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Full Length Research Paper

Some soil parameters in *Campanula* species (sect. *Quinqueloculares*) from Mediterranean climate areas in Turkey

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Ten soil samples from the Mediterranean region of Turkey were analysed to evaluate the ecology of *Campanula* species. Most soils in the research area were alkaline and salt content was high. Degrees of saturation were considered normal in all the soil samples and, generally, total nitrogen values were low. For all samples, the total concentration of macro- and micro-elements were determined. There were significant differences in concentration of Mg, P, N in the upper zone of the soils, and in pH, salinity, lime, saturation (%) between species. There were no significant differences in the concentrations of Ca, Cu, Fe, K, Mn, Na, and Zn between the upper and lower zones.

Key words: *Campanula*, macro- and micro-elements, Mediterranean region (Turkey).

INTRODUCTION

Of approximately 300 known species belonging to the Campanula genus around the World, 150 are found in the Mediterranean region (Cronquist, 1988; Heywood, 1998). The genus is among the genera containing the highest number of endemic species in the region, with an endemic ratio of more than 50%. The East Mediterranean region, which includes Turkey, is especially rich in *Campanula* spp, with more than half of the 150 species being found in this region. The East Mediterranean region, which includes Turkey, is considered as the diversification region of *Campanula* according to Contandriopoulos (1984) and the genus is represented by 131 taxa.

The species examined, belonging to the sect Quinqueloculares in Turkey were *Campanula crispa* Lam., *C. tomentosa* Lam., *C. vardariana* Bocquet, *C. iconia* Phitos, *C. lyrata* Lam. subsp. *lyrata, C. hagielia* Boiss., *C. sorgerae* Phitos, *C. betonicifolia* Sm., *C. telmessi* Hub.-Mor. & Phitos, *C. davisii* Turrill (Damboldt, 1978; Davis et al., 1988; Güner *et al.*, 2000; Özhatay et al., 1999, Özhatay et al., 2006, Özhatay et al., 2009; Alçitepe and Yildiz, 2010).

General information regarding the *Campanulaceae* family is found only in Metcalfe and Chalk's (1983) study. Damboldt (1976) identified this absence of information regarding the *Campanulaceae* family. Chapman (1966) was the first researcher to analyse the relationship between pollen morphology and taxonomy. Avetisjan (1967, 1973) then researched 31 species in 21 genera that belong in this family. He created an evolutionary scheme for the members of the *Campanulaceae* family based on the development of apertures from a colpus structure to one containing many pores. Dunbar (1973, 1975 and 1975b; 1976, 1981) is another researcher interested in the subject of *Campanulaceae* (Ocak ve Tokur, 1996; Potoğlu et al., 2008).

The long-term effects or mobilization of microelements in soil were studied by Nagy et al. (2004); Iene and Rima, (1998); Sheng et al. (2003) and Gurmani et al. (2003). The use of macro and micronutrients by some plants has been studied by Kök et al. (2007), Sherif et al. (2009) and Kutbay et al. (1999).

Campanulas, just like in the temperate regions of the Northern hemisphere, are spread in the Aegean and Mediterranean coastlines of Turkey annually, biannually, or perennially between the months of February and July.

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With their significance during pollination, the nature of their campanulate flowers, and beautiful colors, their species that are in demand by the European gardens, such as *C. glomerata* and *C. rotundifolia*, are frequently used in the garden culture; and their shrub and herbaceous forms are availed.

The information regarding the *Campanula* species, other than these species, although most of them are endemic for Turkey, on the other hand, is insufficient. The investigation of the feeding habitat of different *Campanula* species by culturing, for their savings, both to the nature and market, was purposed in this study.

MATERIALS AND METHODS

Investigations were conducted in 10 locations where *Campanula* species can be found in the Mediterenean region, which karstic areas were also investigated. The *Campanula* species were surveyed between 2002 and 2005, and collections were kept in the herbarium of Celal Bayar University. The collections were compared with plants in the AEF, ANK, ATA, BULU, EGE, FUH, GAZI, HUB, ISTE, ISTF, IZEF and KNYA herbariums in Turkey and in the LD, OXF, UPA and Missouri Botanical Gardens.

Campanula prefers to live under the drought condition and can survive in shady areas in some parts of the Meditterenean region alongside streams and on riversides. The following 10 taxa were selected for study in these investigations (Figure 1):

1) Campanula crispa Lam. A8 Erzurum: 50 Km from Tortum, calcareous rocks, mostly in maquis, 1800-1900 m, 1.08.2002, E. *Alçıtepe* 2129, Ir.-Tur. El.
2) C. tomentosa Lam. C1 Aydın: Aydın-Đzmir road, roadside, limestone rocks, in maquis, 50-60 m, 26.05.2002, *E. Alçıtepe* 2113, E. Med. El., endemic.
3) C. vardariana Bocquet C1 Aydın: Aydın, Söke, near Cement Factory, rocky slopes, clearing maquis, 100-130 m, 17.05.2004, *E. Alçıtepe* 2265. ibid. *E. Alçıtepe* 2345. E. Med. El., endemic.
4) C. iconia Phitos B3 Konya: Ak ehir, Tekke village-Ortaburun hills, Çiçekli high plateau, North slopes, *Q. ithaburensis*, in pine and quercus forest, mixed deciduous schrub forest, c.1784 m, 11.07.2003, *E. Alçıtepe* 2247, Ir.-Tur. El., endemic.
5) C. lyrata Lam. subsp. *lyrata* B1 Manisa: Spil Mountain, At location, stony slopes, in maquis, 1000 m, 25.03.2003, *E. Alçıtepe* 2148, endemic.
6) C. hagielia Boiss. C2 Muğla: Kaunos ruins, calcareous rocks, mixed pine forest and maquis, c. 100 m, 08.05.2003, *E. Alçıtepe* 2136, E. Med. El., endemic.
7) C. sorgerae Phitos B2 U ak: Between Kula – U ak, 50 km of U ak, rocky, open slopes, c. 900 m, 28.05.2004, *E. Alçıtepe* 2268, endemic.
8) C. betonicifolia Sm. B1 Đzmir: Bozdağ mountain, Küçük Çavdar Pasture, in steppe, on rocks, c. 1500-1600 m, 29.06.2002, *E. Alçıtepe* 2121., E. Med. El., endemic.
9) C. telmessi Hub.-Mor. & Phitos C2 Muğla: Fethiye, Kayaköy, calcareous rocks, moist places and in stone, 150-200 m, 16.06.2002, *E. Alçıtepe* 2115, E. Med. El., endemic.
10) *C. davisii* Turrill C4 Karaman: Ermenek, Kazancı town, Koça location, on rocks, under *Cedrus libani* forest, 1500 m, 22.6.2002, *E. Alçıtepe* 2116. E. Med. El., endemic.

The area of investigation extends from brown forest soil to red Mediterranean soil in the Mediterranean region. Soil samples from 10 locations at 2 different depths (0 to 10 cm and 10 to 20 cm.) during vegetative and generative periods between 2002 and 2005 were investigated. For all soil samples, the total concentrations of Ca, Mg, K, Mn, Na, Fe, Cu, Zn, P, N were determined. 2 kilograms of soil samples in polyethylene bags were taken from maquis, steppe and forest habitats. All samples were ground to 2 mm, air dried and homogenized. Tables were generated from the analysis of texture, organic matter, N (%), salinity, saturation (%), pH, macroelements and microelements.

The texture of the soils was estimated using a Bouyoucos hydrometer (Bouyoucos, 1951). Soil pH was determined using a combination-glass electrode. Soil salinity and conductivity were measured with Orion Salinimeters. The percentage of organic matter in the soil was determined by Walkely and Black's rapid titration method (Jackson, 1962; Levinson, 1983). Organic N was determined with the Semimicro-Kjeldahl procedure (Dommerques and Mangenot, 1970; Bremner, 1965; Bunderson, 1985). Phosphorus in the soil was determined using the method described by Bingham (Abdu, 2006). The concentrations of the minerals Na^{+}, K^{+}, Fe^{+3},Ca^{+2}, Mg^{+2} and Zn^{+2} in the soil were determined using a Perkin 403 atomic absorption spectrophotometer as described by Levinson (1983) and Jackson (1962). Each measurement was repeated three times and mean values for the nutrient content (chemical elements) and physical parameters, presented.

Statistical analysis, mean values and standard deviations of elemental concentrations in soils of all taxa were subjected to a variance analysis (a two-way ANOVA). Chemical and physical (for example, texture, salinity, lime and saturation) soil characterization was also performed and the statistical methodologies, presented in the result tables. Statistical analyses were done by SPSS v.11.5 statistical package and p values equal to or less than 0.05 were regarded as statistically significant.

RESULTS

The results revealed that *Campanula* spp. grow from the calcareous to noncalcareous clayey loam, sandy loam and loamy soils. Generally, the pH, saturation, organic matter, nitrogen and phosphorus values of the saline soils ranged between 9.62 to 6.52; 11.06 to 49.10; 0.30 to 5.48; 0.07 to 0.28 and 1.47 to 2.37, respectively (Tables 1, 2 and 3). Most soils in the research area are alkaline and salt content is much greater than lime. Saturation degrees were considered normal in all the soil samples and total nitrogen values were generally low. Salt and saturation increased in vegetative periods while pH, lime and total N increased in generative periods. Ca, Mg, Mn and P values increased in vegetative periods, while Cu, Fe, K, Na and Zn increased during generative periods. (Tables 4 to 5)

In the upper zone, nitrogen concentrations were higher than in the lower zone. The values of P, Na, Mg, K, Ca were also higher in the upper zone, but Cu, Fe, Mn and Zn were higher in the lower zone in all types of soil (Table 4-5). There were parallel mean values in our study except for K, salinity and $CaCO_3$ values (Table 1) (Kök et al., 2007).

Compared to our results in Salix soil in Egypt, Fe and Na are higher, Mg is similar, and K and Ca are lower (Table 2) (Al Sherif et al., 2009).

The high values of the elements (N, K, Cu, Na), salinity and saturation degrees were found in the soil of *Campanula tomentosa.* High levels of N, K, Zn and

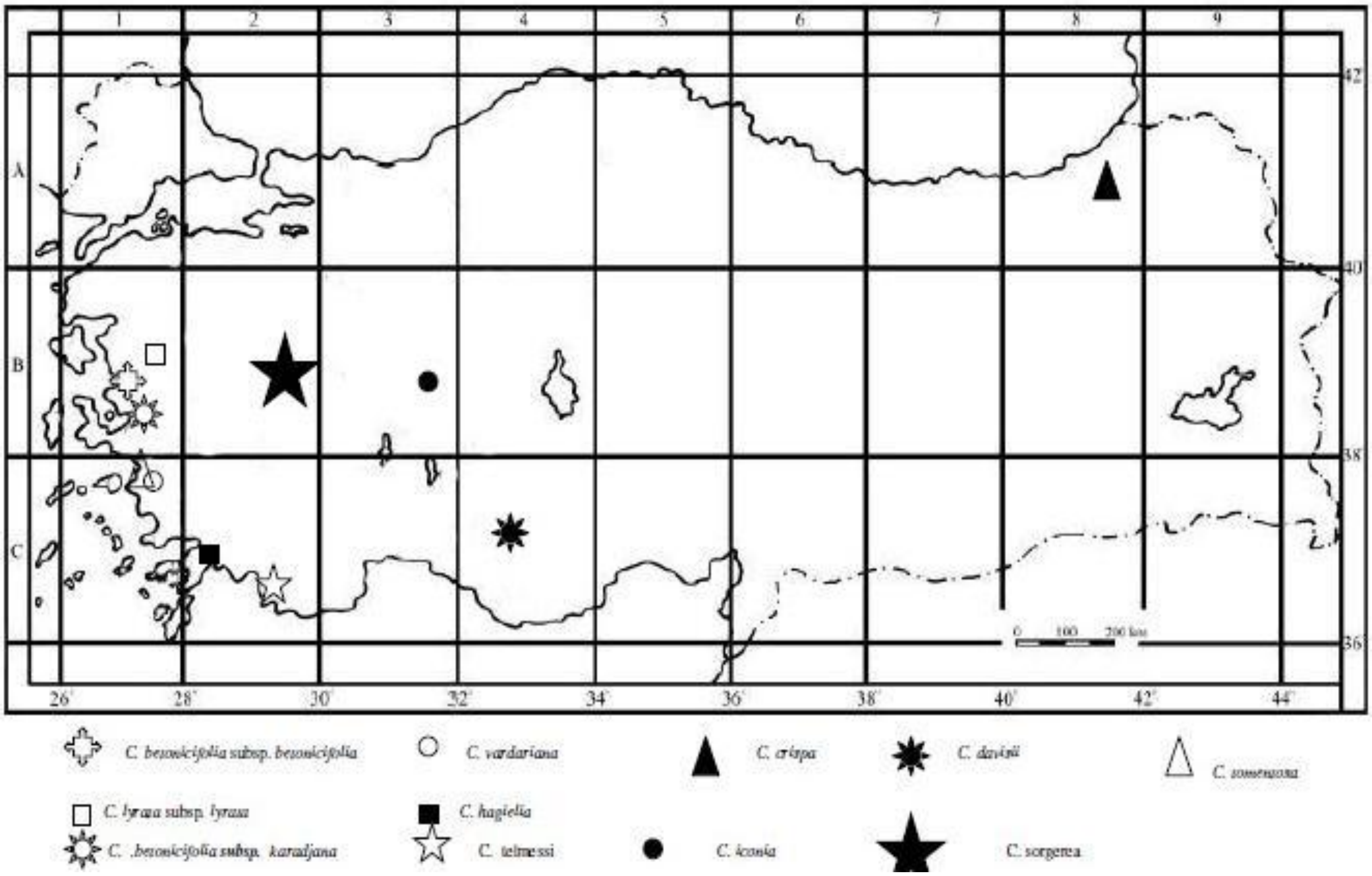

Figure 1. The map of the localities of the collected materials.

saturation were observed in the soil of *C. iconia;* high levels of Mn, P and Zn and a high pH value were found in the soil of *C. crispa;* Ca, Fe, Mg, Zn and lime had high values in the soil of *C. vardariana;* Mg, P and Na had high values in the soil of *C. telmessi;* Ca, K, Fe, saturation and lime had high values in the soil of *C. davisii;* Mg, K, Na, Fe, salinity and pH had high values in the soil of *C. hagielia.* Salinity was low in *C. sorgerae*. pH concentrations and lime concentration were low in the soil of *C. iconia*; saturation concentrations were low in the soil of *C. hagielia;* pH was high in the soils of *C crispa, C. vardariana, C. davisii* and *C. sorgerae;* and finally, all of the elements (N, Ca, Cu, Fe, K, Mg, Mn, Na, P, Zn) and lime values were found were low in the soil of *C. betonicifolia*. All of this data is shown in Tables 6,7 and 8.

Conclusıon

This study found significant differences in the soil concentrations of Mg, P and N in upper zone soils. Significant differences in pH, salinity, lime, saturation (%) were found between species. No significant differences were found in Ca, Cu, Fe, K, Mn, Na or Zn between the upper and lower zones. pH (p = 0.028), salinity (p= 0.002), lime (p = 0.017), saturation (p = 0.012) and total nitrogen (p = 0.048) values were significantly different between species of *Campanula*.

The nutrients (Ca, Cu, Fe, K, Mg, Mn, Na, P, Zn), total N, pH, salinity, lime and saturation (%) did not change significantly between generative and vegetative periods in the soils.

Kök et al., (2007) observed that there were significant differences between the two growth periods in respect of soil N concentration, organic matter, pH and salinity, while P, K and Ca did not change significantly.

According to some researches (Doğan et al., 2003), K and P are deficient in many Mediterranean soils. All the soils of taxa examined for Ca, Mg and K concentrations have them at the highest levels as macroelements compared with the other elements. For all samples, the levels of the elements were found in the following order: Ca, Mg, K > Mn, Na > Fe, Cu, Zn, P.

The Mn and Cu levels were slightly increased while Zn diminished because this element is chemically more mobile than Cu and Mn(this is demonstrated in this study).

Table 1. The present study compared with the *Romulea* soils in Turkey.

Nutrient	Growth phaze	Kök et al., 2007	Our study
N (%)	vegetative	0.48 ± 0.06	0.427± 0.491
	generative	0.29 ± 0.04	0.524± 0.955
P (ppm)	vegetative	4.20 ± 0.01	2.379± 1.602
	generative	2.0 ± 0.004	1.737± 1.474
K (ppm)	vegetative	0.55 ± 0.10	199.856± 133.556
	generative	0.31 ± 0.02	223.954± 111.223
Organic matter (%)	vegetative	4.37 ± 0.50	5.480± 0.300
	generative	7.73 ± 1.36	-
pH	vegetative	6.95 ± 0.17	7.450± 0.741
	generative	6.95 ± 0.17	7.450± 0.741
$CaCO_3$ (%)	vegetative	0.39 ± 0.07	13.986± 14.414
	generative	1.38 ± 0.72	17.230± 15.456
Salt	vegetative	0.05 ± 0.006	374.100± 271.684
	generative	0.07 ± 0.006	328.545± 158.974

Table 2. The present study compared with the *Salix* soil in Egypt.

	Al Sherif et al., 2009	Our study (vegetative)
pH	7.3 ± 0.3	7.235± 0.602
Organic matter (%)	1.1 ± 0.01	5.480± 0.300
Na (ppm)	289.0± 23.1	30.047± 25.535
K (ppm)	11.0± 1.3	199.856± 133.556
Ca (ppm)	572.0± 53.4	3646.090 ± 870.661
Mg (ppm)	144.0± 41.2	190.666± 116.775
Fe (ppm)	73.0 ± 13.2	16.637 ± 9.695

Limed soil is more rich in mobile Cu and Mn (Iene and Rima, 1998). Hernandez et al., (1999) indicate that the associations between the macronutrients optimizes the phytomass production. An increase in the ion content of the soils may be accompanied not only by a decrease in quality, but also by a disturbance in soil-plant cover.

This study has found that *Campanula* species thrive best in soil rich in Ca, Mg, K, P, Na and Fe. The organic material in the soil is the largest resource for the nitrogen inside the soil. On the other hand, there is also a need for mineralization in a ratio developing in relation with pH and humidity. N mineralization level is low in the clayey structures, and therefore, the plant can suffer from a hunger for N. The higher levels of Fe intake can be encountered for unaired soils. Also, the macroelement values (Ca, Mg, P), values in the rocky habitats of maquis are notably high, for example: *C. telmessi* (loamy, noncalcareous), *C. tomentosa* (clayey loam, calcareous), *C. crispa* (loamy, noncalcareous), and *C. vardariana* (sandy loam, calcareous). But a considerable amount of microelements were also found in maquis soils, for example, *C. lyrata* (under maquis), *C. hagielia* (under maquis), *C. iconia* (under Quercus).

Levels of all the elements and lime were low in the steppe soil of *C. betonicifolia.* Generally, $CaCO_3$, organic matter, P and K values were high in *Quercus coccifera* L. in Denizli (Çelik et al., 2004). Similar results may indicate that the avaliability of nutrients is related to maquis. This study is conducted for the preparation of the soil cultures belonging to the different species of *Campanula*, and it determines the limit concentration values of nutritional elements. According to the results of the analysis, it was

Table 3. Comparative of pH, salinity, lime, saturation and total N (%) in vegetative and generative periods of the soils.

	Samples	Mean ± SD	p
pH	vegetative	7.235 ± 0.602	0.478
	generative	7.450 ± 0.741	
Salınıty	vegetative	374.100 ± 271.685	0.641
	generative	328.546 ± 158.974	
Lıme	vegetative	13.986 ± 14.414	0.626
	generative	17.231 ± 15.457	
Saturatıon	vegetative	49.100 ± 15.688	0.279
	generative	42.546 ± 11.067	
Total N	vegetative	0.427 ± 0.491	0.775
	generative	0.525 ± 0.956	

Table 4. Comparative of the elements vegetative and generative periods of the soils.

	SAMPLE	Mean ± SD	p
Ca (ppm)	vegetative	3646.090 ± 870.662	0.925
	generative	3601.455± 1218.495	
Cu (ppm)	vegetative	13.927± 15.416	0.513
	generative	18.770± 17.612	
Fe (ppm)	vegetative	16.637 ± 9.695	0.481
	generative	20.244± 12.871	
K (ppm)	vegetative	199.856± 133.556	0.657
	generative	223.955± 111.224	
Mg (ppm)	vegetative	190.667± 116.776	0.278
	generative	132.815± 120.251	
Mn (ppm)	vegetative	20.076± 11.261	0.448
	generative	15.644± 14.564	
Na (ppm)	vegetative	30.047± 25.536	0.892
	generative	31.435± 20.585	
P (ppm)	vegetative	2.379± 1.602	0.351
	generative	1.737± 1.475	
Zn (ppm)	vegetative	2.875± 7.070	0.740
	generative	4.115± 9.482	

detected that *Campanula* species can live at alkali neutral pH values and in saline and lime soils, and also be content with low levels of N and normal organic matter contents.

Table 5. Comparative of the elements between upper zone and lower zone of the soils.

	Sample	Mean ± SD	p
Ca (ppm)	Lower zone	25222.717± 12775.671	0.135
	Upper zone	33727.633± 14033.560	
Cu (ppm)	Lower zone	11.734 ± 6.024	0.472
	Upper zone	10.132 ± 4.605	
Fe (ppm)	Lower zone	168.858± 104.540	0.611
	Upper zone	149.187 ± 80.422	
K (ppm)	Lower zone	16112.183 ± 7777.956	0.161
	Upper zone	20323.708 ± 6376.229	
Mg (ppm)	Lower zone	4029.645± 1916.678	0.029
	Upper zone	6368.942± 2891.745	
Mn (ppm)	Lower zone	61.285± 31.701	0.489
	Upper zone	50.463± 42.832	
Na (ppm)	Lower zone	795.699± 778.595	0.978
	Upper zone	806.296 ± 1025.090	
P (ppm)	Lower zone	1279.484 ± 622.032	0.041
	Upper zone	2023.278± 1012.593	
Zn (ppm)	Lower zone	36.214± 34.711	0.683
	Upper zone	31.511± 18.577	

Table 6. Comparative of texture, salinity, lime, saturation (%) and pH values of the soils.

Sp.	Texture	Salinity	Lime	Saturation	pH
C. crispa	Loam, noncalcerous	302.500 ± 92.631	18.390 ± 23.434	33.000 ±	8.600 ± 1.443
C.tomentosa	Clayey loam, calcerous	897.500 ± 280.721	24.320 ± 4.299	71.000 ± 15.556	6.740 ± 0.141
C.vardariana	Sandyloam, calcerous	367.000 ± 181.019	36.100 ± 1.612	30.500 ± 0.707	8.195 ± 0.361
C. iconia	Clayeyloam, noncalcerous	300.500 ± 26.163	1.140 ± 0.537	56.000 ± 1.414	6.630 ± 0.156
C. lyrata	Loam, calcerous	261.000 ± 86.267	22.040 ± 5.374	48.000 ± 2.828	7.390 ± 0.396

Table 6. Contd.

C. hagielia	Clayeyloam, calcerous	473.000 ±	8.360 ±	28.000 ±	7.000 ±
C. sorgerae	Loam, calcerous	223.000 ± 11.314	19.760± 19.346	33.500 ± 3.536	8.425 ± 0.346
C.betonicifolia	Loam, noncalcerous	372.500 ± 3.536	1.900± 0.537	48.500±19.092	7.180 ± 0.552
C. telmessi	Loam, noncalcerous	357.000 ± 60.811	3.420± 1.612	40.000 ± 7.071	7.520 ± 0.184
C. davisii	Clayeyloam, calcerous	283.333 ± 20.841	33.440 ± 4.984	50.667 ± 6.658	7.573 ± 0.497

Table 7. Comparative of total N and organic matter between upper zone and lower zone of the soils.

	Sample	Mean ± SD	p
N (%)	Lower zone Upper zone	0.188 ± 0.078 0.282 ± 0.072	0.006
Organic matter (%)	Lower zone Upper zone	1.80 ± 1.73 3.59 ± 1.94 3.27 ± 1.67	

Table 8. The nutrient ratios in the soils of *Campanula* taxa.

Spp./ *P*	N (0.48)	Ca (0.84)	K (0.770)	P (0.730)	Na(0.072)	Mg(0.913)	Mn(0.681)	Fe(0.931)	Cu(0.053)	Zn(0.237)
C. crispa	0.145 ± 0.146	11852.650 ± 11391.303	11201.576 ± 13144.229	1654.260 ± 2091.437	145.794 ± 143.642	2348.901 ± 2942.081	61.038 ± 80.905	135.342 ± 143.846	12.915 ± 10.892	25.129 ± 28.610
C. tomentosa	1.280 ± 1.310	23264.825 ± 20916.781	8196.790 ± 9707.649	965.683 ± 1108.660	726.745 ± 1058.203	3050.315 ± 3139.341	43.992 ± 22.311	91.083 ± 89.087	29.830 ± 19.534	35.294 ± 10.208
C. vardariana	0.150 ± 0.154	26520.725 ± 27842.934	6778.340 ± 7535.169	492.681 ± 574.939	464.489 ± 596.453	4275.475 ± 5170.717	26.891 ± 26.999	101.992 ± 85.474	23.456 ± 19.894	33.678 ± 39.865
C. iconia	0.685 ± 0.537	14488.375 ± 13115.327	8612.588 ± 10879.819	900.492 ± 1284.439	87.544 ± 88.416	1845.540 ± 2060.321	42.345 ± 16.274	61.183 ± 56.585	7.186 ± 3.617	48.791 ± 58.445
C. lyrata	0.345 ± 0.412	15181.375 ± 14708.682	11535.258 ± 13100.414	770.422 ± 1069.337	198.995 ± 210.628	2457.583 ± 2970.850	36.431 ± 12.684	72.841 ± 67.674	20.889 ± 15.958	11.091 ± 11.229
C. hagielia	0.277 ± 0.180	17921.433 ± 11754.694	8321.860 ± 7538.693	915.073 ± 797.141	1365.594 ± 1675.824	3284.433 ± 2920.262	31.441 ± 8.055	95.942 ± 89.480	10.920 ± 6.413	11.735 ± 9.918
C. sorgerae	0.110 ± 0.119	14499.175 ± 13750.990	7487.783 ± 8370.238	578.506 ± 838.037	125.385 ± 80.492	2991.193 ± 3892.692	33.837 ± 33.227	81.944 ± 77.278	7.093 ± 2.757	7.772 ± 9.463
C. betonicifolia	0.096 ± 0.054	4296.950 ± 1602.113	2700.903 ± 2917.972	161.242 ± 185.872	47.284 ± 25.413	450.076 ± 373.202	13.176 ± 11.571	50.466 ± 44.572	4.601 ± 3.945	2.218 ± 1.861
C. telmessi	0.153 ± 0.148	17139.075 ± 15902.914	14758.068 ± 16903.427	1222.806 ± 1455.747	1128.987 ± 1265.290	4897.013 ± 5550.787	43.746 ± 32.022	80.042 ± 70.066	12.725 ± 2.071	10.706 ± 11.644
C. davisii	0.293 ± 0.324	23285.760 ± 26438.262	6837.183 ± 9777.374	668.525 ± 915.678	94.105 ± 112.517	2291.466 ± 3382.904	38.294 ± 45.013	146.330 ± 208.015	11.435 ± 5.770	11.868 ± 15.340

It was determined that the species required for higher values as regards to the Ca, Mg, Na, and K contents constitute the principal elements cation exchange capacity and have significance in relation with the plant ion intake and soil efficiency. The species were determined to be content with low levels of P and Na but can endure heavy metals (micro elements), such as Zn, Cu, and Fe, only in low concentrations.

REFERENCES

Abdu N (2006). Soil-phosphorus extraction methodologies: A review African J. Agric.l Res., 1(5): 159-161.

Al Sherif A, Emad AW, Khodary AES, Azmy W (2009). Ecological Studies on Salix Distribution in Egypt. Asian J. Plant Sci., 8(3): 230-234.

Alçıtepe E, Yıldız K (2010). Taxonomy of Campanula tomentosa Lam. and C. vardariana Bocquet from Turkey''. Turk. J. Bot., 34: 191-200.

Avetisjan EM (1967). Morphology of pollen grains of the families Campanulaceae and allied families (Sphenocleaceae, Lobeliaceae, Cyphiaceae) in relation with their systematics and phylogeny. Trudy Bot. Inst. Armenian Acad. Sci., 16: 5-41.

Avetisjan EM (1973). Palynology of the order Campanulales. In: Spores and pollen morphology of recent plants (in Russian). 3rd. Int. Palynol. Conf., Acad. Sci., 90-93, USSR, Leningrad.

Bouyoucos GS (1951). A Recalibration of the Hydrometer for Mohing Mechanical Analysis of Soil. Agron. J., 43: 434-438.

Bunderson ED, Weber DJ, Davis JN (1985). Soil mineral composition and nutrient uptake in Juniperus osteosperma in 17 Utah Sites. Soil Sci. Soc. Am., 139(2): 139-148.

Chapman JL (1966). Comparative Palynology in Campanulaceae. Trans. Acad. Sci., 69(3-4): 196-200.

Contandriopoulos J (1984). Differentiation and evolution of the genus Campanula in the Mediterranean region. In: Plant Biosystematics, ed. W. F. Grant. Toronto: Academic Pres, pp. 141-156

Cronquist A (1988). The evolution and classification of flowering plants. The New York Botanical Garden, New York.

Cruz A, Moreno JM (2001). Lignotuber Size of Erica australis and Its Relationship with Soil Resources Source. J. Veg. Sci., 12(3): 373-384 Blackwell Publishing http://www.jstor.org/stable/3236851

Çelik A, Çiçek M, Semiz G, Karıncalı M (2004). Taxonomical and Ecological Investigations on Some Geophytes Growing Around Denizli Province (Turkey). Turk J. Bot., 28: 205-211.

Damboldt J (1976). Materials for a flora of Turkey XXXII: Campanulaceae. Notes from the R.B.G. Edinb., 35: 39-52.

Damboldt J (1978). Campanula L. In: Davis PH (ed.) Flora of Turkey and the East Aegean Islands. Edinburgh: Edinburgh Univ. Press, 6: 2-64

Danin A (2000). The inclusion of adventive plants in the second edition of flora Palaestina, Willdenovia, 30 (2): 305-314.

Davis PH (1978). Flora of Turkey and the East Aegean Island, Edinburgh Univ. Press. Vol. 6, Edinburgh.

Davis PH, Milli RR, Kit Tan (1988). Flora of Turkey and the East Aegean Island, (Supplement), Edinburgh Univ. Press., Vol. 10, Edinburgh.

Djukic I, Zehedner F, Mentler A, Gerzabek HM (2009). Microbial community composition and activity in different Alpine vegetation zones. Soil Biol. Chem., pp. 1-7.

Dogan Y, Ba lar S, Aydın H, Mert HH (2003). A study of the soil-plant interactions of Pistacia lentiscus L. Distributed in the western Anatolian part of Turkey. Acta Bot. Croat., 62 (2): 73-88.

Dommerques Y, Maggenot F (1970). Ecologie Microbienne Du Sol, Masson et Chie, 769 p., Paris.

Duchaufour P (1970). Precis de Pedologie. Masson et C, Editeurs Paris, pp. 435-437.

Dunbar A (1973). Pollen ontogeny in some species of Campanulaceae. A study by electron microscopy. Bot. Notiser, 126: 277-315.

Dunbar A (1975). On pollen of Campanulaceae and related families with special reference to the surfare ultrastructure, I. Campanulaceae subfam. Campanuloidae. Bot. Notise,r 128: 73-101.

Dunbar A (1975)b. Pollen of Campanulaceae and releated families with special reference to the surface ultrastructure. II. Campanulaceae subfam. Campanuloidea. Bot. Notiser, 128: 102-118.

Dunbar A (1976). On Polen of Campanulaceae III. A. Numerical taxonomic investigation Bot. Notiser, 129: 69-72.

Dunbar A (1981). The preservation of soluble material on the surface and in cavities of the polen wall of Campanulaceae and Pentaphragmataceae. Micron, 12(1): 47-64.

Eddie WMM, Ingrouville MJ (1999). Polymorphism in the Aegean five-loculed species of the genus Campanula section. Nordic J. Bot., 19(2): 153-169.

Feinborn DN (1978). Flora Palaestina, The Israel Academy of Sciences and Humanities, v.3, Jerusalem Academic Press, 481 p.

Frances AJ, Gogo S, Josselin N (2000). Distribution of potential CO2 and CH4 productions, denitrification and microbial biomas C and N in the profile of a restored peatland in Brittany (France). Eur. J. Soil Biol., 36: 161-168.

Gadella TWJ (1964). Cytotaxonomic studies in the genus Campanula. Wentia, 11: 1 - 104.

Gallardo A (2003). Effect of tree canopy on the spatial distribution of soil nutrients in a Mediterenean Dehesa. Inter. J. Soil Biol., http://www.urbanfisher.de/journals/pedo

Gemici Y (1994). Bolkar Dağları'nın (Orta Toroslar) Flora ve Vejetasyonu Üzerine Genel Bilgiler, Doğa Türk Botanik Dergisi, 18(2): 81-89.

Gimeno-Garcı´a E, Andreu V, Rubio JL (2001). Influence of Mediterranean shrub species on soil chemical properties in typical Mediterranean environment, Commun. Soil Sci. Plant Anal., 32(11-12): 1885-1898.

Gökçeoğlu M (1988). Nitrogen mineralization in volcanic soil under grassland, schrub and forest vegetation in the Aegean region of Turkey, Oecologia, Springer-Verlag, 77: 242-249.

Greuter W, Raus Th (2000). Med-Checklist Notulae, Willdenowia, 30 (2): 229-243.

Gurmani AR, Khan MQ, Bakhsh A, Gurmani AH (2003). Effects of various micro elements (Zn,Cu, Fe, Mn) on the yield components of paddy, Sarhad-J. Agric., 19(2): 221-224.

Güner A, Özhatay N, Ekim T, Ba er KHC (2000). Flora of Turkey and the East Aegean Islands. Edinburgh Univ. Press., Edinburgh, (Supplement 2): 171-175

Hernandez AJ, Adarve MJ, Gil A, Pastor J (1999). Soil salination from Landfill Leacheates: Effects on the macronutrient content and plant Growth of four Grassland species. Chemosphere, 38(7): 1693-1711.

Heywood VH (1998). Flowering Plants of the world. B. T. Batsford Ltd, London.

Hutchinson J (1973). The Families of Flowering Plants. At the Clarendon Press. Oxford.

Iene S and Rima V (1998). Influence of humus and its composition to the amount of mobile microelements in the soil. Anal. Chem., 28(2): 160.

Jackson ML (1962). Soil Chemical Analysis, Ist.Edn, cnstable and company Ltd, Prentice-Hall, Inc., New Jersey, USA, London, p. 934.

Jackson DB (1895). Index Kwensis PLantarum Phanerogamarum annen umeration of the genera and species of flowering plants, v.2, Oxford at the clarendon press., 1299 p.

Kacar B (1972). Bitki ve Toprağın Kimyasal Analizleri: III, Ankara Üniversitesi Ziraat Fakültesi Yayınları, 300 s.

Kalavrouziotis IK, Robolas P, Koukoulakis PH, Papadopoulos AH (2008). Effects of municipal reclaimed wastewater on the macro- and micro-elements status of soil and of *Brassica oleraceae* var. italica, B. oleraceae var. gemmifera. 2008. Agric. Water Manage., 95: 419-426.

Kandemir A (2008). A new Campanula (Campanulaceae) from east Anatolia, Turkey. Nordic J. Bot., 25(1-2): 53-57.

Kızıl S, Turk M, Çakmak Ö, Özgüven M, Khawar KM (2009). Microelement Contents and Fatty Acid Compositions of some Isatis species seeds. Not. Bot. Hort. Agrobot. Cluj., 37(1): 175-178.

Klemmedson JO (1987). Influence of oak in pine forest of central Arizona on selected nutrients of forest floor and soil. Soil. Sci. Soc. Am. J., 51: 1623-1628.

Klemmedson JO and Wiebhold BJ (1992). Nitrogen mineralization in soils of a Chaparral watershed in Arizona. Soil. Sci. Soc. Am. J., 56: 1629-1634.

Klopatek JM (1987). Nitrogen mineralization and nitrification in mineral soils of pinyon-juniper ecosystems. Soil. Sci. Soc. Am. J., 51: 453-457.

Korboulewsky N, Dupouyet S, Bonin G (2002). Environmental Risks of Applying Sewage Sludge Compost to Vineyards: Carbon, Heavy Metals, Nitrogen, and Phosphorus Accumulation. J. Environ. Qual., 31: 1522-1527.

Kök T, Bilgin A, Özdemir C, Kutbay HG, Keskin M (2007). Macroelement (N, P, K) Contents of *Romulea columnea* Seb. and Mauri subsp. columnea during Vegetative and Generative Growth Phases. J. Plant Sci., 2(4): 440-446.

Kutbay HG, Nerev N, Ok T (1999). Di budak Yapraklı Kanatlı Ceviz (Pterocarya fraxinifolia (Poiret and Spach) nın Anatomik, Fitososyolojik ve Ekolojik Özellikleri, 23(5): 1189-1196.

Lauber K, Wagner G (2001). Flora Helvetica. Bern, 3: 1614.

Lemee G (1967). Investigations sur la mineralisation de l' azote et son evolition annuelle dans des humus forestiers *in situ*. Ecol. Plant, 2: 285-324.

Levinston AA (1983). Analtical methods for atomic absorption spectrophotometry, Perkin-Elmer corp. Norwalk, Connecticut. Geochim. Cosmochim. Acta, 33: 1325-1316.

Luis Roca-Pérez L, Pérez-Bermúdez P, Gavidia I, Boluda R (2005). Relationships among soil characteristics, plant macronutrients, and cardenolide accumulation in natural populations of Digitalis obscura. J. Plant Nutr. Soil Sci., 168: 774-780

Malagoli M, Canal A, Quagıotti S, Pegoraro P, Bottacin A (2000). Differences in nitrate and ammonium uptake between Scots pine and European larch. Plant and Soil, 221: 1-3.

Martı´nez F, Cuevas G, Calvo R, Walter I (2003). Ecosystem Restoration, Biowaste Effects on Soil and Native Plants in a Semiarid Ecosystem. J. Environ. Qual., 32: 472-479

Metcalfe CR, Chalk L (1983). Anatomy of the Dicotyledons. Vol. II. Clarendon Press. Oxford, 1983.

Meteoroloji Müdürlüğü (1974). Meteoroloji Bülteni, Ortalama Ekstrem Kıymetler, Meteoroloji Müdürlüğü Yayını, Ankara, pp. 383-384.

Nagy P, Bakonyi G, Bongers AMT, Kadar I, Fábián M, Kiss I (2004). Effects of microelements on soil nematode assemblages seven years after contaminating an agricultural field. Sci. Total Environ., 320: 131-143.

Ocak A, Tokur S (1996). Anatomical Investigations on Campanula L. Taxa That Distributed in (B3) Eskisehir Region, Turk. J. Bot., 20: 221-231.

Özbucak TB, Kutbay HG, Kılıç D, Korkmaz H, Bilgin A, Yalçın E, Apaydın Z (2008). Foliar Resorption of Nutrients in Selected sympatric tree species in gallery forest Black sea Region. Polish J. Ecol., 56(2): 227-237.

Özcan T, Bayçu G (2005). Some Elemental Concentrations in the Acorns of Turkish Quercus L. (Fagaceae) Taxa Pak. J. Bot., 37(2): 361-371.

Özen F, Kara EE, Özkoç Đ (1996). Anacamptis pyramidalis (L.) L. C. M. Richard (Orchidaceae)' in Beslenme Đhtiyaçlarının Belirlenmesi Üzerine Ekolojik Bir Çalı ma, Turkish J. Bot., ek sayı; 20: 1-3.

Özhatay N, Kültür (2006). Check-List of Additional Taxa to the Supplement Flora of Turkey III, Turk. J. Bot., 30: 281-316.

Özhatay N, Kültür , Aksoy N (1999). Check-List of Additional Taxa to the Supplement Flora of Turkey II. Turk. J. Bot., 23: 151-169.

Özhatay N, Kültür (2006). Check-List of Additional Taxa to the Supplement Flora of Turkey III. Turk. J. Bot., 30: 281-316.

Özhatay N, Kültür , Aslan (2009). Check-List of Additional Taxa to the Supplement Flora of Turkey IV. Turk. J. Bot., 33: 191-226.

Phitos D (1965). Die quinquelokulären Campanula-Arten. Österr. Botan. Zeitschrift, 112(4): 449-498.

Polunin O (1969). Flowers of Europe. Oxford Univ. Press. New York, 1969.

Potoğlu I, Ocak A, Pehlivan S (2008). Pollen morphology of some Turkish Campanula spp. and their taxonomic value. Bangladesh J. Bot., 1-37

Quattrocchi U FLS (1999). CRC. World Dictionary of plant names, press LLC. Florida, 1-4: 300 p.

Rapp M, Regina SL, Rico M, Humberto AG (1999). Forest Ecology and Management. Biomas, Nutrient content, litterfall and nutrient return to the soil in Mediterranean oak forest, pp. 39-49

Rovira P, Vallejo VR (1997). Organic carbon and nitrogen mineralization under mediterranean climatic conditions: The effect of incubation depth. Soil Biol. Biochem., 29(9/10): 1509-1520.

Sağlam MT (1979). Toprakta Mevcut Bazı Azot Formlarının Tayini ve Azot Elveri lilik Đndeksleri, A. Ü. Ziraat Fak., Erzurum, 137 s.

Sağlıker AH, Darıcı C (2005). Nutrient Dynamics of *Olea europea* L. Growing on soils Derived from two different parent materials in the eastern Mediterenean Region (Turkey). Turk. J.Bot., 29: 255-262.

Sayın M, Gülüt KY (1996). Phosphate Sorbtion by some calcareous soils from the Mediterenean Region. Turk. J. Agric. For., 20: 313-318.

Seçmen Ö, Gemici Y, Leblebici E, Görk G, Bekat L (1989). Tohumlu Bitkiler Sistematiği, Ege Üniv. Fen Fak. Kitaplar Serisi No:116, Đzmir.

Schaefer R (1973). Microbial Activity under Seasonal Conditions ro Drought in Mediterranean Climates, Ecol. Stu. Analysis and synthesis, Springer-Verlag Berlin, Germany, 7: 193-197.

Sheng X., Sun J, Liu Y (2003). Effect of land use and land cover change on nutrients in soil in Bashang area, Chine J. Environ. Sci., 15: 548-553.

Skambarks D, Zimmer M (1998). Combined methods for the determination of microbial activity of leaf litter. Eur. J. Soil Biol., 34(3): 105-110.