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AUTECOLOGICAL CHARACTERISTICS OF *CENTAUREA HERMANNII* F. HERM AN ENDEMIC SPECIES FROM TURKEY

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Abstract

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This study was performed on *Centaurea hermannii* F. Herm to acquire information about some characteristics (bioclimatic, edaphic, topographic, biotic etc.) of its habitat and distribution in Istanbul-Turkey. Plant and soil samples were collected between Subaşı and Akalan Villages, in Çatalca District of Istanbul. Soil texture, structure and other physical and chemical measurements such as pH, electrical conductivity (EC), saturation, salinity, organic matter, $CaCO_3$ content were determined by using various analyses.

The result showed that the soils where plants grow on consist of 34% sand, 34% silt and 32% clay. In the plants, the average contents of some elements (%) were measured as 1.05, 1.05, 2.93 for N, 0.015, 0.02 and 0.034 for P, 0.026, 0.025 and 0.029 for Na, 1.46, 2.58 and 1.90 for K, 1.70, 0.48 and 1.70% for Ca in roots, stems and leaves, respectively. The values above were compared with the values of other *Centaurea* species in different regions of Turkey.

Key words: Asteraceae, plant-soil interactions, mineral nutrition

Introduction

Centaurea genus from Asteraceae family is consisted of mainly herbaceous thistle-like flowering plants. There are approximately 600 species within this genus, mainly distributed in north of the equator; and in the Eastern Hemisphere (Engler, 1964).

Centaurea is the third largest genus in Turkey, after *Astragalus* and *Verbascum* and is represented by 190 taxa, of which 117 are endemic (endemism ratio: 61.6%) (Uzunhisarcikli et al., 2005; Formisano et al., 2008). This high ratio shows that Turkey is one of the gene centers of this genus and particularly, the south-western and eastern parts of Turkey are its centers of diversity (Wagenitz, 1975; Davis et al., 1988; Uzunhisarcikli et al., 2007; Martin et al., 2009; Uysal et al., 2012).

Ecological needs of some local endemic *Centaurea* species are very selective and they are specific to a particular area (Eskin et al., 2013). The remaining, which are not endemic have non-selective ecological needs and they can live in various habitat types such as stony calcareous cliffs, vineyards, roadsides, seashores, gypsum fields, open woods and shrubs, waste places, steppes, fallow fields, maquis, sandy beaches, forests, dry meadows, rocky slopes, and maritime limestone cliffs (Turkoglu et al., 2003; Martin et al., 2009).

***Centaurea hermannii* (Figure 1)**

Perennial, stem 30–60 cm, erect, usually simple, with fibrous remains of decayed petioles at base. Leaves usually lyrate at base. Appendages small, brown, broadly triangular with 5–7(9) palmately arranged 3–6(7) mm spinules, central scarcely longer. Flowers yellow or orange, marginal not radiant. Achenes 4.5–5 mm; pappus 8–10 mm, inner row 0.5–1.5 mm. Flowering time is June- July (Wagenitz, 1975).

Centaurea hermannii is endemic to Turkey and Bulgaria (Bilz et al., 2011); found only in Çatalca Peninsula and

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Fig. 1. ***A*** **– Flower of** ***C. hermannii*****,**
B **– Aboveground parts in its habitat**

Ömerli basin, in Istanbul-Turkey, and threatened by habitat loss (Ozhatay and Keskin, 2007). Additionally, *C. hermannii* is classified as an endangered plant species and listed in the Red Data Book of Turkish Plants (Ekim et al., 2000).

Thus, the aims of this autecological study are to find out of some ecological properties of this endemic species by investigating its soil-plant interactions and mineral nutrition status.

Materials and Methods

Study area

Istanbul, which is the largest urban center of Turkey, is the fourth in Europe with nearly 4.5% annual population growth rate and approximately 12 million inhabitants (Demir et al., 2010). The city is located in the northwest part of Turkey, and enclosed the Bosphorus, which separates the city into two parts, which are European (Thrace) and Asian (Anatolia) as seen in Figure 2 (Ozdemir et al., 2008).

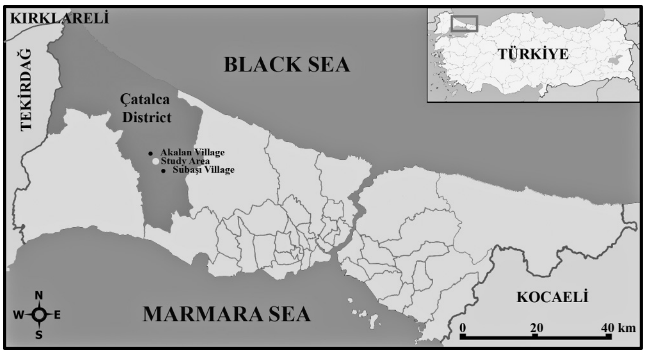

Fig. 2. Map showing the study area-Çatalca District in Istanbul-Turkey

Çatalca District, where the plant and soil samples were collected is located on the European side of Istanbul, 41°09′00″N 28°27′01″E (Eskin et al., 2013). It is a rural district, which has an area of 1,715 km^2 and 13 km of coastline and has a population of 16,170 (Anonymous 1, 2013).

Topography, Soil and Geology: The main topographical structures of Çatalca District are decayed plateaus, which have an elevation of approximately 100-200 m (Anonymous 2, 2013). Alluvial, hydromorphic alluvial, non-calcareous forest, brown, reddish-yellow podzolic and rendzina soils are present in the district. Also, vertisols are locally seen in the study area (Aksiay et al., 1990).

Old Eocene limestones (in the west), old Miocene clay, sand and schist (almost the entire district) and alluvial deposits (Karasu River, in the east) are the formations around the Çatalca District. Eocene, Miocene and young alluvial locate from west to east and play important roles in formation of geomorphic units (Eskin et al., 2013).

Climate: According to Koppen climate classification, the climate of study area is characterized as having either a humid subtropical climate. Besides, it is characterized as a warm-summer Mediterranean climate according to the updated Koppen-Geiger classification system (McKnight and Hess, 2000). The annual average temperature of the Çatalca District is 14.2°C, while the annual average precipitation is 648.4. The lowest and highest temperatures are seen in February and July. The highest precipitation is observed in January as seen in Table 1. The annual average relative humidity is around 71% (Anonymous 3, 2013).

Collection, Preparation and Analyses of Plant and Soil Samples: The plant and soil samples were collected from the localities between Subaşı and Akalan villages in Çatalca District. After the collection of 10 plant samples, plant parts (root, branch and leaves) were separated and oven-dried at 80°C for 24 h, milled in micro-hammer cutter and fed through a 1.5 mm sieve. Soil sampling (about 500 g for each 10 localities) was done by using stainless steel shovel and samples were taken from a depth of 30 cm. Disposable gloves were used during the soil sample collections for prevention of possible contamination. The samples were put into white transparent polythene bags, labeled and brought to the laboratory together with the plant samples.

Electrical conductivity of the soil samples was determined according to Black (1968). An electronic pH-meter was utilized for the measurement of soil pH (in a 1:2.5 soil/water suspension). $CaCO_3$ was measured according to Tuzuner (1990). Modified Kjeldahl (Tuzuner, 1990) method was employed for the total N content estimation in soil samples. Total K and Na of the soil samples were determined using the methods given by Tuzuner (1990) and Ozturk et al. (1997). Flame photometer

Table 1

Climate data for Çatalca (Between 1975–2008)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average temperature, °C	5.9	5.6	7.4	11.8	16.4	21.2	23.8	23.6	20.1	15.8	11.2	7.8	14.2
Average high, °C	8.7	8.8	11.2	16.2	20.9	25.8	28.3	28.2	24.7	19.8	14.5	10.5	18.1
Average low, °C	3.5	2.9	4.5	8.2	12.4	16.8	19.4	19.6	16.3	12.7	8.5	5.4	10.9
Precipitation, mm	82.2	63.2	54.8	50.7	28.9	30.9	24.9	25.2	31.2	70.5	84.3	101.6	648.4

*Prepared using the data of General Directorate of Meteorology, (Anonymous 3, 2013).

was employed in these methods. The method of Olsen and Sommers (1982) was utilized in the estimation of P amounts in the soil samples (Tuzuner, 1990).

For determination of N in the plant parts, wet digestion applications were utilized with salicylic-sulfuric acid mixture and modified Kjeldahl method was used. For K and P analysis, plant samples were subjected to wet ashing treatment with perchloric acid-nitric acid (1:4). P analysis was carried out after reaction with molybdate and stannous chloride, measuring the absorbance at 640 nm by spectrophotometer. K analysis was conducted by Petracourt PFP oneflame photometer. Determination of Ca and Na were done by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). For this aim, all plant samples were mineralized in microwave oven (Berghof-MWS2) as follows: 5 min at 145°C, 5 min at 165°C and 20 min at 175°C. After cooling, the samples were filtered using Whattman filters and volume made up to 50 mL with ultra-pure water in volumetric flasks. Standard solutions were prepared by using multi element stock solutions-1000 ppm (Merck) and Ca and Na measurements were done by ICP-OES.

Results and Discussion

The results of physical and chemical analyses of the soil samples collected from the localities between Subaşı and Akalan villages in Çatalca District are presented in Table 2.

According to the results of physical analyses, *C. hermannii* prefers clayey-loamy (CL) soils. Previous studies performed by using other *Centaurea* species showed that they have ability to grow on different soil types. According to previous results, *C. kilea, C. mucronifera, C. pyrrohoblephara, C. gracillima, C. taochia* and *C. huber-morathii* prefer sandy, *C. bornmuellerii, C. brevifimbriata* and *C. hadimensis* prefer clayey, *C. schiskinii* prefers sandy-clayey and *C. consanguinea* prefers loamy soils (Celik, 2003; Eskin, 2011; Eskin et al., 2013).

The % concentration of $CaCO_3$ (0.63) shows that *C. hermannii* prefers very low levels of Ca (slightly calcareous). Other *Centaurea* species mentioned above prefer higher level of $CaCO_3$ (between 0.73–74.55) in their habitats in comparison with *C. hermannii*. Average pH value in the study area was found to be as 6.00, when saturation was around 55%. The result showed that *C. hermannii* adopted itself to grow on such slightly acidic soils. When compared with other *Centaurea* species (6.6 and 8.8), *C. hermannii* prefers the lowest pH degree. The average organic matter concentration of the soils collected from the study area was measured as 6.10% indicating rich organic matter content. Other *Centaurea* species rather than *C. mucronifera* and *C. pyrrohoblephara* (organic matter content data obtained from this study is similar for those two species) prefer such soils containing low organic matter (between 0.41–5.85%). Electrical conductivity data was found to be as 0.157 mmhos/cm in the study area implies compatibility of non-saline texture (0.03% salinity).

Table 2

Physical and chemical analyses of the soil samples between Subaşı and Akalan Villages

Sand, %	34.0
Silt, %	34.0
Clay	32.0
Texture	Clayey-loamy (CL)
$CaCO_{3,}$ %	0.63
Organic matter, %	6.10
EC, mmhos/cm	0.157
Salinity, %	0.03
pH	6.00
Saturation, %	55.0

Chemical analyses of the soil samples, collected from the habitat of *C. hermannii* showed that average N content (%) was 0.1 (Table 3). According to literature, N % contents of mineral soils are between 0.02 and 0.5, and the average value is 0.15 (Kacar and Katkat, 2010). Our results showed that

Table 3

Chemical analyses of the plant parts of *C. hermannii* and soil from the study areas

	Leaf	Stem	Root	Soil
N, %	2.93	1.05	1.05	0.1
P, %	0.034	0.020	0.015	0.0009
K, %	1.90	2.58	1.46	0.046
Na, %	0.029	0.025	0.026	0.002
Ca, %	1.70	0.48	1.70	Not Studied

average N content in the study area is within normal ranges. From previous studies, it is known that *C. kilaea* prefers soils containing similar N contents in the same district (Çatalca), whereas *C. consanguinea*, *C. gracillima*, *C. taochia*, *C. brevifimbriata* and *C. pergamacea* prefer soils containing lower, and *C. mucronifera*, *C. pyrrohoblephara*, *C. bornmuellerii*, *C. huber-morathii*, *C. schiskinii* and *C. hadimensis* prefer soils containing higher N contents (Celik, 2003; Eskin, 2011; Eskin et al., 2013). Also, the average N content (%) in the plant parts collected from Çatalca District were 1.05 in both stems and roots and 2.93 in leaves. The average N content (%) in plants generally varies between 0.2 and 6 (Ozdemir and Ozturk, 1996). According to our data, N levels (%) of *C. hermanni* in all plant parts were within normal limits. Higher N levels in plants in comparison with the co-located soils imply that the plant is capable of taking N for its own need. Previous works stated that N contents (%) of different *Centaurea* species vary between 0.05 to 6.66 (Celik, 2003; Eskin et al., 2013). In these studies, it is noticed that N contents of *C. pergamacea* and *C. hadimensis* are lower, whereas N contents of *C. pyrrohoblephara*, *C. gracillima*, *C. bornmuellerii*, *C. brevifimbriata* and *C. huber-morathii* are higher than *C. hermannii* in their roots, stems and leaves (Celik, 2003).

Average soil P value was measured as 0.0009% and this result shows that soil P (%) is average/slightly higher in the area as mentioned by Tuzuner, 1990 (0.0006 and 0.0009). The average P contents (%) of *C. hermanni* were determined as 0.034, 0.020 and 0.015 respectively in leaves, stems and roots respectively. P content (%) in plants is approximately 0.2 (Epstein, 1999). In our study, although soil P levels were within normal limits, P levels in all plant parts were found to be lower than normal limits. However, P uptake by the plant is carried out sufficiently. Because P contents in the plant parts are higher than the soils. Previous studies indicated that except *C. kilaea* and *C. consanguinea* P contents of all other *Centaurea* species are higher than P content of *C. hermanni* (Celik, 2003; Eskin, 2011; Eskin et al., 2013).

The average concentration of soil K (%) was 0.046. Normal limits (%) of K in soil lie between 0.013 and 0.058, therefore, it can be concluded that K levels in the soils of *C. hermannii* are within normal limits. Like plant P values, only *C. kilaea* and *C. consanguinea*'s soil K levels are lower than our soil levels, while K levels of other studied soils are higher than results of this study (Celik, 2003; Eskin, 2011; Eskin et al., 2013). The average K contents (%) of *C. hermanni* were between 1.90, 2.58 and 1.46 in leaves, stems and roots, respectively, in Çatalça District. Epstein (1999) reported that the average K content in plants is around 1% and our findings are higher than the average. This indicates that an efficient K uptake is carried out by the plant. K contents of *Centaurea* species from previous studies showed that K content of *C. hermannii* is higher or equal to K contents of other plant species (Celik, 2003; Eskin, 2011; Eskin et al., 2013).

The average soil Na level (%) from the study area was found to be (0.002) is lower than normal limits (0.0046) (Tuzuner, 1990). Previous studies showed that, *C. hermannii* and *C. hadimensis* prefer such soil type containing similar Na levels. Also, *C. kilaea*, *C. consanguinea*, *C. mucronifera*, *C. pyrrohoblephara*, *C. gracillima*, *C. taochia*, *C. huber-morathii*, *C. schiskinii* grow lower, and *C. bornmuellerii* and *C. brevifimbriata* grow on soils containing higher Na levels in comparison with soils where *C. hermannii* grows on (Celik, 2003; Eskin et al., 2013). Measured Na contents (%) were approximately similar in all plant parts (0.029 in leaves, 0.025 in stems and 0.026 in roots). In plants, the average Na concentration (%) is around 0.001 (Epstein, 1999). Thus, it can be said that Na concentrations of *C. hermanni* are higher than the normal values although the soil of its habitat contains lower Na (non-saline texture with 0.03% salinity). Previous studies showed that, Na contents of plant parts of *C. mucronifera*, *C. pyrrohoblephara*, *C. gracillima*, *C. bornmuellerii*, *C. brevifimbriata*, *C. huber-morathii*, *C. schiskinii* and *C. pergamacea* were lower than Na level of *C. hermannii*. Other *Centaurea* species accumulate higher or equal Na (Celik, 2003; Eskin et al., 2013).

Ca levels (%) in the plants were measured as 1.70 in leaves and roots, and 0.48 in stems. Literature indicates that the normal Ca levels (%) in plant parts are within the range of 0.02-3.0 and sufficient amounts (%) for plants are between 0.03 and 1.0 (Kacar and Katkat, 2010). Measured plant Ca levels imply that *C. hermannii* is capable of uptake and accumulate efficient amounts of Ca although it grows on such soils containing very low Ca levels (slightly calcareous). Previous studies showed that *C. gracillima*, *C. taochia* and *C. schiskinii* accumulate higher Ca whereas other *Centaurea* species accumulate lower or equal Ca in their plant bodies in comparison with our results (Celik, 2003; Eskin et al., 2013).

Habitat preferences of *C. hermannii* are different from those other *Centaurea* species prefer and *C. hermannii* adapted itself to such clayey-loamy soils containing very low $CaCO_3$, low Na and high organic material amounts and requesting very low pHs. In addition to low P content and high K uptake by *C. hermannii* suggests that *C. hermannii* could have different metabolic mechanisms in comparison with other *Centaurea* species. Although many endemic *Centaurea* species prefer different habitats for living, narrow endemic *C. hermannii* is a special one between them because of bearing distinct features mentioned above. At last, this work should be supported by the molecular and physiological analyses.

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