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PHYSICAL AND CHEMICAL SOIL PROPERTIES OF ORCHID GROWING AREAS IN EASTERN TURKEY

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ABSTRACT

The aim of this study was to determine and characterize some physical and chemical soil properties of orchid growing areas in Eastern Turkey and to evaluate the differences in soil properties according to orchid species (Dactylorhiza spp., Orchis spp.). A total of 36 soil samples from different orchid growing areas were collected and analyzed based on water retention characteristics, pore size distribution, bulk density, electrical conductivity (EC), pH, organic matter, carbonates and micro elements. The results showed that physical and chemical parameters of soils did not vary regards to orchid species. The amount of water retained at the low tensions (<0.03 MPa) in orchids growing areas soils were between 20.24 and 57.43 based on % of volume. The highest and lowest water retention capacity between 0.03-1.5 MPa was 30.96% and 5.15%, respectively. Among the samples, the highest and lowest volume of macropores and bulk density were between 36.85% and 13.79%, and 1.01 g cm^{-3} and 0.19 g cm^{-3}, respectively. EC, pH, organic matter and $CaCO_3$ values of samples varied from 0.47 dS m^{-1} to 2.97 dS m^{-1}, from 5.71 to 7.81, from 1.06% to 38.96% and from 0.31% to 43.50%, respectively. In addition, the micro element (Cupper, Iron, Zinc, Cadmium, Lead, Chromium and Manganese) content of soils differed significantly from each other. It was noticed that higher altitudes of more than 2000 m were not suitable for the Orchis spp. whereas the Dactylorhiza spp.

Keywords: Soil properties, Dactylorhiza spp., Orchis spp., Turkey

INTRODUCTION

Orchid is the largest family in the plant kingdom with more than 20 thousand species, scattered throughout the world which can be divided into two main groups, namely epiphytic and terrestrial orchids (Korkut, 1998).

Epiphytic orchids are generally found in the tropical belt and grown for florists. This group of orchids anchors onto the body and branches of other plants instead of striking roots into land. They provide their nutrients via photosynthesis and they have pseudo-bulbs. In contrast, terrestrial orchids generally live on soil. The terrestrial orchids have tubers instead of pseudobulbs. They are extremely diverse in appearance and produce an erect stem. Their inflorescence is a cylindrical to globular spike 5-15 cm long with yellow, red to purple flowers. These orchids are distributed throughout the subarctic and temperate northern hemisphere: in Europe, from Scandinavia to North Africa; also on Madeira, Iceland, West Asia, North Asia, the Himalayas, North America and even in Alaska (Korkut, 1998; Pillon *et al.,* 2006).

The terrestrials orchids start flowering at the base, slowly progressing upwards, except the Monkey orchid (*Orchis simia*) that flowers in reverse order. The tuberous orchids belongs to terrestrial group are also called as 'Salep' which has polymeric structure, aphrodisiac effect, and the other medicinal characteristics (Esitken *et al.*, 2004). More recently, these tuberous orchids are extremely high demanded and they fatch very high market price (Esitken *et al.,* 2005). Despite all the laws put into effect, tubers of these orchids are being continuously digged out illegally and many species are now within endangered plant classes (Ari *et al*., 2005).

Turkey is one of the countries of the region rich in orchids. Approximately twenty-four genera and almost 100 terrestrial species belonging to the Orchidaceae family have been determined in Turkey (Ari *et al*., 2005). About 10% of them are endemic and 85% of them have tubers (Sezik, 2002).

Due to their beauty and fascinating biology orchid species have attracted the attention of botanists since the times of Darwin. Therefore, their morphology and biology have been studied more intensively than those of most other plants(Schlegel *et al.,* 1989). However, even a short survey of the recent literature reveals that many characteristics of orchid growing soils remain unknown. Sometimes the type of soil only allows a certain plant to grow on it. Volume of air and water retention capacity of growing medium is generally considered as the quality factors for plants (Bruckner, 1997; Caron and Nkongolo, 1999). A common way to compare different soil growing conditions is to describe them on the basis of their physical properties. Within the physical properties the air-water ratio is most important (Orozco *et al*., 1997). The relationship between water energy status and water content of the soil is a reflection of the pore size distribution of the soil. Pore size distribution is valuable for characterizing soils for various applications relating to soil-plant interactions, aeration, irrigation, drainage and liquid waste disposal. Pore sizes have traditionally been divided into macropores, mesopores, micropores and ultramicropores (Sahin *et al*., 2002; Sahin *et al*., 2005; Sahin and Anapali, 2006). The macropores (>100 µm diameter) supply drainage and aeration, the mesopores (100-30 µm diameter) supply water conductivity, and the micropores (30-3 µm diameter) supply water retention. The water retained in ultramicropores (<3 µm diameter) is unavailable for plant use.

On the other hand, the increase in cultivation intensity with the increasing demand for higher yields and better quality has resulted in increasing demand for micro elements. Plant productivity has increased along the years due to genetic development and selection of high yielding cultivars. These cultivars with intensive cultivation methods were found to remove higher quantities of micro elements from the soil, leading to deficiencies occurring in many soils (Ergene, 1993). Therefore evaluation of microelements in different soils is very meaningful.

MATERIALS AND METHODS

In this study, a total of 36 soil samples where orchids grown from different parts of Eastern Anatolia of Turkey were sampled. The site, coordinates, species of orchids and altitude of sample collection areas were shown in Table 1. The soil samples in each area were collected from effective root deepth of orchid plants (30 cm).

The soil water characteristic curve (pF curve) was determined using pressures plates (Klute, 1986), and was used as the basis for the calculation of the pore size distribution. Water held at 0.001 MPa, 0.01 MPa, 0.03 MPa, 0.10 Mpa and 1.5 MPa was obtained when water output stopped for a given suction. Porosity was estimated according to Danielson and Sutherland (1986) by using bulk densities and specific gravities of soils and bulk density was determined by the cylinder method (Blake and Hartge, 1986), on samples packed by dropping the sample cylinders from a height of 10 cm for 20 times.

Electrical conductivity was determined by an EC-meter in saturation extract (Rhoades, 1996), pH by a pH-meter in saturation extract (Mc Lean, 1982), organic matter using the Smith-Weldon method (Nelson and Sommers, 1982) and carbonates by the calcimeter method (Nelson, 1982). Micro elements (Cu, Fe, Zn, Cd, Pb, Cr and Mn) contents of soils were determined with extraction and analyzed using an atomic absorption spectrophotometer according to Lindsay and Norvell (1978).

Analysis of variance (ANOVA) for the data of pore size distribution, amounts of moisture retained in different tensions, bulk density and soil chemical properties was done. (Steel *et al*., 1997).

RESULTS AND DISCUSSION

In the field expedition, it was noticed that terrestrial orchids were more populated in the wet meadows, bogs, heath land and in areas sparsely populated by trees.

Some physical and chemical properties of soils in orchids growing areas are shown in table 2 and 3, respectively. There were significant differences ($p<0.01$) in data of all of the researched characteristics.

The water retention capacity values at the low tensions (<0.03 MPa) of the orchids growing areas soils was between 20.24% and 57.43% (Table 2). These values were higher than 25% for 34 growing area soils. The highest and lowest water retention capacity values of soils between tensions of 0.03-1.5 MPa were 30.96% and 5.15%, respectively, and the values of 30 growing areas soils were between 10% and 20%. The bulk density values of soils varied from 0.19 g cm^{-3} to 1.01 g cm^{-3} (Table 2). The maximum and minimum macropores (<100 µm) values were obtained as 36.85% and 13.79%, respectively. These values were higher than 20% for 20 growing areas soils. For suitable air volume in soils, it is suggested that the macropores be greater than 20% (Sahin and Anapali, 2006). The maximum values were determined as 15.26% for mesopores (100-30 µm), as 27.75% for micropores (30-3 µm) and as 41.69% for ultramicropores (<3 µm). The minimum mesopores, micropores and ultramicropores values were determined as 0.77%, as 1.30% and as 21.66%, respectively. The ultra micro pores values were higher than 30% for 20 growing area soils. Lower bulk density and higher amount of moisture retained at the low tensions (<0.03 MPa) of orchid soils could be explained by the high organic matter in these soils (Table 3). In addition, the pore size distribution could be affected by mineralization of organic matter.

The electrical conductivity EC values of the soils were found to be between 0.47 dSm^{-1} and 2.97 dS m^{-1} (Table 3). The EC values of 35 growing areas soils were lower than 2.00. According to the USDA Natural Resources Conservation Service (NRCS), there was no salinity problem in the soils analyzed (Soil Survey Staff, 1993). The pH of soil samples varied from 5.71 to 7.81. Orchids can be classified within horticultural plants and most of the horticultural plants prefer a pH around 6.50 (Agaoglu *et al*., 1995). Organic matter content on the soils searched was between 1.06% and 38.96% (Table 3). The organic matter was higher than 4.1% for 28 areas. Therefore, much of the investigated soils of orchid growing areas could be classified into high organic matter

Table 1: The site, coordinates and altitude of orchids growing areas in Turkey

Area No.	Site	Coordinates	Altitude (m)	Orchid species
1	Ilica-Erzurum	39º 56 N' ; 41º 04 E'	1756	Dactylorhiza spp., Orchis spp.
2	Ilica-Erzurum	39 º 56 N' ; 41º 02 E'	1751	Dactylorhiza spp.
3	Ilica-Erzurum	39 º 56 N' ; 40º 58 E'	1750	Dactylorhiza spp.
4	Ilica-Erzurum	39 º 54 N' ; 40º 53 E'	1710	Dactylorhiza spp.
5	Kandilli-Erzurum	39 º 54 N' ; 40º 48 E'	1698	Dactylorhiza spp.
6	Dumlu-Erzurum	40 º 02 N' ; 41º 20 E'	1774	Dactylorhiza spp.
7	Dumlu-Erzurum	40 º 02 N' ; 41º 20 E'	1779	Dactylorhiza spp.
8	Dumlu-Erzurum	40 º 04 N' ; 41º 21 E'	1811	Dactylorhiza spp., Orchis spp.
9	Tafta-Erzurum	40 º 05 N' ; 41º 22 E'	1831	Dactylorhiza spp., Orchis spp.
10	Karagobek-Erzurum	40 º 09 N' ; 41º 25 E'	1963	Dactylorhiza spp.
11	Karagobek-Erzurum	40 º 10 N' ; 41º 26 E'	2007	Dactylorhiza spp., Orchis spp.
12	Guzelyayla-Erzurum	40 º 12 N' ; 41º 28 E'	2099	Dactylorhiza spp.
13	Askale-Erzurum	39 º 56 N' ; 40º 47 E'	1698	Dactylorhiza spp.
14	Askale-Erzurum	39 º 56 N' ; 40º 45 E'	1690	Dactylorhiza spp., Orchis spp.
15	Askale-Erzurum	39 º 56 N' ; 40º 36 E'	1626	Dactylorhiza spp., Orchis spp.
16	Pirnakapan-Askale	39 º 59 N' ; 40º 33 E'	1818	Dactylorhiza spp.
17	Kop-Bayburt	40 º 02 N' ; 40º 31E'	2376	Dactylorhiza spp.
18	Nenehatun-Erzurum	39 º 57 N' ; 41º 24 E'	1864	Dactylorhiza spp.
19	Nenehatun-Erzurum	39 º 58 N' ; 41º 25 E'	1839	Dactylorhiza spp., Orchis spp.
20	Nenehatun-Erzurum	39 º 58 N' ; 41º 28 E'	1810	Dactylorhiza spp., Orchis spp.
21	Koprukoy-Erzurum	40 º 01 N' ; 41º 59 E'	1583	Dactylorhiza spp., Orchis spp.
22	Horasan-Erzurum	40 º 05 N' ; 42º 19 E'	1522	Orchis spp.
23	Tasliguney-Cat	39 º 46 N' ; 41º 02 E'	2132	Dactylorhiza spp.
24	Tasliguney-Cat	39 º 43 N' ; 40º 58 E'	2242	Dactylorhiza spp.
25	Cat-Erzurum	39 º 36 N' ; 40º 58 E'	1909	Orchis spp.
26	Cat-Erzurum	39 º 36 N' ; 40º 58 E'	1894	Orchis spp.
27	Karliova-Bingol	39 º 35 N' ; 40º 55 E'	1865	Orchis spp.
28	Karliova-Bingol	39 º 33 N' ; 40º 55 E'	1792	Orchis spp.
29	Yagan-Erzurum	39 º 53 N' ; 41º 57 E'	1772	Orchis spp.
30	Guzelhisar-Erzurum	39 º 49 N' ; 41º 59 E'	1934	Dactylorhiza spp., Orchis spp.
31	Hinis-Erzurum	39 º 38 N' ; 41º 56 E'	2022	Dactylorhiza spp.
32	Hinis-Erzurum	39 º 36 N' ; 41º 54 E'	2053	Dactylorhiza spp.
33	Hinis-Erzurum	39 º 35 N' ; 41º 45 E'	1857	Orchis spp, Dactylorhiza spp.
34	Hinis-Erzurum	39 º 23 N' ; 41º 41 E'	1650	Orchis spp, Dactylorhiza spp.
35	Hinis-Erzurum	39 º 34 N' ; 41º 44 E'	1856	Orchis spp, Dactylorhiza spp.
36	Yagan-Erzurum	39 º 47 N' ; 41º 47 E'	1760	Orchis spp

Table 2: The amount of moisture retained at different tensions (% of volume), bulk density (γ_s) and pore size distribution (%) of soils in orchids growing areas in Eastern Turkey

Area No.	Tensions (Mpa)		γ_s	Pore Size (µm)			
	<0.03	0.03-1.5	(g cm^{-3})	>100	100-30	30-3	<3
1	36.79	9.69	0.81	25.25	3.42	11.28	26.30
2	29.08	13.58	0.74	18.84	9.18	4.36	34.65
3	31.66	14.25	0.75	23.11	7.21	4.79	32.67
4	37.71	10.69	0.78	27.39	9.22	1.30	29.41
5	35.19	12.73	0.82	25.66	6.58	3.59	30.06
6	29.98	11.95	0.82	16.87	2.74	13.16	31.76
7	33.61	12.04	0.86	16.98	1.61	17.98	27.59
8	29.16	10.66	0.91	16.22	2.81	12.14	30.89
9	35.64	10.75	0.74	21.03	9.33	9.03	28.15
10	39.98	17.47	0.34	25.90	1.30	19.72	33.64
11	28.42	14.36	0.76	17.97	5.30	11.38	32.32
12	40.68	11.53	0.74	31.39	6.05	6.65	25.29
13	30.91	9.46	0.79	22.95	2.94	10.56	31.00
14	27.39	9.62	0.84	18.63	5.75	9.07	31.52
15	40.54	5.15	0.47	21.42	11.15	11.80	32.76
16	57.43	11.37	0.24	36.85	14.32	9.54	25.71
17	31.32	14.41	0.68	18.98	4.14	13.48	33.38

18	30.24	13.21	0.66	18.24	5.40	12.09	35.08
19	49.89	20.54	0.19	30.93	13.56	11.81	32.30
20	20.24	18.60	0.75	14.80	0.77	10.25	41.69
21	30.82	13.33	0.85	23.69	3.19	8.07	30.74
22	45.88	30.96	0.19	32.37	6.60	27.75	21.66
23	37.44	10.71	0.71	29.05	3.75	6.89	30.36
24	33.04	14.11	0.64	18.81	9.37	11.17	29.52
25	32.12	11.80	0.72	21.25	7.22	7.06	32.55
26	25.17	15.89	0.72	13.79	8.21	8.62	37.17
27	34.95	13.18	1.00	24.85	6.60	6.66	22.75
28	31.76	12.35	0.81	21.94	7.89	7.30	28.32
29	40.64	17.36	0.45	17.11	15.26	13.38	33.37
30	40.71	9.65	0.77	27.46	9.44	8.12	23.76
31	39.01	12.12	0.57	23.59	9.78	11.55	29.67
32	31.39	13.32	0.78	18.79	7.46	12.08	29.66
33	35.30	14.02	0.79	22.61	7.35	9.28	26.03
34	29.08	12.38	0.83	17.72	7.86	8.84	28.47
35	25.64	13.56	0.78	15.02	5.26	10.97	32.77
36	23.73	12.61	1.01	15.29	3.62	10.22	25.16
$LSD_{0.01}$	4.22	1.62	0.03	5.35	2.01	2.73	2.05

Table 3: chemical properties of soils in orchids growing areas in Eastern Turkey

Area Number	EC (dS m^{-1})	pH	Organic Matter (%)	$CaCO_3$ (%)	Micro Elements (ppm)						
					Cu	Fe	Zn	Cd	Pb	Cr	Mn
1	1.32	7.42	5.38	24.03	1.41	6.74	0.69	0.04	0.97	4.19	5.54
2	1.46	7.04	7.38	14.34	2.95	4.98	0.71	0.05	1.28	2.31	4.98
3	1.69	7.34	6.94	13.63	5.01	7.43	0.54	0.05	1.37	1.87	14.03
4	0.90	7.37	4.34	7.44	3.09	5.92	0.09	0.02	0.66	2.26	0.00
5	1.10	7.33	3.77	5.71	2.07	6.23	0.01	0.04	0.68	3.23	13.24
6	0.95	7.60	2.09	4.88	1.70	3.89	0.04	0.03	0.98	2.29	3.50
7	0.84	7.38	4.56	3.06	1.65	4.13	0.13	0.06	1.00	8.36	3.06
8	0.74	7.63	3.25	12.90	1.14	4.25	0.00	0.06	1.31	4.72	5.67
9	0.81	7.46	7.66	6.88	2.90	4.04	0.08	0.08	1.27	2.75	4.67
10	0.91	6.56	17.29	1.25	0.13	47.43	0.08	0.07	0.99	4.36	5.09
11	0.88	7.29	4.75	11.49	3.48	5.03	0.02	0.07	0.99	6.50	12.95
12	0.89	7.53	6.04	16.27	2.65	10.12	0.00	0.05	0.97	5.09	2.79
13	1.90	6.86	4.48	23.90	3.92	15.14	0.00	0.03	0.96	2.37	5.67
14	1.21	6.84	3.94	18.94	2.63	7.90	0.00	0.05	1.11	5.28	4.13
15	0.97	6.89	25.80	7.10	3.66	20.17	0.14	0.06	1.16	6.99	3.34
16	1.31	7,19	34.92	0.78	0.60	24.27	0.02	0.03	0.99	6.65	15.89
17	1.22	7.10	6.53	1.54	4.98	8.00	0.46	0.05	1.24	3.15	15.95
18	0.98	7.22	8.72	13.57	2.50	5.00	0.00	0.12	0.98	6.32	13.98
19	0.89	6.81	38.96	1.49	0.11	105.75	0.01	0.03	1.16	4.34	2.52
20	1.46	7.81	5.00	6.76	3.17	4.56	0.02	0.04	1.36	5.27	0.00
21	0.90	7.46	2.19	5.03	3.77	6.10	0.00	0.04	1.66	4.71	4.30
22	0.47	5.71	33.52	1.09	0.00	131.61	0.03	0.03	1.20	2.82	2.26
23	1.18	6.83	8.82	0.31	4.14	52.82	0.01	0.11	1.43	6.96	16.41
24	2.97	6.95	10.39	11.44	2.65	20.35	0.18	0.12	1.89	5.61	14.00
25	1.52	6.57	7.03	0.71	1.95	8.31	0.02	0.08	1.58	5.46	14.87
26	0.96	6.91	4.88	0.44	4.18	9.65	0.22	0.11	1.59	2.86	14.80
27	1.15	7.53	1.06	36.60	0.23	5.06	0.06	0.05	1.05	2.76	2.09
28	1.18	7.25	4.44	14.02	2.94	6.15	0.12	0.05	1.68	6.03	4.03
29	1.93	7.00	15.33	20.72	2.53	17.62	0.32	0.04	1.91	8.65	12.78
30	0.69	6.78	5.24	0.71	1.14	36.00	0.16	0.05	1.40	6.20	16.57
31	1.54	6.94	14.09	17.69	3.89	18.86	0.41	0.11	2.40	5.46	15.63
32	1.40	7.22	3.48	19.85	3.00	4.79	0.12	0.04	2.55	6.93	5.16
33	0.81	7.46	4.58	5.16	3.14	15.57	0.18	0.06	2.19	6.37	14.43
34	1.09	7.23	3.74	12.99	2.38	5.50	0.17	0.05	2.93	7.50	4.31
35	0.72	7.44	6.46	14.98	3.84	5.73	0.24	0.06	2.58	6.76	12.70
36	0.48	7.54	5.21	43.50	0.71	4.02	0.11	0.05	2.10	6.99	2.81
$LSD_{0.01}$	0.36	0.03	0.22	1.33	0.67	2.65	0.04	0.03	0.26	1.43	0.52

soils (Sezen, 1995). The highest and lowest carbonate values were obtained as 43.50 % and 0.31% (Table 3). According to the analysis results, carbonate values of orchid growing areas soils were higher than 5.0% for 25 area soils. Therefore, these soils could be classified as medium, high and very high carbonates include groups (Ergene, 1993).

The statistical differences among the growing areas soils was observed based on Cu, Fe, Zn, Cd, Pb, Cr and Mn contents (Table 3). The Cu, Fe, Zn, Cd, Pb, Cr and Mn values of soil searched were between 0.0 ppm and 5.01 ppm, 3.89 ppm and 131.61 ppm, 0.0 ppm and 0.71 ppm, 0.02 ppm and 0.12 ppm, 0.66 ppm and 2.93 ppm, 1.87 ppm and 8.65 ppm and 0.0 ppm and 16.57 ppm, respectively. The significance of micro elements for plant growth and development is well documented in literature (Ergene, 1993).

Conclusion: The Chemical and physical analyses of the soils did not show any distinguishable results in relation to orchid species, but in altitude of locations. It was noticed that higher altitudes of more than 2000 m were not suitable for the Orchis spp. whereas the Dactylorhiza spp. was not affected. According to these results, it could be concluded that the type of mycorrhizae in the soil and climate factors of region are more effective in orchid species distribution than soil characteristics.

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