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Distribution of Some Elements in *Veronica scutellata* L. from Bolu, Turkey: Soil-Plant Interactions

(Taburan Beberapa Unsur dalam *Veronica scutellata* L. dari Bolu, Turki: Saling Tindakan Tanih-tumbuhan)

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ABSTRACT

Veronica scutellata *L. occurs in moist and wet habitats, such as ponds, marshes and other wetlands. This study was conducted on this species to examine its mineral element uptake status in terms of interactions between soil and plant. Experimental materials were taken from the Southern coast of Black Sea at coordinates 40º36'N and 31º16'E at an altitude of 1400 m above sea level from Bolu – Turkey; using standard methods and plant (root, stem and leaf parts) and soil mineral element measurements (Al, B, Ca, Cu, Fe, K, Mg, Mn, Na, Ni and Zn) were done. During the study,* ICP-OES *was employed for the measurement of mineral elements. It was observed that considerable amounts of B, Ca, K, Mg, Mn, Na and Zn are accumulated by the plant.*

Keywords: Autecology; grassleaf speedwell; plant nutrition; trace elements

ABSTRAK

Veronica scutellata *L. wujud di habitat lembab dan basah seperti kolam, rawa dan tanah bencah lain. Kajian dijalankan ke atas spesies ini untuk meneliti status pengambilan unsur mineral daripada segi saling tindakan antara tanih dan tumbuhan. Bahan percubaan telah diambil dari Pantai Timur Laut Hitam pada koordinat 40º36'U dan 31º16'T pada altitud 1400 m atas paras laut dari Bolu, Turki dengan menggunakan kaedah piawai dan tumbuhan (bahagian akar, batang dan daun) dan pengukuran unsur mineral tanih (Al, B, Ca, Cu, Fe, K, Mg, Mn, Na, Ni dan Zn) telah dilakukan. Semasa kajian,* ICP-OES *telah digunakan bagi pengukuran unsur mineral. Telah diperhatikan bahawa sejumlah amaun B, Ca, K, Mg, Mn, Na dan Zn telah terkumpul oleh tumbuhan.*

Kata kunci: Autekologi; grassleaf speedwell; nutrisi tumbuhan; unsur surih

INTRODUCTION

Veronica is a large genus with about 500 species mostly distributed in central and southern Europe and Turkey (Albach et al. 2003, 2004). The cosmopolitan genus is a member of Plantaginaceae family (formerly placed in Scrophulariaceae) (Albach et al. 2003, 2004; Davis 1965-2001). It consists of annual or perennial herbs, with alternate or opposite leaves and solitary flowers or flowers in racemes. The corolla has a very small tube and four, frequently unequal, lobes (Juan et al. 1997). *V. scutellata* commonly known as grassleaf speedwell, skullcap speedwell and marsh speedwell is a perennial and rhizomatous herb with an upright or decumbent stem, up to 60 cm high. Vegetative and generative parts are mostly glabrous, leaves opposite, purple green or reddish, lanceolate or smooth edged. Inflorescence contains several flowers on thin and straight pedicels. Flowers are blue, white or purplish with purple veining, with four lobes and upper lobe is the largest. Each flower is up to 1 cm wide. Fruit is a small notched flat capsule, with a width of few mm (Davis 1965-2001; Juan et al. 1997).

V. scutellata is uncommon and occurs only in a few locations in Turkey (Figure 1). Marshes, wet meadows, low areas along springs, low muddy areas along ponds and swamps (Turker & Guner 2003). One of these habitats is on the edge of seasonal pond; a site of number of rare plants; located in a mountainous area near the southern coast of the Black Sea at 1400 m above sea level in the State of Bolu (Figure 2). It was found growing on calcareous soil. The most interesting associate of this plant in this area is *Isoetes anatolica*, an endemic species found only here in the world (Prada & Rolleri 2005). The character of the water, topographic features and other factors play an important role in the occurrence and existence of rare plants in this locality.

The calcareous seasonal pond constitutes a restricted class of habitat in the region. The present study focuses on mineral element uptake status of *V. scutellata* in order to enlighten the plant-soil interactions of this species. Attempts have been made to investigate the conditions for maintenance of these rare plant populations.

MATERIALS AND METHODS

Samples of plant and soil were taken for the mineral element analysis from five different points at each

FIGURE 1. The photos were taken from Abant Region in August showing A- Natural habitat of *V. scutellata*, B- Aboveground parts of the plant and C- Flowers

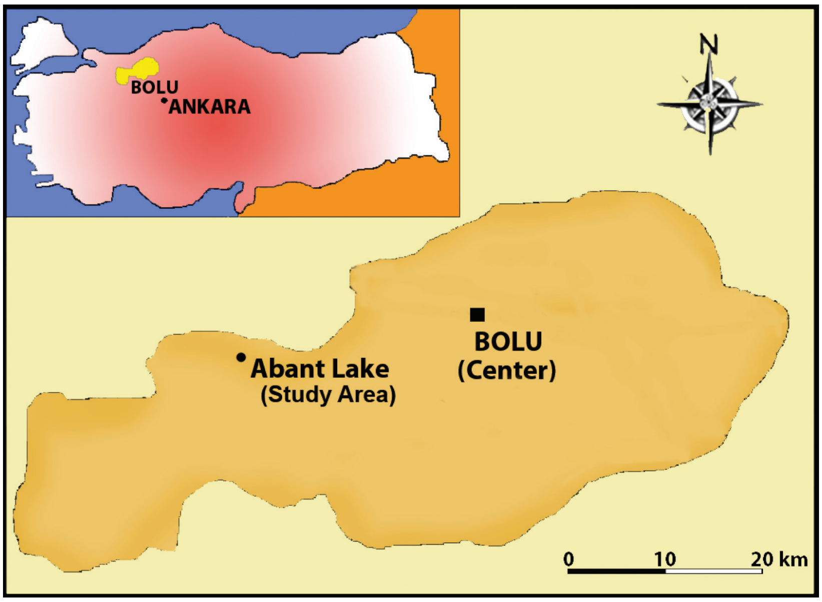

FIGURE 2. Map showing the study area (location of Abant Lake region, Bolu-Turkey)

sampling site. pH of water near the collection sites was also recorded. Soil sampling (about 500 g for each) was done by using stainless steel shovel and samples were taken from a depth of 0-10 cm. A bulk was formed from the samples at each sampling site and a representative sample obtained for each site. Disposable gloves were used during the soil sample collections for prevention of possible contamination. The samples were put into white transparent labeled polythene bags and brought to the laboratory together with the plant samples.

Plants were separated into parts, oven-dried at 80°C for 24 h, milled in micro-hammer cutter and fed through a 1.5 mm sieve. Samples were weighed as 0.3 g and transferred into Teflon vessels and then 8 mL 65% HNO_3 was added.

Soil samples were also oven-dried at 80°C for 24 h and fed through a 2 mm sieve. They were weighed as 0.3 g and transferred into Teflon vessels and then 5 mL 65% HNO_3, 3 mL 37% HCl and 2 mL 48% hydrofluoric acid (HF) were added. All 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. These were stored in falcon tubes. Standard solutions were prepared by using multi element stock solutions-1000 ppm (Merck) and mineral element (Al, B, Ca, Cu, Fe, K, Mg, Mn, Na, Ni and Zn) measurements were done by Inductively Coupled Plasma Optical Emission Spectroscopy (PerkinElmer-Optima 7000 DV).

Results and Discussion

The sampling region experiences a transitional climate between Mediterranean and Oceanic climates (Cobanoglu & Akdemir 2004; Turker & Guner 2003). The geographical conditions revealed that this site is totally closed to the dry southern wind and opens to the northern winds therefore high humidity is recorded in the region (DMI 2011). The meteorological data covering the period 1930-2001 in Bolu shows, the mean annual temperature is 10.3°C but that of Abant Lake 7.3°C, because its altitude is 600 m higher than Bolu. The lake has come into being in the Paleozoic era. Average precipitation is 534.4 mm per year, 32% is in winter, 29% in spring, 21% in autumn and 18% in summer. The mean annual precipitation of Abant is expected to be between 800 and 900 mm (Mater & Sunay 1985). The lake region is known for its natural scenic beauty with unique geological features. The area is considered to have unique species richness (Celekli et al. 2007) and is home to a rich flora and fauna. There are sandy, clayey and calcareous soils formed from schist and serpentine bedrock (Mater & Sunay 1985).

Table 1 shows that pH of water in the seasonal pond is in the range of 6.12-6.47, average being 6.23 ± 0.17. This value points out that *V. scutellata* grows in slightly acidic soil and water. Element analysis of plant parts are given as mg/kg dw. The values were 993.400 in leaf, 532.955 in stem and 541.213 in root for Al; 12.494 in leaf, 12.478 in stem and 12.524 in root for B; 9437.2 in leaf, 8600.675 in stem and 5590.835 in root for Ca; 4.207 in leaf, 5.965 in stem and 5.354 in root for Cu; 630.440 in leaf, 338.045 in stem and 350.824 in root for Fe; 8507.2 in leaf, 11450.690 in stem and 5968.684 in root for K; 115.384 in leaf, 126.797 in stem and 428.433 in root for Mn; 2076.56 in leaf, 1406.684 in stem and 1234.785 in root for Mg; 122.412 in leaf, 239.768 in stem and 355.458 in root for Na; 1.274 in leaf, 0.156 in stem and 5.180 in root for Ni and 30.876 in leaf, 30.902 in stem and 23.545 in root for Zn. Average values for Al, B, Ca, Cu, Fe, K, Mn, Mg, Na, Ni and Zn in soil samples were 4229.205, 1.657, 1481.504, 6.730, 2583.815, 2917.436, 168.928, 2068.482, 90.939, 6.810 and 16.983, respectively. Attempts to evaluate the interrelations between mineral element contents in the soil and the plant show that, the normal limits of Al, B, Cu, Fe, Mn, Ni and Zn in plants are reported to lie in the range of 7-104, 10-100, 5-30, 2-250, 30-300, 0.1-5, 25-150 mg/kg dw and between or over 400, 50-200, 20-100, 400-1000, 300-500, 10-100, 100-400 mg/kg dw are accepted as toxic levels, respectively (Guleryuz et al. 2010; Kabata-Pendias & Mukherjee 2007; Kabata-Pendias & Pendias 2001; Ozdemir & Ozturk 1996; Ozturk 1979; Ozturk & Gork 1979). According to these values, the concentrations of B, Cu and Zn in this study were within normal limits in the plant whereas the values of Al, Fe, Mn and Ni exceeded normal limits. The concentrations of Al, Fe and Mn were in the range of toxic level. The data suggested that the plant accumulates excessive Al, Fe and Mn from the soil.

Excess amount of any mineral element is toxic for plants, when excess of an element is inside the cells, the mechanisms to tolerate start operating. One of the mechanisms is compartmentalization of elements in different organelles of plant cells in the shoot, leaf and root. Our study depicts that much of Al, Fe and Mn entering the cell is reduced by its sequestration into the vacuole as pointed out by Gaxiola et al. (1999) and Apse et al. (1999). Although they were not in the range of toxic levels, accumulation of some elements (B, Ca, K, Na and Zn) was observed within the plant in comparison to their levels in the soil (Table 2). Mineral nutrient availability to plants is strongly influenced by soil pH. When soil pH drops, there is an increase in the solubility of Mn, Zn, Cu, and Fe, whereas reductions are observed in the availability

TABLE 1. pH values of water samples (WS) in habitat of *V. scutellata*

WS 1	WS 2	WS 3	WS 4	WS 5	Average
6.12	6.33	6.13	6.09	6.47	6.23 ± 0.17

TABLE 2. Mineral element (Al, B, Ca, Cu, Fe, K, Mg, Mn, Na, Ni, and Zn) concentrations of soil and leaf stem and root samples of *V. scutellata*

Elements	Leaf (mg/kg)	Stem (mg/kg)	Root (mg/kg)	Soil (mg/kg)
Al	993.400 ± 29.211	532.955 ± 13.877	541.213 ± 10.285	4229.205 ± 262.533
B	12.494 ± 0.436	12.478 ± 0.810	12.524 ± 0.543	1.657 ± 0.092
Ca	9437.2 ± 327.471	8600.675 ± 305.14	5590.835 ± 379.473	1481.504 ± 54.266
Cu	4.207 ± 0.323	5.965 ± 0.495	5.354 ± 0.216	6.730 ± 0.102
Fe	630.440 ± 16.174	338.045 ± 9.473	350.824 ± 14.995	2583.815 ± 196.693
K	8507.2 ± 227.912	11450.690 ± 492.185	5968.684 ± 266.673	2917.436 ± 89.878
Mn	115.384 ± 3.572	126.797 ± 5.804	428.433 ± 21.740	168.928 ± 14.580
Mg	2076.56 ± 114.916	1406.684 ± 126.816	1234.785 ± 59.585	2068.482 ± 43.248
Na	122.412 ± 6.906	239.768 ± 14.196	355.458 ± 18.388	90.939 ± 2.550
Ni	1.274 ± 0.022	0.156 ± 0.005	5.180 ± 0.262	6.810 ± 0.279
Zn	30.876 ± 0.323	30.902 ± 0.222	23.545 ± 0.287	16.983 ± 0.075

of N, K, Ca, Mg and S when soil pH falls (Hodges 2010). At very low pH, the solubility of some mineral nutrients increases which can become toxic to sensitive plants. At high pH values, the solubility of some mineral elements can become so low that plants are unable to obtain adequate supplies from the soil. The pH range within 6.0 to 6.5 is preferable by most plants for optimum growth. This assures high availability of most demanded nutrients for plants (Ronen 2007). In our study average pH value is 6.23. The degree of K fixation partly depends on the pH. K fixation is strongly influenced by the kind of adsorbed cations or anions within the system (Harris 1937; Rich 1968; Sparks & Huang 1985). K fixation occurs in soils with pH ranging from 5.3 to 8.5. A marked increase in K fixation in alkaline soils is observed. There is no fixation when pH value is 2.5 (in acidic soils); as a result of competition between K -Fe and Al-H ions (Martin et al. 1946; Sezen 1975, 1991; Thomas & Hipp 1968; Volk 1934). Table 2 shows that K level is much higher than Al and Fe in plant as compared to pH value of the soil. Individual soil characteristics too have effect on the plant elements but joint impacts are also seen due to interactions between them.

It is well known that soil pH and plant potassium and soil potassium and plant calcium are significantly and positively correlated. However, negative correlations exist between soil organic matter and plant sodium and soil organic matter and plant manganese content. The data for this indicated that the soils of these plants appear to be poor in nutrients (Baslar & Mert 1999). In our study, there was a positive correlation between soil K and plant Ca, also plant Na and Mn levels were high in comparison to the soil. Availability of mineral elements to plants is determined by some interactions occurring in the soil and the plant tissues. Plant Mg can be influenced by several factors. When soil level of K to Mg exceeds 4:1 or when the soil level of Ca:Mg exceeds 8:1, Mg uptake by some plants is depressed (Hodges 2010). Therefore, a proper balance of Mg to both K and Ca is important. In this study, the balance of Mg to K and Ca was proper and therefore uptake of Mg by the plant was not inhibited. Quite high uptake rate for Zn in our study was a consequence of low N and P levels. It means there were no significant antagonistic interactions between P-Zn and N-Zn (Camp & Fudge 1945; Ozanne 1955; Stukenholtz et al. 1966; Thorne 1957). B accumulation was very high in comparison to the soil in the plant. Higher Ca concentration can be employed to correct boron toxicity. A requirement for normal growth in plants in addition to other factors is to have certain balance between the uptake of Ca and B (Jones & Scarseth 1944). Our results showed consistency with this. Accelerated Zn or Mn uptake causes a marked reduction in Fe concentration in plants (Epstein & Stout 1951; Ronen 2007) as observed in this study. The level of Cu in the plant was adequate in our sites. Cu deficiency occurs primarily on high organic matter soils (Hodges 2010). The soil appears to contain enough Cu amounts in our work. High Zn in the trees may promote Fe deficiency as found during this study. The level of Fe in the plant was low in comparison to the level in the soil. The plant retained high level of Zn, which could be a contributing factor in inducing Fe deficiency. Al is not an essential nutrient (Vardar & Unal 2007) but can be a factor affecting plant growth (Foy 1992). Al toxicity occurs in plants when soil pH is very low (Hodges 2010). The level of Al was low in the plant in comparison to the soil. This is expected because pH value was not very low in this study. But surprisingly, the level of Al in leaf was higher than stem and root in the plant. It shows that the plant has a unique ability to accumulate excess amount of Al in the leaf part.

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