (mg/plant)				Zn content of the roots (mg/plant)			
N	P	K	I	II	III	Mean	I	II	III	Mean
N <sub>0</sub>	P <sub>0</sub>	K <sub>0</sub>	0.108	0.119	0.108	0.112	0.096	0.122	0.130	0.116
		K <sub>1</sub>	0.109	0.107	0.096	0.104	0.082	0.106	0.075	0.088
	P <sub>1</sub>	K <sub>0</sub>	0.163	0.174	0.172	0.197	0.121	0.100	0.131	0.117
		K <sub>1</sub>	0.097	0.097	0.121	0.105	0.027	0.024	0.025	0.025
	P <sub>2</sub>	K <sub>0</sub>	0.090	0.069	0.080	0.079	0.102	0.070	0.086	0.086
		K <sub>1</sub>	0.113	0.140	0.121	0.125	0.116	0.110	0.180	0.135
N <sub>1</sub>	P <sub>0</sub>	K <sub>0</sub>	0.201	0.230	0.173	0.201	0.161	0.212	0.198	0.190
		K <sub>1</sub>	0.217	0.211	0.233	0.220	0.251	0.191	0.160	0.201
	P <sub>1</sub>	K <sub>0</sub>	0.282	0.273	0.308	0.288	0.088	0.095	0.118	0.101
		K <sub>1</sub>	0.177	0.243	0.230	0.216	0.172	0.139	0.182	0.164
	P <sub>2</sub>	K <sub>0</sub>	0.136	0.138	0.155	0.143	0.045	0.069	0.078	0.064
		K <sub>1</sub>	0.158	0.182	0.206	0.182	0.196	0.199	0.193	0.196
N <sub>2</sub>	P <sub>0</sub>	K <sub>0</sub>	0.323	0.310	0.305	0.313	0.134	0.151	0.125	0.136
		K <sub>1</sub>	0.255	0.279	0.284	0.273	0.221	0.212	0.203	0.212
	P <sub>1</sub>	K <sub>0</sub>	0.264	0.280	0.293	0.279	0.118	0.135	0.144	0.132
		K <sub>1</sub>	0.284	0.293	0.299	0.292	0.145	0.121	0.126	0.131
	P <sub>2</sub>	K <sub>0</sub>	0.160	0.159	0.170	0.163	0.095	0.110	0.108	0.104
		K <sub>1</sub>	0.249	0.222	0.241	0.237	0.223	0.290	0.268	0.260
N <sub>3</sub>	P <sub>0</sub>	K <sub>0</sub>	0.363	0.373	0.386	0.374	0.126	0.102	0.153	0.381
		K <sub>1</sub>	0.305	0.352	0.328	0.328	0.188	0.238	0.249	0.225
	P <sub>1</sub>	K <sub>0</sub>	0.271	0.232	0.246	0.250	0.121	0.138	0.175	0.145
		K <sub>1</sub>	0.306	0.296	0.321	0.308	0.149	0.143	0.141	0.144
	P <sub>2</sub>	K <sub>0</sub>	0.193	0.207	0.210	0.203	0.125	0.111	0.141	0.126
		K <sub>1</sub>	0.255	0.231	0.227	0.238	0.098	0.90	0.97	0.162

Statistical analysis results of the Zn content values from the experiment were given on Table 3. As seen from Table 3, it was found that effect of the N application on Zn uptake was statistically significant ( $p < 0.01$ ) for both green parts and roots. On the other hand, a decrease was recorded by P application. While the effect of K application on Zn content of root parts was statistically significant ( $p < 0.01$ ), it was not statistically significant for green parts. Multi-variate analysis of Zn content of green part and roots by fertiliser rates was also performed and results were given in Table 4.

Table 3. Variance analysis results for Zn contents of green parts and roots of tomato plant

Source of Variation	Zn content of green parts			Zn content of undergreen parts	
	DF	MS	F	MS	F
N	3	0.0992	389.59**	0.0177	36.13 **
P	2	0.0372	146.25 **	0.0096	19.72 **
K	1	0.0003	1.414	0.0207	42.16 **
N*P	6	0.0062	24.36 **	0.0033	6.78 **
N*K	3	0.0007	2.97 *	0.0087	17.81 **
P*K	2	0.0086	33.69 **	0.0124	25.36 **
N*P*K	6	0.0035	13.66 **	0.0067	13.60 **
Error	48	0.00023		0.00049	

\* : Significant at % 5 level

\*\* : Significant at % 1 level

Table 4. Multi variate analysis results for Zn content of green parts and roots of tomato plant

N Rates	N <sub>0</sub>	N <sub>1</sub>	N <sub>2</sub>	N <sub>3</sub>
Zn content of green parts (mg/dry matter).	0.116 d	0.208 c	0.259 b	0.283 a
Zn content of root (mg/ dry matter)	0.094 d	0.152 ab	0.167 a	0.143 bc
P Rates	P <sub>0</sub>	P <sub>1</sub>	P <sub>2</sub>	
Zn content of green parts (mg/ dry matter).	0.241 a	0.238 a	0.171 b	
Zn content of root (mg / dry matter)	0.162 a	0.123 b	0.133 b	
K Rates	K <sub>0</sub>	K <sub>1</sub>		
Zn content of green parts (mg/ dry matter).	0.214 a	0.240 a		
Zn content of root (mg/ dry matter)	0.122 b	0.156 a		

It was found that the effect of N rates on Zn content was significant and means were different. Average Zn content of the plants for N<sub>0</sub> rate were 0.116, while they were 0.208, 0.259 and 0.283 for N<sub>1</sub>, N<sub>2</sub> and N<sub>3</sub> rates respectively. It was clear from these figures that there was an increase in Zn content in green parts parallel to N rates. The highest increase in Zn content was obtained from N<sub>3</sub> application. Likewise, the effect of N rates on Zn content of root was found to be statistically significant (Table 4.). The means of Zn contents of roots were 0.094, 0.152, 0.167 and 0.143 for N<sub>0</sub>, N<sub>1</sub>, N<sub>2</sub> and N<sub>3</sub> rates respectively. Zn content of green parts decreased by increasing rates of P application. This decrease was found to be statistically significant and means were different (Table. 4). Means of Zn contents of the plants were 0.241, 0.238 and 0.133 for P<sub>0</sub>, P<sub>1</sub> and P<sub>2</sub> rates respectively. Means of Zn contents for P<sub>0</sub> and P<sub>1</sub> were close while P<sub>2</sub> rates yielded the lowest Zn content. In the same way, applied P rates resulted in decrease Zn content in roots, which was statistically significant. Means of Zn contents of the roots were 0.162, 0.123 and 0.133 for P<sub>0</sub>, P<sub>1</sub> and P<sub>2</sub> rates. The highest Zn content in root was obtained control group (P<sub>0</sub> doze).

In their similar studies, Jackson et. al. (1967) and Aksoy (1974) were also found that phosphorus fertiliser application caused a decrease in Zn content.

Zn content of the parts were not statistically significant. The effect of different rates of N, P, K fertilisers on Zn content in green parts and roots were shown in Figure 1.

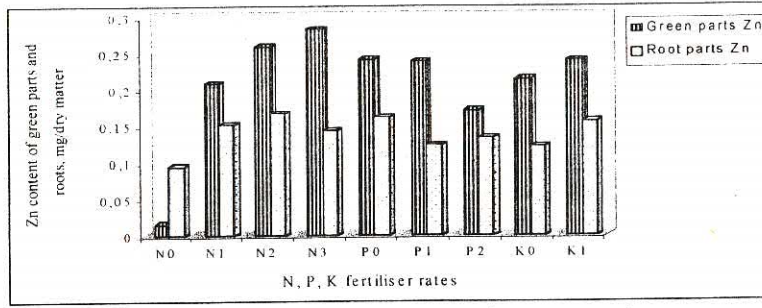


Figure 1. The effect of N, P, K fertilisers on Zn content of green parts and roots.

In conclusion, different rates of N, P and K fertilisers were applied to tomato plant caused an increase of Zn content in green parts and roots was observed with increasing rates of N. The highest Zn content was observed in green parts and roots with N<sub>3</sub> rate and N<sub>2</sub> rates respectively. Application of P rates decreased Zn content in green parts and root parts. The Zn content of non-P applied plants was found to be the highest. Whereas, Zn content decreased in P-applied plants. The highest decrease in Zn content was determined with P<sub>2</sub> rate. The increase of Zn content of green parts because of K application was not statistically significant. As a result, it can be concluded that N application increases the Zn content of the plant parts while Zn content goes down with P application. K application has no effect on Zn content.

#### REFERENCES

- Aksoy, T., 1974. Dörtüol D.Ü.Ç. Turunçgiller işletmesinde portakallarda görülen çinko noksanlığının fosfor ile ilişkisi üzerine bir araştırma. A.Ü. Z. F. Yayınları, 627 Ankara.
- Anonymous (1982) Dalaman D.Ü.Ç. Topraklarının Etüt ve Haritalanması. D.Ü.Ç. Genel Müdürlüğü, Ankara.
- Aydın, A., Sezen, Y. 1995. Toprak Kimyası Uygulama Kitabı. Atatürk Üniv. Ders Yayınları No: 174. Erzurum.
- Bayraklı, F. (1987) Toprak ve Bitki Analizleri. (Çeviri). Yazarlar: Ir.J.Ch.van Schouwenburg, Dr.Ir.V.J.G.Houba, Dr.Ir.I.Novozamsky ve I.Walinga. Samsun.
- Baysal, A., 1997. Gıdaların çinko içerikleri ve diyet çinkosunun biyoyararlılığı. I. Ulusal Çinko Kongresi. Eskişehir.
- Çakmak, İ., Maschner, H., Bangerth, F., 1989. Effect of zinc nutritional status on growth, protein metabolism and levels of indole-3-acetic and other phytohormones in bean. J. Exp. Bot. 40; 405-412.
- Demiralay, İ., 1993. Toprak Fiziksel Analizleri. Atatürk Üni. Yayınları No: 143. Erzurum.
- Ergene, A. (1995) Toprak Biliminin Esasları (Genişletilmiş 5. Baskı). Atatürk Üni. Yayın No: 586, Ziraat Fak. Yayın No: 267, Ders Kitapları Serisi No: 42.
- Jakson T.L., Hay J., Moore, D.P., 1967. The effect of Zn on yield and chemical composition of sweet corn in the willamette valley. Amer. Soc. Hort. Sci. 91; 462-471.
- Jenne, E. A., 1997. In Symposium on Mo in Environment, pp 425-453. Marcel Dekkar Inc. Newyork.
- Kacar, B., 1995. Bitki ve Toprağın Kimyasal Analizleri, III. Toprak Analizleri. Ankara Üni. Ziraat Fak. Eğitim, Araştırma ve Geliştirme Vakfı Yay. No:2.
- Olsen, S. R., 1972. Micronutrients Interactions. Soil Sci. Soc. Of America, Madison, W. pp. 243-264
- Patra, D., Haldar, M., Mandal L., 1982. Effect of P, Cu and Zn application on the growth and Zn, Cu, Fe and P nutrition of rice in Water-logged soil, Indian Agr. 26; 229-235.
- Youngdahl, L. J., Succ L. V., Lebhart, W. C., Teel, M. R., 1977. Changes in the zinc-65 distribution in corn root tissue with a phosphorus variable. Crop Sci. 17; 66-69.
- Yıldız, N. ve Bircan, H. (1991) Araştırma ve Deneme Metodları. Atatürk Üniversitesi Yayınları No:697. Ziraat Fakültesi Yayınları No: 305. Ders Kitapları Serisi No:57. Erzurum.



# CONSIDERING SPATIAL VARIABILITY IN ORGANIC MATTER VALUES FOR SITE SPECIFIC N-FERTILIZER RECOMMENDATION IN WHEAT

M.Rüştü Karaman, Sabit Erşahin

Gaziosmanpaşa University, Agricultural Faculty, Department of Soil Science, Tokat/Turkey.

## ABSTRACT

This study aimed to determine nitrogen fertilizer demands based on spatial variability of organic matter values on a field under wheat production. The study was conducted to determine spatial variability in organic matter of topsoils (0-30 cm) and subsoils (30-60 cm) in a 8.5 ha alluvial field near Tokat Airport, 25 km north of downtown Tokat, Turkey. Total amount of fertilizer recommended based on variable rate application program was compared with that recommended based on classical fertilizer recommendation program suggested by various fertilizer agencies in Turkey. For variable rate N fertilizer recommendation program, soil samples were taken based on a regular grid spacing of 25 x 25 m. For classical N fertilizer recommendation program, samples at each part of the field were averaged to represent that particular portion. A great variability occurred in organic matter values for topsoils and subsoils, indicating that site-specific management practices of water and nitrogen are needed to decrease amount of fertilizer N used and amount of N leached. Application of site specific N fertilizer recommendation will be beneficial to use of suitable fertilizer N rate for optimal crop production. This approach will also help minimize amount of N fertilizer used and decrease adverse effect of N fertilizers on environment in large agricultural areas.

The main data used for this paper were obtained from the project sponsored by The Scientific and Technical Research Council of Turkey, Project No: TARP-1871

## INTRODUCTION

All sources of plant-available N should be considered to maximize crop yield and quality, and to decrease the impact of these fertilizers on environment. The considerations on improved N fertilizer recommendation will increase fertilizer N use efficiency and lower overall N fertilizer consumption. The utilization of N fertilizers by crops generally is below 50%. Mechanisms, such as leaching, volatilization, and denitrification significantly affect N losses (Jackson et al., 1988; Webster et al., 1992). Therefore, heavy nitrogen fertilization should be avoided and determination of the most effective N-fertilizer recommendation scheme depending on soil fertility analysis is essential to increase N-use efficiency for a better management practice.

Different soil sampling methods may be used in soil fertility analysis for N fertilizer recommendations. In the simple random sampling, which is the classic sampling method, all points are randomly selected on the field, whereas in a systematic sampling program, sampling points are located in a grid format (Berry, 1962). Compared with classic sampling method, systematic sampling is more expensive and greater expenditure of time and effort than random sampling. Thus, systematic sampling method has been principally restricted, as a result of these limitations (Wilding, 1985). Compared with the results from random sampling, results from systematic sampling are more convenient to determine spatial variabilities of soil properties. Determination of spatial variability of soil properties can make valuable contributions to the beneficial use of field soil (Arnold and Wilding, 1991). In site specific management of fertilizers, local needs of crops are considered. Knowledge of the spatial variability in soil organic matter content is essential in determining the local N needs of crops. The demands for more precise information about N fertilizer recommendations will increase with the developing of technology and other possibilities.

In the soil fertility analysis, a knowledge of organic matter content of soils is essential in predicting the N demand of crops. The dynamic and complex chemistry of soil organic matter makes it a main source of plant nutrients. The soil organic matter fraction, with about 95 % of soil nitrogen, can supply most of the nitrogen needed for plant growth (Smith et al., 1991). A great variability in organic matter values occur in agricultural areas. Thus, application of variable method to determine N demand of crops will be beneficial to recommend suitable fertilizer N rate for large agricultural areas. In this study, a new approach was employed for N fertilizer recommendations in wheat production. In this approach, N fertilizer recommendation is based on the spatial variability of the soil organic matter

content across the field. This approach will help minimize amount of N fertilizer used and decrease adverse effect of N fertilizers on environment.

## MATERIALS AND METHOD

This study was conducted to determine spatial variability in organic matter of topsoils (0-30 cm) and subsoils (30-60 cm) on a 8.5 ha alluvial field near Tokat Airport, in 25 km north of downtown Tokat, Turkey. Total amount of N fertilizer recommended based on variable rate application program was compared with that recommended based on classical N fertilizer recommendation program suggested by various fertilizer agencies in Turkey. For variable rate N fertilizer recommendation program, soil samples were taken based on a regular grid spacing of 25 x 25 m. For classical N fertilizer recommendation program, soil samples at each part were averaged to represent that particular portion. Organic matter contents as well as other soil properties of the topsoil and subsoil samples were determined. Organic matter contents were determined by the Walkley-Black method from Jackson (1956). In addition, inorganic N (Bremner, 1965), available P (Olsen et al., 1954), C.E.C. (Richards, 1954),  $\text{CaCO}_3$  (Allison and Moodie, 1965) and pH (McLean, 1986) were also determined. The textural analysis of experimental soil was made with a Bouyoucos hydrometer (Gee and Boudet, 1986). Values of maximum, minimum, mean, standard deviation, coefficient of variance, kurtosis and skewness were calculated with the computer program StatMost (Kleinbaum et al., 1988; StatMost, 1995).

## RESULTS AND DISCUSSION

### Selected soil properties

The results of the maximum, minimum, coefficient of variance (C.V.), kurtosis and skewness values revealed that a great spatial variability occurred in available P content, C.E.C. and organic matter content for topsoil and subsoil (Table 1 and 2). All other selected soil properties generally exhibited a medium variability in both topsoils and subsoils. The variabilities of 31.79, 28.62 and 21.70% C.V. were observed in available phosphorus, C.E.C. and organic matter content for topsoil, respectively. A maximum variability of 62.93 % C.V. was observed for organic matter content in subsoil.

Table 1. Selected physical and chemical properties of the topsoils.

Soil properties	Max.	Min.	Mean	Std. Deviation	C.V. <sup>+</sup> %	Kurtosis	Skewness
Sand, %	46.97	21.94	33.46	6.10	18.23	2.25	0.134
Silt, %	52.23	30.83	42.00	5.18	12.33	2.14	-0.055
Clay, %	31.01	17.79	24.60	2.57	10.44	3.65	0.012
C.E.C, mol <sub>c</sub> kg <sup>-1</sup>	1.02	0.20	0.41	0.12	28.62	8.32	1.577
$\text{CaCO}_3$ , %	20.95	7.28	14.42	2.47	17.15	2.75	-0.113
pH	9.50	7.03	8.14	0.26	3.21	10.38	0.811
Avail. $\text{P}_2\text{O}_5$ , kg da <sup>-1</sup>	12.59	2.75	6.60	2.09	31.79	2.55	0.250
Org. matter, %	5.61	1.91	3.85	0.84	21.70	2.25	-0.141

<sup>+</sup>C.V.; Coefficient of variation

Table 2. Selected physical and chemical properties of the subsoils.

Soil properties	Max.	Min.	Mean	Std. Deviation	C.V. <sup>+</sup> %	Kurtosis	Skewness
Sand, %	37.79	7.93	20.94	6.68	31.91	2.54	0.340
Silt, %	56.25	35.24	43.85	3.98	9.07	2.99	0.048
Clay, %	49.64	22.05	35.50	5.17	14.57	2.98	0.377
C.E.C, mol <sub>c</sub> kg <sup>-1</sup>	0.68	0.01	0.37	0.15	39.99	3.18	-0.574
$\text{CaCO}_3$ , %	22.60	7.32	15.45	3.02	19.55	2.99	-0.385
pH	9.90	7.26	8.30	0.43	5.23	6.36	1.494
Avail. $\text{P}_2\text{O}_5$ , kg da <sup>-1</sup>	12.13	2.52	6.97	2.48	35.69	2.03	0.080
Org. matter, %	4.01	0.01	1.43	0.90	62.93	2.76	0.464

<sup>+</sup>C.V.; Coefficient of variation



### Spatial pattern of organic matter values in the field

Three-dimensional maps for organic matter contents for topsoils and subsoils indicated that considerable variability in organic matter content occurred in the experimental area (Fig. 1). Results also indicated that organic matter contents of topsoils were greater than those of subsoils due to continuous addition of organic matter to topsoils. The representation of organic matter distribution for spatial location is also shown in contour plot (Figure 2). according to boundary values from General Directorate of Rural Services (Ülgen and Yurtsever, 1984); For topsoils, 1.4 % low, 16.4 % medium, 35.0 % sufficient, and 47.2 % was high; and for subsoils, 36.4 % very low, 40.7 % low, 17.1 % medium, 5.0 % sufficient and 0.8 % was high in organic matter (Table 3 and Figure 2).

### Site-specific N fertilizer recommendation

A significant variability occurred in N fertilizer rate recommendations depending on the spatial variability of organic matter content of the topsoils (Table 3). Based on the variable-rate N fertilizer recommendation program, of the 85000 m<sup>2</sup> experimental area, 14 kg N ha<sup>-1</sup> was recommended for 1190 m<sup>2</sup>, 153 kg N ha<sup>-1</sup> was recommended for 13940 m<sup>2</sup>, 268 kg N ha<sup>-1</sup> was recommended for 29750 m<sup>2</sup>, and 361 kg N ha<sup>-1</sup> was recommended for 40120 m<sup>2</sup>. However, amount of N fertilizer recommended for the all experimental field based on the classical fertilization program, which consider field, averaged organic matter content, is 108 kg N ha<sup>-1</sup>. Application of this classical recommendation program will lead overfertilization in 69870 m<sup>2</sup> and underfertilization in 15130 m<sup>2</sup> of 85000 m<sup>2</sup> total experimental field.

Table 3. Amounts of site specific N-fertilizer needed based on the spatial variability of organic matter contents in the study area.

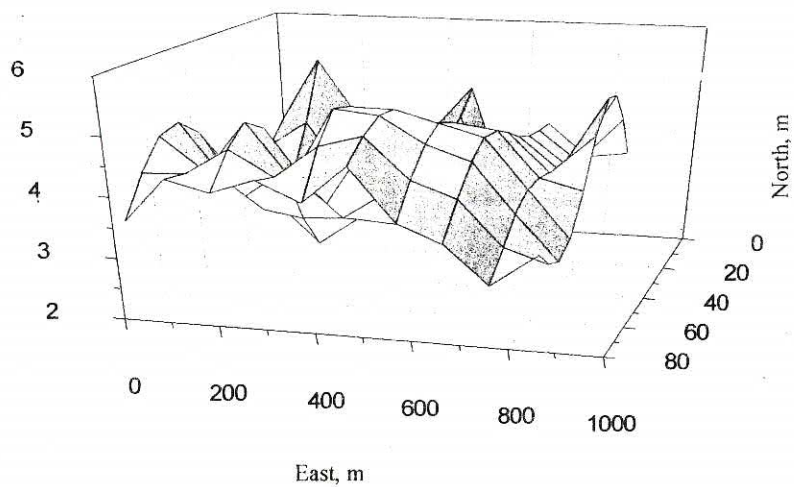
Org. matter content Of topsoil, % (Walkley-Black)	Area covered, m <sup>2</sup> (for 8.5 ha)	N fertilizer Recommended* kg N.ha <sup>-1</sup>	Total N fertilizer needed kg N.area <sup>-1</sup>
< 1	0	130	0
1.1-2.0	1190	120	14
2.1-3.0	13940	110	153
3.1-4.0	29750	90	268
4 <	40120	90	361
Total	85000		796

\* These N rates, recommended for wheat production on Central Anatolian Region, were obtained from the fertilizer and fertilization handbook of Turkey (Ülgen and Yurtsever, 1984).

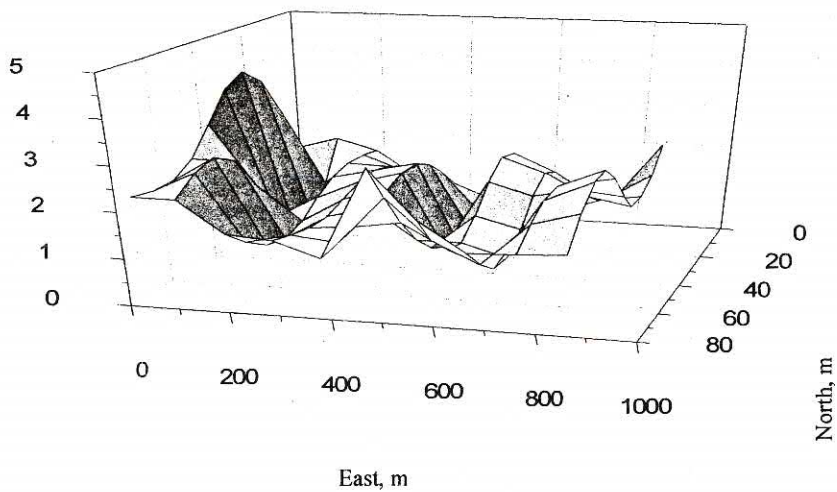
This variability may reach to even higher levels for other agricultural areas. Site-specific N fertilizer recommendation considering spatial variability in organic matter values will supply suitable and more realistic N fertilizer rates for optimal crop production in large agricultural areas. Thus, the site-specific N fertilization will have more potential for both environmental and economic benefits for those agricultural areas.

In conclusion; a great variability occurred in O.M. values, indicating that site-specific management practices of nitrogen fertilizers are needed to decrease amount of N-used by the crops and amount of N leached. Thus, a knowledge of spatial variability of organic matter content of soils will be beneficial to recommend suitable fertilizer N-rate for large agricultural areas. If inorganic N content of soils will be essential in predicting the N demand of crops, which is known as Nmin method, application of variable method to determine N demand of crops will also be beneficial to recommend suitable fertilizer N-rate for these agricultural areas. By this approach, the site effect of N-fertilization on environment may be decreased.



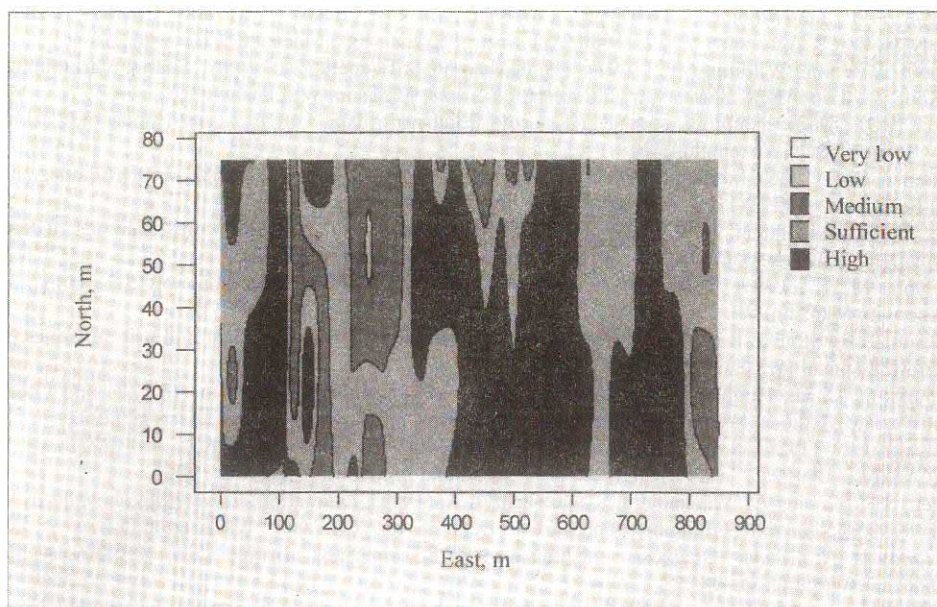


a. Topsoil

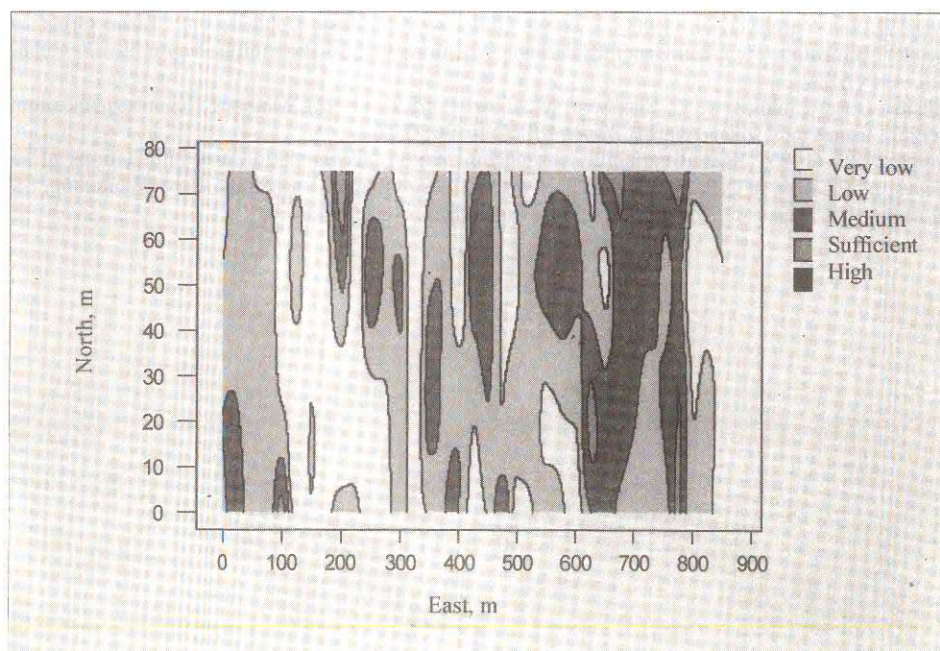


b. Subsoil

Figure 1. Spatial pattern of organic matter contents of topsoils and subsoils in the wheat field



a. Topsoil



b. Subsoil

Figure 2. Contur map of organic matter contents of topsoils and subsoils

## REFERENCES

- Allison, L.E. and Moodie, C.D. (1965). Carbonate. In: C.A. Black et al. (ed.) *Methods of Soil Analysis, Part 2*. Agronomy 9:1379-1400. Am. Soc. of Agron., Inc., Madison, Wisconsin, USA.
- Arnold, R.W. and Wilding, L.P. (1991). The need to quantify spatial variability. *Spatial Variabilities of Soils and Landforms*. SSSA Special Publication No:28, Madison, Wisconsin, USA.
- Berry, B.J. (1962). Sampling, coding and storing flood plain data. USDA Agric. Handb. 237, U.S. Gov. Print. Office, Washington, DC.
- Bremner, J.M. (1965). Inorganic forms of nitrogen, In: C.A. Black et al. (ed.) *Methods of soil analysis*. part II. Agron. 9:1149-1178. ASA Madison, WI.
- Gee, G. W. and Boudet, J. W. (1986). Particle Size Analysis. In: A. Clute (edit.) *Methods of Soil Analysis, Part 1*, Agronomy No. 9. Am. Soc. Agron., Madison, WI, p. 825-844.
- Jackson, M. L. (1956). *Soil Analysis. Adv. Course. Fourth Print.* Dept. of Soil Sci. Univ. of Wisconsin, Madison. WI.
- Jackson, L.E., Strauss, R.B., Firestone, M.K. and Bartolome, J.W. (1988). Plant and soil dynamics in California annual grassland. *Plant Soil*. 110:9-17.
- Kleinbaum, D. G., Kupper, L.L. and Muller, K.E. (1988). *Applied Regression Analysis and Other Multivariate Methods*. Second ed. Wadsworth Publishing Company, Belmont, California 94002.
- McLean, E.O. (1986). Soil pH and Lime Requirement pp 199-224. In Page, A.L. (Ed.) *Methods of Soil Analysis, Part 2*. 2<sup>nd</sup> ed. Agron. Monogr. 9. ASA. and SSSA, Madison, WI, 1986.
- Olsen, S.R., Coole, V., Watanable, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. of Agr. Cric. 939, Washington D.C.
- Richards L. A. (1954). Diagnosis and improvement of saline and alkaline soils, U.S.D.A. Agric. Handb. 60. Washington, D.C.
- Smith, J.L., Papendick, R.I., Bezdicek, D.F. and Lynch, J.M. (1991). Soil organic matter daynamics and crop residue management. Agricultural Research Service. U.S. Department of Agriculture, Pullman, Washington, USA.
- StatMost. (1995). Dataxiom Software Inc. User's Guide: StatMost. 5<sup>th</sup> Ed. Dataxiom Soft. Inc., LA, CA. USA.
- Ülgen, N. and Yurtsever, N. (1984). Türkiye Gübre ve Gübreleme Rehberi, T.C. Tarım Orman ve Köyişleri Bakanlığı, Topraksu Genel Müdürlüğü, Araştırma Dairesi Başkanlığı, Yayın No:47, Rehber No:8, ANKARA.
- Webster, C.P., Goulding, K.T., Shepherd, M.A. and Lord, E. (1992). Methods for measuring nitrate leaching from sandy soils. *Aspects Applied Biology*. 30:77-80.
- Wilding, L.P. (1985). Spatial variability: Its documentation, accomodation and implications to soil surveys, p. 166-189. In D.R. Nielsen and J. Bouma (ed.) *Soil Spatial Variability*. Proc. Workshop, SSS and SSSA, Las Vegas, 30 Nov.-1 Dec. 1984, Wageningen, Netherlands.



# **AN INVESTIGATION ON SOME NUTRIENT ELEMENTS OF THE SOILS CONTAINING HIGH LEVEL OF PHOSPHORUS AND IN WHICH SUNFLOWER AND WHEAT ARE GROWN IN THRACE REGION**

Aydm Adiloğlu, Korkmaz Bellitürk  
T.U. Tekirdağ Agricultural Faculty. Soil Sci. Dept. 59030-Tekirdağ/Turkey

## **ABSTRACT**

20 percent of fertilizers used in our country has been consumed in the Region of Thrace. This plays an important role especially in the usage of phosphorus fertilizers. Intensively application of these fertilizers has been destroying the balance of nutrients. In this research, 25 soil samples were collected from the soils containing high level phosphorus and in which sunflower and wheat are grown in this region and the contents of some nutrient elements were determined. According to the results, nearly 72 % of the soils were found to be insufficient in the contents of organic matters. The potassium contents of all the soil samples were sufficient or high. Although calcium contents of the soils were usually sufficient, it was insufficient in the 12 % of the samples. As for the magnesium contents, the ratio of insufficient sample was 16 %. The iron contents were generally sufficient except for the 8 %. It was also determined that all the soils had high contents of manganese. However zinc contents were found highly insufficient, which covers 76 %. The ratio of soil samples containing poorly copper was 36 %.

## **INTRODUCTION**

In order to increase the agricultural production, the best method is to apply more fertilizers in the field now-days. Excess fertilizer applied to the soil disturbs the nutrient balance and causes some problems of plant nutrition.

Thrace Region is one of the region where the soil used intensively. In order to, increase the production more fertilizers are used in this region. According to the results of researches, twenty percent of fertilizers used in our country consumed in Thrace Region (Sağlam et. al., 1997). This situation is very important for using of phosphorus fertilizers.

Phosphorus fertilizers are used excessively for the sunflower and wheat crops every year in this region. Excessive application of phosphorus fertilizers increases more accumulation of phosphorus in the soils. On the other hand, according to researches of this subject, the application of phosphorus in increasing rates showed that the yield of sunflower and wheat crops were not affected (Katkat et. al., 1987; Sağlam et. al., 1997). According to the researches, the cause of this situation is the sufficiency of available phosphorus in the soils.

Excessive application of phosphorus fertilizers hinders the uptake of some nutrient elements for plants, especially zinc and iron (loneragan, 1978). According to the researcher, excess of phosphorus in the soil causes the deficiencies of calcium, copper, manganese and boron in plants. Excess amount of phosphorus fertilizers are used in Thrace Region. Therefore, these nutrient elements may be deficient in this region.

The aim of this research to determine some macro and micro element contents of the soils which contain high level phosphorus and compare these levels with the critical values and decide whether the recent fertilizer application programme is sufficient or not.

## MATERIALS and METHODS

Twenty-five soil samples (from 0-20 cm depth) containing high level phosphorus, were taken from Thrace Region. The locations where the soil samples were taken were shown in Table-1.

Table 1. The locations of the soil samples.

Soil No	Locations
1	Tekirdağ-Marmara Ereğlisi-Gümüşyaka sınırı, yolun solu
2	Tekirdağ-Çorlu-Ulaş köyü-Ovalık mevkii
3	Tekirdağ-Saray-Safaalan köyü-Hendekli mevkii
4	Tekirdağ-Muratlı-Aşağı Sevindikli köyü-Köyiçi mevkii
5	Tekirdağ-Merkez-Yağcı köyü-Çakar mevkii
6	Tekirdağ-Merkez-Osmanlı köyü-Kavaklık mevkii
7	Tekirdağ-Merkez-Nusratlı köyü-Yoıboyu mevkii
8	Tekirdağ-Hayrabolu-Kabahöyük köyü-Derelik mevkii
9	Edirne-Keşan-Çamlıköy-Ardıç mevkii
10	Edirne-İpsala-Esefçe köyü-Sırt mevkii
11	Edirne-Keşan-Kumdere köy-Köyaltı mevkii
12	Edirne-Keşan-Türkmen köy-Sıraağaç mevkii
13	Edirne-Uzunköprü-İlçenin Hayrabolu girişi, yolun sağ
14	Edirne-Meriç-Küplü Kasabası-Köy arkası mevkii
15	Edirne-Meriç-Subaşı köyü-Karaağaç mevkii
16	Edirne-Uzunköprü-Salarlı köyü-Çiftlik mevkii
17	Edirne-Havsa-Arpacı köyü-Çukur mevkii
18	Kırklareli-Babaeski-Taşköprü köyü-Hanoğlu mevkii
19	Kırklareli-Vize-Develi köyü-Selvi mevkii
20	Kırklareli-Vize-Düzova köyü-Bahçe mevkii

21	Kırklareli-Vize-Küçükyayla köyü-Kızılcık mevkii
22	Kırklareli-Merkez-Demircihalil köyü-Ağaçlık mevkii
23	Kırklareli-Merkez-Eriklice köyü-Tarlayanı mevkii
24	Kırklareli-Merkez-Asilbeyli köyü-Çeşmelik mevkii
25	Kırklareli-Pınarhisar-Kaynarca köyü-Arkiçi mevkii

pH values, organic matter contents, available phosphorus amounts, exchangeable potassium, calcium and magnesium amounts of the soil samples were determined according to Sağlam (1997); while the texture according to Tuncay (1994). The available Fe, Cu, Zn and Mn contents of the soil samples were determined following DTPA extraction method (Lindsay and Norwell, 1978).

Table-2 was considered to evaluate some macro and micro element contents of soil samples (Follet and Lindsay, 1971; FAO, 1990; Anon., 1991).

Table-2. The values of classification for some macro and micro element amounts and some chemical properties of the soil samples.

Nutrient elements	Insufficient	Moderately sufficient	Sufficient	Highly	Excessive
P, mg/kg	< 2.5	2.5-8.0	8.0-25.0	25.0-80.0	> 80.0
K, "	< 50	50-140	140-370	370-1000	> 1000
Ca, "	0-380	380-1150	1150-3500	3500-10 000	> 10 000
Mg, "	0-50	50-160	160-480	480-1500	> 1500
Mn, "	< 4	4-14	14-50	50-170	> 170
Zn, "	< 0.2	0.2-0.7	0.7-2.4	2.4-8.0	> 8.0
	Moderately sufficient	Sufficient	Highly		
Fe, "	< 0.2	0.2-4.5	> 4.5		
	Insufficient	Sufficient			
Cu, "	< 0.2	> 0.2			
Organic matter, %	0-1	1-2	2-3	3-4	> 4
	Medium acid	Light acid	Neutral	Light alkaline	Alkaline
pH (1:2.5 water)	4.5-5.5	5.5-6.5	6.5-7.5	7.5-8.5	> 8.5

## RESULTS and DISCUSSION

The results of some physical and chemical analyses of the soil samples were presented in Table 3. According to Table 3, the pH values of the soil samples were between 5.08 and 7.67; the organic matter contents of the soil samples were between 0.62 % and 4.39 %; the available



Table 3. Some physical and chemical properties of the soil samples.

Soil Sample No	pH (1:2.5 water)	Organic matter %	Nutrient elements, mg/kg										Particle-size distribution %				Texture
			Nutrient elements, mg/kg										Particle-size distribution %				
			P	K	Ca	Mg	Fe	Zn	Mn	Cu	Clay	Silt	Sand				
1	6.57	1.17	43.34	257	1290	280	2.26	0.66	46.12	4.01	34.34	36.58	33.95	CL			
2	7.34	1.13	48.92	302	2100	290	23.02	0.58	94.30	4.04	58.15	20.59	21.26	C			
3	7.44	1.22	44.28	231	1750	320	8.84	0.50	45.70	0.68	47.52	21.19	31.29	C			
4	6.56	2.73	63.56	161	1600	140	6.50	0.57	35.60	0.83	17.16	18.89	63.95	SL			
5	7.32	4.39	57.08	235	3955	580	4.76	0.51	56.90	0.05	43.60	39.15	17.25	C			
6	7.22	1.26	44.05	278	2340	370	9.88	0.48	59.60	2.92	19.61	25.30	55.09	SL			
7	7.33	1.17	48.29	315	1780	380	2.87	0.66	16.53	0.12	17.48	26.27	56.25	SL			
8	7.62	0.91	56.20	292	4510	650	0.12	0.68	19.81	0.08	44.90	23.10	32.00	C			
9	7.14	1.86	43.70	423	2240	470	6.25	0.50	28.72	0.16	48.00	26.00	26.00	C			
10	7.16	1.95	47.64	218	1950	290	2.14	1.19	23.17	2.17	44.93	23.74	31.33	C			
11	7.56	2.33	49.24	178	4140	720	4.07	0.41	40.67	0.14	42.10	30.50	27.40	C			
12	7.25	1.38	43.16	456	2300	670	5.88	0.34	16.43	4.28	29.60	22.90	47.50	SCL			
13	7.27	1.27	54.77	329	2240	540	2.71	0.29	53.05	0.15	27.05	33.95	29.00	CL			
14	6.16	1.87	70.64	285	2320	210	7.41	0.75	78.17	4.01	32.20	28.52	39.28	CL			
15	6.89	1.52	71.35	404	2210	260	0.82	1.10	28.97	1.05	28.10	19.90	52.00	SCL			
16	6.69	2.14	45.30	178	1950	250	1.43	0.57	23.80	2.97	20.83	24.04	55.13	SCL			
17	5.78	1.46	42.82	248	950	120	3.97	0.46	21.22	3.15	32.01	15.45	52.54	SCL			
18	7.40	1.22	51.01	188	3870	720	8.60	0.54	73.02	0.18	32.90	28.50	38.60	CL			
19	5.08	1.91	52.80	184	1100	110	2.07	0.71	29.22	4.10	14.93	24.35	60.72	SL			
20	6.98	1.92	47.44	272	2350	180	2.07	0.53	23.28	4.08	36.90	23.10	40.00	CL			
21	7.23	2.45	41.56	178	2540	240	6.93	0.54	24.71	3.92	27.14	24.45	48.41	SCL			
22	7.62	2.23	41.74	299	3480	750	0.13	0.63	23.71	0.15	28.36	25.04	46.60	SCL			
23	6.06	0.62	45.51	235	2010	280	8.94	2.29	36.02	1.98	27.68	27.15	45.17	SCL			
24	5.81	2.16	44.05	245	1120	140	9.12	1.92	32.35	4.07	19.60	28.40	52.00	SL			
25	7.67	1.51	52.80	218	3620	820	1.02	0.49	17.15	0.16	25.57	27.09	47.34	SCL			
Max.	7.67	7.39	71.35	456	4510	820	23.02	2.29	94.30	4.07	58.15	39.15	63.95				
Min.	5.08	0.62	41.56	161	950	110	0.12	0.29	16.53	0.05	14.93	15.45	21.26				

phosphorus amounts were between 41.56 and 71.35 ppm; exchangeable potassium, calcium and magnesium amounts were between 161-456 ppm; 950-4510 ppm and 110-820 ppm, respectively. The available iron contents were between 0.12 and 23.02 ppm; available copper contents were between 0.05 and 4.07 ppm; available zinc and manganese contents were between 0.29-2.29 ppm and 16.53-94.30 ppm, respectively. The texture of the soil samples were generally medium texture (Sandy Clay Loam. SCL).

pH values, organic matter contents, available phosphorus amounts and exchangeable potassium amounts of the soil samples were evaluated according to Table 2 and their results were plotted in Figure 1.

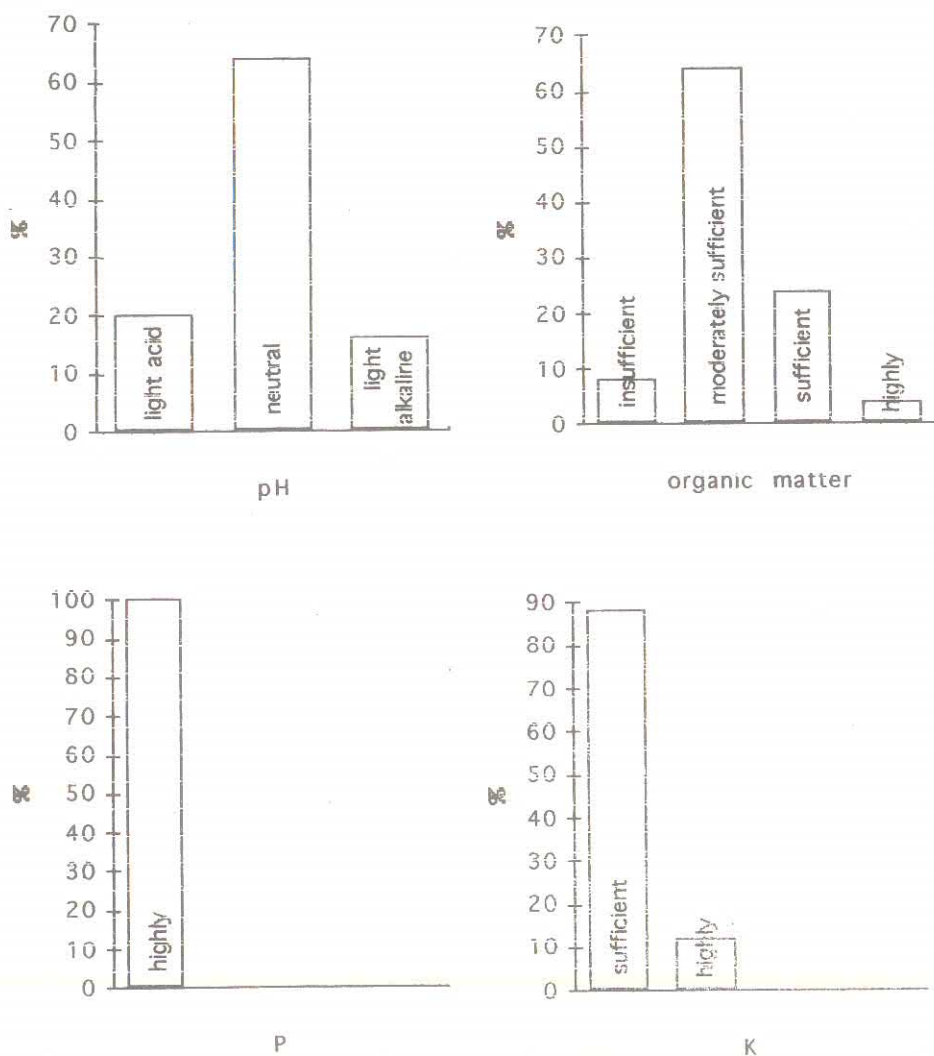


Figure 1. The distribution of pH, organic matter, P and K amounts of the soil samples.

When from Figure 1, it can be seen that pH values of the soil samples are generally neutral. Organic matter contents are generally moderately sufficient, available phosphorus amounts are generally high and exchangeable potassium amounts are generally sufficient.

Calcium and magnesium amounts of the soil samples were evaluated according to Table 2, and their results were shown in Figure 2.

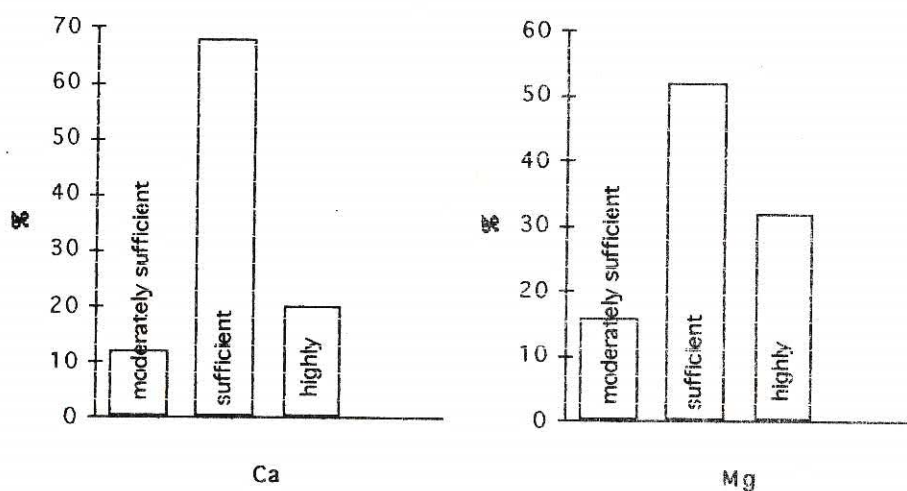


Figure 2. The distribution of Ca and Mg amounts of the soil samples.

Figure 2 shows that the exchangeable Ca and Mg amounts of the soil samples are generally sufficient.

The available Fe, Cu, Zn and Mn contents of the soil samples are evaluated according to Table 2, the contents of Fe are generally high, Cu contents are sufficient, Zn contents are <sup>moderately</sup> sufficient and Mn contents are generally sufficient (Figure 3).



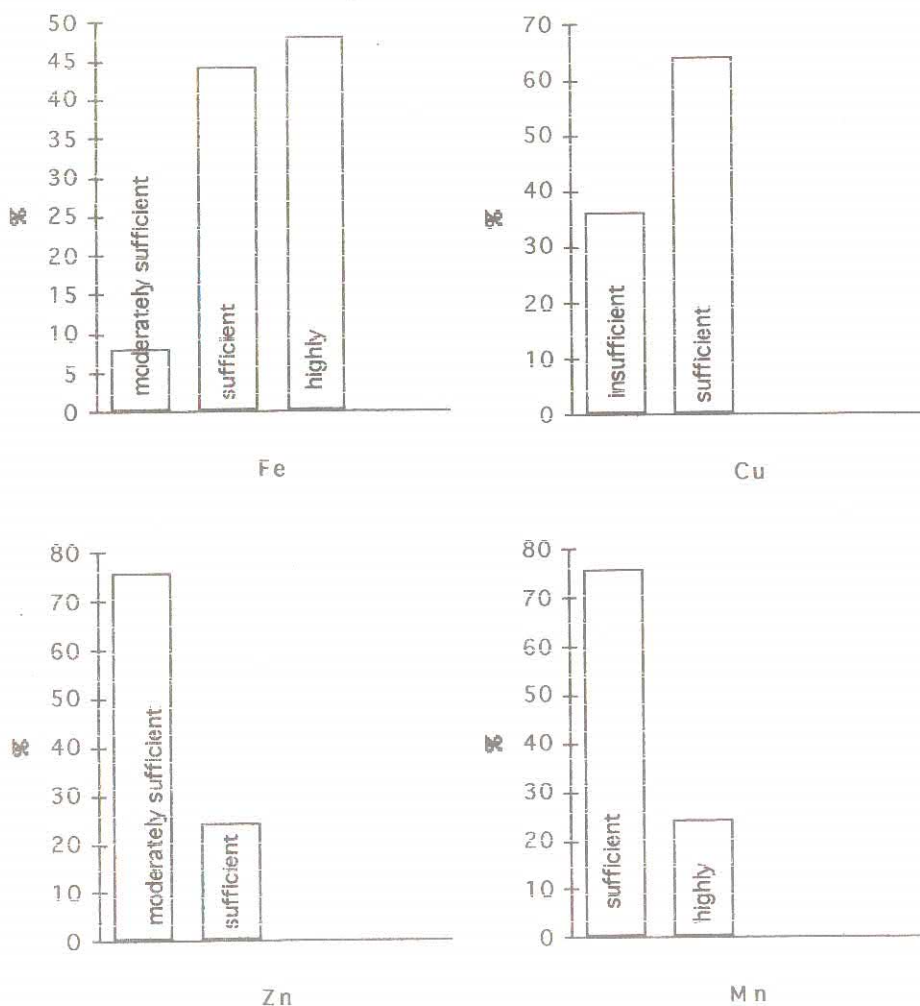


Figure 3. The distribution of Fe, Cu, Zn and Mn contents of the soil samples.

## CONCLUSION

In this research, it was investigated some physical and chemical properties of soil samples containing high level of phosphorus. According to the results, the usage of excessive phosphorus fertilizers disturbed the nutrient balance in the soil. Time to time, Ca and Mg deficiencies were also observed. But the real problem is that deficiencies were observed in trace elements. Fe and Mn deficiencies were not seen as a problem at the present time. But for the Zn, due to the P-Zn antagonism its deficiency is at high levels. Cu deficiency should also be taken into account. Therefore, in this region excessive use of phosphorus fertilizer should be abandoned. Fertilizers

containing low level of phosphorus is to be preferred for sunflower and wheat plants. Additionally, fertilizers containing trace elements, especially Zn, Cu should be used.

## REFERENCES

1. Sağlam, M.T.; A. Adiloğlu ve H. Altay (1997). Tekirdağ Koşullarında Buğday ve Ayçiçeğine Normal Doz ile Azalan Miktarlarda Fosfor Uygulamasının Bazı Verim Özellikleri Üzerindeki Etkisi. 1. Trakya Toprak ve Gübre Sempozyumu, 20-22 Ekim, Tekirdağ.
2. Katkat, V.; A. Özgümüş ve M. Kaplan (1987). Azotlu ve Fosforlu Gübrelemenin Cumhuriyet-75 Buğday Çeşidinde Tane Verimi ile Tanelerin N, P, K Kapsamları Üzerine Etkileri, Toprak İlmi Derneği 10. Bilimsel Toplantısı, 30 Haziran-4 Temmuz, Kırklareli.
3. Loneragan, J.F. (1978). Anamolies in the Relationship of Nutrient Concentrations to Plant Yields. Proc. 9th Intern. Coll. Plant Anal. and Fertil. Problems, Auckland, New Zealand, 283-298.
4. FAO (1990). Micronutrient, Assesurent at the Country Level: An International Study. FAO Soils Bulletin by Mikko Sillanpao, Rome.
5. Follet, R.H.; W.L. Lindsay (1971). Profile Distrubition of Zinc, Iron, Manganese and Cooper in Colarado Soils. Colarado state Univ. Exp. Station Bull.
6. Anonim (1991). Türkiye Toprakları Verimlilik Envanteri, Tarım Orman ve Köyişleri Bakanlığı, Köy Hiz. Gen. Müd. Yay.

# THE NUTRITION STATUS OF *Vitis vinifera* L. GROWN AROUND ŞANLIURFA IN TURKEY

İlhan Kızılgöz<sup>(1)</sup>, Rıdvan Kızılkaya<sup>(2)</sup>, Saadettin Gürsöz<sup>(3)</sup>

<sup>(1)</sup> Asst.Prof.Dr., Harran University, Fac. of Agric., Department of Soil Science Şanlıurfa/Turkey

<sup>(2)</sup> Asst.Prof.Dr., Ondokuz Mayıs University, Fac. of Agric., Dep. of Soil Science Samsun/Turkey

<sup>(3)</sup> Assoc.Prof.Dr., Harran University, Fac. of Agric., Department of Horticulture Şanlıurfa/Turkey

## ABSTRACT

This study was carried out in order to determine relationships between nutrition status of *Vitis vinifera* L. grown around Şanlıurfa and soil properties. Soil samples were taken from 0-20, 20-40 and 40-60 cm soil depths and 25 plant samples from 14 different *Vitis vinifera* L. were taken.

According to the results obtained from this study the mineral contents of N, P, K, Cu, Zn, Fe and Mn of *Vitis vinifera* L. samples were determined 0.20 %, 0.47 %, 0.32 %, 7.96 ppm, 13.70 ppm, 53.12 ppm and 9.22 ppm respectively. N, K, Fe, Zn and Mn contents were low, P contents was high and Cu content was sufficient according to the results obtained from leava analysis.

## INTRODUCTION

Turkey is situated in one of the most suitable climatic zones for *Vitis vinifera* L. and at the centre of the geography where *Vitis vinifera* L. was first cultured. Therefore, Turkey has a deep rooted tradition at producing *Vitis vinifera* L. and a rich *Vitis vinifera* L. gene potential (Çelik et al., 1998).

In the GAP region, there are many varieties of grapes most of them with locally named. Tahannebi (sofralık), Hatunparmağı (sofralık), Hönüsü (sofralık), Muhammediye (sofralık), Kabarcık (şıralık and sofralık), Dökülgen (şıralık and sofralık), Besni (sofralık and kurutmalık), Rumi (şıralık and kurutmalık) ve Horozkarası (sofralık, şaraplık and şıralık) are considered standart varieties due to superior qualities (Kaplan, 1994).

Most important vine growing centers of South East Turkey, their surface are and 1996 production data are given in Table 1. Total growth area and production for grape varieties in the GAP Region which are now below the desired level are predicted to rise potentially with improvements in irrigation.

Table 1. Major Grape Growing Centes of South East Turkey Surface Area and Production for 1996 (Anonymous, 1998).

Centers	Surface Area (ha)	Production (tons/year)
Şanlıurfa	23048	57290
Diyarbakır	22012	115655
Mardin	20996	103305
Adıyaman	10185	60685

Best way to determine nutrition status of plants is to establish The experiments is time consuming and needs extra expenses, thus, most researches use the survey method. In this method; soil, leaf and fruit samples collected from the selected area in the light of the criterion established, are analyzed (Bould, 1966).

According to the physiological and biochemical functions, nutrients are,

- C, H and O (basic building blocks for organic molecules) and N, S (building blocks of enzymes, organic structure and albumin)
  - P and B (used in energy transmitting reactions)
  - K, Ca, Mg Cl and Mn (balances osmotic pressures within the plant and activates enzymes)
  - Fe, Zn, Mo, Cu (takes part in photosynthesis by causing electron carriage through charge exchange)
- (Mengel and Kirby, 1982; Mengel, 1984).



The objective of this study is to investigate the nutrient status of vines (*Vitis vinifera* L.) growing around Şanlıurfa and to determine nutrition deficiency problems of vines by examining the state of nutrition levels before the initiation of irrigation practices in these areas. This was the first scientific study of its kind in the Şanlıurfa areas and it is intended to provide a data base for future studies concerning fertilization types, methods and doses.

## MATERIALS AND METHODS

25 plant samples were taken from 14 different types of vines for this investigation. Soil samples collected from vineyards located in villages around Şanlıurfa. Soil samples were taken from 0-20, 20-40 and 40-60 cm depths according to the methods by Jackson (1962) and were prepared for analysis.

Texture of soil samples, was measured according to methods proposed by Bouyoucos (1951), pH and KDK as proposed by Richards (1954) and lime content was measured as proposed by Çağlar (1952). As for plant samples, 8-10 pieces of middle exile of kinds of healthy *Vitis vinifera* L. are taken, labelled and prepared for analysis in the laboratories after routine operations. The nutrient contents of plants are determined according to Kacar (1972) reported.

## DISCUSSION

Physical and chemical properties of soil samples are given in table 2.

Table 2. The Results of Analysis of Texture, pH, Lime Content and CEC of Soil Samples

Sample No	Taken Place	The Type of <i>Vitis vinifera</i> L.	Clay (%)	Silt (%)	Sand (%)	Texture Class	pH	Lime (%)	CEC (meq/100 gr)
1	Diphisar-2	Çiloreş-1	62.2	21.4	16.4	C	7.83	31.3	43.2
2	Diphisar-4	Çiloreş-2	33.2	30.4	36.4	CL	7.59	76.5	15.6
3	Büyüksalkım-1	Çiloreş-3	32.1	34.3	33.6	CL	7.86	70.0	16.5
4	Büyüksalkım-2	Çiloreş-4	71.7	17.5	10.8	C	7.93	9.5	55.5
5	Kızlar-1	Çiloreş-5	39.1	32.5	28.4	CL	7.88	79.5	16.6
6	Diphisar-1	Hönüsü-1	51.9	22.0	26.1	C	7.80	49.3	31.5
7	Büyüksalkım-1	Hönüsü-2	32.1	34.3	33.6	CL	7.86	70.0	16.5
8	Büyüksalkım-2	Hönüsü-3	71.7	17.5	10.8	C	7.93	9.5	55.5
9	Kızlar-1	Hönüsü-4	39.1	32.5	28.4	CL	7.88	79.3	16.6
10	Diphisar-3	Sergikarasi-1	64.0	18.6	17.4	C	7.66	33.7	43.8
11	Diphisar-4	Sergikarasi-2	33.2	30.4	36.4	CL	7.59	76.5	15.6
12	Kızlar-1	Sergikarasi-3	39.1	32.5	28.4	CL	7.88	79.3	16.6
13	Büyüksalkım-2	Küllahi-1	71.7	17.5	10.8	C	7.93	9.5	55.5
14	Kızlar-1	Küllahi-2	39.1	32.5	28.4	CL	7.88	79.3	16.6
15	Diphisar-4	Bastikkabarcığı-1	33.2	30.4	36.4	CL	7.59	76.5	15.6
16	Kızlar-1	Bastikkabarcığı-2	39.1	32.5	28.4	CL	7.88	79.3	16.6
17	Kızlar-1	Gülgülü	39.1	32.5	28.4	CL	7.88	79.3	16.6
18	Kızlar-1	Kabarcık	39.1	32.5	28.4	CL	7.88	79.3	16.6
19	Kızlar-1	Çilorut	39.1	32.5	28.4	CL	7.88	79.3	16.6
20	Diphisar-4	Hatunparmağı	33.2	30.4	36.4	CL	7.59	76.5	15.6
21	Kızlar-1	Tilgören	39.1	32.5	28.4	CL	7.88	79.3	16.6
22	Kızlar-1	Azezi	39.1	32.5	28.4	CL	7.88	79.3	16.6
23	Kızlar-1	Ketengömleği	39.1	32.5	28.4	CL	7.88	79.3	16.6
24	Kızlar-1	Besni	39.1	32.5	28.4	CL	7.88	79.3	16.6
25	Kızlar-2	Tahannebi	57.7	22.4	19.9	C	7.65	44.7	33.2

The contents of clay, silt and sand were found 32.1-71.7 %, 17.5-34.3 %, 10.8-36.4 % respectively. These results shows that the clay content of soil samples are very high. It's determined that the lime content of soils are ranged between 9.5 % and 79.5 %. The soil samples are rich in lime. pH values of soil samples were determined between 7.59 and 7.93 and all the soil samples were found in

alkaline characters. It's determined that CEC values of soils in the study are changing between 15.6-55.5 meq/100 gr.

The data gathered from the chemical analysis of plant samples are shown in the Table 3.

Table 3. Macro and Micro Nutrient Contents of Plant Samples

Sample No	The Type of <i>Vitis vinifera</i> L.	Taken Place	Macroelements (%)			Microelements (ppm)			
			N	P	K	Cu	Zn	Fe	Mn
1	Çiloreş-1	Diphisar-2	1.48	0.47	0.31	3.21	12.02	58.02	10.00
2	Çiloreş-2	Diphisar-4	2.56	0.69	0.29	8.08	11.66	44.76	7.89
3	Çiloreş-3	Büyüksalkım-1	2.14	0.45	0.37	18.45	15.95	40.16	7.16
4	Çiloreş-4	Büyüksalkım-2	2.06	0.14	0.28	3.63	9.30	27.99	5.22
5	Çiloreş-5	Kızlar-1	2.01	0.46	0.31	8.08	14.87	64.25	11.00
6	Hönüsü-1	Diphisar-1	2.15	0.52	0.39	13.16	24.18	45.58	8.02
7	Hönüsü-2	Büyüksalkım-1	2.36	0.48	0.36	8.98	13.23	61.54	10.57
8	Hönüsü-3	Büyüksalkım-2	2.59	0.16	0.30	11.46	13.23	75.61	12.81
9	Hönüsü-4	Kızlar-1	2.54	0.27	0.41	3.42	11.11	59.92	10.31
10	Sergikarasi-1	Diphisar-3	1.98	0.62	0.35	5.32	9.84	56.94	9.83
11	Sergikarasi-2	Diphisar-4	2.54	0.63	0.24	11.46	12.39	50.18	8.75
12	Sergikarasi-3	Kızlar-1	2.12	0.42	0.28	3.00	14.38	38.81	6.94
13	Küllahi-1	Büyüksalkım-2	2.26	0.48	0.32	3.00	12.57	58.84	10.13
14	Küllahi-2	Kızlar-1	2.48	0.42	0.34	3.42	12.14	49.36	8.62
15	Bastıkabarcığı-1	Diphisar-4	3.01	0.65	0.23	7.86	13.11	43.95	7.76
16	Bastıkabarcığı-2	Kızlar-1	1.26	0.64	0.31	7.97	12.32	43.68	7.72
17	Gülgülü-	Kızlar-1	2.63	0.85	0.35	5.75	14.32	64.79	11.08
18	Kabarcık	Kızlar-1	2.96	0.63	0.29	8.29	11.90	53.69	9.31
19	Çilorut	Kızlar-1	2.22	0.16	0.28	3.42	11.24	92.12	15.44
20	Hatunparmağı	Diphisar-4	2.46	0.48	0.29	8.29	9.48	48.28	8.45
21	Tilgören	Kızlar-1	2.15	0.45	0.32	7.23	12.39	55.86	9.66
22	Azezi	Kızlar-1	2.48	0.36	0.36	15.49	14.26	49.36	8.62
23	Ketengömleği	Kızlar-1	2.14	0.63	0.48	3.84	22.00	41.52	7.37
24	Besni	Kızlar-1	2.36	0.37	0.28	14.85	14.32	37.19	6.68
25	Tahannebi	Kızlar-2	2.23	0.26	0.34	11.46	20.37	65.60	11.21
Average			2.20	0.47	0.32	7.96	13.70	53.12	9.22

According to Bergmann (1988)'s standart values (See Table 4), the kinds of *Vitis vinifera* L. growing around Şanlıurfa were low in N, K, Fe, Zn and Mn. Additionally, Cu contents of plant samples were found at high levels (See Table 3). This results are confirmed by the literature values with Şahin (1987); Bergmann, (1988); Aktaş, (1994) and Marschner (1997).

Table 4. Standart Nutrient Content Levels of *Vitis vinifera* L.(Bergmann, 1988).

Nutrients	Enough Level
N, %	2.30-2.80
P, %	0.25-0.45
K, %	1.20-1.60
Cu, ppm	6-12
Mn, ppm	30-100
Zn, ppm	20-70

Also, Bergmann (1988) informed that the rate of P/Zn of balanced nutrished *Vitis vinifera* L. changes between 150 and 190. In this study, this ratio was found as 343. This is a very high ratio. This is because of the low level of zinc content of *Vitis vinifera* L. growing around Şanlıurfa.



The soil was only source of nutrient elements in this research area. So, implimentation of irrigation nutrient deficiency problems might be increased. Therefore, some measurements must be taken. These are:

1. Similar studies should be considered with other fruits (i.e. pistachia, almond and pomegranate).
2. Leave fertilization techniques should be considered to solve the nutritient deficiency problems.
3. Nonsensitive plants for nutrition deficiency can be considered .
4. Soil is main reason for impaired plant growth. Therefore, increasing number of investigation on determining nutritient content of soils should be considered.

## REFERENCES

- Aktaş, M., (1994). Bitki Besleme ve Toprak Verimliliği (II. Baskı). AÜZF Ders Kitabı No: 395 Ankara
- Anonymous, (1998). Tarımsal Yapı (Üretim, Fiyat, Değer). T.C. Başbakanlık Devlet İstatistik Enstitüsü Yayını No. 2097 Ankara.
- Bergmann, W., (1988). Ernährungsstörungen bei Kulturpflanzen. Gustav Fischer Verlag- Stuttgart-New York.
- Bould, C., (1966). Leaf Analysis of Decidious Fruits. Nutrition of Fruit Crops (Ed. N. F. Childers). Hort Publications. Rutger The State Uni. Nichola Ave. New Brunswick N. J. USA p. 655-681
- Bouyoucos, G. J., (1951). A Recalibration of Hidrometer Method for Making Mechanical Analysis of Soils. Agronomy Journal Vol. 143. No: 9
- Çağlar, (1958). Toprak İlimi. AÜZF Yayını No: 10 Ankara
- Çelik, H., Ağaoğlu, A. S., Fidan, Y., Maraslı, B., Söylemezoğlu, B., (1998). Genel Bağcılık. Sun Fidan A. Ş. Mesleki Kitaplar Serisi No: 1 ISBN: 975- 96656-0-3, 253 s.
- Jackson, M. L., (1962). Soil Chemical Anayyses. Pretice-Hall, Inc. Eng. Cliffs. USA
- Kaplan, N., (1994). Diyarbakır ve Mardin İllerinde Yetiştirilen Üzüm Çeşitlerinin Ampelografik Özelliklerinin Saptanması Üzerinde Bir Araştırma. Ankara Üniv. FBE. (Doktora Tezi). 206 s. Ankara
- Marschner, H., (1997). Mineral Nutrition of Higher Plants. (2 nd. ed.). Academic Press. pp. 1-889. Harcourt Brace and Company Publishers. ISBN: 0-12-473543-6 London, Great Britain.
- Mengel, K., Kirby, E. A., (1982). Principles of Plant Nutrition. Publ. Int. Potash Inst. Bern, Schweiz, 3 Aufl.
- Mengel, K., (1984). Ernährung und Stoffwechsel der Pflanze. 6. Aufl. VEB Gustav Fischer. Jena.
- Richards, L. A., (1954). Diagnosis and improvement of saline and alcali soils. Agricultural Handbook No: 6 USA
- Şahin, G., (1987). Bazı Asma Çeşitlerinin Değişik Dönem ve Konumlarından Alınan Yaprak Örneklerinde Besin Maddesi Düzeylerinin Araştırılması. Ç.Ü. FBE. Bahçe Bitkileri Anabilim Dalı Master Tezi. Kod No: 200



# DETERMINATION OF IRON , ZINC , MANGANESE , COPPER AND BORON LEVELS OF THE VINEYARDS IN HADIM - ALADAĞ REGION

Fatih Er<sup>(1)</sup>, Fethi Bayraklı<sup>(2)</sup> And Mevlüt Mülayim<sup>(1)</sup>

<sup>(1)</sup> Selcuk Uni. Çumra Meslek Yüksekokulu 42500, Çumra -Konya

<sup>(2)</sup> 19 Mayıs Uni. Agricultural Fac. Dept. of Soil Science Kurupelit – Samsun

## ABSTRACT

This study was carried out to determine the problems of vineyards nutrition in Hadim Aladağ region. Soil samples different depths, plant samples at fruit set and veraison period were obtained from 52 vineyards . Some physical and chemical analysis on soil samples and leaf lamina and petiole were also made.

Soil textures were sandy silt, sandy clayey silt , soil was slightly alkaline , poor interms of organic material. % 74 of the soils was medium to high in CaCO<sub>3</sub> and % 63 was different interms of phosphorus. Plant samples had sufficient Mn and Cu . These values in plant samples were 65.4 , 65 and 27 % for Zn , B and Cu.

From fruit set to veraison Fe and Mn increased , B decrased and there wasn't a trend with respect to Zn and Cu.

## INTRODUCTION

Anatolia has vine of culture. It is home Anatolia about economical. Beside this, it has got a vineyard of culture.

The vineyard was been subject to legend in Anatolia and it has got an important place in the life of person and it is important for their health It is nutritious The vineyard was examined carefully about climate soil and places of consumption. Some technique ways were improved about climate for vineyard and the consumption was agumented (Brohi,1984).

The vineyard is 37, 926, and its consumption is 117.132 t in city of Konya. This vineyard has got a place about 6,7 % and 3,2 % of Turkey. The consumption of the wet grapes is about 600 kg in Turkey, and 308,80 kg/da in Konya. But in Hadim-Aladağ is about 239,40 kg/da (Anonymous, 1994). The vine soil of *Hesapali* grow grape hasn't got enough phosphorus and it is Average of calcareous and it has must be phosphorus about 40%( Bayraklı et.al, 1997).

We must make use of the plants and the soil for grow the plants. Beside this , we must appraise from exchangeables to grow the plants.In our and in the world a lot of works were made about the soil analysis , a specially the trees which are pouring leaf trees.

## MATERIALS and METHODS

In Hadim-Aladağ is a narrow valley between the Average Tourus Mountains and it is through the Göksu lake. The altitude is down on the valley floor about 700m. In here, warm is about 30,5 °C from the langer-years, in July. But it can be -13,6°C in January. The Average warm is 9,2°C and the wet is 59,7% and rain quantity is 615mm in a year.

In the searching place, many pictures were taken about the soil at fruit set in the 0-30 and 30-60 cm in the soil (Table 1).

Soil textures were sandy silt, sandy clayey silt , soil was slightly alkaline , poor interms of organic material. % 74 of the soils was medium to high in CaCO<sub>3</sub> and % 63 was different interms of phosphorus ( Table 1 ). We can take this pictures from 52 vineyard. From the same vineyard fruit set and veraison (Porro et.al, 1995). It was taken examples the plants as leaf lamina (Beyers, 1962 and the leaf petiol (Christensen, 1984).

The searching vineyards were taken from "Hesapali , S. Dimrit, Keçimen, Göğüzüm, Bardas" as be different grapes (Bouycous ,1951). 1: 2,5 we can understand the soil-water pH and whole salt ( Bayraklı 1987) and calcareous scheibler calsimetres from the soil examples.With the phosphorus metod , Mg , Ca , Na quantity can learn from (Sağlam, 1978).

Tablo 1. Physical and chemical properties of the Vine-yards soils of Hadim- Aladağ

Parameter	0 - 30 cm				30 - 60 cm			
	Min	Mak	Mean	Median	Min	Mak	Mean	Median
Sand,%	25.1	85.4	52.1	51.9	27.7	81.0	52.3	52.1
Silt,%	8.4	52.3	28.4	27.6	9.1	46.8	28.3	25.6
Clay,%	0.1	36.9	19.6	21.3	3.1	42.8	19.3	19.8
PH	7.42	8.30	7.81	7.78	7.31	8.30	7.78	7.78
T. Salt %	0.012	0.101	0.040	00.32	0.005	0.064	0.030	0.027
Calcerus%	0.20	42.3	11.95	10.45	0.20	46.2	11.24	9.35
Or.Mt. %	0.85	5.05	2.32	2.00	0.72	4.50	1.98	1.63
P mg kg <sup>-1</sup>	2.27	49.58	14.65	10.13	1.19	38.20	11.88	12.25
Mg meq	0.47	7.25	2.66	2.05	0.41	7.01	2.50	2.18
Ca meq	4.60	26.60	12.77	12.25	2.23	27.17	12.56	12.07
K meq	0.54	3.65	1.42	1.33	0.36	2.72	1.29	1.24
Na meq	0.07	0.27	0.16	0.15	0.09	0.40	0.16	0.15
Ca+Mg/K	2.14	34.13	12.63	10.68	4.23	48.87	13.92	11.24

The plants examples were ready with clean , dry and crush analysis. The crush examples of H<sub>2</sub>SO<sub>4</sub>+H<sub>2</sub>O<sub>2</sub> with the other exchangeables were supplied. Fe , Zn , Mn , Cu , GBC 902 A.A.S. with dry matter as ppm(mg.kg<sup>-1</sup>) search (Bayraklı 1987) B and Azomethin-H method were give UV-160 A. The results were moden as dry matter ppm (mg.kg<sup>-1</sup>) (Bayraklı 1987).

E.Ü. Tarist packet program was used as statistics analysis.

## DISCUSSION

We can see in term of fruit set and veraison Fe, Zn, Mn, Cu , and B in the leaf lamina and petiol, which are at the 3 and 2 Table.

From the searchig vineyards, the leaf lamina and petiol is changing about Fe, 19,76 – 170,47 & 23,30-95,00 ppm Fe (Average 84,11& 56,68 ppm) in the fruit set 55,59 –195,78 &10,30-175,00ppm (Average 139,29 & 77,13ppm) in the veraison ( Table 2 and 3 ).

The Fe's value was saved as the time. This save can develop from root. Although, Kacar (1984) in the plants this save can fall down, but as fixed.

The Fe, absorb in the root as Fe<sup>+2</sup> and Fe. The Fe of the plants is fall down with pH and phosphorus and Calcium. Beside this the Fe can't find in the plants organ. But the Fe is very important for grapes. Because itis growing with Fe. We must give Fe for bad grapes, and it is becoming wonderful grapes (Kabala-pendias and Pendias 1984).

Tablo. 2. Nutrient Status of leaf lamina of Vine-yards (ppm mg.kg<sup>-1</sup>)

Nutrient content	Fruit Set				Veraison			
	Min	Mak	Mean	Median	Min	Mak	Mean	Median
<b>Fe</b>	19,76	170,47	84,11	80,70	55,59	195,78	139,29	147,30
<b>Zn</b>	4,75	83,18	31,84	30,10	2,23	103,60	21,71	18,10
<b>Mn</b>	28,90	211,4	115,78	120,60	38,40	233,74	144,68	146,70
<b>Cu</b>	5,53	29,52	16,66	15,50	3,05	19,28	11,23	11,20
<b>B</b>	29,75	105,80	53,68	43,90	25,12	74,60	46,11	39,80

Beside this the Fe is rising in the plants towards the time of veraison. We can see this same result in the other exchangeables ( Ergenoğlu and Erdoğan 1992).

The Fe isn't enough for the examples leaf lamina in the of fruit set. It was explained by Beyers (1962) and (60-18ppm Fe ) or 27% and explained by Porro et.al,(1995) (45ppm Fe) or 19%.



In the other way; we can see the quantity as 12.5%. This result is the same with leaf lamina time. As a result, Porro et.al, (1995) was explained the Fe is very important for the plants in the time of take the pictures and examples plants.

From the examples value of Zn time of leaf lamina and leaf petiol time of fruit set is 4,75-83,18ppm. Zn (Average of 31,84 ppm) time of veraison is 2,23-103,60ppm. Zn (Average of 21,71 ppm) we can see this values.

Zn of leaf lamina can seen change or it is less. Because of copperly preparat which is in the vineyard. When it is used, you can make use of antagonistik of Zn. The Zn value of vine can change, this exchangeable was explained by Cummings (1977) & Aktaş and Karaçal(1988). From this exchangeable we can understand that the Zn is too much in the leaf petiol than leaf lamina.

The fruit set, the value of Zn is 35ppm in the leaf lamina. It was explained by Alexander and Woodhom (1964). Beside this Zn isn't enough for vine, it is too less (60%) All the searchers can explain less of Zn for soil (65,4%) or plants (69,2%) But this results are the same for these. Value of Mn time of leaf lamina is 28,90-211,40ppm Mn (Average of 115,78ppm) time of veraison is 38,40-233,74ppm Mn (Average of 144,86ppm) this values can change.

The value of Mn can change to words to veraison. We can understand this from search which was explained by Aktaş and Karaçal (1988) and Erenoğlu and Erdoğan (1992) This value (22ppm Mn) is enough for plants and was explained it (Christensen, 1984).

If the Mn is too much in the plants, the plants can saved by Mn or fungusid. But this exchangeable isn't real it is guess. Although this value is enough for plants and vine, the plants were bad. Aspecially time of leaf petiol. This event is born from the Fe/Mn. Beside this a micro is useful for plants which is in the soil (Aydemir and Köleli 1994).

Table 3 . Nutrient Status of leaf petiol of Vine-yards (ppm mg.kg<sup>-1</sup>)

Nutrient content	Fruit Set				Veraison			
	Min.	Mak	Mean	Median	Min	Mak	Mean	Median
Fe	23,30	95,00	56,58	55,90	10,30	175,00	77,13	76,70
Zn	16,70	41,70	24,73	23,50	13,30	53,30	30,37	29,20
Mn	13,30	186,70	59,54	53,90	31,70	310,00	113,31	82,50
Cu	3,30	25,00	14,35	13,30	3,30	50,00	15,77	15,00
B	19,80	59,80	34,43	32,90	18,30	42,00	29,26	28,70

Cu is use full for plants and its value is 5,53-29,52ppm (Average of 16,66ppm) time of veraison is 3,05-19,28ppm Cu (Average of 11,23ppm)

The value of Cu can less or too much time of leaf lamina and term colour . The value of Cu is lessing time of leaf lamina, but it is too much time of leaf petiol. In the plants 13% value need Cu and in the soil is 7%.

From the searching vineyards, the leaf lamina and leaf petiol is changing about B 29,75-105,80 & 19,80- 59,80 ppm (Average of 53,68 & 34,43 ppm) in the fruit set. 25,12 – 74,60& 18,30-42,00 ppm B (Average of 46,11 & 29,26 ppm) in the veraison. ( Table 2 and 3 ). The B is leaf lamina than leaf petiol.

In the vineyards the value of B is less towards to veraison. This is explained by (Porro et.al, 1995). In the time of leaf lamina an the B is too much , it was explained by Chsirtensen (1984) and (45ppm) and the value is 57,7% not enough for plants.

Beside this, 62,5% value is enough for plants and vine or soil. We can see this results the examles of plants.

Examples of soil organic material is 0-30cm in depth of soils. Beside this we can see Fe in the soils about ( $p < 0,01$ ) and this is positive. This is first depth. But second depth is important ( $p < 0,05$ ) and positive. Fe is increasing with this the organic material are incresing too. This exchangeable was explained by (Saatçı et.al, 1980). In the second depth , we can see this exchangeable between K and P, ( $p < 0,01$ ) and positive , Ca+Mg/K is important , ( $P < 0,05$ ) and negative. Between organic material and



exchangeable K which is important was explained by Atalay (1987 a,b) and Sezen (1975). But P was explained by ( Mengel, 1988).

In the soil's depth P and Zn is important, too ( $p<0,01$ ) and negative. This information is the same with P-Zn which was explained by; Beside this , between P and Cu is important ( $p<0,05$ ) and negative. But P is abtacting the P-Zn is and Fe – Cu. This is explained by (Brohi et.al, 1994).

In the soil is Cu is the same with clay which is in the soil. And this is important in second depth. ( $p<0,05$ ) and positive. Between organic material and Cu can make of useful for plants about ( $p<0,01$ ) and positive. This was explained by Loneragan (1981) and Bayraklı and Gezgin (1991).

Between Zn and organic material is important ( $p<0,05$ ) and positive. We can see the same similar in plain of Gediz, by Atalay (1987 a,b) who was explained. The leaf lamina and Fe, the leaf lamina and Cu , there is a similar between them and it was explained (  $p<0,05$ ) and positive ; we can see this example at grow cucumber .

The leaf lamina and Zn, there is a similar between them , and there is a similar between leaf lamina and B ( $p<0,05$ ) and negative. In the leaf lamina the Zn is increasing and B is lessing. This similar was explained by Singh and ark. (1990). This exchangeable is the same between B and wheat.

The leaf and Fe, the leaf and Zn, there is a similar between them. Between Fe and Zn was explained about value of them. When the corn's began to Grow, the p is lessing with Zn, this was explained by ;the leaf lamina and Fe with leaf lamina and B is similar. Was explained it Fe which is lessing not similar B and Mn ( Çelebi and Yalçın,1990).

The salt can change with leaf lamina and Fe and K ( $p<0,05$ ) and positive. In second depth the lime is ( $r = 0,339^*$ ) , whale salti is ( $r = 0,358^{**}$ ) and K( $r=0,359^{**}$ ) The P is very important for pants for increase Fe (Brohi et.al, 1994). Jolley and ark. (1988) Fe is very important too for plants , a Specially tomatoes and soybean. We can see this exchangeable in the examples which were explained tomatoes and soybean examples.

Both first and second depth, the leaf lamina, there is a similar between P and Zn are important ( $p<0,05$ ) and negative. P is need for grow the plants and beside this Zn .

Between B and the leaf lamina in the soil depth about 0-30 cm, and with cu. The leaf lamina is ( $r_{B-Cu} = -0,437^{**}$ ). Beside this ( $p <0,05$ ) and positive and 30-60cm in soil depth and ( $p<0,01$ ) and positive. The similars were explained by (El Sheik et.al, 1971). Beside this pH and Ca is not important for vine , B is enough. In the soil the clay is increasing , the Mn is lessing. (  $p<0,05$ ) We can see this exchangeable in Bursa in garden which is peach garden (Katkat et.al, 1994).

In the soil and between B and leaf petiol is important ( $p<0,05$ ) and negative, it was explained by Keren and Bingham (1985) PH is increasing and it is lessing the B about 6,5.

The clay is much important than the organic material. The some similar was explained by Sözüdoğru et.al, (1996) and Marzadori et.al, (1991).

The leaf lamina can taken with B by the plants about ( $p<0,01$ ) and positive. But B's value is changing in the soil of sand. It is changing. So B is important and its value is important for the plants and for the soils. It was explained by (El-sheik et.al, 1971).

## REFERENCES

- Aktaş, M. ve Karaçal, İ. (1988). Kırıkkale ve Delice ilçelerinde Hasandede Çeşidi Üzüm çeşitlerinin Bitki Besin Kapsam durumu. Doğa TU. Tarım ve Ormancılık dergisi, 12:3, 291-304.
- Alexander,D.McE., and Woodham, R.C.(1964).Yield Responses by Sultanas to Application of Zn and Superphosphate. Austrailan J. of Expt. Agric. and Animal Husbandary, 4, 169-172.
- Anonymous. (1994) Türkiye İstatistik Yıllığı. T.C. Başbakanlık D.İ.E. Ankara
- Atalay, İ.Z. (1987) a. Gediz Havzası Kolüvyal Topraklarının Besin Element Durumu ve Bunların Bazı Toprak Özellikleri. E.Ü. Ziraat Fakültesi Dergisi. Cilt:24, Sayı:1, 161-174, İzmir.
- Atalay, İ.Z. (1987) b. Gediz Havzası Alüvyal Topraklarının Besin Element Durumu ve Bunların Bazı Toprak Özellikleri. E.Ü. Ziraat Fakültesi Dergisi. Cilt:24, Sayı:1, 61-74, İzmir.
- Aydemir, O. ve Köleli, N. (1994). Mikro besin elementleri Arasındaki ilişkiler ( derleme) Atatürk Üni. Ziraat Fak. 25, (3) ,469-478.Erzurum.

- Bayraklı, F. ve Gezgın, S. (1991). Konya. Ereğli ve Çumra Ovası Topraklarının Elverişli Fe, Zn, Mn ve Cu Miktarları ile Bazı Toprak Özellikleri Arasındaki İlişkiler Üzerine Bir Araştırma. S.Ü. Ziraat Fakültesi Dergisi. 1 (2): 99-110.
- Bayraklı, F., (1987) Toprak ve Bitki Analizleri (Çeviri ve Derleme) 19 Mayıs Üniversitesi Ziraat Fakültesi., No:17, Samsun.
- Bayraklı, F., Er, F. and Brohi, A.R. (1997). Determination of Nutritional Status Vine-Yards Grown in Hadım Aladağ Part of Konya Region. XXVII<sup>th</sup> Annual Meeting of ESNA / jointly Organised with UIR. August 29- September 2, 61-66 sf., Ghent, Belgium.
- Beyers, E. (1962) Diagnostic leaf analysis for deciduous fruit. South African Journal of Agricultural Science, 5: No:2, 315-319.
- Bouyoucos, G.J. (1951). A recalibration of the hydrometer method for making mechanical analysis of soils Agronomy Jovr. 43: 434-438.
- Brohi, A.R. (1984). Bağcılıkta gübrelemenin önemi, Tokat Bağcılığı Sempozyumu, C.Ü.Z.F., Tokat.
- Brohi, A.R., Aydeniz, A., Karaman, M.R. ve Erşahin, S. (1994) Bitki Besleme. G.O.P.Ü. Ziraat Fak. Yay.:4, Kitap Serisi : 4 ,230 sf Tokat.
- Christensen, P. (1984). Nutrient Level comparisons of leaf Petioles and Blades in Twenty-Six Grape Cultivars Over Three Years (1979 through 1981). Am. J. Enol. Vitic., Vol. 35, No:3, 124-133.
- Cummings, G.A. (1977) Variation in the Concentration of certain Elements in Muscadine Grape Leaves Related to Season, Leaf Portion and Age. J. Amer. Soc. Hort. Sci. ,68, 141-156.
- Çelebi, G. ve Yalçın, S.R. (1990). Demir uygulamasının mısır bitkisinde gelişme ile demir, çinko, mangan ve bor kapsamları üzerine etkisi, A.Ü. Ziraat Fakültesi Yıllığı. Cilt: 41, No: 1-2, 225-239, Ankara.
- El-Sheik, A.M. Ulrich, A. Awad, S.K. and Mawady, A.E. (1971). Boron Tolerance of squash, melon, cucumber and corn. J. Amer. Soc. Hort. Sci., 96: 536-537.
- Ergenoğlu, F. ve Erdoğan, M. (1992). Çukurovası Bölgesinde Bazı Yerli ve Yabancı Kökenli Asma Çeşitlerinde Bitki Besin Maddelerinin Durumu. Doğa-Tr.J. of Agriculture and Forestry 16, 200-211 sf. Ankara.
- Jolley, V.D., Brown, J.C., Blaylock, M.J. and Miller, G. (1988) A role for Potassium in the use of iron by plants, J. Plant Nutr. 11: 1159-1175.
- Kabala-Pendias, A. and Pendias, H. (1984). Trace element in soils and plants. CRC Press, Boca Raton, FL.
- Kacar, B. (1984). Bitki Beslenme A.Ü. Yay. No:899. Ders Kitabı:250, 304 sf. Ankara.
- Katkat, A.V. Özgümüş, A., Başar, H. ve Altınel, B. (1994). Bursa yöresindeki Şeftali Ağaçlarının Demir Çinko, Bakır ve Mangan ile Beslenme Durumları. Tr.J. of Agricultural and Forestry 18: 447-456.
- Keren, R. and Bingham, F.T. (1985). Boron in Water, soils and plants, Adv. Soil Sci. 1: 229-276.
- Loneragan, J.F. (1981). Copper in Soils and Plants. Academic Press. 70 s., New York.
- Marzadori, C., Vittori, Antisari, L., Gavatta, C. and Segui, P. (1991) Soil Organic Matter Influence on adsorption and desorption of boron. Soil Sci. Soc. Am. J. 55: 1582-1585.
- Mengel, K. (1988). Bitkinin Beslenmesi ve Metabolizması (Çeviri). Ç.Ü. Ziraat Fakültesi. Yay:162 Ders Kitabı:12. Ankara.
- Porro, D., Stefanini, M., Failla, O. and Stringari, G. (1995). Optimal leaf sampling time in diagnosis of grapevine nutritional Status. Acta Horticulturae 383: 135-142, Italy.
- Saatçi, F., Altınbaş, Ü. ve Taysun, A. (1980). İzmir İli Güümüşsu Ovası sulama sularının nitelikleri ile toprak özellikleri ve mandarin yaprakları mikroelement içeriği arasındaki ilişkiler üzerine bir araştırma. E.Ü. Zir. Fak. Yayınları No: 396. İzmir.
- Sağlam, M.T. (1978). Toprak Kimyası Tatbikat Notları., 154 sf. Erzurum.
- Sezen, Y. (1975). Doğu Anadolu'nun Değişik Yerlerinden Alınan Toprak Örneklerinin Bitkiye Yararlı Potasyum Sağlama Durumları üzerine Bir Araştırma. A.Ü. Ziraat Fakültesi Yayınları. No:195, Erzurum.
- Singh, J.P., Dahiya, D.J. and Narwal, R.P., (1990). Boron uptake and toxicity in wheat in relation to zinc supply. Fert. Res. 24, 105-110.
- Sözüdoğru, S., Omar, Satea, M., ve Usta, S. (1996). Topraklarda Bor Adsorpsiyonu. A.Ü. Ziraat Fakültesi Tarım Bilimleri Dergisi. 2 (1): 19-22.



# ESTIMATION OF SOIL COMPACTION USING SOME SOIL PROPERTIES CAUSED BY WHEEL TRAFFIC

Cevdet Şeker<sup>1</sup>, A. Ali Işıldar<sup>2</sup>, Saim Karakaplan<sup>1</sup>

<sup>1</sup> Department of Soil Science, Faculty of Agriculture, University of Selçuk, 42031 Konya-Turkey

<sup>2</sup> Department of Soil Science, Faculty of Agriculture, University of S. Demirel, Isparta-Turkey

## ABSTRACT

The aim of this experimental study was to estimate soil compaction caused by wheel traffic using some soil properties. The study was conducted on a sandy loam soil at the experimental area of Agricultural Faculty, University of Selçuk. The soil surface was compacted by passing a tire wheel tractor once, twice or four times. The soil was sandy loam and its water content was approximately at field capacity. Penetration resistance and some soil properties were measured in the soil profile in order to determine their interactions. The results showed a positive relationship between penetration resistance and bulk density, and negative relationships between penetration resistance and total porosity, void ratio, air porosity and drainage porosity. Correlation coefficients of those relationships were 0.874\*\*, -0.850\*\*, -0.856\*\*, -0.852\*\* and -0.708\*\*, respectively.

## INTRODUCTION

Wheel traffic of agricultural prime movers is well recognised as a major contributor to detrimental soil compaction (Hunter, 1991; Wood et al., 1991). Soil penetration resistance, bulk density, and pore size distribution have been used for determination of soil compaction (Gupta et al., 1989; Carter, 1990). Soil penetration resistance may vary rapidly depending on soil water content changes, soil structure and stoniness of soil (O'Sullivan et al., 1987; Busscher, 1990). Soil penetration resistance readings that need to be compared are often taken at different soil water contents. Because, soil water changes may significantly affect soil penetration resistance, it is often difficult to determine the penetration resistance differences caused by water content or treatment (Busscher, 1990). To be able to compare penetration resistance readings, it would be necessary to adjust for differences from water content changes (Busscher, 1990). The relationship between penetration resistance and soil water content depends on soil physical properties, such as bulk density, soil porosity, texture and structure (Gerard et al., 1982; Spivey et al., 1986; Busscher, 1990; Carter, 1990). Calibration of soil penetration resistance readings with regard to soil water content changes takes a long time and is difficult. The purposes of this article are to develop relationships between soil penetration resistance readings and bulk density, total porosity, void ratio, air porosity and drainage porosity, and to estimate soil compaction from cited soil properties if soil conditions are different such as soil water content, soil structure and stoniness.

## MATERIALS AND METHODS

The study was conducted on a Calcic xerosol sandy loam soil at the experimental area of Agricultural Faculty, University of Selçuk. The soil has relatively high sand and calcium carbonate content.

Particle size distribution was determined by the hydrometer method (Day, 1965); clay (<2 µ): 24 %; silt (2-50 µ): 26 % and sand (50-2000 µ): 50 %. Water content as a percentage of dry weight representing field capacity (25 %, w/w) and permanent wilting (12 %, w/w) was determined according to Peters (1965). Soil pH and electrical conductivity in water (1:2.5) was 7.78 and 192 dS/m, respectively (Peech, 1965; Bower and Wilcox, 1965). Organic matter content of the soil was 2.25 % (Allison, 1965). The CaCO<sub>3</sub> equivalent of the soil was 29 % (Allison and Moodie, 1965). Particle density was 2.65 g.cm<sup>-3</sup> (Blake, 1965a). Bulk density and total porosity, void ratio, air porosity, drainage porosity were measured according to Blake, (1965b) and Vomocil, (1965), respectively. All measurements were made at three different soil layers (0-10, 10-20 and 20-30 cm) and replicated thrice.



Experimental plots ( 15x30 m ) were filled to a depth of 10 cm. Plots were irrigated to the measurement depth by sprinkler irrigation. The soil water content was determined periodically, sampling holes not affected subsequent measurement of the physical properties. When the soil water content was about the field capacity, the soil surface was compacted by passing a tire wheel tractor once, twice or four times. A two wheel drive Steyr model 8073-70 tractor, with a power of 51.5 kW, a weight of 2900 kg was used. The pressure of the rear and front tires of the tractor were 0.18 Pa and 0.21 Pa, respectively. The tractor forward velocity was 4.5 km.h<sup>-1</sup>. Penetration resistance of every soil layer was calculated by taking on arithmetic mean of six replications.

A soil penetrometer, with a cone angle of 30<sup>0</sup> and cone diameter of 12.83 mm, was used to determine of soil penetration resistance . It was pushed by hand into the soil to a depth of 30 cm, and penetrometer resistance for each 1 cm depth interval was recorded. Data were subjected to correlation and regression analyses by using SPSS software (SPSS, 1988).

## RESULTS AND DISCUSSION

The effects of different passing number of a tire wheel tractor on soil cone penetration resistance are shown in Fig 1. Passes of the tractor on the soil surface increased cone penetration resistance. Maximum increase of cone penetration resistance occurred at the soil surface (0-10 cm).

Bulk density, total porosity, void ratio, air porosity and drainage porosity of the untrafficked soil and of the soil after 1, 2 and 4 passes of the tire wheel tractor are illustrated in Figs 2 to 6. Passes of the tractor increased bulk density and decreased total porosity, void ratio, air porosity and drainage porosity ( Figs 2-6 ).

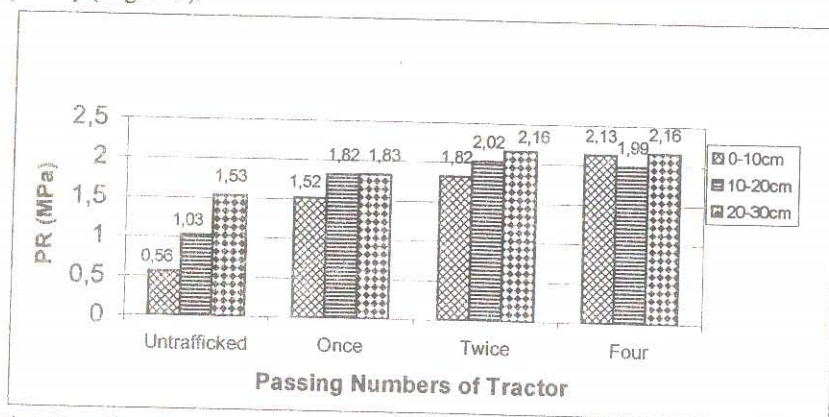


Fig 1. The effects on cone penetration resistance (PR) in soil profile of passing numbers of tractor.

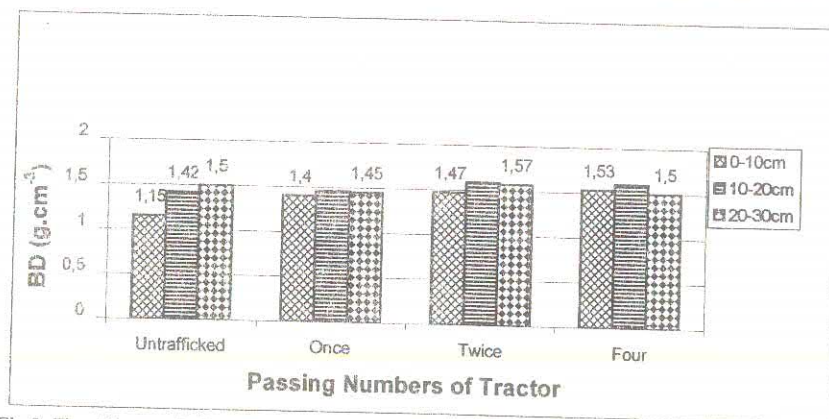


Fig 2. The effects on bulk density (BD) in soil profile of passing numbers of tractor.

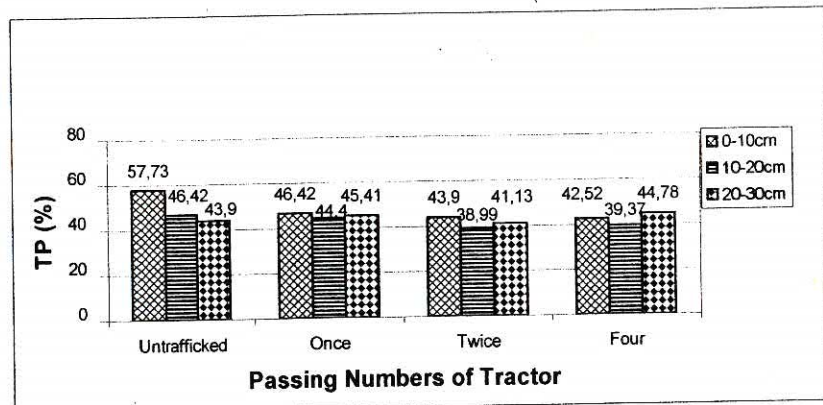


Fig 3. The effects on total porosity (TP) in soil profile of passing numbers of tractor.

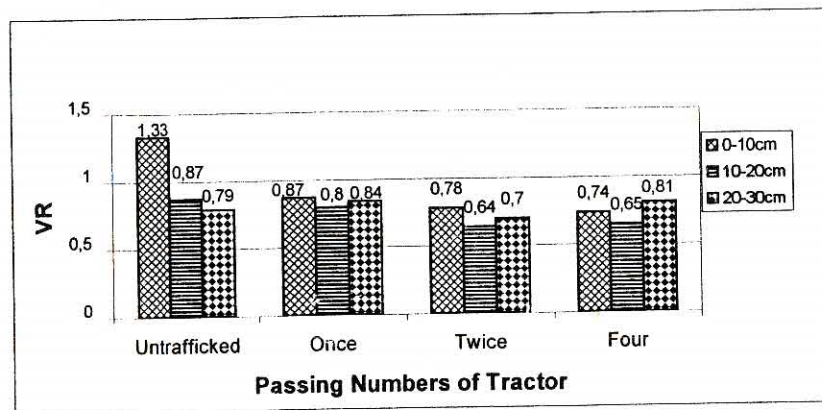


Fig 4. The effects on void ratio (VR) in soil profile of passing numbers of tractor.

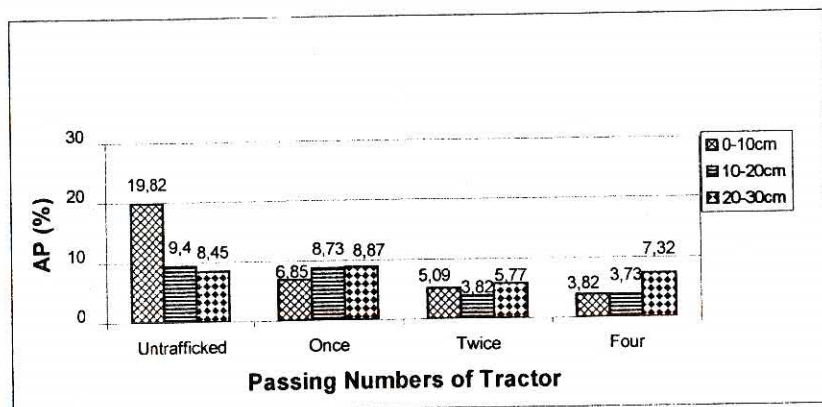


Fig 5. The effects on air porosity (AP) in soil profile of passing numbers of tractor.

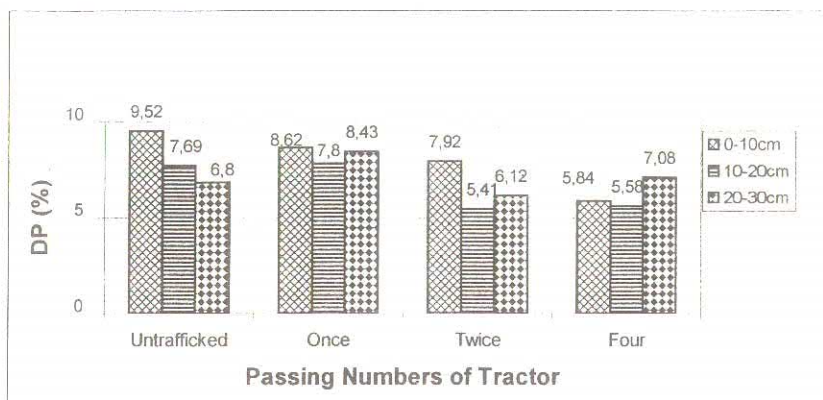


Fig 6. The effects on drainage porosity (DP) in soil profile of passing numbers of tractor.

Analysis of correlation was done to determine the relationships between cone penetration resistance and bulk density, total porosity, void ratio, air porosity, drainage porosity and available water porosity (AWP; size of between  $8.6\mu$ - $0.2\mu$ ). Correlation coefficients of relationships between penetration resistance and measured soil properties are given in Table 1. The relationships between penetration resistance and total porosity, void ratio, air porosity and drainage porosity were found take negative and statistically significant at the 1% level. Correlation coefficients of these relationships were  $-0.850$ ,  $-0.856$ ,  $-0.852$  and  $-0.708$ , respectively.

Table 1. Correlation Coefficients Between Penetration Resistance and Measured Soil Properties in Experiment Plot.

Soil Properties	PD (MPa)	BD ( $\text{g/cm}^3$ )	TP (%)	VR	AP (%)	DP (%)	AWP (%)
PR	1.000						
BD	0.874**	1.000					
TP	-0.850**	-0.990**	1.000				
VR	-0.856**	-0.985**	0.995**	1.000			
AP	-0.852**	-0.929**	0.949**	0.959**	1.000		
DP	-0.708**	-0.884**	0.855**	0.818**	0.766**	1.000	
AWP	-0.259ns	-0.103ns	0.018ns	0.048ns	-0.016ns	-0.005ns	1.000

\*\* :  $p < 0.01$

ns: not significant statistically

Statistical analyses and regression equations relating penetration resistance and bulk density, total porosity, void ratio, air porosity and drainage porosity are given in Table 2. Coefficients of determination of regression equations between penetration resistance and bulk density, void ratio, air porosity, total porosity and drainage porosity were 0.83, 0.83, 0.81, 0.80 and 0.60, respectively.

Table 2. Coefficients of Determination and Regression Equations

Dependent Variable	Independent Variable	$R^2$	Degree of Freedom	F	Regression Equations
PD	BD	0.83	10	49.81**	$PR = 0.336 \times BD^{1.122}$
PD	TP	0.80	10	38.95**	$PR = 41.953 \times 0.93^{TP}$
PD	VR	0.83	10	47.37**	$PR = 8.383 \times 0.134^{VR}$
PD	AP	0.81	10	42.58**	$PR = 3.013 \times 0.922^{AP}$
PD	DP	0.60	9	6.70*	$PR = -1.403 + 1.158 \times DP \times -0.097 DP^2$

\*\* :  $p < 0.01$  ; \* :  $p < 0.05$



## CONCLUSIONS

- Penetration resistance was affected importantly by soil water content. Therefore, there were various difficulties to compare each other penetration resistance readings at different soil conditions such as soil water content, soil structure and soil stonier.
- There were statistically significant relationships between penetration resistance and bulk density, total porosity, void ratio, air porosity and drainage porosity.
- Bulk density, total porosity, void ratio and air porosity which have high coefficients of determination with penetration resistance could be used to compare the soil compaction at different soil conditions.

## REFERENCES

- Allison, L.E., (1965). Organic carbon. In: Black, C.A. (ed.), *Methods of Soil Analysis. Part II*, American Society of Agronomy. Madison, Wisconsin, 1367-1378.
- Allison, L.E., Moodie, C.D., (1965). Carbonate. In: Black, C.A. (ed.), *Methods of Soil Analysis. Part II*, American Society of Agronomy. Madison, Wisconsin, 1379-1396.
- Blake, G.R., (1965a). Particle density. In: Black, C.A. (ed.), *Methods of Soil Analysis. Part I*, American Society of Agronomy. Madison, Wisconsin, 371-373.
- Blake, G.R., (1965b). Bulk density. In: Black, C.A. (ed.), *Methods of Soil Analysis. Part II*, American Society of Agronomy. Madison, Wisconsin, 374-390.
- Bower, C.A., Wilcox, L.V., (1965). Soluble salt. In: Black, C.A. (ed.), *Methods of Soil Analysis. Part II*, American Society of Agronomy. Madison, Wisconsin, 933-951.
- Busscher, W.J., (1990). Adjustment of flat-tipped penetrometer resistance data to a common water content. *Transactions ASAE* 33: 519 - 524.
- Carter, M.R., (1990). Relative measures of soil bulk density to characterise compaction in tillage studies on fine sandy loams. *Can. J. Soil Sci.* 70: 425-433.
- Day, P.R., (1965). Particle fractionation and particle-size analysis. In: Black, C.A. (ed.), *Methods of Soil Analysis. Part I*, American Society of Agronomy. Madison, Wisconsin, 545-566.
- Gerard, C.J., Sexton, P., Shaw, G., (1982). Physical factors influencing soil strength and root growth. *Agronomy J.* 74: 875-879.
- Gupta, S.C., Sharma, P.P. DeFranchi, S.A., (1989). Compaction effects on soil structure. *Adv. Agron.* 42: 311-338.
- Hunter, A.G.M., (1991). Soil-vehicle interaction. *J. Terramechanics* 28: 297-308.
- O'Sullivan, M.F., Dickson, J.W. Campbell, D.J., (1987). Interpretation and presentation of cone resistance data in tillage and traffic studies. *J. Soil Sci.* 38: 137-148.
- Peech, M., (1965). Hydrogen-ion activity. In: Black, C.A. (ed.), *Methods of Soil Analysis. Part II*, American Society of Agronomy. Madison, Wisconsin, 914-926.
- Peters, B.D., (1965). Water availability. In: Black, C.A. (ed.), *Methods of Soil Analysis. Part I*, American Society of Agronomy. Madison, Wisconsin, 279-285.
- Spivey, L.D., Busscher, W.J. Campbell, R.B., (1986). The effects of texture on strength of southeastern Coastal Plain Soils. *Soil Till. Res.* 6: 351-363.
- SPSS, (1988). SPSS/PC+V.2.0. Base Manuel for the IBM PC/XT/AT and PS/2, Marija and Moruis. SPSS Inc.
- Vomocil, J.A., (1965). Porosity. In: Black, C.A. (ed.), *Methods of Soil Analysis. Part I*, American Society of Agronomy. Madison, Wisconsin, 315-318.
- Wood, R.K., Morgan, M.T., Holmes, R.G., Brodbeck, K.N., Carpenter, T.G. Reeder, R.C., (1991). Soil physical properties as affected by traffic: Single, dual, and flotation tires. *Transactions ASAE* 34: 2363-2369.

# PEDOGENESIS AND CLASSIFICATION OF SOILS IN KAHRAMANMARAŞ PROVINCE, TURKEY

Kadir Yılmaz, Recep Gündoğan, Ali Rıza Demirkıran  
Kahramanmaraş Sütçü İmam University, Faculty of Agriculture, Department of Soil Science,  
Kahramanmaraş-Türkiye

## ABSTRACT

Kahramanmaraş province, Turkey, has significantly variability in climate, vegetation, topography, and parent material type. Different combinations of soil formation factors have been observed in the study area. This study was conducted to characterise soils widely found in Kahramanmaraş and classify them according to criteria in Soil Taxonomy. pH values ranged from 7.06 to 8.33. Cation exchange capacity (CEC) of soils ranged from 20 to 180 cmol kg<sup>-1</sup> and base saturation were very high. Carbonate content increased with depth and reached to 50 % in some profiles. Smectite was dominant clay mineral and followed by illite, kaolinite, paligorskite and vermiculite respectively. Pedogenesis of soils had been affected by parent material, climate and topography. The soils were classified as Typic Haplocambid, Typic Humaquept, Typic Haplargid, Vertic Haploxerept, Aridic Haploxeroll, Typic Petrocalcic, Lithic Haploxeralf, Aquic Haploxerert, Typic Haplohemist and Mollic Xerofluvent according to the Soil Taxonomy.

## INTRODUCTION

Kahramanmaraş Province is located in the East Mediterranean Region of Turkey. Mediterranean and Continental climate conditions are dominated. Landscape is characterised by steep bedrock hills and cliffs of limestone, sandstone and metamorphic rocks, and nearly level depression plains (Pamir and Tolun, 1968).

Soils are classified as Red-Mediterranean, Red-Brown-Mediterranean, Brown, Red-Brown, Non-Calcareous-Brown, Brown-Forest, Non-Calcareous-Brown-Forest, Chestnut, Alluvial, Colluvial and Organic great soil groups according to modified system of Baldwin et al. (1938). Red-Mediterranean and Red-Brown-Mediterranean soils developed on limestone and conglomerate. These soils were rich in carbonate and had 2.5 YR and 5 YR hue. While Chestnut soils occurred on upland, Brown and Red-Brown soils occurred on the lowland of northern area. These soils had 7.5 YR and 10 YR hue and high carbonate content. Non-Calcareous-Brown and Non-Calcareous-Brown-Forest soils formed over non-calcareous parent materials on upland had reddish B horizon due to Fe-rich illuvial clay and sesquioxides. Alluvial and Colluvial soils occurred in the depression plains of the southern and northern study areas and narrow valleys (Topraksu, 1973). Organic soils developed on the muck at local depression in the southern region (Tigem, 1991).

The soils on the study area were not entirely classified according to Soil Taxonomy as well as other provinces of Türkiye. Some researchers such as Senol and Dinç (1986), Durak (1989), Ekinçi (1990) and Cangir and Ekinçi (1995) studied to classify the great soil groups in some regions of Türkiye.

The purpose of this study was (i) to determine some physical, chemical and mineralogical properties of soil pedons representing great soil groups in Kahramanmaraş Province, (ii) to classify them according to Soil Taxonomy (Soil Survey Staff, 1998) and (iii) to describe and evaluate genesis of soils, in these semi-arid and arid regions of Türkiye.

## MATERIALS and METHODS

### Description of Study Area

Kahramanmaraş is located in the East Mediterranean of Turkey. It lies between 37° 11' and 38° 36' North, and between 36° 15 and 37° 42' East and covers about 1450 km<sup>2</sup>. The area is generally hilly, and elevation ranges 450 to 3081 m above mean sea level (msl).

The study area has two climatic regions: The Continental and Mediterranean Climate Regions. The Continental climate region has been dominated in northern area with monthly mean temperature ranges from -0.4 C° in December to 23 C° in July, with mean annual value of 10.3 C°. The average annual precipitation is about 386 mm. The southern area has Mediterranean climate. The total annual



precipitation is about 710 mm, most of this occurs in winter, December through April. The mean annual temperature is 16.5 °C, and monthly mean temperature ranges from 4.5 °C in January to 28 °C in August (Kaya, 1996). The soils in the northern area has mesic soil temperature and aridic moisture regime. The soils on the central and the southern area have thermic temperature regime and xeric moisture regime. Aquic moisture regime appears in the local depression area in the southern area (Tigem, 1991)

Geology of study area consists of metamorphic and sedimentary rocks including schist, serpentine, limestone, sandstone, marl, conglomerate, and alluvial and colluvial deposits. There are locally found basalt rocks in the study area.

Maquis and coniferous forests are dominant vegetation including pinus, cedrus abiece essp. But quercous and juniperus can also be found especially in the northern region. The plains and uplands in the southern and northern regions are mainly consisted of cultivated farmlands.

## METHODS

Thirteen pedons were selected for characterisation that represent each great soil group in Kahramanmaraş Province. All soil pedons were described and sampled according to standard procedures (Soil Survey Staff, 1993). Soil samples were air dried, crushed, sieved through 2-mm sieve, and reserved for subsequent analysis.

Particle size distributions were determined by hydrometer method (Bouyoucus, 1951). pH was determined with glass electrode in saturated soil after 4-h equilibration period. Electrical conductivity were measured in saturated samples (Richards, 1954). Exchangeable cations were extracted from the soil by 1N ammonium acetate at pH 7.0, and then extractions were analysed by an atomic absorption spectroscopy (Jackson, 1969). Cation exchange capacity (CEC) was determined by the ammonium saturation method at pH 7.0 (Soil Survey Staff, 1993). Organic carbon was determined by Walky-Black wet oxidation method (Allison, 1965). The total carbonate contents were measured using scheibler calcimeter (Allison and Moodie, 1965). Clay samples (<2 µm) selected from surface and subsurface horizons were treated with Citrate Bicarbonate Ditionite (CBD) to remove free oxides and prepared for XRD analysis using the method described by Jackson (1969). Clay fractions were saturated with K and Mg and then clay minerals were identified using X-Ray diffractometer (XRD). Soils were classified according to Soil Taxonomy (Soil Survey Staff, 1998).

## RESULTS and DISCUSSION

### Soil Morphology, and Physical and Chemical Properties

The classification and landscape positions of soils studied are showed in Table 1. Cambic horizon and ochric epipedon are commonly found in the studied pedons. Argillic horizon, mollic and histic epipedons are rarely found. Petrocalcic horizons were found especially in the northern area. The main pedogenic processes were calcification, clay illuviation, transformation, such as clay formation and soil colours, and petrocalcic horizon formation. Vertic and redoximorphic features were observed in some pedons. Table 2 shows the morphologic characteristics of soils.

All pedons have slightly alkaline reaction, pH 7.1-8.3, and very high base saturation. The organic matter contents were found between 0.20 and 3.48 % in the soils formed on inorganic parent materials. Organic matter contents in Histosol were reached to 66.81 % (Table 3).

Entisols, P13, developed from alluvial sediments. Colours were 10 YR hue. Entisols had very weak, fine, granular in the surface, and massive or single grain in the subsurface horizon. Textures varied from loam to clay. Organic matter content varied between 0.93 and 0.15 % and irregularly distributed within profile. This is associated with sediment stratigraphy. CEC ranged from 25.4 to 34.8 cmol kg<sup>-1</sup>.

Inceptisols developed from coluvium, basalt and limestone (P2, P4 and P12). Colours varied from 2.5 YR and 7.5 YR hues, related sesquioxides accumulation. P2 had 2.5 Y hue, associated with perched water. Soils had moderate, medium granular or subangular blocky structure in surface horizons and weak, coarse blocky or moderate, medium subangular blocky structure in subsurface horizons. All pedons had high clay content. Many researchers reported that soils on the limestone and basalt rocks Southern Turkey, had fine textures (Ergene, 1963; Topraksu, 1973; Kapur et al., 1986;



Senol and Dinç, 1986). But only P4 and P12 had vertic features. Because smectite is dominate in these soils (Table 4).

Mollisol developed from mica schist (P5) had sandy loam texture. Colour was 2.5 Y hue, and related to the parent material Structure was weak, fine granular in surface horizons and structurless in C horizons.

Table 1. Landscape Features and Classification of The Soils Studied

Profile No	Landscape Position	Classification (Soil Survey Staff,1998)	Great Soil Groups Modified Baldwin et al. (1938)
P1	Basin	Typic Haplocambid	Non-Calcareous Brown Forest
P2	Footslope	Fluvaquentic Endoaquept	Coliuvial
P3	Toeslope	Typic Haplargid	Non-Calcareous-Brown
P4	Backslope	Vertic Haploxerept	Non-Calcareous-Brown
P5	Footslope	Aridic Haploxeroll	Chestnut
P6	Toesslope	Typic Petrocalcic	Brown
P7	Backslope	Typic Haplocambid	Brown
P8	Basin	Typic Petrocalcic	Red-Brown
P9	Backslope	Lithic Haploxeralf	Brown-Forest
P10	Basin	Aquic Haploxerert	Alluvial
P11	Depression	Typic Haplohemist	Organic
P12	Backslope	Vertic Haploxerept	Red-Brown-Mediterranean
P13	Basin	Mollic Xerofluent	Aluviyal

P1, P3, P6, P7 and P8 classified as Aridisols. P3 pedon developed on the serpentine had 2.5 Y hue. P1, P6 and P7 pedons developed on the marl had 10 YR hues. P8 pedons developed on the limestone had 5 YR hue. Soil colours related to clay content of parent material. Because higher clay content in the parent material decreased oxidation. Many researchers reported that soils formed on the limestone or conglomerate more redder than one on the marl in the arid and semi arid region of Turkiye (Akalan, 1963; Topraksu, 1973; Köy Hizmetleri, 1990 ). P3 had argillic horizon, P6 and P8 had petrocalcic horizon and other pedons had cambic horizon as diagnostic horizons. Clay illuviation in P3 and formation of petrocalcic horizon in P6 and P8 are not associated with the present climatic conditions (Fanning and Fanning, 1989; Kapur et al. 1990; Sancho et al., 1992; Atalay, 1996). In general, they had moderate, medium granular structure in surface horizons, moderate medium or fine subangular blocky in subsurface horizons.

Pedon 9 developed over shale classified as an Alfisol. The soil colour was not changing through profile and was 2.5 Y hue. Clay content is increasing thorough the soil profile, and while it is 16.8 % in the Ap horizon, clay content reaches to 22.8 % in the Bt horizon (8 cm to 19 cm). Field observations (clay coatings on ped surfaces and around pores) and clay increase was sufficient for argillic horizon definition. Coarse and medium texture of this profile helped clay illuviation (Fanning and Fanning, 1989). Bt and BC horizons had moderate medium subangular blocky structure and A horizon had weak fine platy structure.

Vertisol (P10) pedon ranged from 64.7 % to 85.0 %. The soil had massive structure. The shrinking and swelling of clay minerals accompanying drying and wetting cycles, will not allow to form a stable structure. The rupture and slippage of soil masses in the diagonal directions as a result of the great swelling pressures developed in these soils when the are wetted causes structure disturbance (Fanning and Fanning, 1989; Buol et al. 1997). Matrix colour was 5 Y hue, and very low chroma (<2). Low chroma is related to poor drainage conditions. This soil also had 0.15 % total salt in depth between 25 cm and 150 cm.

Histosol (P11) pedons are found locally in the study area. These soils have high organic matter content. This soil had slightly alkaline reaction, about pH 7.6. CEC varied from 92.9 to 182.7 cmol kg<sup>-1</sup> and base saturation was high. Organic mater characteristic resulted in these properties. Organic matter had eutropic characteristic, associated with environment condition in where they had developed (Dinç et al., 1993).

Table 2. Morphological Characteristics of The Soils (Soil Survey Staff, 1993)

Horizon	Depth (cm)	Colour (Dry, Moist)	Texture	Structure	Consistence (Dry, Moist, Wet)	Special features
Typic Haplocambid (Profile No: 1)						
A	0-28	D 10 YR 4/4; M 10 YR 3/4	SL	2mgr	sh, fr, ms, mp	m, ba
Bw1	28-41	D 10 YR 4/6; M 10 YR 3/4	SCL	2msbk	h, fr, ms, mp	c, ba
Bw2	41-64	D 10 YR 4/6; M 10 YR 4/6	SL	2msbk	h, fr, ms, mp	
C1	64-86	D 10 YR 5/6; M 10 YR 4/4	SL	k	h, fr, ms, mp	
C2	86-115	D 2.5 Y 6/3; M 2.5 Y 4/3	SL	k	sh, fr, ns, np	
Aquic Torrifluent (Profile No: 2)						
Ap	0-26	D 2.5 Y 4/6; M 2.5 Y 3/3	CL	2mgr	vh, fr, ms, mp	c, ba
Bw	26-40	D 2.5 Y 4/6; M 2.5 Y 4/3	C	2msbk	vh, fr, ms, mp	c, ba
Cg1	40-68	D 2.5 Y 5/4; M 2.5 Y 4/3	C	k	vh, fr, ms, mp	c, mo
Cg2	68-95	D 2.5 Y 5/4; M 2.5 Y 3/3	C	k	vh, fr, ms, mp	m, mo
Cg3	95-107	D 2.5 Y 5/4; M 2.5 Y 3/3	CL	k	vh, fr, ms, mp	m, mo
Typic Haplargid (Profile No: 3)						
A1	0-13	D 2.5 Y 4/3; M 2.5 Y 3/3	SL	2mgr	sh, fr, ss, sp	m, ba
A2	13-29	D 2.5 Y 4/4; M 2.5 Y 3/3	SL	1mgr	sh, fr, ss, sp	m, ba
Bt	29-48	D 2.5 Y 4/6; M 2.5 Y 4/6	SCL	1fsbk	sh, fr, ss, sp	f, ba; f, cs
BC	48-61	D 2.5 Y 5/4; M 2.5 Y 4/4	SL	1fsbk	sh, fr, ss, sp	
R	61+					
Vertic Haploxerept (Profile No: 4)						
A	0-12	D 7.5 YR 2/3; M 7.5 YR 2/3	C	2msbk	vh, fr, ms, mp	f, ba
Bwss	12-50	D 7.5 YR 3/2; M 7.5 YR 2/2	C	1cbk	vh, fr, ms, mp	
C	50-70	D 7.5 YR 5/3; M 7.5 YR 4/3	C	k	vh, fr, ms, mp	
R	70+					
Basalt						
Aridic Haploxeroll (Profile No: 5)						
A1	0-10	D 2.5 Y 5/4; M 2.5 Y 3/4	SL	2fgr	so, fr, ns, np	
A2	10-22	D 2.5 Y 5/4; M 2.5 Y 3/4	SL	2fgr	so, fr, ns, np	
C1	22-53	D 2.5 Y 4/6; M 2.5 Y 4/6	SL	k	sh, fr, ss, sp	
C2	53-88	D 2.5 Y 5/6; M 2.5 Y 4/6	SL	k	sh, fr, ss, sp	
R	88+					
Mica schist						
Typic Petrocalcic (Profile No: 6)						
A1	0-12	D 10 YR 6/4; M 10 YR 4/4	CL	2mgr	sh, fr, ms, mp	c, ba
A2	12-21	D 10 YR 6/4; M 10 YR 4/4	C	2mgr	sh, fr, ms, mp	f, ba
Bw	21-32	D 7.5 YR 5/4; M 7.5 YR 4/4	C	2msbk	sh, fr, ms, mp	
Ckm	32-45		Calich			
C1	45-120	D 10 YR 7/3; M 10 YR 6/3	SCL	k	sh, fr, ms, mp	
2C2	120+		Conglomerate			
Typic Haplocambid (Profile No: 7)						
A1	0-11	D 10 YR 6/3; M 10 YR 4/3	CL	1mgr	sh, fr, ms, mp	c, ba
A2	11-25	D 10 YR 6/4; M 10 YR 4/4	C	1fgr	vh, fr, ss, sp	c, ba
Bw	25-54	D 10 YR 6/4; M 10 YR 4/6	CL	1fsbk	vh, fr, ss, sp	f, ba
BC	54-71	D 10 YR 7/4; M 10 YR 5/6	C	k	sh, fr, ss, np	
C1	71-100	D 10 YR 8/3; M 10 YR 7/4	SL	k	so, fr, ss, np	
C2	100-123	D 10 YR 8/2; M 10 YR 7/4	SL	k	sh, fr, ss, np	
Typic Petrocalcic (Profile No: 8)						
Ap	0-11	D 5 YR 4/6; M 5 YR 4/6	C	1mgr	vh, fr, ms, mp	f, ba
A	11-25	D 5 YR 4/6; M 5 YR 4/6	C	1fsbk	vh, fr, ms, mp	
Bw	25-39	D 5 YR 4/4; M 5 YR 4/6	C	1msbk	h, fr, ms, mp	
BC	39-50	D 5 YR 6/4; M 5 YR 5/6	C	k	vh, fr, ms, mp	
Ckm	50+		Calich			
Lithic Haploxeralf (Profile No: 9)						
A	0-8	D 2.5 Y 5/4; M 2.5 Y 4/4	SL	1flv	so, fr, ss, sp	c, ba
Bt	8-19	D 2.5 Y 4/4; M 2.5 Y 3/3	SCL	2msbk	sh, fr, ss, sp	c, ba; f, cs
BC	19-26	D 2.5 Y 5/3; M 2.5 Y 4/4	SL	2msbk	sh, fr, ns, np	f, ba
R	26+					
Clay stone						
Aquic Haploxerept (Profile No: 10)						
Ap	0-25	D 5 Y 2/2; M 5 Y 2/1	C	k	vh, fr, vs, vp	mk, rl
Ad	25-60	D 5 Y 3/1; M 5 Y 2/2	C	k	vh, fr, vs, vp	f, ba, f, pb (2-5mm)
Ass	60-120	D 5 Y 4/1; M 5 Y 2/1	C	k	vh, fr, vs, vp	f, pb (2-5mm)
ACss	120-150	D 5 Y 5/1; M 5 Y 3/1	C	k	vh, fr, vs, vp	f, pb (2-5mm)
Css	150-178	D 5 Y 5/2; M 5 Y 3/2	C	k	vh, fr, vs, vp	f, pb (2-5mm), c, mo
Typic Haplohenist (Profile No: 11)						
Oa	0-17	D 10 YR 1.7/1; M 10 YR 1.7/1	-		so, fr, ns, np	m, ba
Oe	17-62	D 10 YR 1.7/1; M 10 YR 1.7/1	-		so, fr, ns, np	m, ba
Oi	62-97	D 10 YR 2/3; M 10 YR 1.7/1	-		so, fr, ns, np	mc, ba
C	97+	D 5 Y 5/1; M 5 Y 3/1	SiL	k	h, fr, ms, np	
Vertic Haploxerept (Profile No: 12)						
Ap	0-16	D 2.5 YR 3/3; M 2.5 YR 3/3	C	2mgr	h, fr, ms, mp	c, ba
Ad	16-40	D 5 YR 3/4; M 5 YR 3/4	C	2msbk	vh, fr, ms, mp	c, ba
Bw	40-60	D 5 YR 3/4; M 5 YR 4/4	C	1msbk	vh, fr, ms, mp	
C1	60-90	D 5 YR 5/4; M 5 YR 5/6	CL	k	vh, fr, ms, mp	
R	90-113					
Limestone						
Mollie Xerofluent (Profile No: 13)						
Ap	0-24	D 10 YR 4/4; M 10 YR 3/3	L	1fgr	so, fr, ns, np	
A	24-40	D 10 YR 4/4; M 10 YR 3/4	CL	k	h, fr, s, p	
C1	40-75	D 10 YR 5/4; M 10 YR 4/4	L	k	h, fr, s, p	
C2	75-108	D 10 YR 5/4; M 10 YR 4/3	L	k	h, fr, ns, np	
C3	108-135	D 10 YR 4/4; M 10 YR 4/4	L	sg	h, fr, ns, np	
C4	135+	D 10 YR 5/4; M 10 YR 3/3	SCL	k	h, fr, ns, np	

Structure: (shape) sbk-subangular blocky, bk-angular blocky, pt-platy, gr-granular, k-massive, sg-single grain; (size) f-fine, m-medium, c-coarse; (grade) 1-weak, 2-moderate, 3-strong. Consistence: so-soft, sh-slightly hard, h-hard, vh-very hard, fr-friable, fi-firm, ns-non-stick, ss-slightly stick, ms-moderately sticky, vs-very sticky; np-non-plastic, sp-slightly plastic, mp-moderately plastic, vp-very plastic. Special features: (kind) mo-mottled, pb-pebble, ba-biologic activity, cs-clay skin (amount) f-few, mc-moderately common, m-many. Symbols are same given in the Soil Survey Manual (1993)



## Clay Mineralogy

Many researchers reported that smectite is the dominant silicate mineral in arid and semi arid region of Turkey (Ergene, 1963; Gülçur, 1964; Gürel, 1985; Kapur et al., 1991).

These similar results were found in this study. According to X-ray diffraction analysis (Table 4), smectite is the dominant silicate minerals in the soils (P1, P3, P4, P9, P10, P12) and illite occurs as the second dominant clay mineral in these soils (P2, P5). In addition, the soil samples have given peaks that indicative of paligorskite, kaolinite and vermiculite. The other pedons have smectite, illite, kaolinite, paligorskite and vermiculite in the same proportions P6, P7, P8 and P11)

## CONCLUSIONS

Soils in Kahramanmaraş Province show that pedogenic processes are strongly depending on the parent materials and the climatic conditions. Especially, there were significantly relation between soil colours and parent materials. While soils derived from marl had 10 YR hue, other parent material rich in carbonate such as limestone and conglomerate had 5 YR or 7.5 YR hue.

The leaching of carbonate and clay in the central and southern province were more than elsewhere. Argillic horizon and petrocalcic horizon formation was not related with the present arid climate conditions on the northern province.

Topography was an important factor in pedogenesis. The profiles which were formed on slopy areas were influenced by moderate and severe erosion. Therefore, these soils had very shallow soil depths. The soils which formed on depression topography had insufficient drainage and salinity problems.

While smectite is the dominant silicate minerals, illite occurs as the second dominant clay mineral in these soils. Soils had vertic features associated with smectite clay mineral.

## ACKNOWLEDGEMENTS

The authors thank İsmet KÖKSAL and Asuman NALBANTOĞU for help with laboratory

## REFERENCES

- Akalan İ. (1963). Aşağı Fırat havzası toprakları. A.Ü. Ziraat Fak. Yay. No: 226. Ankara.
- Allison L. E., (1965). Organic carbon. Walkley-Black Method. in C. A. Black (ed). Methods of analysis. Agronomy Monographs no: 9. Part 2. American Society Agronomy. Madison. Wisconsin. USA. 1367-1378 p.
- Allison L. E., Moodie C. D., (1965). Carbonate volumetric calcimeter method. In C. A. Black (ed). Methods of analysis. Agronomy Monographs. No: 9. part 2. American Society Agronomy. Madison. Wisconsin. USA. 1389-1392 p.
- Atalay İ., (1996). Paleosols as indicators of climatic changes during Quaternary Period in South Anatolia. Journal of Arid Environments. 32: 23-35 p.
- Baldwin M., Kellogg C., Thorp J., (1938). Soil classification. In Soils and Men. USDA yearbook. Gov. Printing Office. Washington. D.C. 937-1001 p.
- Buol S. W., Hole F. D., Mc. Cracken R. J., Southard R. J., (1997). Soil genesis and classification (fourth ed.). Iowa State University Press. Ames. Iowa. 527 p.
- Bouyoucos G. J., (1951). A Recalibration of the hydrometer method for making mechanical analysis of soils. Agron. Jour. 43, 434-438 p.
- Cangir C., Ekinci H., (1995). Marmara Bölgesinde yer alan Büyük Toprak Gruplarının Toprak Taxonomisinde ve FAO/ UNESCO Dünya Toprak Sınıflamasına göre değerlendirilmesi. İlhan Akalan Toprak ve Çevre Sempozyumu. Yayın no:7.. 184-193 s. Ankara
- Dinç U., Şenol S., Kapur S., Atalay İ., Cangir C., (1993). Türkiye toprakları. Ç. Ü. Ziraat Fakültesi ders kitabı yayınları no: 12. 233 s. Adana
- Durak A., (1989). Türkiye Genel Toprak Haritasının Toprak Taxonomisine göre düzenlenebilme olanaklarının Tokat Bölgesi örneğinde araştırılması. Ç.Ü. Fen Bil. Enst., Toprak Anabilim Dalı, (Doktora tezi). Adana.
- Ekinci H., (1990). Türkiye Genel Toprak Haritasının Toprak Taxonomisine göre düzenlenebilme olanaklarının Tekirdağ Bölgesi örneğinde araştırılması. Ç.Ü. Fen Bil. Enst. Toprak Anabilim Dalı (Doktora tezi). Adana.



- Ergene A., (1963). Fırat Nehri ile Amanos Dağları arasındaki bölgede teşekkül eden kıvıll topraklar üzerinde bir araştırma (Doktora tezi). Ankara Ün. Ziraat Fak. Yayın no: 2. Ankara.
- Fanning D. S., Fanning M. S. B., (1989). Soil morphology, genesis and classification. John Wiley and Sons. New York. 395 p.
- Gülçur F., (1964). Bazı terra rossa toprakların toz fraksiyonlarının mineralojik tabiatı ve kimyasal terkibi üzerine araştırmalar. İ. Ü. Orman Fak. Dergisi seri: A. Cilt: XIV. Sayı: 1. İstanbul.
- Gürel N., (1985). Ceylanpınar ovası bazaltik topraklarının genesisi. Ç.Ü. Fen Bil. Ens. (Doktora tezi). Adana.
- Jackson M. L., (1969). Soil Chemical Analysis. advanced course. 2. nd Ed. published by the Author. Univ. of Wisconsin. 8955 Madison. USA.
- Kapur S., Çavuşgil V. S., Şenol M., Gürel N., Fitzpatrick E. A., (1990). Geomorphology and pedogenic evolution of Quaternary Calcareous in the Northern Adana Basin of Southern Turkey. Annals of Geomorphology. Zeischrift Für Geomorphology. Berlin.
- Kapur S., Sayın M., Gülüt K. Y., Şahan S., Çavuşgil V. S., Yılmaz K., Karaman C., (1991). Mineralogical and micromorphological properties of widely distributed soil series in the Harran Plain. Türkiye Bilimsel ve Teknik Araştırma Kurumu. Proje no: TOAG-535. 11-20 p. Ankara.
- Kaya F., (1996). Kahramanmaraş İlinin iklim özellikleri (Yüksek lisans tezi). K. S. U. Sosyal Bilimler Enstitüsü. Kahramanmaraş. 144 s.
- Köy Hizmetleri., (1990). Şanlıurfa-Birecik ovası sulama proje sahası detaylı toprak etüdleri. Köy Hizmetleri Genel Müdürlüğü, Etüd ve Proje Daire Başkanlığı. Ankara.
- Richards L. A., (1954). Diagnosis and improvement of saline and alkaline soils. USDA agriculture handbook no: USA.
- Sancho C., Melendez A., Signes M., Bastida J., (1992). Chemical and mineralogical characteristics of pleistocene calich deposits from the Central Ebro Basin. Ne Spain. Clay Minerals. 27. 293-308 p.
- Şenol S., Dinç U., (1986) Akdeniz Bölgesi Büyük Toprak Gruplarının Toprak Taxonomisi ve FAO/ UNESCO Dünya toprak haritası lejandına göre sınıflandırılması. Toprak İlimi Derneği 9. Bilimsel toplantı tebliğleri. Yayın no: 4. 1-5.
- Soil Survey Staff., (1993). Soil Survey Manual. USDA. handbook no: 18. Washington D.C. 437 p.
- Soil Survey Staff., (1998). Keys to Soil Taxonomy. eighth edition. USDA. Natural Resources Conservation Service. U. S. Government Printing Office. Washington. D.C. 644 p.
- Tigem., (1991). Kahramanmaraş tarım işletmesi topraklarının etüd ve haritalanması. Tarım İşletmeleri Genel Müdürlüğü. Yayın no: 11. 54 s.
- Topraksu., (1973). Ceyhan Havzası Toprakları. Topraksu Genel Müdürlüğü. yayın no: 285. Ankara.

Table 3. Physical and Chemical Properties of The Soils

Table 3. Physical and Chemical Properties of Soil														
Horizon	Depth (cm)	pH	Total salt (%)	CEC (cmol kg <sup>-1</sup> )	Exchangeable Cations (cmol kg <sup>-1</sup> )				CaCO <sub>3</sub> (%)	Org. Matter (%)	Particle Size Distribution (%)			Texture Class
					Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>++</sup>	Mg <sup>++</sup>			Sand	Silt	Clay	
Typic Haplocambid (Profile No: 1)														
A	0-28	7.49	0.036	31.54	0.59	0.26	26.25	4.44	1.72	3.19	53.9	28.0	18.1	SL
Bw1	28-41	7.46	0.046	32.14	0.79	0.14	24.37	6.84	3.03	2.61	55.1	24.2	20.7	SCL
Bw2	41-64	7.16	0.060	28.73	0.81	0.12	21.64	6.16	4.55	2.03	56.0	25.9	18.1	SL
C1	64-86	7.33	0.051	28.27	0.83	0.12	21.30	6.02	2.27	1.25	59.6	24.3	16.1	SL
C2	86-115	7.65	0.041	19.43	0.75	0.07	14.49	4.12	3.83	1.11	59.0	25.2	15.8	SL
Aquic Torrifluent (Profile No: 2)														
Ap	0-26	7.50	0.087	34.91	0.60	0.34	31.02	2.95	4.13	2.61	32.2	29.2	38.6	CL
Bw	26-40	7.56	0.100	38.16	0.73	0.31	33.74	3.38	4.20	1.90	27.0	28.9	44.0	C
Cg1	40-68	7.65	0.190	39.22	0.93	0.22	34.77	3.30	2.49	1.38	33.0	26.9	40.1	C
Cg2	68-95	7.42	0.080	33.68	0.27	0.26	29.99	3.16	2.02	1.50	30.2	29.1	40.7	C
Cg3	95-107	7.35	0.094	29.21	0.34	0.25	25.39	3.23	1.72	0.92	31.1	29.9	39.0	CL
Typic Haplargid (Profile No: 3)														
A1	0-13	7.26	0.032	25.98	0.19	0.81	20.79	4.19	1.61	2.61	57.0	28.2	14.8	SL
A2	13-29	7.25	0.036	26.33	0.27	0.41	20.79	4.86	1.91	1.21	68.7	20.0	11.3	SL
Bt	29-48	7.17	0.036	26.03	0.21	0.26	20.45	5.11	1.99	1.50	61.3	18.5	20.2	SCL
BC	48-61	7.70	0.055	22.39	0.31	0.22	14.60	7.26	1.28	0.36	77.5	12.5	10.0	SL
Vertic Haploxerept (Profile No: 4)														
A	0-12	7.23	0.220	44.36	0.27	0.56	16.87	26.66	3.49	1.16	18.3	20.4	61.3	C
Bwss	12-50	7.06	0.230	59.69	0.23	0.36	13.80	45.29	1.24	0.64	19.4	16.6	64.0	C
C	50-70	7.68	0.217	40.74	0.26	0.22	13.46	26.80	1.94	0.20	40.1	11.9	48.0	C
Aridic Haploxerol (Profile No: 5)														
A1	0-10	7.88	0.040	20.01	0.15	0.29	19.26	0.31	4.77	2.43	54.0	28.4	17.6	SL
A2	10-22	7.91	0.025	20.57	0.16	0.14	20.11	0.16	4.97	3.19	56.2	26.2	17.6	SL
C1	22-53	7.53	0.039	21.16	0.28	0.13	20.62	0.13	3.13	0.92	55.0	25.3	19.7	SL
C2	53-88	7.84	0.043	16.84	0.26	0.12	16.36	0.10	1.57	1.10	54.9	25.3	19.8	SL
Typic Petrocalcid (Profile No: 6)														
A1	0-12	7.68	0.088	45.01	0.20	0.98	41.58	2.25	12.63	2.90	30.1	40.9	29.0	CL
A2	12-21	7.67	0.074	45.83	0.37	0.72	42.60	2.14	13.56	3.48	29.6	26.2	44.2	C
Bw	21-32	7.77	0.087	49.65	0.32	0.57	46.69	2.07	9.23	1.11	25.4	26.8	47.8	C
Calich														
Ckm	45-120	7.62	0.070	31.25	0.70	0.17	28.80	1.58	57.26	0.55	46.6	16.2	27.2	SCL
Typic Haplocambid (Profile No: 7)														
A1	0-11	7.81	0.075	35.66	0.48	1.18	32.21	1.79	31.09	2.32	42.5	24.5	33.0	CL
A2	11-25	7.71	0.060	41.96	0.70	0.70	38.00	2.56	26.56	1.74	33.1	22.3	44.6	C
Bw	25-54	7.73	0.081	42.10	0.68	0.30	38.34	2.78	32.50	0.83	25.7	34.5	39.8	CL
BC	54-71	7.62	0.123	37.92	1.00	0.21	34.25	2.46	48.82	0.55	25.6	24.5	49.9	C
C1	71-100	7.86	0.070	33.23	1.19	0.10	30.33	1.61	63.52	0.92	58.8	24.4	16.8	SL
C2	100-123	7.90	0.094	30.94	1.72	0.08	27.10	2.04	66.07	0.35	53.6	30.1	16.3	SL

The experimental design was completely randomised factorial design with four salts ( NaCl, NaNO<sub>3</sub>, Na<sub>2</sub>SO<sub>4</sub> and mixture), four doses, ( 0,2.5, 5.0 ve 7.5 gr salt/kg soil) two plants (spinach and beans) and three replication ( 4x4x2x3=96 pots)

2- kg soil passed through 2 mm-sieve was put into pots. As basal fertiliser, nitrogen ( 10 kg N/da as 45 % urea), phosphorus ( 10 kg P<sub>2</sub>O<sub>5</sub>/da as 46 % P<sub>2</sub>O<sub>5</sub> TSP) and potassium ( 10 kgK<sub>2</sub>O/da as 50 % K<sub>2</sub>O K<sub>2</sub>SO<sub>4</sub>) were applied. Five spinach and three beans seed were planted, but 2 spinach and 1 beans plant were left in each pot following germination. Ten weeks after plantation, plants were harvested, dried at 68 °C, and dry-matter contents were recorded. In addition, plant samples were analysed for N, P, K, Ca, Mg, Na, Fe, Mn, Zn and Cu nutrients (Bayraklı, 1987).

## RESULT AND DISCUSSION

Some physical and chemical properties of soils used in this study were shown in Table 1.

Table1. Some Physical and Chemical Properties of Soils Before and After the Experiment

Salt	NaCl				NaNO <sub>3</sub>				Na <sub>2</sub> SO <sub>4</sub>				Mixed	
Dose	0 (I)	2.5	5.0	7.5	2.5	5.0	7.5	2.5	5.0	7.5	2.5	5.0	7.5	7.5
PH (1:2.5)	6.9	7.6	7.7	7.7	7.6	7.7	7.8	7.5	7.6	7.7	7.5	7.6	7.6	7.6
O.M (%)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
CaCO <sub>3</sub> (%)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
CEC me/100g)	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3	24.3
Ca+Mg(me/100g)	19.8	18.8	17.3	17.0	18.9	17.8	17.5	19.1	18.4	17.9	18.9	18.3	17.6	17.6
K (me/100g)	1.9	1.6	1.5	1.2	1.7	1.5	1.4	1.8	1.6	1.5	1.7	1.5	1.4	1.4
Na (me/100g)	0.3	1.8	3.1	4.8	1.7	2.8	3.3	1.4	2.1	2.9	1.8	3.0	3.5	3.5
Available P <sub>2</sub> O <sub>5</sub> /da	4.6	5.0	4.8	4.8	4.9	5.0	5.0	4.9	4.9	4.6	5.1	4.8	4.7	4.7
Available Fe ,ppm	11.5	11.0	10.8	10.5	11.7	10.8	9.7	10.8	10.5	10.6	11.3	10.8	10.7	10.7
AvailableMn,ppm	10.8	11.0	10.6	10.4	10.7	10.4	9.9	10.2	9.9	10.6	10.9	10.3	10.0	10.0
Available Zn ,ppm	1.5	1.4	1.1	0.9	1.5	0.9	0.9	1.4	1.1	0.9	1.3	1.3	1.1	1.1
AvailableCu ,ppm	1.9	1.7	1.7	1.5	1.6	1.6	1.5	1.7	1.6	1.6	1.6	1.4	1.3	1.3
EC.10 <sup>3</sup> mmhos/cm	0.56	6.8	12.3	17.8	3.6	10.5	14.1	3.1	4.2	6.6	4.2	8.4	12.1	12.1
In Soil Salt%	0.03	0.26	0.43	0.67	0.14	0.40	0.53	0.13	0.14	0.22	0.13	0.32	0.40	0.40
Soil.SaltClas <sup>(2)</sup>	0	I	II	III	0	II	II	0	0	I	0	I	II	II
Sand (%)	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0
Loam (%)	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1
Clay (%)	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9
Tekxture Clas	L	L	L	L	L	L	L	L	L	L	L	L	L	L

(1): 0: Zero dose; properties of soil before the experiment

(2): 0; Saltness, I; Medium salty, II; Salty, III; High Salty

Soil textural class was loamy (Demiralay, 1993), soil reaction was nötr (Ergene, 1995), organic matter content,, CaCO<sub>3</sub> content and plant available phosphorus were low (Anon, 1982; Aydın ve Sezen, 1995) , exchangeable cations (Ca, Mg, K,Na) and available Fe, Mn,Zn and Cu were enough (Elgala et.all.1986), electrical conductivity was 0.56 EC 10<sup>3</sup> mmhos/cm and soluble salt content was 0.03 %. (U.S.S., 1954). There was no salinity problem in the study soil at the beginning of the study.

Electrical conductivity and soluble salt contents of soil as well as exchangeable Na amount increased by increasing rates of salt application, but exchangeable Ca, Mg, K and available Fe, Mn, Zn and Cu generally decreased (Table 1). These changes were natural result of Na-salts. Increase and decrease in soil properties were dependent on sodium salts and doses. The most effective salt and dose were NaCl and 7-5 g salt /kg-soil, respectively. Plant growth was also negatively affected by salt application.



### Effect of Different Sodium Salts on Plant Growth

The effect of different sodium salts applied at different doses had significant affect on plant growth and especially on dry-matter content (Table 2).

Plant growth was reduced by increasing rates of salts, and it was completely stopped at the rate of 7.5 gr salt NaCl/kg soil dose.

Table 2. Dry-Matter Contents of Experiment Plants (gr/pot, 68 °C)

Salts	Dose	Spinach (g/pot)				Beans (g/pot)			
		1	2	3	Average	1	2	3	Average
NaCl	0.0	5.16	4.79	5.58	5.08	4.73	4.45	4.62	4.60
	2.5	3.94	3.56	3.72	3.74	2.47	2.58	2.20	2.45
	5.0	1.76	1.93	1.15	1.78	-	-	-	-
	7.5	-	-	-	-	-	-	-	-
NaNO <sub>3</sub>	0.0	5.46	5.03	4.77	5.09	4.87	4.27	4.60	4.58
	2.5	5.68	5.42	5.49	5.53	3.05	3.37	2.99	3.47
	5.0	3.10	2.49	3.25	2.95	0.76	0.93	1.20	0.96
	7.5	0.77	0.70	0.57	0.68	0.35	0.40	0.25	0.33
NaSO <sub>4</sub>	0.0	4.47	5.28	5.46	5.07	4.71	4.68	4.30	4.56
	2.5	4.76	4.17	4.97	4.63	3.91	3.37	4.11	3.80
	5.0	3.46	4.05	4.01	3.84	3.36	2.68	3.00	3.01
	7.5	3.31	3.15	3.03	3.16	1.69	1.07	1.36	1.37
Mixed	0.0	5.05	5.28	5.00	5.11	4.80	3.98	4.66	4.48
	2.5	5.12	4.43	4.95	4.83	3.29	2.70	3.81	3.30
	5.0	3.54	3.72	3.34	3.53	0.90	1.34	1.26	1.17
	7.5	1.91	1.83	1.86	1.86	0.78	0.84	0.73	0.79

As seen in Table 2, dry -matter content decreased by increasing rates of salts applied to soil. The doses of 5- 7.5 gr salt NaCl/ kg-soil for beans and 7.5 gr salt NaCl / kg-soil for spinach caused in plant die. Güneş at.all.,( 1997) in wheat and Taban at. all.,( 1999) in corn were found similar results that increasing rates of salts resulted in low rates of dry-matter.

Decrease in dry-matter content as the mean of salts and doses was 30 % for beans and 45 % for spinach. This indicated that beans was more sensitive for salts as compared to spinach.

The effect of salts and doses on dry-matter content showed differences. As the mean of plant and doses, the rates of decreases for NaCl, NaNO<sub>3</sub>, Na<sub>2</sub>SO<sub>4</sub> and mixture were 54 %, 39% , 23.5 % and 34,6% respectively. NaCl was the most effective salt causing on low dry-matter content (Table 2).

Statistical analyses of data indicated data the effect of salts, doses, plant type and interactions on dry-matter content were statistically significant. Duncan's Multiple Comparison test was applied for mean comparisons, which was shown in Table 3 and Table 4. (Yıldız and Bircan, 1991).

Table 3. ANOVA for Dry-Matter Contents of the Experimental Plants

Source of Variation	D.F	SS	F
Plant	1	30.40	337.8**
Salt	3	9.08	100.9**
Dose	3	71.47	794.1**
Plant x Salt	3	0.35	3.9*
Plant x Dose	3	1.72	19.1**
Salt x Dose	9	2.05	22.8**
Plant x Salt x Dose	9	0.55	6.1**
Error	64	0.09	

\*\*= % 1 significant level

\*= % 5 significant level

Table 1. Some chemical characteristics of the tobacco waste.

O.M %	Ph (1/5)	EC(1/5) (µs/cm)	Ca (µg/g)	Mg (µg/g)	N (%)	K (%)	P (µg/g)	Na (µg/g)	Fe (µg/g)	Cu (µg/g)	Zn (µg/g)	Mn (µg/g)
41	5.80	10700	8050	9400	2.35	1.95	973	572	3150	84	90	279

Table 2. Some chemical and physical properties of experimental alkaline soils.

Doses (Ton/dec)	Depth (cm)	pH		O.Matter(%)		EC(µS/cm)		ESP		CEC		Texture		
		B.E	A.E	B.E	A.E	B.E	A.E	B.E	A.E	B.E	A.E	Clay	Silt	Sand
0	0-30	8.64	8.58	0.99	0.73	2250	2300	40	39	32	32	53	30	17
	30-60	9.06	9.07	0.88	0.66	2300	2100	46	48	38	37	57	34	9
5	0-30	8.71	8.20	0.94	1.88	2090	2400	31	22	31	33	53	26	21
	30-60	9.26	8.80	0.81	1.41	2500	2950	46	40	35	34	57	30	13
10	0-30	8.61	8.06	1.11	2.51	2000	2400	22	14	35	38	52	38	10
	30-60	9.16	8.53	0.69	0.91	2000	2200	30	26	37	38	56	32	12
15	0-30	8.65	8.42	1.26	3.11	2500	2700	38	26	39	41	48	34	18
	30-60	9.34	8.93	0.80	1.23	2450	2600	37	31	38	37	62	22	16
20	0-30	8.91	8.20	1.23	3.95	2050	3160	52	19	32	35	5	34	13
	30-60	81	8.75	0.69	1.79	2050	2880	51	32	29	30	61	28	11

B.E: Before Experiment, A.E: After Experiment

## RESULTS AND DISCUSSION

### Macro Element Status of Soil and Effect of Tobacco Waste

Tobacco waste applied to experimental soils increased macro and micro element concentration and electrical conductivity of soils (table 3).

Table 3. Macro and Micro Element Status of Soils After Tobacco Waste Application

Doses (ton/dec)	Depth (cm)	N (µg/gr)	P (µg/gr)	K (µg/gr)	Fe (µg/gr)	Cu (µg/gr)	Zn (µg/gr)	Mn (µg/gr)
0	0-30	122	17	1677	5.9	6.3	0.61	14.2
	30-60	94	13	6482	5.8	6.4	0.50	6.2
5	0-30	168	41	2457	6.6	7.4	1.1	24.6
	30-60	111	30	1950	6.2	7.6	0.91	18.7
10	0-30	206	52	3939	8.4	7.6	1.4	28.6
	30-60	135	44	2730	7.1	7.1	0.90	21.3
15	0-30	251	65	5148	8.3	8.0	2.6	25.0
	30-60	152	47	3120	5.8	7.8	1.8	16.3
20	0-30	331	89	5772	10.4	9.2	3.2	27.8
	30-60	160	58	3217	9.1	8.6	1.9	30.1

Available P and K concentration in experimental soils before tobacco waste application was higher than suggested values for an adequate plant production (table 3 and 4). The high amounts of available phosphorus and potassium in experimental soils were due to high pH and Na which dispersed soil and initiated new reactions.

Chhobra et.al (1981) reported that alkaline soils contain high amounts of available phosphorus because phosphorus constitute easily soluble compounds in soils with high pH and alkalinity. Işık and Usta (1998) reported that increasing SAR increased available phosphorus concentrations. Pal (1985) suggested that high potassium concentration in alkaline soils was due to dissolution of potassium fixing minerals.



Table 4. Evaluation of macro and micro elements status in soil (Alpaslan et. al 1998, Ergene 1993)

	Very low	Low	Moderate	High	Very high
Org. Matter	0-1	1-2	2-3	3-4	>4
P (ppm)	<3	3-6	6-10	10-15	>15
K (ppm)	<50	50-140	140-370	370-1000	>1000
N (ppm)	450	450-900	900-1700	1700-3200	>3200
Zn(ppm)	<0.2	0.2-0.7	0.7-2.4	2.4-8	>8
Mn (ppm)	<4	4-14	14-50	50-170	>170
Fe (ppm)	<0.2(low)	0.2-5(Moderate)	>4.5	2.4-8	>8
Cu (ppm)	< 0.2(Insufficient)	>0.2 (Sufficient)			

Although, total N contents increased with increasing application rates of tobacco waste, the total N content of the soil was still under recommended values for a adequate plant production. This case was caused by volatilization of ammonia to atmosphere due to turning of ammonium to ammonia under high pH and alkaline conditions. Fenn and Kissel (1973) found a positive relationship between increasing pH and ammonia volatilization.

#### Effect of Tobacco Waste on Micro Element Status of Soils

Before tobacco waste applied to the experimental soils, except for Zn, values for available Fe, Cu and Mn concentrations were above than recommended limit values. This could be resulted from properties of the experimental soils. In generally, it was determined that available Fe, Cu and Mn concentration were sufficient, but zinc concentration is insufficient in Kazova soils (Anonymous, 1999). Eyüpoğlu et.al (1993) reported that available Zn concentration was insufficient in approximately 14 millions ha. are as of Turkey.

Depending on increasing application doses, microelement concentrations, including Zn, increased. This increase was significant ( $P<0.01$ ) for Fe, Cu, Zn and Mn ( $P<0.05$ ). The increasing in the values of available Fe, Cu, Mn and Zn was due to the decomposition of organic matter. Decomposition of the organic matter would stimulate chelat formation and decreasing soil pH.

Increase in Zn concentration was lower than the other microelements. This could be due to the fact that Zn forms more stable complexes with soil organic matter components than those of formed by other microelements. Tisdale et al. (1993) reported that effect of organic matter on Zn was highly depended on quantity and quality of organic matter, and Zn was immobilized by high molecular weight organic substance as such lignin, humic and fulvic acids. On the other hand, the same researchers also suggested that formation of soluble chelates with Zn enhanced Zn concentration in solution. Increase in solution Zn concentration at high pH was suggested to increase mobilization of Zn by soluble dispersed organic matter ( Jeffry and Uren, 1993 ).

#### Effect of Tobacco Waste on Physical and Chemicals Properties of Soils

Soil pH and ESP (Exchangeable Sodium Percentage) decreased with increasing amount of tobacco waste (Table 2). Soil organic matter content increased with increasing application doses. This increase was significant ( $P<0.01$ ) (Table 2 ).

Soil hydraulic conductivity was among 0, 0.1, 2.9, 3.3, 3.5, cm/hour, and structure stability index was among 36.97, 43.80, 45.78, 46.20, 49.50 at 0, 5, 10, 15 and 20 tons/dec. respectively. Soil hydraulic conductivity and structure stability index increased when applications doses of tobacco waste increased .Hydraulic conductivity was zero in control; in 5 ton/dec. very low; in 10, 15 and 20 ton/dec. was moderate. Statistical relationship between soil organic matter content and hydraulic conductivity was significant ( $P<0.05$ ), and structure stability index was also significant ( $P<0.01$ ).

When hydraulic conductivity is lower than 0.125cm/h, it is very low, but hydraulic conductivity is higher than 2 cm/h, it is moderate (Tüzüner 1990). Our results showed that applications of tobacco waste 10 ton/dec. and above rates to the experimental soils adequately increased hydraulic conductivity to the optimum rate for plant production. Bender et al (1998) observed that tobacco waste increased



water resistant aggregates (SDA) percentage of soil. Increasing SDA percentage also increased hydraulic conductivity. Observed data showed that while soil pH and ESP were decreasing, soil physical properties became better when tobacco waste was applied to alkaline soils. Depending on application doses increase soil EC was found significant ( $P<0.05$ ).

Soils should be drained following application of tobacco waste to avoid a possible salinization caused by the salty waste material. Therefore, the tobacco waste should be applied to the alkaline soils before winter rains to leach the salts released from the waste material.

In conclusion, application of tobacco waste to artificially drained alkaline soils improved not only physical and chemical properties of soils but also the status of available plant nutrients. Thus, grain and forage crops which have relative tolerance to alkaline soils could be grown on these soil after eight months treated with tobacco waste.

## REFERENCES

- Abrol, I.P., Bhumbra, D.R., Meelu, O.P. 1985. Influence of Salinity and Alkalinity on Properties and Management of Ricelands. Soil Physics and Rice. Publishing of International Rice Research Institute. P.O. BOX 993. Manila, Philippines
- Alpaslan, M., Güneş, A., İnal, A. 1998. Deneme Tekniği. (Turkish). Ankara Üniversitesi Ziraat Fakültesi. Yayın No :1501. Ankara
- Anonymous. 1999. Tokat Kazova Yöresinde Çinko ile Gübrelemenin Buğday verimi Üzerine Etkisi Yer Seçimi İçin Yapılan Analizler. Basılmamış. Tokat Köy. Hiz. Arş. Ens. Müd. Tokat.
- Bender, D., Erdal İ., Dengiz, O., Gürbüz, M. 1998. Farklı Organik Materyallerin Killi Bir Toprağın Bazı Fiziksel Özelliklerine Etkisi. (Turkish). M.Ş.Yeşilsoy International Symposium on Arid Region Soil. Sh : 387-394. Menemen /İzmir .
- Kacar, B. 1972. Bitki ve Toprağın Kimyasal Analizleri II. Bitki Analizleri. Ankara Üni. Zir. Fak. Yayın No:453.
- Chhabra, R., I.P. Abrol., M.V.Singh. 1981. Dynamics of Phosphorus During Reclamation of Sodic Soils. Soil Science. 132 : 319-324
- Deniralay, I. 1993. Toprak Fiziksel Analiz Yöntemleri. (Turkish). A.Ü.Z.F. Erzurum
- Durak, A., Brohi, A.R., 1986. Tütün tozunun organik gübre olarak değerlendirilmesi. (Turkish). Türkiye Tütüncülüğü ve Geleceği Sempozyumu. 261-269. Tokat.
- Ergene, A. 1993. Toprak Biliminin Esasları. (Turkish). A.Ü. Z. F. Yayın no:267. Erzurum
- Eyüpoğlu, F., N. Kurucu., S. Talaş., Ü. Canisay. 1994. Türkiye Topraklarında Bitkiye Alınabilir Mikroelement Durumu. (Turkish). Toprak ve Gübre Araştırma Enstitüsü Yıllık Raporu. 1993. Rapor No:118 Ankara.
- Fen, L.B., Kissel, D.E. 1973. Ammonia Volatilization from Surface applications of ammonium Compounds on Calcareous Soils. I. Soil Science Society. America. J:37 : 855-859
- Gök, M., Onaç, I., Kapır, B., Sağlamtimur, T., Coşkun, A., Tansı, V., Kızılsimşek, M., 1988. Hasat atıkları, Tütün atığı ve hayvan Gübresi uygulamalarının Toprakta azot mineralizasyonunu , immobilizasyonunu ve Toprağın Bazı Biyolojik özelliklerine etkisi. M.Ş.Yeşilsoy. International symposium on Arid Soil. P: 551-557. Menemen - İzmir/ Turkey .
- Gupta, R.K., R.R.Singh and I.P. Abrol. 1988. Influence of Simultaneous Changes in Sodicity and pH on the Hydraulic Conductivity of an Alkali Soil Under Rice Culture. Soil Sci. 146: 382-386
- Işık, E., Usta, S. 1998. Tuz Konsantrasyonunun ve Sodyumluluğun Aridic Toprakta Fosfor Çözünürlüğü Üzerine Etkisi. M. Ş. Yeşilsoy International Symposium on Arid Region Soil: 387-394. Menemen -İzmir/Turkey .
- Pal, D.K. 1985. Potassium Release from Muscovite and Biotite Under Alkaline Conditions. Pedologie 35:133-136
- Tisdale, S. L., Nelson. W.L., Beaton, J.D., Hawlin. J. L. 1993. Soil Fertility and Fertilizers. Fifth Edition. Macmillan Publishing Company. Newyork.
- Tüzüner, A. 1990. Toprak ve Su Analiz Laboratuvarları El Kitabı. (Turkish). Köy Hiz. Gen. Müd. Ankara

# A RESEARCH ON SALINITY AND ALKALINITY PROBLEMS IN SOILS OF GREAT MENDERES DELTA

Hüseyin Ekinci, Orhan Yüksel

Trakya University, Faculty of Agriculture, Dept. of Soil Science, 59030 Tekirdağ / Turkey

## INTRODUCTION

Land degradation is, also, the temporary or permanent lowering of the productive capacity of land, or of its potential for environmental management (Pieri et al. 1996). Desertification is a kind of land degradation in the arid, semi-arid and dry subhumid zones resulting from various factors, including climatic variations and human activities. Land degradation processes include water and wind erosion, chemical degradation, physical and biological degradation. Chemical degradation consists of salinization/alkalization and, acidification and leaching (Kertesz, 1999).

In this research, degree of salinity and alkalinity problem depending on climate, soil and topographic conditions, irrigation with poor quality water, inadequate drainage and sea effect in Great Menderes delta was investigated.

## MATERIAL AND METHODS

The study area which is about 20.000 hectares is located in between Miletos and Priene antique cities in Söke. The climate is a typical Mediterranean (1001.7 mm/year precipitation, 17.6 °C mean annual temperature, 1917.1 mm/year evaporation). The all study area are bottom land and its elevation changed between 0-1.5 m. The total precipitation between April-September is 133,6 mm and the evaporation of 1519.2 mm. The highest temperature recorded July as 26.8 °C (DSİ, 1981). Great Menderes delta which is a graben area contains paleozoic metamorphic formations consisting of gneiss, schist, crystalline limestone (MTA, 1974).

Total 59 soil samples were taken from the research area. 15 out of 59 soil samples were taken from three different soil profiles according to horizon base. The rest of the soil samples were taken by 14 bores. Sampling depths of bores were 0-30, 30-60 and 60-90 cm. All samples were taken about 10 days after irrigation in 1998. In addition, two groundwater samples were taken from profile 1 and 2 and, one water sample from Great Menderes.

The following analyses in soil and water samples were made by using common methods; texture, pH, total soluble salts, soluble cations and anions in water extracts,  $\text{CaCO}_3$  equivalent, cation exchange capacity (CEC), exchangeable sodium and organic matter (Richards, 1954; Klute, 1986; Sparks et al. 1996).

## RESULTS AND DISCUSSION

Some chemical and physical analyses were carried out on taken soil samples.

In extract of the water-saturated soil paste pH 7.01-8.46, electrical conductivity (EC) 1.18 – 32.50 (dS/m), soluble sodium 4.35-266.30 (me/l), soluble Ca 1.62-34.83 (me/l) and Mg 2.43-68.85 (me/l) were measured. Exchangeable sodium 0.63-25.25 ( $\text{cmol} \cdot \text{kg}^{-1}$ ), CEC 4.55-34.54 ( $\text{cmol} \cdot \text{kg}^{-1}$ ), exchangeable sodium percent (ESP) 4.74-112.57 were determined. Sodium absorption rate (SAR) in the most of research soils 2.04-49.52 were found. Generally, the SAR value was higher than 13. Thus, the research soils have the dispersion of organic matter and clay, low permeability (0.11-2.66 cm/h) and aeration and structural degradation.

Physical and chemical characteristics of soil samples from bore 2 (250 m. distance from the sea) showed an exceptional situation. For example, in the extract of bore about 7.00 pH, 1.46-3.66 (%) soluble salt 494.57-760.87 (me/l) soluble Na, 17.82-60.75 (me/l) soluble Ca and 134.46-253.13 (me/l) soluble Mg were found. Exchangeable Na, CEC and ESP were 21.26-63.32 ( $\text{cmol} \cdot \text{kg}^{-1}$ ), 5.06-17.81 ( $\text{cmol} \cdot \text{kg}^{-1}$ ) and 355.53-541.21 respectively.

The common texture class of soils was silty clay, clay and silt loam. Dominant soluble cations are sodium and magnesium, and anion is chloride. Carbonate was found to be in trace amount. Groundwater samples taken from 1 and 2 profiles were classified as C4S4 class whereas those of Great Menderes were C3S1.



The research area is a field which was gained by filling of the sea shore. Cotton farming has been done in this areas for 30 years. Major part of the soil has saline and alkali character. Drainage system was constructed after 1980. Following this date, farmers improved land leveling and leaching by their own possibilities. Unfortunately, these efforts of the farmers were insufficient. When we compared our results with the works of Tuncay (1978) and DSİ (1981), it was shown that the problem had increased significantly related with sodium. However, the problem has decreased compared with the previous years in the local land consolidation area of Yuvaca willage. In this field, EC decreased from 4-8 dS/m to 1.87, ESP from 15 to about 5-7 compare with last two decades. Above decreases is a result of closed drainage system and land leveling processes in the consolidated area.

Obtained results belonging out of the consolidated area has shown that salinity and alkalinity problem is still going on due to following reasons; Water leakage from sea towards research field (DSİ, 1981), insufficiency of discharge channels depending on topographic situation, unusing of the chemical reclamation agents such as gypsum which is facilitate sodium leaching from soil, natural drainage insufficiency which is stem from topography and soil texture, and groundwater rising, decreasing of the permeability due to sodium and climate. In addition, irrigation water, contains high level of salt and middle level of sodium (C3S1) provided from Great Menderes river is another reason of salinity and alkalinity.

#### REFERENCES

- DSİ, (1981). Çine-Menderes projesi Söke ovası ıslah ve sulaması detaylı arazi tasnif raporu cilt 1, Ankara.
- Kertesz, A. (1999). Land degradation, soil conservation and large-scale farming. ESSC Int. Conf. Bratislava, Slovak Republic (17-23)
- Klute, A. (1986). Methods of Soil Analysis: Physical and Mineralogical Methods. Part 1. SSSA. Madison, Wisconsin, USA.
- MTA, (1974). Explanatory text of the geological map of Turkey. Denizli. (Ed. Cahit Erentöz. Ankara.
- Pieri, C., Dumanski, J., Hamblin, A., and young, A., (1996). Land quality indicators. World Bank Discussion Papers-315. Washington DC.
- Sparks, D.L. (1996). Methods of Soil Analysis. Part 3. Chemical Methods. SSSA. Madison, Wisconsin, USA.
- Richards, L. A. (1954). Diagnosis and improvement of saline saline and alkali soils. U.S. Agriculture Handbook. No.60. 159p.



# RESEARCH OF UTILIZATION IN IRRIGATION AND POLLUTION CRITERIONS OF BAFRA BADUT CANAL THAT SOILED DUE TO VARIOUS EFFECTS

Saadet Sarıcaoğlu, İbrahim Kaya Ersöz, Kenan Avcı, Solmaz Gençoğlu  
Directorate of Rural Services Samsun Research Institute

## SUMMARY

Research was carried out using lysimeters in Bafra. Its aims were to determine pollution elements which created city waste water that discharged to Badut Canal, usefulness of soiled water in irrigation and improving possiblness of water properties by a small prepurification. The research subjects were; irrigation with raw waste water, irrigation with filtered raw waste water, irrigation with sounding water and 50 % waste water + 50 % sounding water. During four years of research was sowed wheat, maize and red cabbage. The effect of waste water was analysed on plant productivity too.

## INTRODUCTION

Today fast industrialism and rising of population were also brought many problems on together. Humanity used the comforts and easiness of industry. However, they met with problems of environment destruction and pollution due to changes of natural and ecological equilibriums.

Researchers studying to determine revaluation of soild and liquid wastes in analysis of many environment problems. For example; the main subjects are usefulness of wastes from meat processing factories in forestry irrigations (Russel, 1991); effects of city sewerage slushs on plant growing (Öztürk et al., 1983); availability of distillery waste waters in agricultural irrigation.

Sahai et al. (1979, 1983) reported best seedling growing in 5 % waste water concentrations in experiments which conducted by waste water of fertilizer and alcohol factories; Saygıdeğer (1992) determined plumula lenght of plants with application of SEKA waste was better than control in concentrations from 50 % to 75 %, However, Kipnis et al. (1983) declared increase of dry matter yield in grass and pasture lands that applied distillery city waste water.

## MATERIAL AND METHOD

### Material

This research was carried out in Bafra Plain, Aşağı Kızılırmak Watershed, Middle Black Sea Region. Bafra Plain soils of Aşağı Kızılırmak Watershed are alluvial soils and it was formed in IV. geologic time.

Generally, irrigations were applied from the canals that were constructed by DSİ and with drilling waters in Bafra Plain. Wheat, maize and sunflower were mostly sowed in the plain.

In this experiment, TTM – 813 (maize) was used, the variety is single hybrid and middle earlyriser. Gören (wheat) variety that is variety of resistant to rust and lying. In addition, the red cabbage of Frutratkahl variety with Netherlands origin was used. This variety was widely produced in region.

The lysimeters were constructed with 1.0x2.0x2.0 m concrete in experiment. A sand filter was used for simple prepurification of water. Sand filters were constructed to isolate water from heavy matter as sand and gravel. The act of filtering can be used alone or with other a purification procedure.

Some filths were attached by filter materials when used waters passed through filtre bed. Nevertheless, microorganisms that are living in filter bed and bed surface comsume some of nutrients by biologic function in water.

### Method

The experimental design v. randomized split plots. The experiment was applied with there replications in lysimeters. Rotation of maize, wheat and red cabbage was applied. Maize and red cabbage were sowed and planted on 50 cm row spacing and 33 cm row top. Wheat was sowed on 16.6 cm row spacing.

The experiment subjects are :

A - Irrigation with waste water

B - Irrigation with filtered waste water

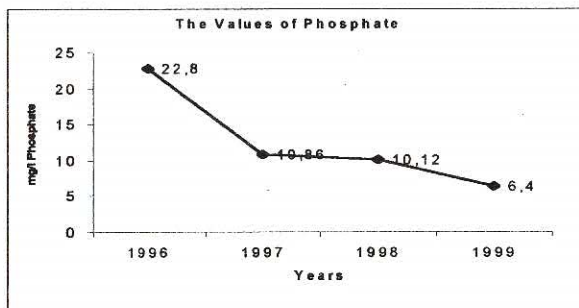
C - Irrigation with sounding water

D - Irrigation with 50 % waste water + 50 % sounding water

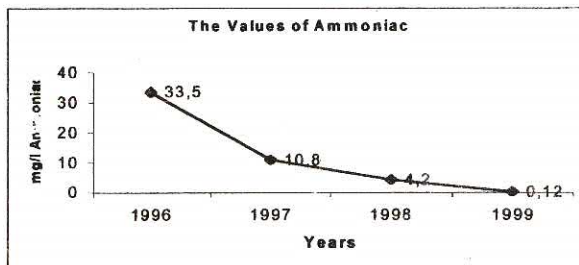
The water samples were taken from where waste water of Bafra town was poured in the canal middle section of the canal and where the canal was poured in lake in irrigation term, every month. Chemical and microbiological pollution parameters were investigated in water samples.

### **FINDINGS :**

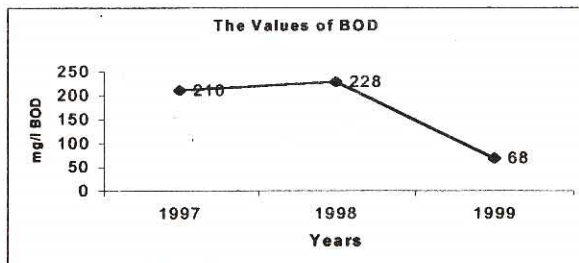
The values of phosphate of Badut Canal water according to the years



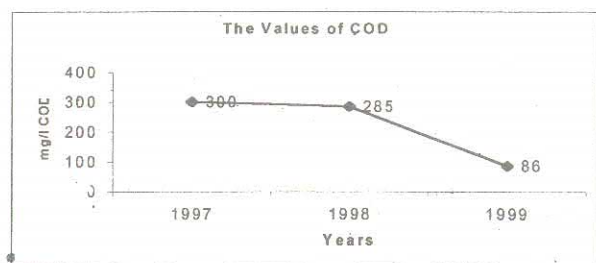
The ammoniac values of Badut Canal water according to the years



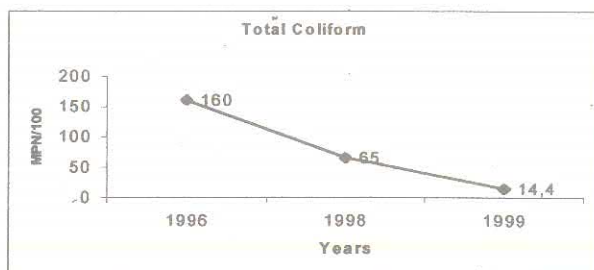
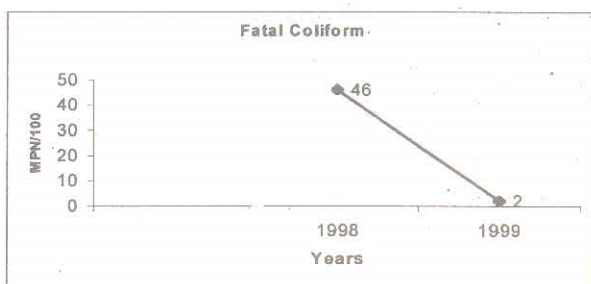
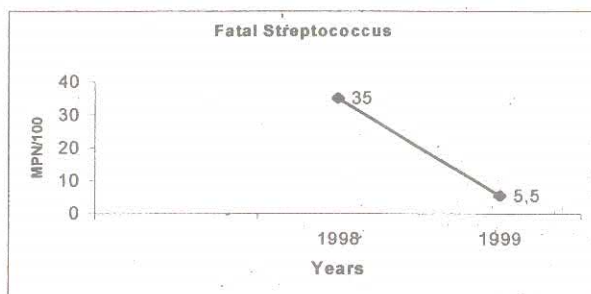
The values of biological oxygen demand of Badut Canal water according to the years



The values of chemical oxygen demand of Badut Canal water according to the years



The values of microbiological pollution of Badut Canal water according to the years





## RESULT

Chemical and microbiological properties of water samples were determined by City Control Laboratory and our Institute. The water samples were taken from three separate section of Badut Canal, in irrigation term. every mounth. However, the one numbered sample place that is the beginning of the canal and the section where discharged of Bafra sewerage were shut in july of 1999. After this event, Bafra sewerage was connected to purification establishment. Therefore, the sample can't be taken from the one numbered place as from July. Because, there wasn't water here. Nevertheless, microbiological pollution was most important pollution in canal water. In order to quality standard of irrigation water the number of fatal coliform bacterium musn't exceed on thousand in water. In this case, this water can't be used in irrigation (Munsuz, N). Whereas, microbiological pollution of Badut Canal water was much more than limit value.

## REFERENCES

- Kipnis, T., Feign, A., Vaisman, I., Shalhevet J., (1983). Waste water application, dry matter production and nitrogen balance of rhodesgras grown on fine textured soil or on sand dunes. Proceeding of the XIV.Int. Grassland Congress.
- Munsuz N. (1995 ). Water quality, Ankara Universty Agricultural Faculty Publications.
- Öztürk, M., Gökçeoğlu, M., Pirdal, M., (1983).Plant-Soil Relationships Application Book, E.Ü. F. F. Biology Department.
- Russel J.M., Cooper J.M.,(1991). Reuse of waste water from meat processing plant for agricultural and forestry irrigation, Water Sci. And Tech. 24:9.
- Sahai R., Agrawal, N., Khosla, N. (1979). Effect of fertilizier factory effluent on seed germination seedling growth and chlorophyll content of phascolus radiatus linn. Tropical Ecol. Vol.20.
- Sahai R., Jebeen, S., Saxena, P.K. (1983). Effect distillery waste on seed germination, seedling growth and piment content of rice, Indian Jurnal Ecol. Vol 10.
- Saygıdeğer S.(1994). Effects of liquefied SEKA waste on various plant seeds germination, Tr. Jurnal of Botany Volum 18.

# THE EFFECTS OF HERBICIDES 2,4-D ON TOTAL BACTERIA AND *Bacillus cereus* var. *mycoides* GROWTH IN SOIL

Rıdvan KIZILKAYA

Ondokuz Mayıs University, Agricultural Faculty, Department of Soil Science, Samsun / TURKEY

## ABSTRACT

In this study, the effects of different concentration of herbicides 2,4-D (0, 0.2, 0.4, 0.8, 1.6  $\mu\text{g.g}^{-1}$ ) on total bacteria and *Bacillus cereus* var. *mycoides* growth in soil were investigated under pure culture and soil conditions. For this aim, standard *B. cereus* var. *mycoides* and total bacteria isolated from the same soil sample were used in this study.

Under pure culture conditions, 0.2, 0.4, 0.8 and 1.6  $\mu\text{g.g}^{-1}$  doses of 2,4-D decreased the turbidimetrically determined total bacteria growth after 24 hours ( $p<0.01$ ). *B. cereus* var. *mycoides* growth was increased non significantly by application of 0.2  $\mu\text{g.g}^{-1}$  dose but it was decreased by 0.4, 0.8 and 1.6  $\mu\text{g.g}^{-1}$  doses of 2,4-D ( $p<0.01$ ).

Under soil conditions, the effects of 0.2  $\mu\text{g.g}^{-1}$  dose on the total bacteria growth was not significant. However, 0.4, 0.8 and 1.6  $\mu\text{g.g}^{-1}$  doses decreased the total bacteria growth ( $p<0.01$ ). *B. cereus* var. *mycoides* growth was increased during the first and the second day of incubation period by each dose of 2,4-D. On the other hand, it was determined that while 0.2  $\mu\text{g.g}^{-1}$  dose increased *B. cereus* var. *mycoides* growth in each incubation period, it was decreased in 1<sup>st</sup> and 2<sup>nd</sup> day of the incubation periods by 0.4, 0.8 and 1.6  $\mu\text{g.g}^{-1}$  doses.

The effects of herbicides 2,4-D on total bacteria and *B. cereus* var. *mycoides* growth under pure culture and soil conditions showed the big similarities in the high concentration of herbicide and the big differences in the low concentration of herbicide.

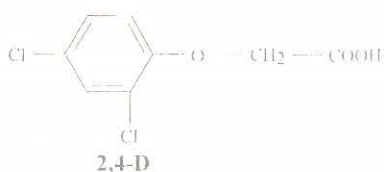
**Key words :** *Bacillus cereus* var. *mycoides*, Total bacteria, Herbicide 2,4-D, Pure culture, Soil

## INTRODUCTION

In recent years, herbicides have become widely used in agriculture. Regular application of wide spectrum of herbicides can result in their accumulation in the environment and in a change in its biological component.

2,4-D is one of the herbicides that are widely used throughout the world. It can be most often purchased in the form a solution from containing the dimethylamine that can be diluted with water. The content of the effective compound is 500 g/L.

2,4-D (2,4-dichlorophenoxyacetic acid) belongs to the group of aryloxy.



Most of the 2,4-dichlorophenoxyacetic acids are metabolized by microorganisms. The readily degraded compounds are the most readily lost from soil. Of the more widely used herbicides 2,4-D is the most quickly degraded.

In the study by Cork and Krueger, (1991), a number of microbes were isolated and identified that could metabolize 2,4-D. The ether linkage of 2,4-D was cleaved by enzymes present in various soil bacteria. The complete degradation mechanisms is shown in Figure 1.

A negative effect of the herbicide on soil microflora was also reported. Studying biochemical decomposition of 2,4-D in soil, the authors observed a complete degradation quickly in depends on the soil type. The main product of decomposition are succinic acid and chlorosuccinic acid.

Data on both inhibitory and stimulatory effect of herbicides on soil microflora were published, e.g. on phytopathogenic fungi (Gristein et al. 1976), soil bacteria and fungi (Moorman, 1986; Cernakova et al. 1991; Martens and Bremner 1993; Kizilkaya and Arcak 1996).

The purpose of this study was to examine the effect of 2,4-D on growth of total bacteria and *Bacillus cereus* var. *mycoides* growth under pure culture and soil conditions.





## MATERIALS & METHODS

In this study, standard culture of *Bacillus cereus var. mycoides*, total bacteria and soil sample taken from wheat harvested field were used. Soil analysis were done according to Black (1965). Total bacteria was isolated from the same soil used in this study. After standard culture of *B. cereus var. mycoides* and total bacteria were grown separately in Nutrient Glucose Agar (pH 7.0), total bacteria and *B. cereus var. mycoides* were inoculated from Nutrient Glucose Agar to Nutrient Glucose Liquid media (pH 7.0). Their activities were increased using an orbital shaker (36 rpm) at  $25 \pm 2^\circ\text{C}$  for 24 hours.

### Determining The Effects of 2,4-D Under Pure Culture Conditions

250  $\mu\text{l}$  of each concentration of 0, 0.2, 0.4, 0.8 and 1.6  $\mu\text{g.gr}^{-1}$  herbicide 2,4-D was transferred in to 5000  $\mu\text{l}$  sterilized tubes. Also, 2250  $\mu\text{l}$  of the culture whose activity increased in Nutrient Glucose Liquid media was transferred in to each tube. These tubes were placed on the orbital shaker (36 rpm) at  $25 \pm 2^\circ\text{C}$  for incubation. After 24 hours incubation, bacterial growth was determined turbidimetrically at 420 nm (Gürgün and Halkman 1988; Temiz 1994).

### Determining The Effects of 2,4-D Under Soil Conditions

After transferring 10 g oven dry soil into each tube of 250 mm height and 25 mm in diameter. Tubes were closed using cotton and aluminum folio and autoclaved at  $121^\circ\text{C}$  for 30 min. 50 mg glucose and 1 ml of *B. cereus var. mycoides* and total bacteria culture ( $2 \times 10^9$  bacteria per ml) whose activity increased in the Nutrient Glucose Liquid media (pH 7.0) were added into each tube. Soil moisture content was adjusted to 60 percent of maximum holding capacity. After 24 hours, 1 ml of each concentration of 0, 0.2, 0.4, 0.8 and 1.6  $\mu\text{g.gr}^{-1}$  herbicide 2,4-D was transferred in to the each tube and incubated. After 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup> and 7<sup>th</sup> day of the incubation period, Dehydrogenase activities of the soil samples were determined (Thalman, 1968).

### Statistical Analysis

Statistical analysis were done using SPSS package program and evaluated according to Düzgüneş (1963). The percentage effects of 2,4-D on total bacteria and *B. cereus var. mycoides* growth were calculated using the following equation;  $(A-B/A) \times 100$ . Where A is control, B is bacterial growth.

## DISCUSSIONS

Some properties of the soil sample used in the research are given in Table 1. Soil sample has clay loam texture class, alkaline reaction. EC, lime and organic carbon contents in the soil are low.

Table 1 : Some properties of the research soil

Texture	Sand, %	41,01
	Silt, %	21,90
	Clay, %	37,07
	Class	CL
pH, (1:2.5, soil : dH <sub>2</sub> O)		7,65
Electrical Conductivity, $\mu\text{S/cm}$		230
Organic Carbon, %		1,15
Lime Content, % CaCO <sub>3</sub>		0,94
Cation Exchange Capacity, meq/100g		32,50

### Determined Effects Under Pure Culture Conditions

In order to determine the effects of different concentration of 2,4-D on total bacteria and *B. cereus var. mycoides* growth under pure culture conditions, percentage values, which obtained from turbidimetrically determined transmission values (T%) at the end of the 24 hours, and statistical results are given in Figure 2.

Under pure culture conditions, except 0.2  $\mu\text{g.g}^{-1}$  dose, higher doses of 2,4-D inhibited total bacteria and *B. cereus var. mycoides* growth ( $p < 0.01$ ). These inhibitory effects in *B. cereus*

*var.mycoides* growth were obtained less than that in total bacterial growth. Effect of a herbicide on bacteria species can be different. A herbicide can also have different effects on the different species of the same bacteria. Kızılkaya and Aksoy (1999) studied on the effects of different pesticides on *Bacillus* spp. growth under pure culture conditions. In their study, they observed that herbicide 2,4-D increased *B. thuringiensis* growth, but, it decreased *B. cereus var.mycoides*, *B. sphaericus* 2362 *B. sphaericus* 1593 and *B. pumilis*.

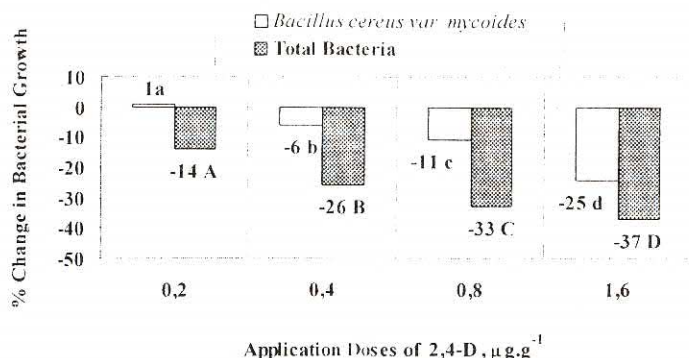


Figure 2: The Effects of Herbicides 2,4-D on Total Bacteria and *B. cereus var.mycoides* Growth under Pure Culture Condition

#### Determined Effects Under Soil Conditions

In order to determine the effects of herbicide 2,4-D on total bacteria growth under soil conditions. The results obtained from this study and their statistical evaluation are given in Table 3. According to the control application, percentage effects of increasing doses of 2,4-D on total bacteria population are given in Figure 3.

Table 3: The Effects of Herbicides 2,4-D on Growth of Total Bacteria under Soil Conditions (DHG activities, mg TPF. g<sup>-1</sup> dry soil) and statistical results.

Doses µg.g <sup>-1</sup>	Incubation periods, days						
	1.	2.	3.	4.	5.	6.	7.
0	0.762 E <sup>a</sup> **	1.116 Eb	1.675 Ec	2.073 Ed	2.319 Ee	2.683 Ef	2.745 Eg
0.2	0.671 Da	0.953 Db	1.475 Dc	1.638 Dd	1.938 Dc	2.218 Df	2.562 Dg
0.4	0.657 Ca	0.946 Cb	1.333 Cc	1.404 Cd	1.575 Ce	1.643 Cf	1.893 Cg
0.8	0.646 Ba	0.904 Bb	1.152 Bc	1.220 Bd	1.304 Bc	1.311 Bf	1.567 Bg
1.6	0.573 Aa	0.621 Ab	0.679 Ac	0.743 Ad	0.985 Ac	1.076 Af	1.437 Ag

\* Numbers within a column followed by different capital letter(s) are significantly different at p<0.01.

\*\* Numbers within a row followed by different letter(s) are significantly different at p<0.01.

The total bacterial growth in every incubation period was inhibited by all the applications of 2,4-D (Table 2 and Figure 3). The most inhibitory effect in the total bacterial growth was observed for 1.6 µg.g<sup>-1</sup> doses of 2,4-D and the fourth day of the incubation period. The small increments in the inhibitory effects on bacterial growth continued in the fifth, sixth and seventh day of the incubation period. The inhibitory effects on bacterial growth in pure culture conditions were more than that in soil condition. In the study about the effects of herbicide 2,4-D on soil microbial activity under laboratory conditions by Olson and Lindwall (1991), the nitrification ratio was decreased 11-79 % by herbicide 2,4-D in the soil. Also in another study, Kızılkaya and Arcaç (1996), found that 0.2 µg.g<sup>-1</sup> dose of herbicide trifluraline increased the nitrification, the effect of 0.4 µg.g<sup>-1</sup> dose of herbicide trifluraline on nitrification was not significant and 0.8 and 1.6 µg.g<sup>-1</sup> doses decreased the nitrification.

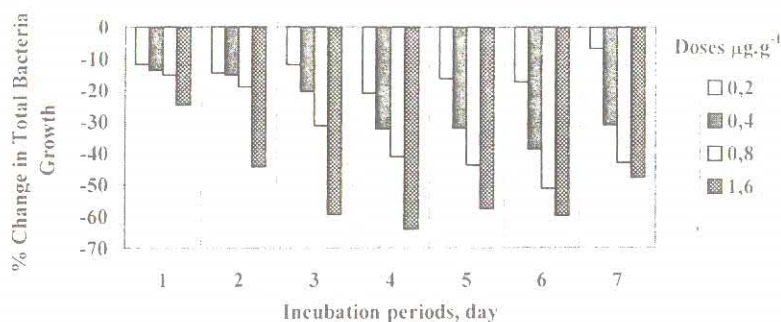


Figure 3 : Percentage Effects of Herbicides 2,4-D on Total Bacteria Growth According to the Control Dose

In order to determine effects of herbicide 2,4-D on *B. cereus* var. *mycoides* population on soils, the data and statistical analysis results obtained from this study are given in Table 4. According to the control dose, the percentage effects of increments in the doses on the total bacterial population are given in figure 4.

Table 4 : The Effects of Herbicides 2,4-D on Growth of *Bacillus cereus* var. *mycoides* in Soil Conditions (DHG activities, mg TPF. g<sup>-1</sup> dry soil) and statistical results.

Doses µg.g <sup>-1</sup>	Incubation periods, days						
	1.	2.	3.	4.	5.	6.	7.
0	0.565 A <sup>a</sup> **	0.602 Ab	1.663 Ac	2.485 Cd	5.656 De	5.761 Df	6.615 Dg
0.2	0.614 Ba	0.665 Bb	2.021 Bc	3.150 Dd	6.950 Ef	6.755 Ee	7.733 Eg
0.4	0.739 Ca	0.774 Cb	1.750 Cc	2.466 Cd	5.188 Cf	4.863 Ce	5.529 Cg
0.8	0.816 Da	0.826 Da	1.584 Db	2.079 Bc	4.883 Be	4.622 Bd	4.957 Bf
1.6	0.938 Ea	0.936 Ea	1.586 Db	1.950 Ac	3.855 Ae	3.804 Ad	4.641 Af

\* Numbers within a column followed by different capital letter(s) are significantly different at p<0.01.

\*\* Numbers within a row followed by different letter(s) are significantly different at p<0.01.

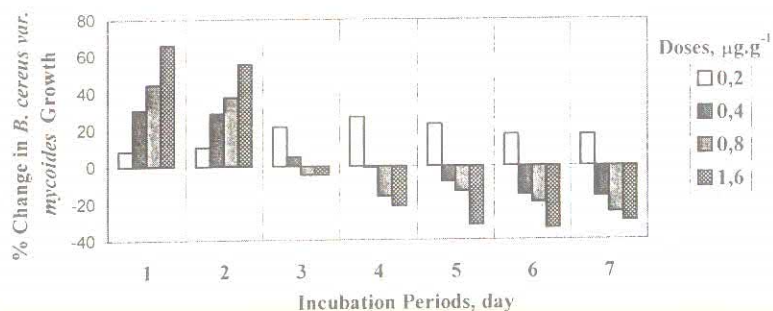


Figure 4 : Percentage Effects of Herbicides 2,4-D on *B. cereus* var. *mycoides* Growth According to the Control Dose



Every dose of 2,4-D in the 1<sup>st</sup> and the 2<sup>nd</sup> day increased the activity of *B. cereus var. mycoides*. While 0.2 and 0.4 µg.g<sup>-1</sup> doses showed increase effects on *B. cereus var. mycoides* activity in the 3<sup>rd</sup> day of incubation period, 0.8 and 1.6 µg.g<sup>-1</sup> doses of 2,4-D decreased this activity.

Cernakova et al. (1991) studied about the effects of herbicide bentanex on soil microorganisms. They found that higher doses of this herbicide decreased the microorganism growth in soil. In their study, all application doses did not effect on *Aspergillus flavus* growth, but 2.0, 4.1 and 6.1 mol/L doses inhibited *Penicillium purpurogenum*, *Penicillium chrysogenum* and *Fusarium oxysporum* growth completely. In the study on the effects of 5 mg.kg<sup>-1</sup> doses of 28 different herbicides on *Nitrosomonas* and *Nitrobacter* growth by Martens and Bremner (1993), after 7 day, nitrification period was decreased 80% by herbicide 2,4-D.

Under pure culture conditions, the low increments in *B. cereus var. mycoides* growth were observed in only 0.2 µg.g<sup>-1</sup> dose application of 2,4-D. Under soil conditions, however every dose of 2,4-D increased the *B. cereus var. mycoides* growth in the first and the second day of the incubation period. In the other incubation periods, except 0.2 µg.g<sup>-1</sup> doses, the other doses of 2,4-D inhibited the *B. cereus var. mycoides* growth. This situation can be explained with absorption or hydrolyzed mechanism of herbicide 2,4-D by soil organic matter result in delaying or decreasing negative effect of herbicide on *B. cereus var. mycoides*. Haktanır (1989) also indicated that most soil microorganisms were not much affected by normal or low concentration level of herbicide. Furthermore, it can be thought that Cl<sup>-</sup> anions by degradation of 2,4-D can have a decrease effect on microorganism growth. On the other hand the lower doses of 2,4-D can increase the *B. cereus var. mycoides* growth.

## REFERENCES

- Black, C.A. (1965). Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. American Society of Agronomy, Inc., publisher. Madison, Wisconsin, USA.
- Cernakova, M., Kurucova, M., Fuchsova, D. (1991). Effect of Herbicide Bentanex on Soil Microorganisms and Their Activity. Folia Microbiol. 36 (6) : 561-566.
- Cork, D.J., Krueger, J.P. (1991). Microbial Transformations of Herbicides and Pesticides. Advances in Applied Microbiology. Volume 36. Academic Press. Inc.
- Düzgüneş, O. (1963). Bilimsel Araştırmalarda İstatistik Prensipleri ve Metodları. Ege Üniversitesi. Matbaası. İZMİR.
- Gristein, A., Katan, J., Eshel, Y. (1976). Effect of Dinitroaniline Herbicides on Plant Resistance to Soilborne Pathogens. Phytopathology. 66 : 517 - 522.
- Gürgün, V., Halkman, A.K. (1988). Mikrobiyolojide Sayım Yöntemleri. Gıda Teknolojisi Derneği Yayın No. 7. ANKARA
- Haktanır, K. (1989). Pestisidlerin ve Ağır Metallerin Topraktaki Biyolojik Olaylar Üzerine Etkileri. Türkiye Çevre Sorunları Vakfı Yayını. ANKARA
- Kızılkaya, R., Arcak, S. (1996). Trifluralin'in Nitrifikasyon Üzerine Etkisi. Ondokuz Mayıs Üniversitesi Ziraat Fakültesi Dergisi. 11 (3): 145-154.
- Kızılkaya, R., Aksoy, H.M. (1999). Bazı Pestisitlerin *Bacillus* spp. Gelişmesi Üzerine Etkilerinin Belirlenmesi. Ondokuz Mayıs Üniversitesi Ziraat Fakültesi Dergisi. 14(3):76-87.
- Martens, D.A., Bremner, J.M., (1993). Influence of Herbicides on Transformations of Urea Nitrogen in Soil. J. Environ. Sci. Health. 1328 (4): 377-395.
- Moorman, T., Thomas, S. (1986). Effect of Herbicides on Survival of *Rhizobium japonicum* strains. Weed Sci. 34 : 628 - 644.
- Olson, B.M., Lindwall, C.W. (1991). Soil Microbial Activity Under Chemical Fallow Conditions : Effects of 2,4-D and Glyphosate. Soil Biol. Biochem. 23(11) : 1071-1075.
- Temiz, A. (1994). Genel Mikrobiyoloji Uygulama Teknikleri. Şafak Matbaacılık Ltd. Şti. ANKARA
- Thalman, A. (1968). Zur Methodik der Bestimmung der Dehydrogenase Aktivitaet im Boden Mittels Triphenyltetrazoliumchlorid (TTC). Landwirtsch. Forsch. 21 : 249 - 251.

# THE DISTRIBUTION OF AVAILABLE MICRONUTRIENTS (Fe, Cu, Zn and Mn) IN GREAT GROUPS OF EDİRNE PROVINCE AND THEIR RELATIONSHIP WITH SOME SOIL CHARACTERISTICS

Hüseyin Ekinci, Feridun Çarpık, Orhan Yüksel  
Trakya University, Faculty of Agriculture, Dept. Of Soil Science, 59030 Tekirdağ / Turkey

## INTRODUCTION

It was pointed that the various levels of available micronutrients were effected in terms of some soil characteristics. An important constituent of micronutrients in soil is fixed by organic and inorganic colloids of the soil. As a result of this, the total amounts of the micronutrients under studies in the soil were not noticeably reflected for the amount to the plants. On the hand, a very little part of the total amount of these elements was in a position for their availability to the plants.

The various researchers had investigated in relations to the availability of Fe, Cu, Zn, and Mn as micronutrients amongst pH, organic matter, calcium carbonate contents and clay, cation exchange capacity (CEC) with regard to soil characteristics (Özbek and Aksoy, 1970; Elinç, 1997a); Sağlam et al. 1997 ; Ekinci and Adiloğlu, 1997). The above cited researchers had obtained some important results which explore the reduced availability of a significant part of the elements especially in respect of high pH and  $\text{CaCO}_3$ . In the present research, the available Fe, Cu, Zn and Mn contents and their relations with some of the soil characteristics of surface horizon with regard to Great Groups in Edirne province (central Edirne, Lalapaşa, Havsa and Uzunköprü) were studied.

## MATERIAL AND METHOD

In this study, 22 total soil samples were examined which were treated as the representative of 11 great groups. The soil samples to be tested were analysed for the available Fe, Cu, Zn, and Mn contents which were demonstrated by using the extract with the aid of DTPA extraction solution (0.005 M DTPA, 0.01 M  $\text{CaCl}_2$  and 0.1 M TEA) in the atomic absorption spectrophotometer (AAS) (Lindsay and Norvell, 1978). The soil characteristics including pH,  $\text{CaCO}_3$ , clay, sand, CEC, organic matter and  $\text{P}_{205}$  were determined as described by Ekinci and Çarpık (1999). Mstatc packet programme was used for statistically analysis.

## RESULTS AND DISCUSSION

The highest contents of available Cu in the Fluvaquents ( $3.61 \text{ mg kg}^{-1}$ ) and in the Xerofluvents ( $1.63 \text{ mg kg}^{-1}$ ) were found. Contrary to the above, the lowest Cu in the Xerochrepts ( $0.33 \text{ mg kg}^{-1}$ ) and in the Xerorthents ( $0.43 \text{ mg kg}^{-1}$ ) were determined.

The highest available Zn in the Xerofluvents ( $3.06 \text{ mg kg}^{-1}$ ) while, the lowest in the Haploxeralfs ( $0.04 \text{ mg kg}^{-1}$ ) and Xerorthents ( $0.12 \text{ mg kg}^{-1}$ ) were detected.

The available Fe contents had been found is highest in the Haploxeralfs ( $55.19 \text{ mg kg}^{-1}$ ), where as the lowest level was observed in the Xerorthents and Calcixererts ( $0.05 \text{ mg kg}^{-1}$ ). The Haploxeralfs had the highest level of available Mn contents ( $89.37 \text{ mg kg}^{-1}$ ). However, the lowest value of the aforementioned element was determined in case of Xerochrepts ( $2.60 \text{ mg kg}^{-1}$ ).

Sağlam et al. (1997) found similar results in the soils of Thrace region. In a study made in the Meriç watershed soils by Elinç (1997 b), the available Cu contents ranged  $0.60\text{-}1.84 \text{ mg kg}^{-1}$ , Zn  $0.28\text{-}1.93 \text{ mg kg}^{-1}$ , Fe  $1.38\text{-}10.95 \text{ mg kg}^{-1}$  and Mn  $2.05\text{-}37.15 \text{ mg kg}^{-1}$  were estimated. In the presence of an exception, the available Zn, in general, was lower available micronutrient contents of soils with highly pH. In contraction to this the available micronutrients were higher in the coarse textured soils in relatively heavier soils.

The relationship between available micronutrients of undermentioned soils and some soil characteristics are presented in the Table 1.



Table 1. The correlation coefficients (r) between available micronutrients of soils and their characteristics.

Microelement	pH	CaCO <sub>3</sub>	Org. M	P <sub>2</sub> O <sub>5</sub>	CEC	Sand	Clay
Cu	0.364ns	-0.123ns	-0.036ns	0.426ns	0.254ns	-0.483*	0.333ns
Zn	0.194ns	-0.186ns	-0.095ns	0.305ns	-0.231ns	0.276ns	-0.424*
Fe	-0.637**	-0.262ns	0.670**	-0.126ns	-0.431*	0.413ns	-0.470*
Mn	-0.526*	-0.242ns	0.198ns	0.150ns	-0.107ns	0.165ns	-0.041ns

Generally, negative relations were revealed in terms of pH value and CaCO<sub>3</sub> contents amongst the available Fe, Cu, Zn and Mn contents (Aydemir and İnce, 1988). In this research, pH value was highly negative significant results correlated with the available Fe however, negative significant findings were observed related to the available Mn contents. Nevertheless, pH was not found to be significant pertinent to the available Zn, Cu and CaCO<sub>3</sub> depicting the similar style of record was made Sakal et al. (1988) and by Sağlam et al. (1997).

The soil containing organic matters had found highly significant results with regard to the available Fe. In the rest of microelements, however, the results had not been found significant at p=0.01 and 0.05. Almost similar observation has been reported by Man et al (1977), illuminating that the organic Carbon with the available Fe, Zn and Cu had positive significant differential responses in terms of the soils of Punjab province. Similarly a very close demonstration to our studies were considered as explained by Rajagopal et al. (1974) and Aiyer et al. (1975), reporting that organic carbon with the available Fe, had positive significant relationship. In this studies, the available P<sub>2</sub>O<sub>5</sub> with Cu was found positive significant relationship.

In the analysis, the available Fe with CEC and percentage of clay, available Zn with percent clay and available Cu with percent sand had responded negative, significant relationship.

In the present studies, the soil region in view of the critical level evaluation, the available Zn was low, while, available Mn was found to be sufficient. The available Cu and Fe to much extend exhibited some changes between themselves. The possibility of this cause may be attributed to the variation of soil characteristics from where soil samples for studies were collected. Over all, it can be concluded that the analysis of soil in determining whether or not the available Fe, Cu, Zn and Mn contents are not found satisfactory to the level of confirmation in the soil sample to be studied, rather it is imperative to detect the requisite amount of available micronutrients in the plants by conducting trials on the crops grown in the field or in the greenhouse. This idea might bring prosperity for better yield and production of crop in the future.

## REFERENCES

- Aiyer, R.S., Rajagopal, C.K and Money, N.S., (1975). Available zinc, copper, iron and manganese status of acid rice soils of Kuttanad, Kerala State. *Agricultural Research J. of Kerala*. 13:1, 15-19.
- Aydemir, O., İnce F., (1988). Bitki Besleme. D.Ü. Eğitim Fakültesi Yayınları, No:2 Diyarbakır.
- Ekinci, H. and Adiloğlu, A., (1997). Tekirdağ İli Büyük Toprak Gruplarının yayayışlı Zn içerikleri bakımından incelenmesi üzerine bir araştırma. I.Ulusal Çinko Kongr., Eskişehir.131-141.
- Ekinci, H. and Çarpık, F., (1999). A research on great groups (Soil Taxonomy) and some of their physical and chemical characteristics in Edirne Province, Turkey. 6<sup>th</sup> International Meeting on Soils with Mediterranean Type of Climate. Barcelona.
- Elinç, F. (1997 a) Meriç Havzası Vertisol ve Kireçsiz Kahverengi Topraklarında yayayışlı Zn, Fe, Mn, Cu ve B düzeyleri ile bazı toprak özellikleri arasındaki ilişkiler. I. Trakya Toprak ve Gübre Sempozyumu, Tekirdağ.
- Elinç, F. (1997 b). Meriç havzası vertisol ve kireçsiz kahverengi topraklarında farklı derinliklerde önemli bazı toprak özellikleri ve mikro element dağılımı. I. Trakya toprak ve gübre sempozyum, Tekirdağ.
- Lindsay, W.L., and Norvell, W.A., (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am.* 48: 843 - 847.
- Liu, C; Tang, L.G., Chu, C.C., Han, Y.C. and Ouyang, T., (1978). Content and distribution of trace elements in soils of China. *Acta pedologia Sinica*. 15:2, 138-150.
- Mann, M.S, Takkar P.N., Bansal, R.L. and Randhawa, N.S., (1977). Micronutrient status of soils. I. available zinc, copper, iron and manganese status of soils of Sangrur District (Punjab State). *Journal of Research Punjab Agricultural Univ.* 14:1, 23-28.



- Özbek, N. and Aksoy, T., (1970). Trakya Bölgesinde mısır ziraatı yapılan toprakların alınabilir çinko muhtevaları üzerinde bir araştırma. A.Ü. Ziraat Fak. Yıllığı 20, 2, 435 -456.
- Rajagopal, C.K., Sheriff, M.M., Selvakumari, G., Madappan, K. and Devarajan, R., (1974). Relation between organic carbon and available micronutrients in the soils of Nilgiris. J. of the Indian Soc. of Soil Sci. ZZ: 4, 347-351.
- Sağlam, M.T., Tok, H.H., Adiloğlu, A., Demirkıran A.R., ve Bellitürk, K., (1997). Trakya yöresinden alınan bazı toprak özelliklerinin elverişli Fe, Cu, Zn ve Mn kapsamaları üzerinde bir araştırma. I. Trakya Toprak ve Gübre Sempozyumu, Tekirdağ.
- Sakal, R., Singh, A.P. and Singh S.P., (1988). Distribution of available zinc, copper, iron and manganese in old alluvial soils as related to certain soil characteristics. Journal of the Indian Society of Soil Science. 36:1,59-63.

# EFFECT OF STRAW-STUBBLE BURNING ON SOIL TEMPERATURE TRANSPORT AND WATER CONTENT

Havva Kaptan, Nuri Munsuz  
Ankara University, Faculty of Agriculture, Ankara

## ABSTRACT

In this research, effects of straw-stubble burning on soil temperature transportation and water content were investigated under laboratory conditions. Straw-Stubble burning is often used to reduce fuel loads on the soil surface and to prevent weed growing. However, straw-stubble burning increases the soil surface temperature dramatically and may alter some soil properties such as organic matter, nitrogen, phosphorous and sulfur contents, kill roots, seeds and soil fauna. It is important to know optimal soil conditions to maximize the benefits and minimize the damages.

In this study, three different soil samples, sandy loam, clay loam and sandy clay loam, were packed into cylindrical containers and digital thermocouples were placed at 0,1,3,5,10 ve 15 cm depths respectively. Three soil moisture levels, air-dry,  $\frac{1}{2}$  field capacity and field capacity were set before burning treatments. Soil moisture distribution was determined before and after burning. Soil temperatures were recorded with thermocouples at different time intervals thorough five hours for each experiment set.

In this research, also soil temperature, thermal conductivity and heat flux density was computed by using computer program. All measurements were analyzed statistically. Results show that soil temperature rised abruptly at the surface by burning for each soil. These abrupt temperature changes gradually decreased with increasing depth. Soil moisture prevented sudden temperature rises at the surface. However, soil moisture increased the thermal conductivity. Effects of soil texture on temperature changes were not important statistically. Soil moisture was one of the most important factors on thermal conductivity.

## INTRODUCTION

The purpose of this research is to investigate changes of temperature on different depths and effect of tmeperature on soil water content during burnig straw-stubble.

In order to find out the effects of straw-stubble burning changes of temperatures on different depths of 0-1, 1-3, 3-5, 5-10 and 10-15 cm were measured. Before and after burning, soil samples were taken from same depths and then water contents were predicted.

The temperature during burning was observed on the surface and it reached the top value at 90-150 in second average. Temperatures were determined between 131.767 – 136.900 °C, 100.733 – 118.233 °C and 91.200 – 93.233 °C on air dry,  $\frac{1}{2}$  field capacity and field capacity in the soil, respectively. Soil temperatures in 1-3 cm were increased by burning, however after the rising of soil temperature, they were decreased rapidly. The results of burning show that there were abrupt and short time rising on soil surface. Soil temperature at the depth of 1-3 and 3-5 cm were change more slighly.

The temperature occured by burning effect on the soil depth of 1-5 cm, however, this effect wasn't abrupt and higher than in depth of 5-10 and 10-15 cm. The temperature was observed more quickly rising on both treatment of  $\frac{1}{2}$  field capacity and field capacity than air dry soil. It is considered that it is changed depending on soil water content. After burning conducting soil temperature occured after burning is increased by soil moisture however, this temperature caused abrupt rising on the soil surface with air dry soil.

All the treatments, air dry,  $\frac{1}{2}$  field capacity and field capacity effect on soil depth of 5-10 and 10-15 cm which occured rising temperature by burning, besides effect of straw-stubble burning on the temperature of 5-10 and 10-15 cm were found not significant.

Although, there were high temperature on soil surface with air dry treatment, it wasn't observed rising the temperature below the surface. The temperature observed on surface wasn't riched at 100 °C on the other treatments,  $\frac{1}{2}$  field capacity and field capacity. But changes of temperatures on these treatments were rapidly by burning.

When considered all the treatments and samples, generally temperature measured was shown changing as like each other. After disappearing fire from surface, change of temperature in the soil layers depends on soil thermal conductivity. Among the majority factors which determine soil thermal conductivity, pore content and pore which filled with air or water.

Changes of temperatures on 1/2 field capacity and air dry treatments with sandy loam were observed abrupt rising. Here, it is obviously that water content effects on 1/2 field capacity treatment, however soil texture effects on air dry soil. Because of their size sandy particules functions as an individual particule. Water percolation of between sandy particules immediately increased due to exist of big pores.

Before and after burning interval thorough five hours for each experiments sets determined. Soil temperatures occurred by straw-stubble burning on different soil depths are recorded.

Recently, new methods are tried to find by using some properties of soils known. It is appered that the computer is an ideal tool for this purpose. Computers are now readily available for using simulation models.

Determination of soil thermal conductivity using computer program is considered that it will make thing easy as both factors of time and economic. Recently, in result of a great many research it is expected to be adapt between theoretical and practical approaches. Also, in this study, it is presented the result of laboratory of surface fires and carried out soil temperature measured and simulated.

Besides determinations of canges of soil temperatures using some soil phisical properties, soil thermal conductivity and heat flux density were also competed by computer program. This program performed well in tihis study.

In this way, the temperature simulated are reasonable, the program appears suitable for predicting fire effect in the field. This study was observed that water content in different soil depth was changed by burning. But, before and after burning it wasn't obtained important differences among all soil layers of 0-1, 1-3, 3-5, 5-10 and 10-15 cm. Moreover, water content of soil was decreased to some extend on surface by burning the straw-stubble. In this case, the transport or loss of heat of vaporization and the movement of soil moisture are important in determining soil temperature

Accordingly, the results of soil analysis for moisture determination indicated that there were no significant differences in the moisure content the soil layers of 0-1, 1-3, 3-5, 5-10 and 10-15 cm. Before burning, for each teratments water indicated were added to soil samples, sandy loam and clay loa, % 8.65, % 9.25 and %13.30, respectively. But, it was observed that water dstribution in each soil layers wasn't homogeneously. The result of soil analysis for moisture determination indicated that there were water content in depth of 10-15 cm highly. This, it shows that there was water storage in depth of 10-15 cm due to soil temperature.

## **MATERIALS&METHODS**

### **Soil Material**

Three different soil samples, sandy loam, sandy clay loam and clay loam were used in this research. Soil samples were dried to air dryness passed through a 2-mm sieve, and stored for used in the burning experiments. Straw-stubble used in the research was air dry and natural structure. Special Soil Can : Cylindrical containers used in this research are 20.4 cm in diameter and 27.0 cm high. Digital thermocouples were placed at different depths of 0,1,3,5,10 and 15 cm. Thermocouples : Digital themocouples used in the study are 3 mm in diameter and 15 cm length.

### **Methods**

The experimental set up was used for etermining heat and water flow. The soil column was packed into a cylindrical container by vibration. Digital thermocouples were placed at side of the can previously indicated location individually. Previoously determined straw-stubble was put on the can filled soil samples.

Before burning, when the digital thermocouples are constant, temperature in the different depths of soil samples were recorded an initial data as °C. Burning experiments were applied same procedure for each treatments of 1/2 field capacity and field capacity. Soil samples of various depths of soil can taken before and after burning were analyzed for determining soil water content. Time was determined as five hours each experiment set.

Temperatures datas were assessed by Repeted Measured Design Anova. Statistical analysis indicated that temperature increases by burning were found highly significant. Averages of combination were compared by Least Significant Differences (LSD).



Percent moisture in different depths of samples were assessed by "Duncan" test. Statistical analysis indicated that moisture changes by burning were found significant.

## DISCUSSIONS

The surface temperature rose to 110 °C, however the underground temperatures rose little in all the experiment sets. On the other hand, the soil temperature rose little at the surface as well as under the ground in the experiments. The soil temperatures generally rise only slightly during burning the straw-stubble. Effect of temperatures on various soil depths are continue until soil depth of 5 cm.

Heat flux in the moist soils at high temperature plays a key role in determining the the temperature distribution in soil samples during burning. While heat transported downwards more quickly in moist soil samples than in dry soil samples at temperatures below 100 °C, the evaporation of water will not allow a moist soil layers to go above about 100 °C. Changes in soil temperatures in different depths of soil sample with sandy loam during burning are shown in figure 1.

Soil temperature effect on all of the physical, chemical and biological events in soils. Biological processes as the uptaken of the nutrients and water by roots. The decomposition of organic matter by soil microorganism the germination of seeds and physical processes, such as water content and movement are affected by soil temperature. Soil water content is the other important factor for plants and vegetation. For this reason, it is important to know why provide optimum temperature conditions to protect readily available water in soil.

Accordingly, the results of this study, although expected benefits such as to reduce fuel loads on the soil and to prevent weed growing, high soil temperatures after soil properties. In spite of budning the straw-stubble, it is highly recommended to remain unburned and titlth under the soil. Therefore, organic matter was derived with nothing any damages and changes on the soil.

On the other hand, the computer programme in this study is generally short and relatively simple. It is, however, quite suitable for use as simulation model. It is advanced to computed soil thermal conductivity and heat flux density. Soil temperatures computed from computer program are shown in table 1.

Finally, it is considered that the results obtained from laboratory conditions are differ from natural field conditions which had diffirent soil and climate conditions. But, computer programs will provide some approaches to know what soil thermal conductivity and heat flux density estimated by using soil temperature are.

Table 1. The value of soil temperature, thermal conductivity and heat flux density on sandy loam computed by using computer program.

TEXTURE : SANDY LOAM							
TREATMENT : AIR-DRY							
AIR TEMPERATURE : 28 °C							
	HEAT FLUX ( $W m^{-2}$ ), $f_h$						
	-66.13201	-9.238405	-5.483877	-1.743832	-0.859432	-0.168920	
	THERMAL CONDUCTIVITY ( $W m^{-1} K^{-1}$ ), K						
DEPTH (m)	K = 3	K = 0.5	K = 0.3	K = 0.1	K = 0.05	K = 0.01	K (I)
	TIME (s)						
	1200	3600	7200	10800	14400	18000	
0	36.740	30.795	30.466	29.064	28.648	28.153	46.69250
0.01125	32.390	29.879	29.864	28.846	28.532	28.129	31.12833
0.028125	29.576	29.034	29.223	28.600	28.394	28.098	20.75222
0.0534375	28.355	28.425	28.649	28.358	28.252	28.066	13.83481
0.1483594	28.003	28.018	28.062	28.050	28.045	28.014	6.148807
0.2337891	28.000	28.000	28.000	28.000	28.000	28.000	0

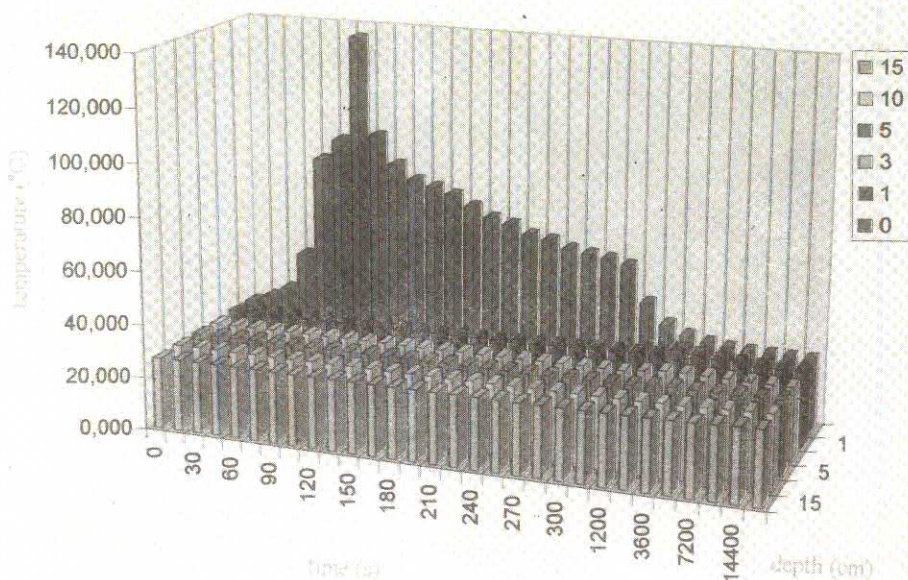


Figure 1. Change of the temperatures in different depths of soil samples, clay loam, with air-dry before and after burning.

## REFERENCES

- Aston, A.R., and A.M. Gill. (1976). Coupled soil moisture, heat and water vapour transfers under simulated fire conditions. *Aust. J. Soil Res.* 14:55-66.
- Borland.(1989). Turbo Pascal 5.5. Borland International, Inc. Scotts Valley, CA.
- Campbell, G.S. (1985). *Soil physics with BASIC: Transport models for soil-plant systems*. Elsevier, Ney York.
- Campbell, G.S., J. D. Jungbauer Jr., S. Shiozawa, and R.D. Hungerford. (1993). A one-parameter equation for water sorption isotherms of soils. *Soil Sci.* 156:302-305.
- Campbell, G.S., J. D. Jungbauer Jr., W.R. Bidlake, and R.D. Hungerford (1994). Predicting the effect of temperature on soil thermal conductivity. *Soil Sci.* 158:307-313.
- Campbell, G.S., and S. Shiozawa.(1992). Predicting of hydraulic properties of soils using particle size distribution and bulk density data. *In* Indirect methods for estimating the hydraulic properties of unsaturated soils. M. Th. van Genuchten, J. J. Jeij, and L.J. Lund (eds). University of California, Riverside, CA.
- Campbell, G.S., Jungbauer, JR.J.D., Bristow, K.L. and Hungerford, R.D. (1995). Soil temperature and water content beneath a surface fire. *Soil Science.* 159(6); 363-374.
- de Vries, D.A. (1958). Simultaneous transfer of heat and moisture in porous media. *Trans. Am. Geophys. Union* 39: 909-916.
- de Vries, D.A. (1963). Thermal properties of soils. *In* Physics of plant environment. W.R. van Wijk (ed.). North Holland Publ. Co., Amsterdam, pp.210-235.
- Hungerford, R.D., M.G. Harrington, W.H. Frandsen, K.C. Ryan, and G.J. Niehoff. (1991). Influence of fire on factors that affect site productivity. *In* Proceeding of the management and productivity of western Montane forest soils. A.E. Harvey and L. F. Neuenschwander, (eds.). US Forest Service, Intermountain Research Station General Technical Report INT-280.
- Nimmo, J.R., and E.E. Miller. (1986). The temperature dependence of isothermal moisture vs. potential characteristics of soils. *Soil Sci. Soc. Am. J.* 50:1105-1113.
- Philip, J.R. and D.A. de Vries. (1957). Moisture movement in porous materials under temperature gradients. *Trans. Am. Geophys. Union* 38:222-232.
- Richards, J. M. (1971). Simple expression for the saturation vapor pressure of water in the range -50 to 140 C. *Br. J. Appl. Phys.* 4: L15-L18.
- Tsuda, S. (1996). Air and Soil Temperature During Burning In A *Phragmites Australis* Community, Central Japan. *Ecological Review*, 23(3); 209-211.

