Sains Malaysiana 42(10)(2013): 1473–1482

Germination Physiology and Autecology of *Centaurea kilaea* Boiss. from Turkey

(Autekologi dan Fisiologi Percambahan *Centaurea kilaea* Boiss. dari Turki)

B. ESKIN*, I.I. OZYIGIT, I. DOGAN, V. ALTAY, G. DEMIR & M. SERIN

ABSTRACT

In this study germination requirements, plant-soil interactions and population biology of Centaurea kilaea *was studied. The plant and soil samples were collected from Sofular Village (Şile District) and shore of Çatalca District (Istanbul) in Turkey by using standard methods. Methods like Scheibler, Wetdigestion, Kjeldahl and Olsen were employed for measurement of soil texture, structure and other physical and chemical characteristics (pH, total protein and electrical conductivity) using spectrophotometer, flame photometer, calcimeter and ICP. The results showed that ranges of different elements in the soil were 0.007-0.2% for N, 0.0007-0.001% for P, 0.001-0.01% for K, 0.0001-0.0002 % for Na. N, P, K and Na values in the plants were 2.17, 0.005, 0.1 and 0.006%, respectively. The data revealed that germination success of the seeds was influenced by the environmental factors such as pH, germination season and temperature.*

Keywords: Centaurea kilaea; *elements; plant; plant-soil interactions; soil*

ABSTRAK

Dalam kajian ini keperluan percambahan, saling tindakan tumbuhan-tanih dan biologi populasi Centaurea kilaea *telah dilakukan. Sampel tumbuhan dan tanih telah dikumpul dari Kampung Sofular (Daerah Şile) dan pantai Daerah Çatalca (Istanbul) di Turki dengan menggunakan kaedah piawai. Kaedah seperti Scheibler, Wetdigestion, Kjeldahl dan Olsen telah digunakan bagi pengukuran tekstur tanih, struktur dan sifat fizikal dan kimia lain (pH, jumlah protein dan kekonduksian elektrik) menggunakan spektrofotometer, fotometer api, kalsimeter dan ICP. Hasil menunjukkan bahawa julat unsur berbeza dalam tanih ialah 0.007-0.2% bagi N, 0.0007-0.001% bagi P, 0.001-0.01% bagi K, 0.0001-0.0002% bagi Na. N, P, K dan nilai Na dalam tumbuhan ialah masing-masing 2.17, 0.005, 0.1 dan 0.006%. Data menunjukkan kejayaan percambahan bagi biji benih telah dipengaruhi faktor persekitaran seperti pH, musim percambahan dan suhu.*

Kata kunci: Centaurea kilaea*; saling tindakan tumbuhan-tanih; tanih; tumbuhan*; *unsur*

INTRODUCTION

Centaurea commonly known as centaury, centory, starthistles, knapweeds and centaureas are the common names for this genus (Arif et al. 2004), is a large genus of Asteraceae family, with approximately 600 species distributed in the north of equator, mostly in the Eastern Hemisphere. The family is particularly species-rich in the Middle East and surrounding regions (Engler 1964).

The herbaceous, thistle-like plants are annuals, biennials or perennials, weedy, rarely small shrubs with spiny branches and evergreen leaves, often with dense short hairs or scales. Leaves are alternate, sometimes radical, rarely spiny (in Turkey), deeply cut into lobes, sometimes decurrent; flowers are pink, purple, yellow, white or blue in colour; disk florets often sterile, morphologically different and much darker or much lighter compared to ray florets. Achenes usually lack hars when ripe, laterally compressed in shape (Davis et al. 1988; Tutin et al. 1980).

In Turkey the genus is represented by about 200 species, distributed mainly in the south-western and eastern parts. Latter areas are the centers of its diversity and approximately 73% of the species here are endemic (Davis et al. 1988; Martin et al. 2009; Uysal et al. 2012; Uzunhisarcikli et al. 2007; Wagenitz 1975). They occur on stony calcareous cliffs, in vineyards, along roadsides, seashores, in gypsum fields, open woods and shrubs, waste places, steppes, fallow fields, maquis, sandy beaches, forests, dry meadows, rocky slopes and on maritime limestone cliffs (Turkoglu et al. 2003).

C. kilaea is an endemic species of Turkey and grows in Kırklareli-Kasatura; Istanbul-Domuzdere, Terkos, Kilyos, Yeşilcay; Adapazarı-Karasu and Bolu (Wagenitz 1975). It is listed as endangered in the *Red Data Book of Turkish Plants* (Ekim et al. 2000). The aims of this study was therefore to investigate the ecological characteristics of this endemic species in particular soil-plant interactions and mineral nutrition status.

MATERIALS AND METHODS

STUDY AREA

Istanbul is located in the northwest part of Turkey and extends both on European (Thrace) and Asian (Anatolia) sides of the Bosphorus (Figure 1). The study areas, Çatalca (in Thrace) and Şile (in Asia), are located on the both sides of Istanbul, 41°09'00"N 28°27'01"E and 41°10'35"N 29°36'46"E, respectively (Cografya Dunyasi 2013). Çatalca is a rural district in Istanbul and has an area of 1.1715 km^2 and 13 km of coastline. It is in Thrace region, on the ridge between Marmara and the Black Sea with a population of 16170. Şile is a small district of Istanbul on the Black Sea. It has a population of 32522 on a land area of 916 km^2 (TUIK 2013).

TOPOGRAPHY, SOIL AND GEOLOGY

The main topographical features of Kocaeli and Çatalca peninsulas are decayed plateaus, which have an elevation of approximately 100-200 m (Municipality 2013). Six different soil types are present in Çatalca namely; alluvial, hydromorphic alluvial, non-calcareous forest, brown, reddish-yellow podzolic and rendzina soils, vertisols are seen locally (Aksiay et al. 1990). There are three different formations around the area; old Eocene limestones in the west of Çatalca, the old Miocene clay, sand and schist and alluvial deposits of Karasu River located just east of the city. Çatalca geomorphologic land units can be divided into; furrow valleys and natural hillsides located in the west with fragmented erosional surfaces on the Eocene limestones, Miocene structure especially with the transition zones from hillsides to almost flat terrain and this continues as narrow unit towards the south.

Non-calcareous and brown forest soils with good drainage conditions cover the largest area in the Şile District. Sand dunes and stretches of beach sands include intrazonal soils depending on the topographic factors, drainage and other factors in connection with lithology. Alluvial soils are widespread in the valley floors. The geological structure in the District of Şile contains Devonian (first age), Triassic and Cretaceous (second age), Paleocene, Eocene and Neogene (third age) and Pleistocene and Holocene (fourth age) originated sedimentary formations. Also, there is an old volcanism found within the upper Cretaceous. Formations have been influenced by the movements of Alpine and Hyrcanian. The wide and deep neogene basin in the west of district is rich with clay-porcelain clay, moulding sand, quartz sands and brown coal (Ertek et al. 1998).

CLIMATE

The climate of the study areas is either humid subtropica according to Koppen climate classification system or a warm-summer Mediterranean climate, according to the updated Koppen-Geiger classification system (McKnight & Hess 2000). Annual average temperature is 14.2°C and annual average precipitation is 648.4 mm in the District of Çatalca. The lowest and highest temperatures are seen in February and August, respectively. The highest precipitation is observed in February (Table 1). Annual average relative humidity is around 71% (DMI 2013). In Şile District, a transition climate between the Mediterranean and Oceanic is seen. Relatively lower drought and evaporation in the summer period and more precipitation and frequent frost in the winter period are observed in comparison with the Mediterranean climate (Thornthwaite 1948). The average temperature is 13.7ºC. The lowest and highest temperatures are seen in January-February (average 5.6ºC) and July-August (average 23.2ºC), respectively. The annual average precipitation is between 600 and 1000 mm in the District of Şile (Table 2).

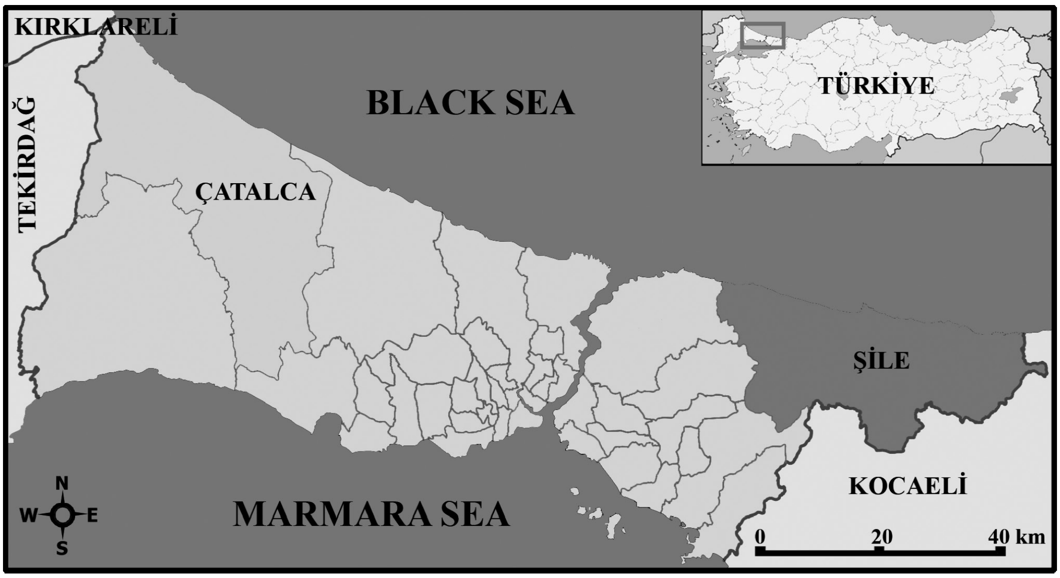


FIGURE 1. Map showing the study areas (locations of Çatalca and Şile districts in Istanbul)

TABLE 1. Climate data for Çatalca (between 1975 and 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

TABLE 2. Climate data for Şile (between 1995 and 2005)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average temperature (°C)	5.6	5.6	6.9	10.9	15.7	20.3	23.4	23.2	19.2	15.1	11.1	7.6	13.7
Average high (°C)	17.4	19.2	21.9	27	29.4	31.5	30.1	29.2	31.8	27.7	23.4	18.7	25.6
Average low (°C)	-3	-3.8	-1.9	0.1	6	10	13.9	13.4	10	5.1	1.1	-1.9	4.08
Precipitation (mm)	84.9	87	89.4	57.9	25.1	30.8	36	109.4	79.1	116.5	82.8	130.3	929.2

*Prepared using the data of General Directorate of Meteorology

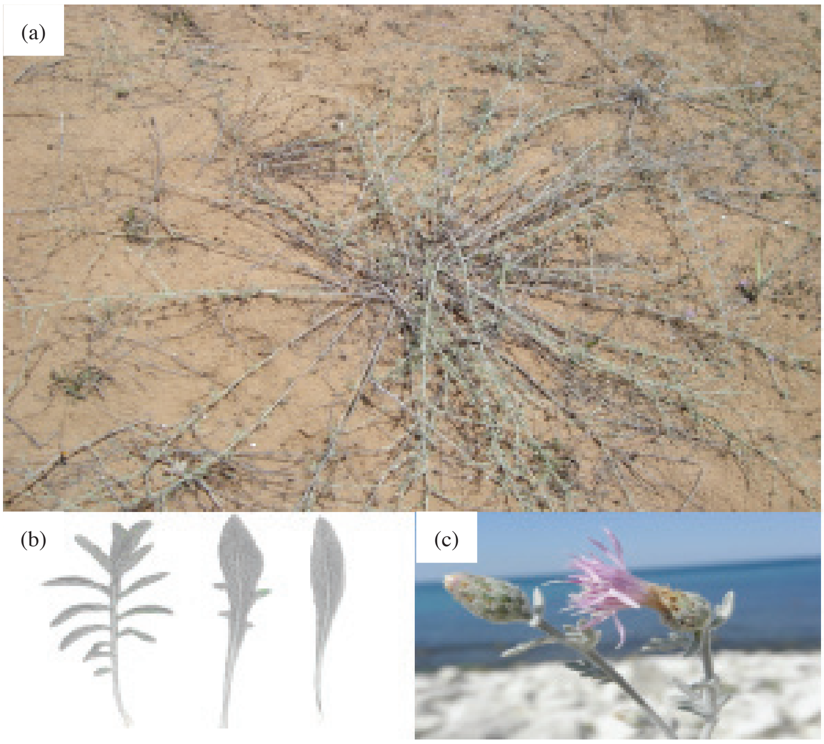


FIGURE 2. (a) General habitat of *C. kilaea*, (b) leaf structure (Atar 2006) and (c) branches with flowers

COLLECTION, PREPARATION AND ANALYSES OF SAMPLES

The plant and soil samples were collected from Karaburun coast in Çatalca District and Sofular Village in Şile District in 2009 during spring, summer and autumn seasons. For morphological studies fresh plant samples collected from the study areas were used. 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. For determination of N, P, and Na in the plant parts, wet digestion method was utilized with salicylic-sulfuric acid mixture. Standard solutions were prepared by using multi element stock solutions-1000 ppm (Merck) and Inductively Coupled Plasma Optical Emission Spectroscopy (Varian-Liberty Series II) was employed for the measurements of K and Na.

Soil samples (about 500 g) were collected from a depth of about 20 cm with a stainless steel shovel, air-dried and passed through a 2 mm sieve. N, P, K, Na, and

$CaCO_3$ for air-dried soil samples were measured by using appropriate methods. Statistical analyses was carried out for the data of analysis obtained. Electrical conductivity 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). Additionally, the modified Kjeldahl (Tuzuner 1990) method was employed for the total N content estimation in soil samples. Total K and Na of the soil samples was determined using the methods given by Tuzuner (1990) and Ozturk et al. (1997). Flame photometer 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).

Results and Discussion

The habitat of a species is the most important part of its life cycle. Therefore there is a need to understand the habitat for an evaluation of the biological features of a species which is also critical for the wildlife management. Habitat of a species is informative about bioclimatic, edaphic, topographic, biotic characteristics of a specific area, it describes sum of the biotic and abiotic factors required by an organism (Thomas 1979). The basis of autecological studies is related to this concept (Celik et al. 2008; Ozdemir & Ozturk 1997; Ozturk 1980(a),1980(b); Ozturk 1982; Ozturk & Gork 1979(a),1979(b); Ozturk & Secmen 1993;). In this study, the autecological features of *C. kilaea* were investigated. It is an endemic species adapted to less rainy Mediterranean climate flourishing on coastal dunes of Karaburun (Çatalca) and Sofular Village (Şile) in Istanbul. A close relationship exists between the plants and soil.

The results of physical and chemical analysis of the soil samples collected from Karaburun (Çatalca) and Sofular Village (Şile) are presented in Table 3. The results showed that the species is capable of growing in sandy soils, slightly alkaline, with pH values of 6.94-7.08 in Çatalca and 7.81-7.85 in Şile, average pH values being 7.08 for Çatalca and 7.82 for Şile.

Concentration of $CaCO_3$ are 60.37 (%) for Çatalca and 22.844 (%) for Şile. The data depicts that plant has the ability to grow in very high calcareous soil. Electrical conductivity was measured as 0.258 mS/cm for Çatalca and 0.140 mS/cm for Şile, which implies compatibility of non-saline texture.

The chemical analysis of soils showed that N values are 0.021-0.200 (%) for Çatalca and 0.007-0.049 (%) for Şile and the average values are 0.0928 (%) for Çatalca and 0.0272 (%) for Şile (Table 3). In general, percentage N contents of mineral soils varies are between 0.02 and 0.5, while the average value is 0.15 (Kacar & Katkat 2010). Our results indicated that N values are within normal range, but lower than average. Chemical analysis of plant plants depicted that N average values were 1.908% in leaf, 2.07% in stem and 2.22% in root for the plant parts collected from Çatalca and 2.088% in leaf, 2.344% in stem and 2.398% in root for the plant parts collected from Şile (Table 4). N content (%) in plants generally varies between 0.2 and 6 (Ozdemir & Ozturk 1996). According to our data N percentages in all plant parts of *C. kilaea* are higher than normal limits. N levels are higher than soils in the plants collected from both locations. It implies that the plant is capable of taking required N. Average P values in the soils were measured as 9.234 mg/kg for Çatalca and 11.104 mg/kg for Şile (Table 3). The average value for soil P is between 0.0006 and 0.0009% (Tuzuner 1990). The results showed that soil P for both locations is high. The average P values of *C. kilaea* in mg/kg were found as 58.11 (55.0-61.75) (0.005811%), 47.9 (45.5-50.0) (0.00479%) and 50.8 (49.0-55.0) (0.00508%) in leaves, stems and roots in Çatalca and 56.32 (55.75-57.1) (0.005632%), 57.65 (57.25-58.25) (0.005765%) and 67.05 (65.0-70.0) (0.006705%) in leaves, stems and roots in Şile, respectively (Table 4). P content in plants generally is approximately 0.2% (Epstein 1999). Our P levels in all plant parts are lower than normal, although soil P values are high. This situation shows that P uptake by the plant is carried out sufficiently, because P values in the plant parts (≥0.0048%) are higher than the soils (~0.001%) (Tables 3 & 4). Average K values in mg/kg were 123.2349

TABLE 3. Physical and chemical analysis of the soil samples from the study areas

Locations Texture	Karaburun (Çatalca District) Sandy		Sofular Village (Şile District) Sandy	
	Values (Min.-Max.)	Average values	Values (Min.-Max.)	Average values
pH	6.94-7.28	7.08	7.81-7.85	7.82
N (%)	0.021-0.200	0.0928	0.007-0.049	0.0272
P (mg/kg)	7.52-10.52	9.234	10.41-11.80	11.104
K (mg/kg)	97.831-141.728	123.235	18.484-45.539	30.501
Na (mg/kg)	1.015-1.6	1.336	1.59-2.39	2.05
$CaCO_3$ (%)	60.212-60.51	60.37	22.595-23.00	22.844
*E.C. (µS/cm)	224-292	258	117-156	140
**T.S.S. (mg/L)	273-296	285	102-129	112

*E.C. = Electrical Conductivity, **T.S.S. = Total Soluble Salt

TABLE 4. Chemical analysis of the plant parts (leaf, stem and root) of *C. kilaea* from the study areas

Locations	Elements	Leaf		Stem		Root	
		Values (Min.-Max.)	Average values	Values (Min.-Max.)	Average values	Values (Min.-Max.)	Average values
Karaburun (Çatalca District)	N (%)	1.87-1.95	1.908	2-2.2	2.07	2-2.5	2.22
	P (ppm)	55.0-61.75	58.11	45.5-50.0	47.9	49.0-55.0	50.8
	K (ppm)	1185.65-1774.0	1424.64	792.95-1206.1	945.8	748.85-1072.7	928.66
	Na (ppm)	48.5-64.66	57.367	53.47-70.93	63.99	55.91-153.40	86.65
Sofular Village (Şile District)	N (%)	2-2.29	2.088	2.29-2.4	2.344	2.3-2.52	2.398
	P (ppm)	55.75-57.1	56.32	57.25-58.25	57.65	65.0-70.0	67.05
	K (ppm)	844.9-1303.05	1084.97	645.1-954.15	783.9	774.35-1015.5	863.63
	Na (ppm)	44.81-59.35	51.69	61.535-72.50	68.14	51.06-76.0	62.84

(0.0123235%) in Çatalca and 30.5004 (0.00305%) in Şile, respectively (Table 3). Normal values of K in soil lie between 0.013 and 0.058%, which are equal to 130 and 580 mg/kg and the average value is 0.0355% (355 mg/kg) (Tuzuner 1990). Therefore, it can be concluded that K levels in the soils of *C. kilaea* are lower than the average. Average K values of *C. kilaea* in mg/kg were as 1424.64 (0.14246%), 945.8 (0.0946%) and 928.66 (0.09287%) in leaves, stems and roots in Çatalca and 1084.97 (0.1085%), 783.9 (0.07839%) and 863.63 (0.08636%) in leaves, stems and roots in Şile, respectively (Table 4). Epstein (1999) reported that K value in plants is around 1%; hence our results are lower than the average. This indicates that sufficient K uptake is carried out by the plant. K values in the plant parts (≥0.08636%) are higher than the soils (~0.00123%) for Çatalca and (0.003%) Şile (Tables 3 & 4). The average of soil Na in mg/kg were measured as 1.3358 (~0.000134%) in Çatalca and 2.048 (~0.000205%) in Şile. These values are lower than normal limits (Table 3) lying around 0.0046% (Tuzuner 1990). Na concentration in *C. kilaea* in mg/kg was measured as follows; 57.367 (0.00574%), 63.99 (0.0064%) and 86.65 (0.0087%) in leaves, stems and roots for Çatalca and 51.69 (0.0052%), 68.14 (0.0068%) and 62.835 (0.0063%) in leaves, stems and roots for Şile, respectively (Table 4). In plants Na concentration should be around 0.001% (Epstein 1999). Thus, it can be said that Na concentrations of *C. kilaea* are higher than the normal values. The plant accumulates Na in its body although the soils contain lower than the average Na content in both locations. Certain plants live under the effects of different climatic factors within certain ranges.

A development outside the range is difficult or impossible for some plants. Climate influences the formation of plant characters and distribution of plants in the world (Ozturk & Secmen 1999). Sometimes temperature drops below freezing point during the winter months in the study areas. These short-term cold exposures affect the dormancy periods of seeds, which probably explains why there is dense vegetation in Çataca and Şile. Also, is an important factor in explaining the wide distribution of *C. kilaea* around these regions.

Time of seed germination is very important for the continuity of a species (Ozturk & Secmen 1999). If environment is not suitable for seeds, germination does not start. In this situation, the seeds stay go dormant. There are many factors affecting the dormancy such as; chemical inhibitors, hard and oxygen impermeable seed coat, period of darkness and light. For example, plants which need light to germinate may remain under the soil for years if they did not get exposed to light (Ozturk & Ay 1986). Germination takes place when the seed is close or on the surface.

The stored seeds remain alive when temperature, moisture content and oxygen and carbon dioxide concentrations are suitable. The stored seeds in the refrigerator were used for planting in our study and germination rate was 26% on 1st and 2nd planting (after 4 and 8 weeks), while the germination rate was around 62% on 3rd and 4th planting (after 12 and 16 weeks). A substantial increase was noticed between these intervals. The germination rate decreased to 44% after 24 weeks. There was an increase in the germination rate (62%) in the following plantings (after 28 weeks) (Figure 7). Therefore, establishing a seed bank is very important task for the protection of endemic *C. kilaea* in future and the storage conditions should be planned according to the data obtained here.

During germination absorption of water, swelling, expansion and division events are controlled by hydration levels that differ from species to species (Hegarty 1978; Uygunlar et al. 1985). Previous studies showed that water uptake is affected by the total water content of seeds as well as temperature. Studies carried out by Vardar and Ozturk (1971) and Ozdemir et al. (1994) showed that water uptake varied in *Myrtus communis* var. *leucocarpa*, *M. communis* var. *melanocarpa*, *Brassica nigra* (L.) Koch. and *B. jancea* (L.) Czern. depending on time and temperature. In our study, 0.008 g of water uptake (the highest) was absorbed at 22°C while 0.001 g of water uptake (the lowest) was absorbed by the seeds of *C. kilaea* at -18 and 5°C at the end of a 2 h period (Figure 3).

Salt affects the germination of seeds by lowering the osmotic potential and makes the water uptake difficult for

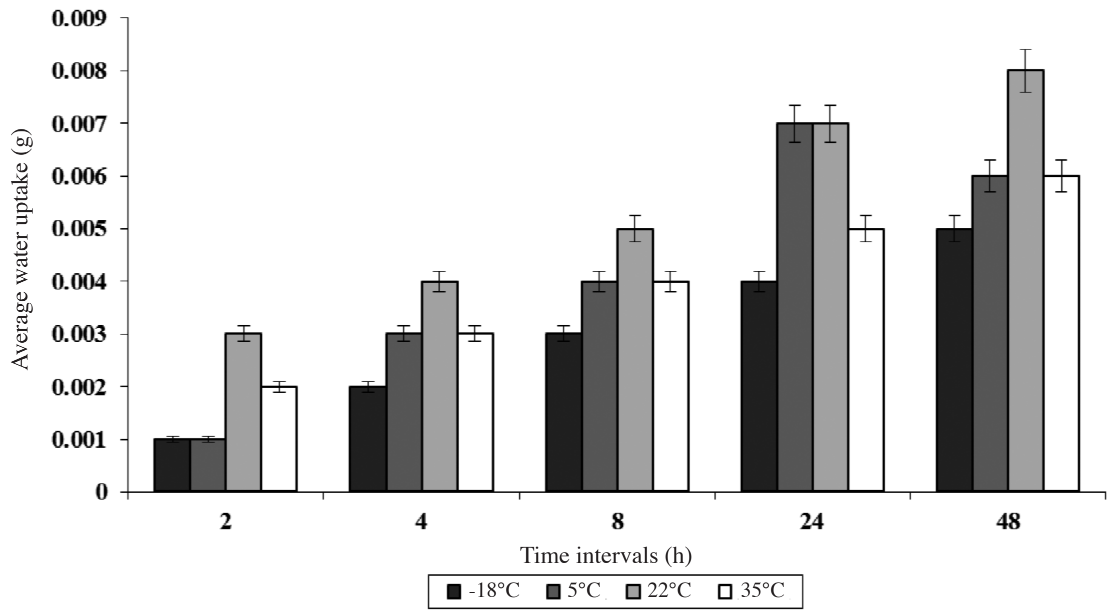


FIGURE 3. The effects of various temperatures on the water uptake of seeds of *C. kilaea*

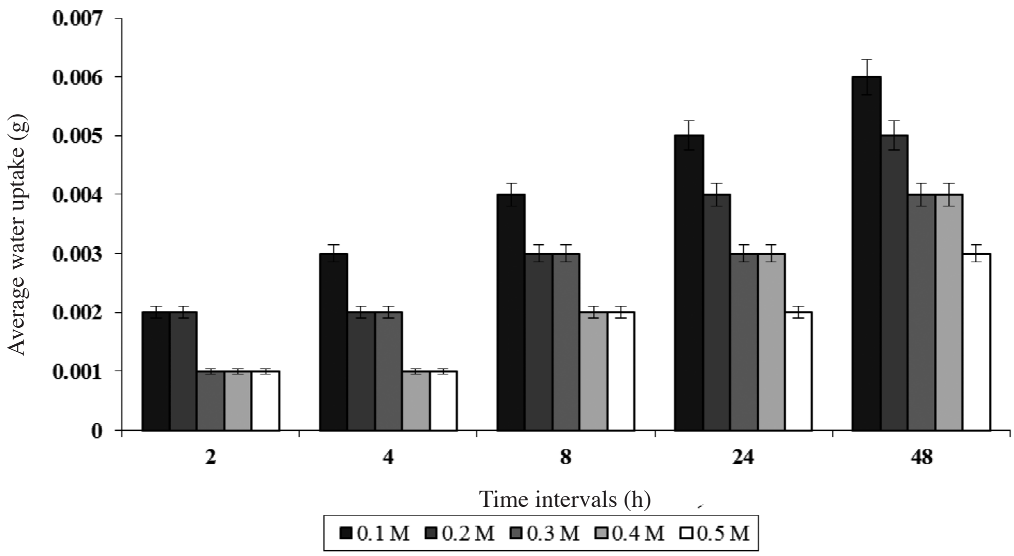


FIGURE 4. The effects of different salt solutions on the water uptake of seeds of *C. kilaea*

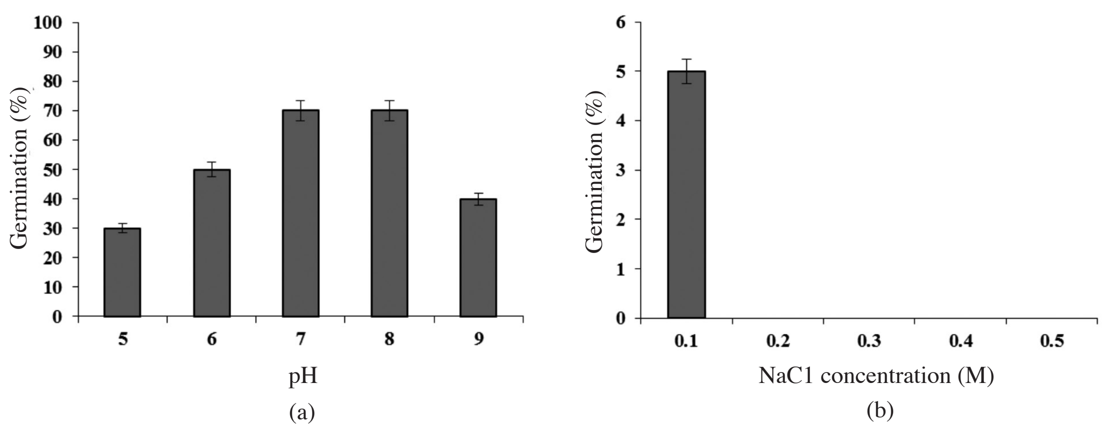


FIGURE 5. Germination of seeds of *C. kilaea* at different pH values (a) and different NaCl concentrations (b)

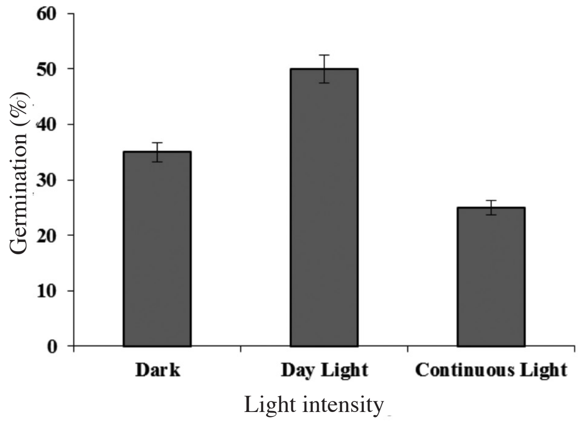


FIGURE 6. The effects of light intensity on seed germination of *C. kilaea*

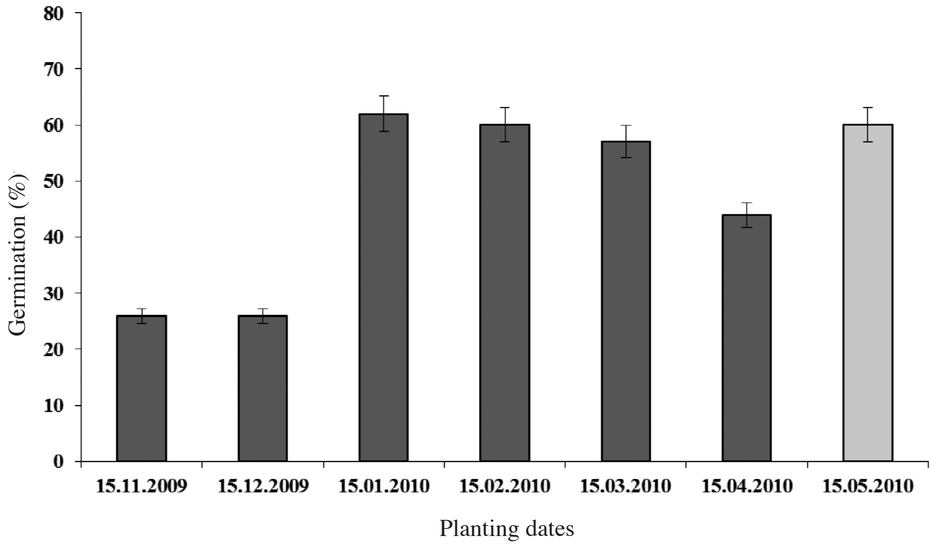


FIGURE 7. The germination status of seeds of *C. kilaea* at different dates

seeds (Bianco & Boari 1997; Ozturk et al. 1992; Ozturk & Secmen 1993). In this study increased salt concentrations led to more reductions in the rates of seed germination. Seed germination of *C. kilaea* was 5% in 0.1 M NaCI, whereas there was no germination in 0.2-0.5 M NaCI (Figure 5b).

The germination of some seeds does not occur if not exposed to enough light or vice versa. So light conditions are very important for the germination (Bannister 1979). Our results showed that germination rate is 50% in normal daylight but only 25% in continuous light for *C. kilaea* (Figure 6).

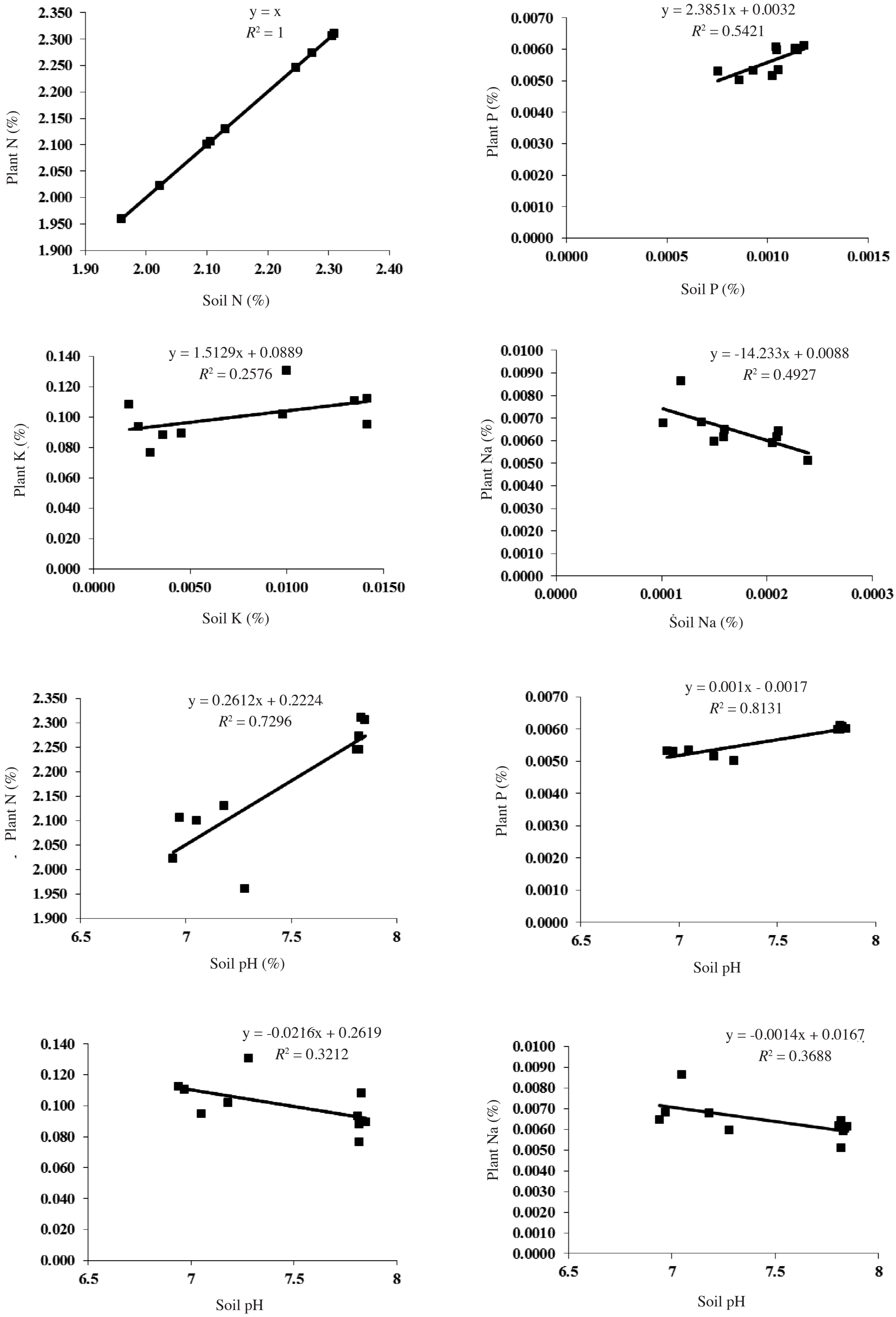
Soil pH is also an important factor affecting the availability of micro-elements. Among the effects of pH, the most important is mainly on the solubility of nutrients and their ionic forms (Ronen 2007). Some nutrients might become unavailable while others might reach high concentrations leading to deficiency or toxicity, respectively, at different levels of pH (Ronen 2007). In our study, optimum pH range is between 7 and 8 for the seed germination. At this range, the rate of germination was 70% during a 15 day period (Figure 5a).

Seeds of *C. kilaea* left in a range of 0.1-0.5 M NaCI solutions for 2, 4, 8, 24 and 48 h. were weighed in order to determine the water uptake rate. The highest water uptake (0.006 g) and the lowest water uptake were observed at 0.1 and 0.5 M NaCI for *C. kilaea,* respectively (Figure 4).

The values of N, P, K, Na in the plant and the values of N, P, K, Na, pH, and $CaCO_3$ in the co-located soil samples collected from Çatalca and Şile were statistically evaluated and the relationships followed by analysis of regression and correlation co-efficient. In soil and *C. kilaea* samples, relatively positive correlations were found between N-N; P-P; K-K; pH-N; pH- P; $CaCO_3$-Na; $CaCO_3$-K; however, negative correlations exist between Na-Na; pH-Na; pH-K; $CaCO_3$-P; $CaCO_3$-N (Figure 8).

ACKNOWLEDGEMENTS

We express our gratitude to Ahmet Yılmaz from Marmara University Science and Arts Faculty, Department of


y = x
R² = 1
Plant N (%)
Soil N (%)
y = 2.3851x + 0.0032
R² = 0.5421
Plant P (%)
Soil P (%)
y = 1.5129x + 0.0889
R² = 0.2576
Plant K (%)
Soil K (%)
y = -14.233x + 0.0088
R² = 0.4927
Plant Na (%)
Soil Na (%)
y = 0.2612x + 0.2224
R² = 0.7296
Plant N (%)
Soil pH (%)
y = 0.001x - 0.0017
R² = 0.8131
Plant P (%)
Soil pH
y = -0.0216x + 0.2619
R² = 0.3212
Soil pH
y = -0.0014x + 0.0167
R² = 0.3688
Plant Na (%)
Soil pH

(Continue)

Continued (FIGURE 8)

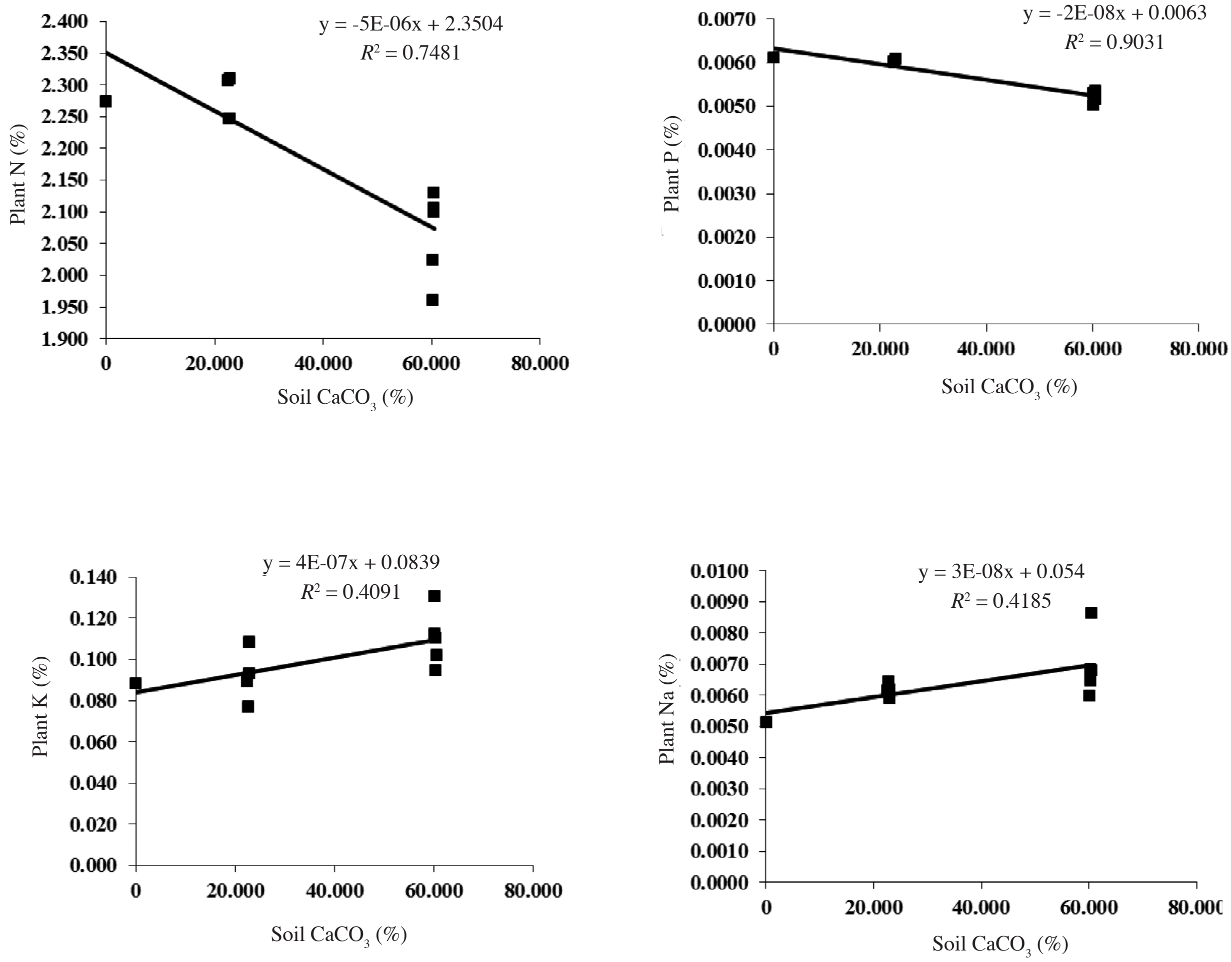


FIGURE 8. Statistical evaluation of *C. kilaea* with various elements in comparison with its co-located soils

Biology and Bahcesehir University, for the technical support.

REFERENCES

Arif, R., Kupeli, R. & Ergun, F. 2004. The biological activity of *Centaurea* L. species. Ankara. *Gazi Universitesi Fen Bilimleri Dergisi* 17(4): 149-164.

Atar, M. 2006. *Centaurea kilaea* Boiss. ve *Centaurea cuneifolia* Sm. uzerinde morfolojik ve palinolojik arastirmalar. Yuksek Lisans Tezi. Marmara Üniversitesi, Fen Bilimleri Enstitusu. Istanbul. Turkiye (Unpublished).

Aksiay, F., Bekbolet, M. & Eroskay, O. 1990. Terkos Golu ve Cevresi. Fiziksel Kimyasal ve Ekolojik Dengesinin Arastirilmasi. *Bogazici Universitesi Cevre Bilimleri Enstitusu*. Istanbul. 88.

Bannister, P. 1979. *Introduction to Physiological Plant Ecology*. London: Blackwell Scientific Publications. p. 273.

Bianco, V.V. & Boari, F. 1997. Up-to-date developments on wild rocket cultivation. *Rocket: A Mediterranean Crop for the World Report of the Workshop*.13-14 Dec., 1996. Legnora (Padova). Italy. International Plant Genetic Resources Institute. Rome. Italy. pp. 41-49.

Black, C.A. 1968. *Methods of Soil Analysis*. Wisconsin. U.S.A.: American Society of Agronomy.

Cografya Dunyasi. 2013. http://www.cografya.gen.tr.

Celik, S.,Yucel, E., Mendes, M., Tug, G.N. & Ozturk, M. 2008. Canonical correlation analysis for studying the relationship between the basic morphological and some soil chemical characteristics of *Centaurea mucronifera* DC. (*Asteraceae*). *Asian Journal of Chemistry* 20(3): 2451-2456.

Davis, P.H., Mill, R.R. & Tan, K. 1988. *Centaurea* L.*–Flora of Turkey and the East Aegean Islands*. Edinburgh: Edinburgh Univ. Press. *Supplement* 10: 166-169.

DMI. 2013. The official website of Turkish State Meteorological Service. http://www.dmi.gov.tr

Ekim, T., Koyuncu, M., Vural, M., Duman, H., Aytac, Z. & Adiguzel, N. 2000. *Red Data Book of Turkish Plants*. Ankara, Bariscan ofset. p. 246.

Engler, A. 1964. *Syllabus Der Pflanzenfamilien*. Vol. 2. Gebrüder Borntraeger. Berlin. p. 494.

Epstein, E. 1999. Silicon. *Annual Review Plant Physiology and Plant Molecular Biology* 50: 641- 664.

Ertek, A., Kozak, R. & Evren, E.N. 1998. *Sile (Dogal Tarihi ve Kulturel Yapisi, Sosyo-Ekonomik Analizi ve Gelisme Stratejileri)*, Sile Belediyesi, Sile.

Hegarty, T.W. 1978. Physiology of seed hydration and dehydration and the relation between water stress and the control of germination: A review. *Plant Cell and Environment* 1: 101-119.

Kacar, B. & Katkat, V. 2010. *Bitki Besleme (Plant Nutrition)* (5. Baskı) Nobel Yayın Dağıtım., Ankara. No: 849.

Martin, E., Dinc, M. & Duran, A. 2009. Karyomorphological study of eight *Centaurea* L. taxa (Asteraceae) from Turkey. *Turkish Journal of Botany* 33: 97-104.

McKnight, T. & Hess, L.D. 2000. *Climate Zones and Types. Physical Geography: A Landscape Appreciation*. Upper Saddle River. NJ: Prentice Hall.

Municipality. 2013. The official website of Istanbul Metropolis Municipality, http://wwwibb.gov.tr.

Olsen, S.R. & Sommers, L.E. 1982. Phosphorus. In *Methods of Soil Analysis* (Part 2), edited by Chemical and Microbiological Properties. ASA-SSSA. Madison.

Ozdemir, F., Ozturk, M. & Guvensen, A. 1994. *Brassica nigra* (L.) Koch. ve *Brassica juncea* (L.) Czern. tohumlarinin su alinimi uzerinde bir arastirma, *XII. Ulusal Biyoloji Kongresi*, 6-8 Temmuz 1994, Edirne.

Ozdemir, F. & Ozturk, M. 1996. Bati Anadolu'da yayilis gosteren *Capparis* L. turlerinin bireysel ekolojisi uzerinde bir arastirma. *Turkish Journal of Botany* 20: 117-125.

Ozturk, M. & Gork, G. 1979(a). Ecology of *Mentha pulegium*. *Ege University Science Faculty Journal* III: 57-72.

Ozturk, M. & Gork, G. 1979(b). Edaphic relations of *Mentha* species in West Anatolia. *Ege University Science Faculty Journal* III: 95-110.

Ozturk, M. & Secmen, O. 1993. *Autecological studies in Turkey*.V.OPTIMA Collogium, Istanbul.

Ozturk, M. 1980(a). Chorology Of *Inula graveolens* (L.) Desf. Tubitak, VII. Sci. Congress, Kusadası, Izmir.

Ozturk, M. 1980(b). Population Differentiation in *Cichorium intybus*. I-Ecad Formation. Tubitak, VII. Sci. Congress, Kusadası, Izmir.

Ozturk, M. 1982. Ecophysiology of *Inula graveolens* (L.) desf. I. edaphic relations. *Ataturk Univ., Sci. Fac. Jour.* Special Issue: 480-492.

Ozturk, M. & Ay, G. 1986. Uzun Omurlu Tohumlar. *Tabiat ve Insan*. 4: 31-33.

Ozturk, M., Gemici, M., Yılmazer, C. & Ozdemir, F. 1992. Alleviation of salinity stress by GA_3, KIN and IAA on seed germination of *Brassica campestris* L. *Turkish Journal of Botany* 17: 47-52.

Ozturk, M., Pirdal, M. & Ozdemir, F. 1997. *Bitki Ekolojisi Uygulamalari*. Ege Universitesi Basimevi. Bornova. Izmir.

Ozturk, M. & Secmen, O. 1999. *Plant Ecology*. 5th ed. Izmir: Ege Univ. Press.

Ronen, E. 2007. *Micro-Elements in Agriculture*. Practical Hydroponics & Greenhouses, July/August. 39.

Thomas, J.W. 1979. *Wildlife Habitats in Managed Forests: The Blue Mountains of Oregon a Washington*. U.S.D.A. Forest Service. Handbook 553. Washington, D.C.

Thornthwaite, C.W. 1948. Approach toward a natural classification of climate. *Geographical Review* 38(1): 55-94.

TUIK. 2013. The official website of Turkish Republic Office of Prime Ministry Statistic. http://www.tuik.gov.tr.

Turkoglu, I., Akan, H. & Civelek, S. 2003. A new species of *Centaurea* (Asteraceae: sect. Psephelloideae) from Turkey. *Botanical Journal of the Linnear Society* 143: 207-212.

Tutin, T.G., Heywood, V.H., Burges, N.A., Moore, D.M., Valentine, D.H., Walters, S.M. & Webb, D.A. 1980. Cambridge University Press. *Flora Europaea* 4: 254-301.

Tuzuner, A. 1990. *Toprak ve Su Analiz El Kitabi*, Tarim, Orman ve Koy Hizmetleri Genel Mudurlugu, Ankara.

Uysal, T., Ozel, E., Bozkurt, M. & Ertugrul, K. 2012. Genetic diversity in threatened populations of the endemic species *Centaurea lycaonica* Boiss. & Heldr. (Asteraceae). *Research Journal of Biology* 2(3): 110-116.

Uygunlar, S., Yazgan, M. & Ozturk, M. 1985. Tohum cimlenmesinde su aliniminin rolu, *Doga. Turk Botanik Dergisi* 9(3): 620-630.

Uzunhisarcikli, M.E., Dogan, E. & Duman, H. 2007. A new species of *Centaurea* L. (*Cardueae*: *Asteraceae*) from Turkey. *Botanical Journal of the Linnean Soc*iety 153(1): 61-66.

Vardar, Y. & Ozturk, M. 1971. Water relations of *Myrtus communis* seeds. Gesell. Switzerland. *Verhandlungen der Schweizer Naturforschenden Gesellschaft*.

Wagenitz, G. 1975. *Centaurea L.* In *Flora of Turkey and the East Aegean Islands,* edited by Davis, P.H. Edinburgh: Edinburgh Univ. Press. 5: 465-585.

B. Eskin*, I.I. Ozyigit & M. Serin
Marmara University
Faculty of Science & Arts
Biology Department
Goztepe, Istanbul
Turkey

I. Dogan
Izmir Institute of Technology
Faculty of Science
Dept. of Molecular Biology/ Genetics
Izmir, Turkey

V. Altay
Mustafa Kemal University
Faculty of Science & Arts,
Biology Department
Antakya, Hatay
Turkey

G. Demir
Bahcesehir University
Engineering Faculty
Environm. Engineering Dept., Besiktas
Istanbul-Turkey

*Corresponding author; email: b_eskin@hotmail.com

Received: 14 April 2013
Accepted: 12 May 2013