African Journal of Agricultural Research Vol. 5 (6), pp. 449-452, 18 March 2010
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X © 2010 Academic Journals

Full Length Research Paper

Some important properties and classification of vertisols under Mediterranean climate

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Accepted 15 February, 2010

Vertisols comprise some of the important arable land in northwestern Turkey. Five sites were selected to present Vertisols occurring in different parent materials of the study area. These soils occur on flat to gently sloping plains of the region. Clay content is high in the studied sites. The high cation exchange capacity and CEC/clay ratios suggest montmorillonitic and mixed mineralogy. Calcium was the most dominant extractable cation followed by magnesium. The similar patterns of distribution for the electrical conductivity values and soluble cations throughout the studied soil sites indicate the low leaching rate, eluviation and illuviation processes within these studied sites. All soils belong to the Haploxererts soil great group.

Key words: Vertisols, soil properties, classification.

INTRODUCTION

Among the ten orders of soils recognized in Soil Taxonomy (Soil Survey Staff, 1975), vertisols are recognized by their propensity to shrink when dried and to swell when moistened. This property is determined by the nature of the soil material, which is characterized by at least 30 percent clay, and the clay itself, which is dominated by a smectitic mineralogy. Extensive swelling and shrinking upon wetting and drying is the major characteristics of these soils. This results to pedoturbation or mixing of the soils and minimal horizonation (Ahmad, 1983). Shrinkage causes the formation of wide deep cracks and washing of surface materials into these cracks. Vertisols may exhibit open cracks, which are up to 50 cm deep and at least 1 cm wide and extend upward to the surface or the base of the plow layer or surface crust (Soil Survey Staff, 1975). Cracking takes place as a result of seasonal fluctuation. The moisture regime influences the duration and intensity of cracking. The degree and frequency of changes in moisture content of the soil are perhaps the most important parameters that control cracking intensity (Mermut et al., 1990). Cyclic cracking and swelling contribute to the formation of slickensides.

Vertisols are typically developed on alluvial material in flat inland areas (Jenny, 1980). Vertisols may form residually from weathered limestone or basalt. These soils are generally developed from parent materials that are rich in alkaline earth cations (Ca and Mg). The weathering of these rocks produces smectite type clays.

Vertisols are among the most productive soils (Acquaye et al., 1992). These soils are little affected by leaching and may remain calcareous if they were formed from calcareous parent materials. The high CEC and low permeability help in retaining the nutrients of added fertilizers. Root penetration is hampered in the more coarsely structured soils, which causes root damage. Erosion hazard and water logging are common in these soils as a result of low permeability. Although these soils are considered among the most fertile soil types, some of their physical properties pose a problem. With limited available water, vertic movement and deep cracking in dry periods lead to breaking of active roots, compaction and an increase in bulk density (Duchaufour, 1982).

Prior to the advent of modern classification systems, soils such as the vertisols were well known to farmers because of their color, the fact that they produced cracks during the dry season, and of equal importance, their difficult workability. These soils are sticky class in the wet season and are hard in the dry season. It is difficult to cultivate these soils with traditional tools such as the hoe or even a bullock-drawn plow.

Vertisols are important agricultural soils in northwestern Turkey. These soils occupy approximately 23,436 ha (Anonymous, 1995) in the region. Soils are mostly used for cereal and summer crops. The aim of this research was to determine the characteristics of these soils and to classify the soils according to the USDA Soil Taxonomy

Table 1. General description of the research area.

Site	Precipitation (mm)	Slope gradient	Parent material	Present land use	Irrigation condition
1	600	Nearly level (%1)	Marn	Summer crops	Irrigated with well
2	600	Nearly level (%1)	Marn	Summer crops	Irrigated with well
3	600	Nearly level (%1)	Marn	Summer crops	Irrigated with well
4	600	Gently sloping (%1-2)	Limestone	Cereal	Non irrigated
5	600	Gently sloping (%1-2)	Limestone	Cereal	Non irrigated

Table 2. The morphological properties of the studied sites.

Horizon	Depth (cm)	Munsell color (moist)	Texture	Structure	Consistency (moist)	Roots	Boundary
Profile 1							
Ap	0 - 20	5YR 3/4	C	3f, sbk	f	c, m	g
Bw	20 - 80	5YR 3/4	C	3m, abk	f	f, f	w
C	80 - 110	5YR 4/4	C	3m, abk	f	---	w
Profile 2							
Ap	0 - 20	5YR 3/2	C	2m, sbk	f	c, m	w
Bw	20 - 70	5YR 3/2	C	3c, abk	f	c, f	s
C	70 - 115	5YR 3/4	C	2c, abk	f	---	s
Profile 3							
Ap	0 - 10	5YR 4/4	C	3m, sbk	f	c, f	w
Bw	10 - 55	5YR 4/4	C	3c, abk	f	c, f	s
C	55 - 105	5YR 4/6	C	3c, abk	f	---	s
Profile 4							
Ap	0 - 25	5YR 3/4	C	2f, sbk	f	c, m	g
Bw	25 - 75	5YR 3/4	C	3m, abk	f	c, m	w
C	75 - 115	5YR 4/6	C	2c, abk	f	---	w
Profile 5							
Ap	0 - 15	5YR 3/4	C	2f, sbk	f	c, f	g
Bw	15 - 70	5YR 3/4	C	3m, abk	f	f, f	g
C	70 - 120	5YR 4/4	C	2m, sbk	f	---	w

Structure: 2 = moderate, 3 = strong. Type: c = coarse, f = fine, m = medium. Class: abk = angular blocky, sbk = subangular blocky. Consistency: f = firm. Roots; abundance: f = few, c = common. Thickness: f = fine, m = medium. Boundary: g = gradual, s = smooth, w = wavy.

(1994).

MATERIALS AND METHODS

The research area is located on between 40° 14′ - 40° 18′ N latitudes and 28° 35′ - 28° 45′ E longitudes in the bursa plain of northwestern Turkey. Five sites were selected in areas where Vertisols occur to include same precipitation zones and different lithology (Table 1).

The soil profiles were described according to Soil Survey Manual (Soil Survey Division Staff, 1993) before taking the samples. The bulk samples were air dried, crushed with mortar and pestle and sieved to remove coarse fragments. Soil samples were analysed for particle size distribution (Gee et al., 1982), pH (Mclean, 1982), organic carbon (Nelson et al., 1982), total nitrogen (Bremner et al., 1982), calcium carbonate (Nelson, 1982), EC (SCS, 1972), CEC (Rhoades, 1982), exchangeable cations (Thomas, 1982), available phosphorus (Olsen and Sommers, 1982) and free iron oxides (SCS, 1972).

The climate belongs to the Mediterranean type, which is characterized by a hot dry summer and cool winter. The soil moisture and temperature regimes are xeric and thermic. The mean annual precipitation and temperature are 600 mm and 14.4℃ in the research area.

RESULTS AND DISCUSSION

The studied soils were under summer crops and cereals

Table 3. The physical and chemical properties of studied sites.

Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture	pH 1:2 soil water	EC ($dS\ m^{-1}$)	Org. C (%)	Total N (%)	C/N	$CaCO_3$ (%)	P, mg kg^{-1}	CEC/ Clay	CEC	Exchangeable cations				BS (%)	Free Fe_2O_3 (%)
															Ca	Mg	K	Na		
														------------cmol (+) kg^{-1}------------						
Profile 1																				
Ap	0 - 20	10.4	43.8	45.3	C	7.6	0.42	1.22	0.09	13.5	4.1	7.24	1.16	39.1	36.6	2.0	0.87	0.65	100	0.88
Bw	20 - 80	6.6	45.0	48.1	C	7.8	0.45	0.98	0.08	12.2	4.8	5.25	1.15	41.7	38.5	2.6	0.63	0.70	100	0.85
C	80 - 110	11.5	42.7	45.5	C	7.8	0.50	---	---	---	4.8	4.92	1.20	38.0	34.6	3.0	0.57	0.81	100	0.81
Profile 2																				
Ap	0 - 20	14.3	41.3	43.7	C	7.8	0.44	1.00	0.08	12.5	5.5	8.15	1.18	37.1	33.2	3.2	0.65	0.91	100	0.78
Bw	20 - 70	10.5	43.0	46.0	C	7.9	0.48	0.70	0.07	10.0	6.0	6.74	1.16	39.5	35.9	3.4	0.50	0.95	100	0.76
C	70 - 115	17.3	40.1	42.1	C	8.0	0.52	---	---	---	6.3	4.92	1.17	32.2	32.2	3.5	0.33	0.97	100	0.74
Profile 3																				
Ap	0 - 10	12.7	39.9	46.7	C	7.8	0.39	0.95	0.08	11.9	6.2	7.81	1.13	41.3	37.4	3.0	0.78	0.80	100	0.67
Bw	10 - 55	7.4	42.3	49.8	C	7.9	0.40	0.63	0.06	10.5	7.8	4.70	1.14	43.5	39.4	3.4	0.54	0.88	100	0.62
C	55 - 105	14.0	40.7	44.9	C	8.0	0.45	---	---	---	8.0	3.23	1.16	38.7	38.5	3.6	0.43	0.93	100	0.60
Profile 4																				
Ap	0 - 25	27.4	35.1	37.0	CL	7.8	0.40	1.03	0.07	14.7	3.8	9.36	1.12	36.5	32.7	2.5	0.93	0.85	100	0.71
Bw	25 - 75	23.6	36.3	39.7	CL	7.9	0.44	0.72	0.06	12.0	5.2	7.88	1.12	39.9	36.5	2.8	0.71	0.92	100	0.69
C	75 - 115	26.5	37.9	35.2	CL	8.0	0.49	---	---	---	5.5	5.02	1.22	32.1	28.7	2.9	0.38	0.99	100	0.67
Profile 5																				
Ap	0 - 15	32.7	32.7	35.4	CL	7.6	0.30	1.17	0.09	13.0	5.2	10.0	1.09	38.4	35.2	2.1	0.95	0.72	100	0.65
Bw	15 - 70	28.1	28.1	37.8	CL	7.7	0.34	0.85	0.08	10.6	5.8	6.12	1.12	40.2	37.0	2.4	0.81	0.77	100	0.63
C	70 - 120	30.8	30.8	33.1	CL	7.8	0.38	---	---	---	6.2	4.03	1.11	36.7	33.1	2.5	0.52	0.85	100	0.62

in this region. The summer crops grown sites were irrigated with well water. The using of well water is common irrigation practices to obtain enough yields for these soils by farmers.

The major morphological properties are presented in Table 2. The studied soils occur in a climatic zone with strongly contrasted seasonal climate. During the wet winter season, these soils are almost saturated conditions and become very dry and desiccated throughout the soil profile in the summer season. Cracks developed to a depth of about 1 m in all the studied sites. Their width at the soil surface range from 1 to 4 cm. Slickensides were observed in all of the studied soils. The paralleled structure was attributed to the soil texture, swelling, shrinkage and pedoturbation in these soils. The surface when dry is moderately hard to loose due to the self-mulching nature of the topsoil. The mulching effect can hide the surface cracks. (Table 3).

Clay content ranged from 33.1 to 49.8% in the studied soils. These values were higher in areas, this probably due to more prolonged weathering. The marn derived soils had higher clay content than limestone derived soils.

Organic matter content of these soils is low. This could be attributed to the prevailing dry conditions where the biomass production is low and the mineralization rate is high. Calcium carbonate is uniformly distributed in all the studied sites. This could be attributed to the low leaching processes because of the high clay content of these soils. The cation exchange capacity values indicate high fertility potential. The high CEC/clay ratio indicated that smectite is the major contributor to the high CEC values. Electrical conductivity values showed that highest value was 0.52 dS m^{-1} in the profile 2. The average electrical conductivity of the soils was around 0.45 dS m^{-1} indicating that these soils are not saline. Free iron oxide values were uniformly distributed throughout the soil profiles. Calcium was the most dominant extractable cation followed by magnesium. The extractablecalcium showed accumulation on the subsurface horizons and decreased slightly with depth in all the studied soils. However, magnesium was increased with depth. Slight differences in the magnesium content were found between surface and subsurface horizons. Extractable potassium and sodium values were lowest in all the studied sites. Available phosphorous values ranged from 3.23 to 10.0 mg kg^{-1} and decreased with depth. The values were low to support the growth of most arable plants. Hence, proper application of phosphorous fertilizer must be suggested in these studied soils. Aydinalp (1996 and 2001) stated that sand and clay content of vertisols in northwestern Turkey is higher than the soils studied. Generally, vertisols showed similar morphological, physical and chemical properties (Table 3) in the region due to similar parent material, topography and climate.

Conclusion

Vertisols are non-saline and slightly alkaline with pH around 7.8. The similar distribution of pH values throughout the soil horizons and in the different studied sites indicates the slow rate of weathering and soil development in the study area. The similar patterns of distribution for the electrical conductivity values and soluble cations throughout the studied soil sites indicate the low leaching rate, eluviation and illuviation process within these studied sites. These soils had high cation exchange capacity due to high clay content. The high CEC/clay ratio suggests montrollonitic and mixed mineralogy. All the studied sites were classified as Chromic Haploxererts.

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