Asian Journal of Chemistry Vol. 19, No. 7 (2007), 5601-5608

Variability in Some Irrigation Related Soil Properties of the Alluvial Soils Formed by the Yesilirmak River

HÜSEYIN SIMSEK*, TEKIN ÖZTEKIN and ALPER DURAK†
Department of Agricultural Structures and Irrigation, Faculty of Agriculture
University of Gaziosmanpasa, Tasliçiftlik Campus, 60240 Tokat, Turkey
E-mail: hsimsek@gop.edu.tr

In this study, the variability of soil horizons and some properties of soil such as the contents of sand, silt, clay, organic matter, bulk density, field capacity, permanent wilting point and horizontal saturated hydraulic conductivity were investigated of the soil along a left transect perpendecular to the Yesilirmak River plain by sampling five pits and one trench. The results showed that the variability of horizons was small or the horizons and their depths were similar to neighbour profiles, except for the neighbour profiles between which a main discriminating route existed. For the profiles far from the river bed, while changing for a couple of layers, in general sand contents decreased depending on depth which was *vice versa* for the clay content. Excluding the values for the surface layers, the bulk density values decreased depending on the distance from the river. Though it was not much strong, available water holding capacity increased depending on the distance from the river and the depth within the same profile. In general, the horizontal saturated hydraulic conductivity values decreased depending on depth within the profiles.

Key Words: Soil properties, Alluvial soils, Yesilirmak river, Saturated hydraulic conductivity, Field capacity, Bulk density.

INTRODUCTION

In alluvial soils (*e.g.*, in river deltas and plains), variability of some irrigation and drainage related soil physical properties can highly vary from site to site. Determining this variability may be needed to design irrigation and drainage systems with varying parameters or apply varying rates of irrigation water throughout the plain.

Spatial variability in physical properties of soil is a direct result of some factors such as climate, organisms, relief, parent material, time, erosion and deposition processes and management practices, *etc*. Rivers cary different amounts of water with varying rates of sediments at different

†Department of Soil Science, Faculty of Agriculture, University of Gaziosmanpasa, Tasliçiftlik Campus, 60240 Tokat, Turkey.

times and these sediments are deposited on their plains with varying sizes and rates based on the distance of the site from the main channel of the river. The stratification of different sediments deposited on the top of each other spatially vary, *e.g.*, sandy sediments on the top of clays or at other locations, clay sediments deposited on sandy or on loamy sediments. Furthermore, alluvial soils are often variable, both laterally and with depth, because changes in both dimensions can result from differences in parent material and depositional processes[1]. Therefore, it is important to study not only the extent of surface spatial variability, but also the distribution of subsurface and deep soil horizons[2].

Saldana *et al.*[1] studied on the terraces of the Henares River (NE Madrid) to analyze the spatial distribution of several soil properties. The analysis confirmed and quantified the decrease in variability of soil properties from close to far deposits. The sand content decreased depending on the distance from the river, while clay content increased both in depth and distance. Furthermore, the silt content increased with depth in close places of river and decreased in far places.

Iqbal *et al.*[2] worked on the cultivated alluvial soils of Mississipi delta to determine the degree of spatial variability of soil physical properties. The authors stated that values for the bulk density in the subsurface horizon were significantly ($p < 0.05$) greater than in the surface and deep horizons. They indicated that the saturated hydraulic conductivity of all surface horizons was on average *ca.* 2 times greater than all subsurface horizons. It is also stated that water contents at the field capacity and permanent wilting point increased significantly ($p < 0.05$) as sampling depth increased among the three horizons, while no significant ($p > 0.05$) differences were found in the mean sand and silt content of the three horizons.

The purpose of this study is to search the variability of horizons and some irrigation related soil physical properties such as horizontal saturated hydraulic conductivity, particle-size distribution, bulk density, organic matter, field capacity and permanent wilting point along a left transect perpendecular to the Yesilirmak River plain by sampling five pits and one trench.

EXPERIMENTAL

The research site is located 25 km northwest of downtown of Tokat, Turkey. The soils at the research site located in a flood plain of Yesilirmak river were developed in an alluvium over lacustrine materials[3]. The plain was initially a swamp area. The drainage studies of plain were started in 1970 and the plain was dammed in 1966. The lands of plain are mainly used for irrigation for agriculture, in particular tomato, sugar beet, peach, maize and wheat. The region is under the effect of both Black Sea region climate and terrestrial climate of the central Anatolian region. Average annual precipitation is 456 mm and temperature is 12.3ºC. The altitude is 560 m above sea level.

According to the soil taxonomy, the soils were classified as fine, smectitic, mesic Fluvaquentic Haplustolls[3]. Five soil profiles (Cerci soil series): one from cultivated field (3rd profile) and four from native lands (never before cultivated) were dug and investigated in the year of 2004. The locations of pits were decided based on the distances from Yesilirmak river. The 5th profile was located probably in the ancient lake. Except for the profile 5, the locations of profiles on the transect were chosen to be align and perpendicular to the principal direction of sediment transport.

A pit about 2 m deep for each profile and a trench along 2nd and 3rd profiles (*ca.* 1.5 m deep and 220 m long) for visual inspection of horizon changes were dug. A profile view of the transect showing the elevations of the profiles is given in Fig. 2. The transect is almost flat. The largest elevation difference is 1.66 m, which is between the pits 5 and 3. The distance between the first and last pits is *ca.* 2 km. The elevation difference between two ends of the trench is *ca.* 20 cm.

The detailed morphological descriptions of the soil profiles were made according to the field book describing and sampling soils and horizons by Gee and Bouder[4]. Bulk soil samples for physical and chemical analyses and 100 cm^3 (5 cm high by 5.1 cm diameter) undisturbed core samples for bulk density and horizontal saturated hydraulic conductivity determination were taken from all horizons. Two core samples from each horizon were taken horizontally with a double-cylinder, hammer-driven core sampler.

Bulk densities (ρ_b) were determined as described by Blake and Hartge[5]. Measurements of saturated hydraulic conductivity (K_{sat}) for samples with high conductivity values were determined by a constant head permeameter in the laboratory and those with low conductivities were determined by a falling head permeameter[6]. Bulk samples were air dried, manually grounded and sieved to remove coarse fragments > 2 mm. Particle size distribution was done using the hydrometer method[7]. To determine the available water holding capacity (AWC) of soils of each horizon, soil water contents at the suctions of field capacity (FC) (1/3 atm.) and permanent wilting point (PWP) (15 atm.) were determined in the laboratory by ceramic plates following the procedures by Klute[8]. The contents of organic matter for the soil samples were determined in the laboratory by following the steps given by Nelson and Sommers[9]. The upper and lower boundaries of horizons were defined in the field.

RESULTS AND DISCUSSION

The depths of horizons and the contents of sand, silt, clay and organic matter; the values of bulk density (ρ_b), field capacity, permanent wilting point, available water holding capacity (AWC) for plants and horizontal saturated hydraulic conductivity (K_{sat}) of the soils in horizons for the profiles were presented in Table-1. The ρ_b and K_{sat} values are the means of two measured values.

Considering the very small elevation differences of the profiles (Fig. 1), the variability of horizons are small or the horizons and their depths are similar for neighbour profiles, which is *vice versa* for the profiles 2 and 3. It looks like the main discriminating route is passing between profiles 2 and 3. Therefore, a trench extending between these two profiles was dug and changes of horizons through this trench were also searched.

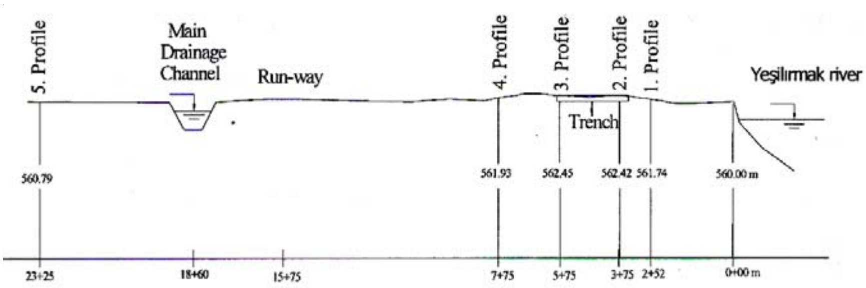

Fig. 1. A profile view of the transect

The closest profile to the river (profile 1) contains silt and clay particles with small percentages only in the soil of surface layer (25 cm depth). This soil is classified as a sandy-loam (Table-1). In the surface layer of profile 2, these percentages increased. The 2nd layer of this profile contains only sand. When compared with the values of the 1st layer, the silt content of the third layer increased while sand and clay contents decreased. The 4th layer was again a sand layer. The soils in the 1st and 3rd layers of this profile were classified as loam. For the profiles 3, 4 and 5, while changing for a couple of layers, in general sand contents decreased depending on depth, which is *vice versa* for the clay content. The present results conforms to the result by Saldana *et al.*[1]. When the depth weighted average values are considered for a whole profile, the sand content is smallest and the clay content is the highest for the profile 4. The depth weighted average silt content decreased depending on the distance from the river. The soils in the layers of profile 3 were classified as loam, clay-loam, silty-loam and silty-clay-loam. In addition, the soils in the layers of profiles 4 and 5 were classified as clay-loam or clay. From textural classification, it seems that the soil is becoming much more clay dominant as the distance from the river gets farther.

The organic matter contents of surface layers of the profiles were high. The values of the deepest horizons for profiles 3 and 4 were also high. They varied both within soil profiles and layers. There was no strong vertical trend. The depth weighted value of the 3rd layer produced the highest one, the 4th followed it.

Excluding the values for the surface layers, the bulk density values decreased depending on the distance from the river. This means that ρ_b is high at the places close to the river and is low at the places far from the river. Among the values of layers, the bulk density values of second or third layers of the profiles 3, 4 and 5 are the highest values such as those by Iqbal *et al.*[2]. When the depth weighted average values are considered, the bulk density value of profile 4 is less than both those of profiles 3 and 5.

The values of field capacity (FC) and permanent wilting point (PWP) changed both in the soils of layers of same profile and among the profiles. Though it was not much strong the values of FC and PWP increased both depending on the distance from the river and the depth within the same profile. This kind of result can be expected because of changes in clay contents of soil as stated above. The values of available water holding capacity (AWC) for plants followed the same pattern of those by FC and PWP. The largest values of AWC for the profiles (except 5) were seen in the soils from the deepest horizons. When the depth weighted average values of AWC are considered, the AWC value of profile 4 is larger than those of profiles 3 and 5.

The saturated hydraulic conductivity (K_{sat}) values also showed variability among profiles and within layers of the profiles. The values of surface layers for the profiles showed high variability (Table-1), which is also similar to Öztekin and Ersahin report[10] for the soils of same region. Except the values of last layers for Profiles 3 and 4, the values decreased depending on depth. This kind of trend was not seen for the profile 5. This may be due to the fact that the 5th profile is located in the ancient lake as stated before.

To search the variability of horizons further, a trench between the profiles 2 and 3, through which a main discriminating route pass, was excavated. The horizons along this trench with short distances were described. Fig. 2 shows these horizons. The variability of horizons with very short distances can be seen from this figure. Most probably these places are the ancient riverbeds. The similarities of the left most horizons to those of profile 2 and the right most horizons to those of profile 3 are apperant. The depths of horizon A along the ditch also showed variability.

TABLE-1
SOME PROPERTIES OF SOILS TAKEN FROM THE HORIZONS OF THE PROFILES†

Profile No.	Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil texture	Org. matter (%)	Bulk density (g cm^{-3})	FC‡ (%)	PWP† (%)	AWC† (%)	K_{sat} (cm h^{-1})
1	A	0-25	71.65	17.05	11.3	Sandy loam	2.50	*	11.09	5.79	5.30	*
	C_1	25-42	100.0			Sand	0.20		3.22	2.17	1.05	
	C_2	42-200	100.0			Sand						
2	A	0-50	50.65	34.55	14.80	Loam	0.61	1.37	17.61	6.78	10.83	9.46
	C	50-67	100.0			Sand	0.20		2.72	2.07	0.65	
	A_b	67-76	48.70	37.50	13.80	Loam	0.50	*	19.40	7.08	12.32	*
	C_1	76-200	100.0			Sand						
3	A	0-35	33.68	43.00	23.32	Loam	5.13	1.19	25.54	14.74	10.80	2.91
	B_w	35-73	30.68	37.00	32.32	Clay loam	5.18	1.42	25.89	14.80	11.09	0.96
	BC	73-99	27.68	40.00	32.32	Clay	0.83	1.50	25.89	14.80	10.50	0.67
	C_g	99-130	23.68	52.00	24.32	Silty loam	0.65	1.39	29.19	18.69	15.56	0.43
	$2C_g$	130-162	26.68	42.00	31.32	Clay loam	1.30	1.39	32.24	16.68	13.53	0.10
	$3C_g$	162-200	19.68	46.00	34.32	Clay loam	1.84	1.35	34.38	20.85	17.60	1.29
4	A	0-24	36.20	32.50	31.30	Clay loam	5.28	1.18	37.92	23.90	14.02	8.62
	B_{w1}	24-56	20.05	27.05	52.90	Clay	1.31	1.40	34.33	24.37	9.96	3.85
	B_{w2}	56-90	20.05	24.55	55.40	Clay	0.96	1.30	37.96	23.82	14.14	0.50
	C_1	90-107	20.05	29.65	50.30	Clay	1.51	1.27	39.08	23.02	16.06	0.02
	C_2	107-141	20.05	44.55	35.40	Clay loam	0.55	1.26	39.39	24.14	15.25	0.01
	C_{g1}	141-200	17.55	27.05	55.40	Clay	1.57	1.05	33.80	15.11	18.69	0.12
5	A	0-24	37.55	24.55	37.90	Clay loam	4.81	1.14	37.45	27.23	10.22	1.18
	B_{w1}	24-38	20.05	27.05	52.90	Clay	1.14	1.35	38.17	23.33	14.84	0.43
	B_{w2}	38-67	20.05	32.05	47.90	Clay	1.81	1.37	39.75	23.71	16.04	0.03
	C_1	67-83	33.40	26.00	40.60	Clay	0.14	1.20	38.90	22.63	16.27	0.28
	C_2	83-92	20.05	34.55	45.40	Clay	1.27	1.18	36.07	23.50	12.57	1.45
	C_3	92-137	22.55	32.05	45.40	Clay	0.32	1.23	34.92	20.34	14.58	0.56
	C_4	137-200	*	*	*		0.26	1.28			*	0.01

†The description of the profiles 1, 2, 4 and 5; and the contents of sand, clay, silt and organic matter for profiles 1, 2, 4 and 5 were taken from Aydin[11].
‡FC: field capacity (% by weight), PWP: permanent wilting point (% by weight)) , AWC: available water holding capacity (% by weight).

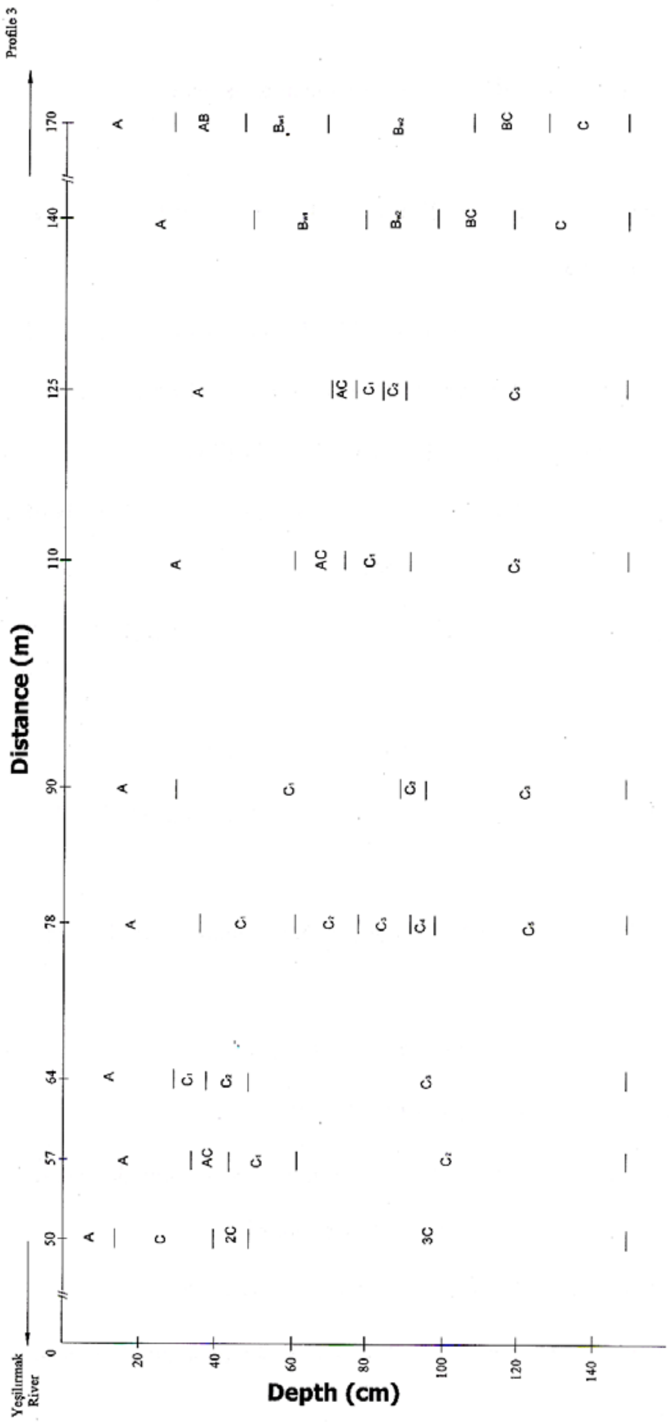

Fig. 2. Horizons along the ditch (225 m long and 150 cm deep) between profiles 2 and 3

Conclusions

The measured irrigation related physical properties of soil for the profiles indicated that these properties were spatially varied and correlated with the distance from the current and ancient Yesilirmak river beds. Textural changes between profiles and among the horizons of the profiles were generally higher especially between Profiles 2 and 3 (main discriminating route). The soil thickness increased depending on the distance from the river bed. The variability of soil physical properties was generally higher within the surface horizons. The sand contents decreased both within the depths of the profiles and within the distances from the river. The soil texture was coarse near the river and fine far from the river. In addition, bulk density was high at the places close to the river and it was low at the places far from the river. Though it was not much strong, the available water holding capacity of soils for plants (AWC) increased both depending on the distance from the river and the depth within the same profile. Finally, horizontal saturated hydraulic conductivity decreased with the depths of profiles.

REFERENCES

1. A. Saldana, A. Stein and J.A. Zinck, *Catena*, **33**, 139 (1998).
2. J. Iqbal, J.A. Thomasson, J.N. Jenkins, P.R. Owens and F.D. Whisler, *Soil Sci. Soc. Am. J.*, **69**, 1338 (2005).
3. A. Durak, H. Gunal, F. Akbas and S. Kilic, *Asian J. Chem.*, **18**, 1953 (2006).
4. G.W. Gee and J.W. Bauder, in ed.: A. Klute, Particle-Size Analysis, Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, SSSA Book Series: 5 (Formerly Agronomy Monograph 9), Madison, Wisconsin, USA, pp. 383-411 (1986).
5. G.R. Blake and K.H. Hartge, in ed.: A. Klute, Particle Density, Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, SSSA Book Series: 5 (Formerly Agronomy Monograph 9), Madison, Wisconsin, USA, pp. 377-382 (1986).
6. A. Klute and C. Dirksen, Hydraulic Conductivity and Diffusivity, Laboratory Methods. Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, SSSA Book Series: 5 (Formerly Agronomy Monograph 9), Madison, Wisconsin, USA, pp. 687-734 (1986).
7. E.O. McLean, in eds.: Page et al., Soil pH and Lime Requirement, Methods of Soil Analysis, Part 2, Argon. Monogr. 9, ASA and SSSA, Madison, WI, edn. 2, pp. 199-224 (1982).
8. A. Klute, Water Retention, Laboratory methods, Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods. SSSA Book Series: 5 (formerly Agronomy Monograph 9), Madison, Wisconsin, USA, pp. 635-662 (1986).
9. D.W. Nelson and L.E. Sommers, in ed.: A. Klute, Total Carbon, Organic Carbon and Organic Matter, Methods of Soil Analysis, Part 2, Microbiological and Biochemical Properties, SSSA Book Series: 5 (formerly Agronomy Monograph 9), Madison, Wisconsin, USA, pp. 539-579 (1982).
10. T. Öztekin and S. Ersahin, *Turk. J. Agric. For.*, **30**, 1 (2006).
11. M.E. Aydin, Soil Formation and Taxonomy in Yesilirmak River Terraces, Master Thesis, Graduate School of Natural and Applied Sciences of Gaziosmanpasa University, Turkey, p. 49 (2006).

(*Received*: 16 December 2006; *Accepted*: 19 June 2007) AJC-5744