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Ali Celik
Pamukkale University

Fatih Yayla
Gaziantep University

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Full Length Article

Ecological Properties and Close Relationships of Some *Scilla* L. Taxa (Asparagaceae) in Turkey

Nezahat Kandemir[1], Ali Çelik[2*] and Fatih Yayla[3]
[1]*Department of Biology, Education Faculty, Amasya University, Amasya, Turkey*
[2]*Department of Biology, Art and Science Faculty, Pamukkale University, Denizli, Turkey*
[3]*Department of Biology, Art and Science Faculty, Gaziantep University, Gaziantep, Turkey*
[*]For correspondence: toygar09@hotmail.com

Abstract

Ecological properties of some *Scilla* L. taxa [*S. bifolia* L., *S. melaina* Speta, *S. siberica* Haw. subsp. *armena* (Grossh.) Mordak, *S.leepii* Speta, *S. ingridae* Speta, *S. mesopotamica* Speta, *S. autumnalis* L., *S. monanthos* C. Koch., *S. rosenii* C. Koch.and *S. cilicica* Siehe] were compared and relationships among taxa were determined. *S.leepii* and *S. mesopotamica* are endemic to Turkey. Because of various reasons, *S. melaina*, *S. leepii*, *S. ingridae*, *S. mesopotamica*, *S. monanthos*, *S. siberica* subsp. *armena, S. rosenii* and *S. cilicica* have limited distribution in Turkey. The investigated taxa have fragrant flowers, so are used as ornamental plant in gardens, parks and balconies in Turkey. Soil samples of the taxa were taken in flowering periods and physical and chemical properties (texture class, % of total salinity, pH, % of $CaCO_3$, % of organic matter, % of total N, P, K, Ca, Mg, Mn, Cu, Fe and Zn (in mg/kg) were determined. According to the similarities and differences in ecological characteristics, the taxa were divided into four groups. 1st group: *S. melaina, S. leepii, S. ingridae* and *S. mesopotamica;* 2nd group: *S. siberica* subsp. *armena* and *S. cilicica*; 3rd group: *S. bifolia* and *S. autumnalis*; 4th group: *S. rosenii* and *S. monanthos*. From the data, it has been found that organic matter, N, P, K, Ca, Fe and Zn values are more effective than the other soil factors in the distributions of the investigated taxa.

Keywords: *Scilla* taxa; Ecological properties; Soil; Relationship; Turkey

Introduction

Asparagaceae is a large family. It contains plants that are used as ornamentals, food, animal feed. These plants are also used to prevent or treat rheumatism, influenza infections and to strengthen the heart. *Scilla* L. genus belongs to the family of Asparagaceae and is represented by eighteen species in Turkey. The rate of endemism is about 33.3% (Mordak, 1984; Özhatay, 2000; Güner *et al*., 2012). Because *Scilla* is an important genus among geophytes, many kinds of chemical substances were identified in *Scilla* taxa (Bangani *et al*., 1999; Özay *et al*., 2013). Chemical substances obtained from the bulbs and leaves of some *Scilla* taxa (specially, *S. autumnalis*) are used in drug production. Furthermore, some *Scilla* taxa produce antioxidants. These antioxidants have beneficial effects on the digestive system, circulatory systemand skin (Tripathi *et al*., 2001; Geraci and Schicchi, 2002; Banciu *et al*., 2010). *S. autumnalis* and *S. bifolia* are widely used as decorative ornamental plants (Peryy, 1974; Sargın *et al*., 2013).

Among the species of *Scilla* genus, *S. ingridae*, *S. melaina S. cilicica* and *S. bifolia* are Mediterranean elements, *S. mesopotamica*, *S. autumnalis*, *S. rosenii*, *S. leepii* and *S. siberica* subsp. *armena* are Irano-Turanian elements and *S. monanthos* is a European-Siberian element. Because of various reasons (dam construction, excessive collection, tourism, agricultural fight, forest fires), *S. melaina, S.leepii*, *S. ingridae*, *S. mesopotamica*, *S. monanthos*, *S. rosenii*, *S. siberica* subsp. *armena*, and *S. cilicica* are under the threat of extinction in Turkey. *S.leepii* and *S. mesopotamica* from the investigated taxa are distributed only in the vicinity of Elazığ, Diyarbakır and Şanlıurfa. The two taxa are endemic to Turkey. *S. mesopotamica* was placed in DD category (insufficient) by Ekim *et al*. (2000). These species were collected only in Halfeti and in the vicinity of Karaca Mountain (Satıl and Akan, 2006) and were placed in CR category (critically endangered). *S. leepii* is in LR (nt) (near threatened) category. Since *S. siberica* subsp. *armena* among investigated taxa has an extremetely limited distribution, it may be included in the rare species of Turkey in the future. However, these taxa are non-endemic in Turkey.

Scilla autumnalis is very common in Mediterranean, South-Western England, Portugal, Libya and North Africa. Therefore, it has been described as a complex and cryptic species (Vaughan *et al*., 1997). *S. autumnalis* is not under threat in Turkey (including within the Kuşadası-Marmaris localities), but it is critically endangered in some countries

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especially Romania (Banciu *et al*., 2010). Also, *S. autumnalis* is different from other investigated taxa in terms of morphologic properties. It flowers in autumn, while the other taxa flower in spring. *S. bifolia* also owes a widespread distribution; that's why the taxa has many problems with its morphological characteristics. *S. dedea* and *S. pruinosa* were described as two new taxa from the south of Turkey by Speta (1991). Later, Özhatay (2000) reported that the two taxa were the same as *S. bifolia*. Furthermore, *Puschkinia bilgineri* is very similar to *S. bifolia* and *S. vardaria* in its flower and seed characteristics (Yıldırım, 2014a). To minimize these problems, it was aimed to determine their relationship degrees and taxonomic places related to the ecological characters of these taxa.

Materials and Methods

The plant samples were collected from different locations between 2011 and 2013. The distribution areas of *Scilla* taxa in Turkey are shown in Table 1. Taxonomic descriptions were made according to Mordak (1984) and Güner *et al*. (2012). The morphological characters of taxa are given in Table 2. The distribution areas of the taxa were coded as A, B, C, D, E, F, G, H, K and L (Table 3).

Soil samples were taken after the ground surface was cleared from the top layer to a depth of 0–20 cm during generative growth period. Analysis of soil samples were made in the Soil Analyses Laboratory of Eğridir–Isparta Fruit Research Station Office. The soil texture, total salinity, calcium carbonate ($CaCO_3$) and pH were determined according to the standard methods (Kacar, 1996). Nitrogen, phosphorus, potassium, organic matter and microelement contents of the soil samples were analyzed by micro–Kjeldahl apparatus, ammonium-molybdate-stannous chloride, flame photometer, the Walkley–Black, DTPA (Diethylenetriaminepentaacetic acid)+CaCl (Calcium chloride) + TEAL (Triethanolomine) methods, respectively (Kacar, 1996).

Statistical Analysis

The mean and standard deviation values of soil analysis results were estimated and given in Table 3. The Kruskall Wallis test was used to determine whether there was a difference between the results of the soil analysis of the species and the Mann Whitney U test was used to determine the various differences occurring between the groups (Büyüköztürk, 2001). According to the statistical results, the graphs were drawn.

Results

Soil Characteristics of *S. autumnalis*

While not endemic to Turkey, *S. autumnalis* is considered a vulnerable species. Soil samples were taken from seven different localities (A1, A2, A3, A4, A5, A6 and A7**)** in Muğla, Denizli, Balıkesir and Samsun. While the soil samples in localities A1, A2 and A7 were clayey-loamy, the soil in localities A3, A4, A5 and A6 had loamy texture structure. The pH values varied from 6.92 to 7.90. The total salinity of soil samples was between 0.25 and 0.61%. The level of $CaCO_3$ content of the soils was between 4.70–8.68%. The organic matter, N, P and K values of soil samples varied between 4.05–8.10%, 1.18–2.65%, 16–19 mg/kg and 185–275 mg/kg, respectively. Zn, Mn and Fe values were 3.00–4.60, 17.10–19.20 and 12.20–14.80 mg/kg, the Ca, Mg and Cu values were 5124–8585, 230–390 and 1.05–1.90 mg/kg, respectively.

Soil Characteristics of *S. cilicica*

Soil characteristics of the species were based on samples taken from three different locations (B1, B2 and B3) in Mersin, Kayseri and Nevşehir. The pH, salinity, $CaCO_3$, organic matter, N, P and K values varied from 6.80 to 7.81, 0.16 to 0.56%, 12.85 to 24.55%, 2.20 to 3.98%, 0.139 to 0.522%, 5 to 8 and 152 to 205 mg/kg, respectively (Table 3). The Ca, Mg, Cu, Zn, Mn and Fe contents varied between 3270–3632, 187–425, 2.20–3.40, 0.50–1.80, 10.48–14.61 and 23.67–27.81 mg/kg, respectively.

Soil Characteristics of *S. ingridae*

Soil samples of the *S. ingridae* were taken from three different localities (C1, C2 and C3) in Gaziantep, İçel and Niğde. The pH values varied from 6.97 to 7.95. The $CaCO_3$ content was high (23.90–27.78%). The soil samples had a clayey-loamy texture structure. The salinity values were low (0.21–0.38%). The organic matter contents were found to be 1.42–1.95%. The N, P and K contents of the soil samples were between 0.617–1.06 %, 2–3 and 197–255 mg/kg, respectively. The Ca and Mg contents changed between 6235–8430 and 290–350 mg/kg, respectively. The Cu and Zn values ranged from 0.87 to 1.56 and from 2.60 to 3.30 mg/kg. The Mn and Fe values of the soils were between 16.40–18.50 and 11.40–13.70 mg/kg, respectively.

Soil Characteristics of *S. melaina*

It has limited distribution in Turkey. Its soil characteristics are based on three localities (D1, D2 and D3) in Adana and Gaziantep. The salinity contents of the soil samples were low (0.18–0.56%). The pH value varied from 7.38 to 7.81. The $CaCO_3$ contents of the soils were high (21.02–26.50%). The soil samples had clayey-loamy and loamy structure (Table 3). The organic matter values ranged from 1.80 to 2.40%. N and K contents were between 0.170–0.576% and 352–531 mg/kg, respectively the P content was between 12 and 16 mg/kg. The Ca, Mg, Cu, Zn, Mn and Fe values were between 5649–7455, 150–161, 1.30–2.90, 0.70–1.90, 9.80–15.70 and 12.00–13.60 mg/kg, respectively.

Table 1: The localities of collection of *Scilla* taxa in Turkey (E: endemic)

Taxa	Description of localities
S. autumnalis	Muğla: Kuşadası, rocky areas
	Muğla: city cemetery, open areas
	Muğla: Göktepe, open areas
	Samsun: Çetirli Pınar Village, open areas
	Denizli: Campus vicinity, open areas
	Denizli: Center Karcı neighborhood, open areas
	Balıkesir: Bigadiç, Below Göcek Village, Alaçam Mountains, rocky areas
S. cilicica	Mersin: Yukarı Fındık Fountain, open steppe
	Kayseri: Pınarbaşı, Tersakan Village, open steppe
	Nevşehir: Göreme, open steppe
S. ingridae	Gaziantep: Nurdağı Passage, steppe areas
	İçel: Anamur-Akpınar Village, step areas
	Niğde:Ala Mountain, rocky areas
S. melaina	Adana: Düldül Mountain, shrub areas
	Gaziantep: Sof Mountain, Işıklı Village rocky areas
	Adana: Tekir Mountain, steppe volcanic rocky
S. mesopotamica E	Urfa: Siverek, Karaca Mountain, Rame Creek, rocky areas
	Urfa: Halfeti, Fırat edge, rocky areas
S. bifolia	Denizli: Honaz Mountain,shrub areas
	Muğla: the between Fethiye Söğüt, open areas
	Edirne: the between Havsa Uzunköprü, rocky areas
	Samsun: Çetirli Pınar Village, open areas
	Antalya: Termessos National Park (Güllük Mountain), oak trees bottom
S. leepii E	Elazığ: the between Ergani Maden, open areas
	Erzincan: Cevizli Village, steppe and metamorphic areas
S. siberica subsp. *armena*	Sivas: Yıldızeli Navruz Plateau, open areas
	Sivas: Zara vicinity, open areas
	Erzurum: Narman vicinity, open areas
S. monanthos	Artvin: Çoruh Valley, rocky areas
	Trabzon: Meryemana Monastery, rocky areas
S. rosenii	Artvin: Çoruh Valley, open areas
	Artvin: Yusufeli, rocky areas

Table 2: Morphological characters of investigated *Scilla* taxa

Taxa	Bulb	Leaves	Scape	Raceme	Bract	Perianth segments	Filament	Ovary	Style	Seeds
S. autumnalis	1(–2)x2(–4)cm, tunics brown	3–12cm,narrowly linear, 2–17 cmx1–2 mm,erect,fleshy	5–30cm, erect	4–25flowered	absent	lilac with darker midrib, 3–4x1.5–2mm	1 mm broad at base	obovoid,(–3)3.5-4 mm	0.5–2mm	3x1.5 mm,elipsoid black exarillate
S. cilicica	1.5–2.5cm tunicfuscous-violet	(–3) 4-6 cm broadly linear, 13–40cm x (7-) 10-20 mm	14–38 cm, erect	(2–)4–6(–8) flowered	2–5(–8)mm ovate truncate	pale or lavender blue 9–16x3–4(–5)mm	0.5–1mm broad below	subglobose 3mm	straight selender 4.5–9mm	ovoid 3(–4) x 2(–3) mm black
S. ingridae	1.8x1.2 cm tunic furcous–violet	(2–)4–5(–6) cm broadly linear 6–15 (–22) cm x4–6(–18) mm	9–20 cm	1–3(–5)flowered	bifid 1–2mm	pale blue–violet 9–16x3–6mm	filiform	8–12x7–9mm	4–6mm	subglobose 2.5 mm exarillate
S. melaina	0.5–1.5cm tunic furcous–violet	(2–)3–5 cm broadly linear 8–24 cm x4–10(–15)mm	8–26 cm	2–3(–4) cm flowered	bifid 1–3mm	dull blue or prussian blue 12–18x3–5 mm	1–1.5mm broad at base	subglobose 3–3.5mm	straight 4.5–6.5 mm	subglobose 3–3.5mm black
S. mesopotamica	2.5x2cm tunics fuscous violet	2–4 (–6) cm broadly linear 15–34 cm x 9–14 mm	36 cm stout	1–5 flowered	bifid 1–2.5 mm	pale blue with darker midrib 12–17x2–4.5 mm	7–10.5mm filiform	globose	7.5–10.5mm	2 mm subglobose exarillate
S. bifolia	0.5–2cm tunic brown	(1–)2(–7) cmbroadly linear 7–19 (–35) cm x(1.5–)3–15mm	Erect 5–28 (–35) mm	1–15(–25) flowered	0.5–1(–4)mm	bright blue, lilac blue or bluish purple 5–10x1.5–2.5mm	0.5–1 (–1.5) mm broad at base	obovoid or subglobose 2–3mm	straight 2–4.5(–6)mm	subglobose 2 mm brown
S. leepii	1.5x1.0cm tunicdark brown	2–4 cm broadly linear 3–10cm x4–8 mm	slender	1(–3) flowered	bifid 1–2.5mm	lilac blue with dark midrib 9–18x2–5mm	6–7mmdilated at base	subglobose 2–3mm	6–8.5(–11)mm	subglobose 2 mm pale brown
S. *siberica* subsp. *armena*	0.7–1.5cm tunic fuscous	2–3(–5) linear 5–6 (–28) cm x4–5(–17) mm	6–8(-14) cm	1–2 flowered	bifid 1–2 mm	deep blue with dark midrib 13–15x4–5mm	1–2mm broad at base	subglobose 3–5mm	4–6mm thick	svoid 3x2 mm pale brown
S. monanthos	0.5–1cm tunic fuscous–violet	3–4(–5) linear lanceolate 3.5–7cm x4–6mm	7–20cm	1–2(–3) flowered	1–3(–4) mm 2 lobed truncate	pale blue or whitish with dark midrib 10–15x3–5mm	1mm broad at base	obovoid 4–5x–2.5–3.5mm	straight 4.5–7mm	ovoid 3x2mm pale brown
S. rosenii	1–1.5cm tunic fuscous–violet	2–3 linear 8–13(–20) cm x6–10 (–15) mm	10–15 (–23) cm	1–2(–3) flowered	2–3 mm 2 lobed turuncate	blue outside with darker midrib 10–25x4–6mm	2mm broad at base	obovoid 5x2 mm	straight 6.5–10 mm	ovoid 3x2mm pale brown

Table 3: Physico-chemical properties of soil samples from different localities (A: *S. autumnalis*, B: *S. cilicica* ,C: *S. ingridae*, D: *S. melaina*, E: *S. mesopotamica*, F: *S. bifolia*, G: *S. leepii*, H: *S. siberica* subsp. *armena*; K: *S. monanthos*, L: *S. rosenii*)

Locality code	Texture	Salinity (%) (EC)	$CaCO_3$ (%)	pH	Organic Matter (%)	N (%)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Fe (mg/kg)
A1	Clayey-loamy	0.40	8.68	7.60	8.10	2.59	19	275	8585	330	1.60	3.00	18.90	14.40
A2	Clayey-loamy	0.61	7.70	7.75	6.65	1.74	16	235	7685	270	1.30	3.30	17.10	12.20
A3	Loamy	0.25	6.20	7.40	4.05	1.64	17	190	5124	350	1.40	4.50	18.20	12.60
A4	Loamy	0.37	4.70	6.95	4.74	2.34	19	220	6780	310	1.80	3.90	17.60	14.80
A5	Loamy	0.32	8.50	6.92	6.20	1.36	16	245	7240	390	1.05	4.60	19.00	13.30
A6	Loamy	0.30	8.20	7.86	4.40	1.18	17	207	5760	290	1.90	4.30	18.40	13.70
A7	Clayey-loamy	0.50	7.30	7.90	4.80	2.65	19	185	6530	230	1.50	4.05	19.20	14.60
Mean ± Sd	-	0.39±0.12	7.32±1.43	6.95±0.41	5.56±1.46	1.92±0.60	1.92±1.40	222±31.9	6813±1163	310±52.9	1.50±0.29	3.95±0.60	18.3±0.77	13.6±1.00
B1	Clayey-loamy	0.50	23.72	7.81	2.89	0.158	8	152	3450	425	2.40	0.50	14.61	25.95
B2	Clayey-loam	0.16	12.85	6.80	2.20	0.139	5	205	3270	280	2.20	1.02	12.08	27.81
B3	Clayey-loamy	0.56	24.55	7.05	3.98	0.522	7	186	3632	187	3.40	1.80	10.48	23.67
Mean ± Sd	-	0.40±0.21	20.3±6.52	7.22±0.52	3.02±0.89	0.27±0.21	6.6 ± 1.52	181±26.8	3450 ± 181	297 ± 119	2.66±0.64	1.1±0.65	12.4±2.08	25.8±2.07
C1	Clayey-loamy	0.30	27.78	7.95	1.79	1.06	2	255	8430	350	1.32	2.90	16.40	12.50
C2	Clayey-loamy	0.21	24.55	7.35	1.42	0.928	2	197	6747	320	0.87	3.30	18.50	13.70
C3	loamy	0.38	23.90	6.97	1.95	0.617	3	225	6235	290	1.56	2.60	16.60	11.40
Mean ± Sd	-	0.29±0.08	25.4±2.07	7.42±0.49	1.72±0.27	0.86±0.22	2.33±0.57	225±29.0	7137±1148	320±24.5	1.25±0.35	2.93±0.35	17.2±1.15	12.5±1.15
D1	Clayey-loamy	0.18	23.45	7.50	2.10	0.425	12	352	6049	261	1.30	0.70	9.80	13.60
D2	Loamy	0.23	26.50	7.81	2.40	0.576	16	531	5689	230	1.80	1.90	10.60	12.70
D3	Clayey-loamy	0.66	21.02	8.06	4.68	0.170	12	429	7455	150	2.90	1.40	15.70	12.00
Mean ± Sd	-	0.35±0.26	23.6±2.74	7.79±0.28	3.06±1.41	0.39±0.20	13.3±2.30	437±89.7	6397±933	213±57.2	2.0±0.81	1.33±0.60	12.0±3.20	12.7±0.80
E1	Clayey-loamy	0.35	25.17	7.25	2.56	1.563	15	192	4692	347	1.80	0.10	13.60	4.60
E2	Clayey-loamy	0.60	27.49	7.54	3.70	2.165	12	122	6449	179	1.10	0.40	11.20	8.20
Mean ± Sd	-	0.47±0.17	26.3±1.64	7.40±0.20	3.13±0.80	1.86±0.42	13.5±2.12	157±49.5	5570±1242	263±188	1.45±0.49	0.25±0.21	12.4±1.69	6.4 ± 2.54
F1	Loamy	0.41	2.17	6.72	6.14	2.610	12	278	3408	187	2.20	0.70	47.60	24.90
F2	Clayey-loamy	0.35	11.49	6.25	4.87	2.189	14	359	3210	240	1.20	0.58	34.40	27.20
F3	loamy	0.56	2.68	7.05	3.12	1.950	14	495	3446	332	0.70	0.30	13.80	27.30
F4	Clayey-loamy	0.23	22.65	6.60	4.82	1.550	12	220	3585	280	1.70	0.49	16.68	21.50
F5	clayey-loamy	0.47	23.78	7.68	7.52	2.870	20	235	3540	290	0.80	0.64	36.60	23.50
Mean ± Sd	-	0.40±0.12	12.5±10.4	6.88±0.57	5.29±1.46	2.23±0.52	14.4±3.28	317±113	3437±145	265±54.8	1.32±0.63	0.54±0.15	29.8±14.25	24.8±2.47
G1	Clayey-loamy	0.65	2.20	6.45	3.85	2.310	9	162	4125	161	0.80	1.94	5.12	8.20
G2	Loamy	0.32	2.77	6.85	1.70	2.840	8	186	3287	149	1.40	0.72	3.38	9.62
Mean ± Sd	-	0.48±0.23	2.48±0.40	6.65±0.28	2.77±1.52	2.57±0.37	8.5±0.70	174±16.9	3706±592	155±8.48	1.1 ± 0.42	1.33± .86	4.25±1.23	8.91±1.01
H1	Clayey-loamy	0.47	7.40	7.78	1.40	0.194	8	149	5148	174	0.30	0.10	3.80	2.60
H2	Clayey-loamy	0.36	8.96	7.52	2.98	0.367	9	256	5464	199	0.70	0.10	4.40	4.70
H3	Clayey-loamy	0.20	7.90	7.92	1.85	0.470	10	162	5234	205	0.50	0.40	4.20	4.40
Mean ± Sd	-	0.34±0.13	8.08±0.79	7.74±0.20	2.07±0.81	0.34±0.13	9±1.0	189±58.3	5282 ± 163	192± 16.4	0.5 ± 0.2	0.2 ± 0.17	4.13 ± 0.30	3.9 ± 1.13
K1	loamy	0.25	1.66	6.50	2.80	1.864	16	210	3152	358	1.90	1.45	2.99	12.30
K2	loamy	0.49	0.53	7.15	1.87	0.771	18	192	2980	330	2.86	1.33	4.47	10.45
Mean ± Sd	-	0.37±1.09	1.02±0.65	6.82±0.45	2.33±0.65	1.31±0.77	17±1.41	201±12.7	3066±121	344±19.8	2.38±0.67	1.39±0.09	3.73±1.04	11.3±1.30
L1	Loamy	0.58	0.55	7.74	6.59	2.061	14	257	4114	175	2.70	2.20	25.20	13.20
L2	Loamy	0.34	1.49	7.20	4.50	2.250	15	205	2960	218	1.20	1.05	14.22	8.80
Mean ± Sd	-	0.46±0.17	1.02±0.66	7.47±0.38	5.54±1.47	2.15±0.13	14.7±0.70	231±36.7	3587±886	196±30.4	1.95±1.06	1.62±0.81	19.7 ± 7.76	11 ± 3.11

Soil Characteristics of *S. mesopotamica*

It is endemic for Turkey and has limited distribution. *S. mesopotomica* is a vulnerable species. Its soil characteristics are based on two localities (E1 and E2) in Urfa. The salinity contents of the soil samples were low (0.35–0.60%). The pH and $CaCO_3$ values were 7.25 – 7.54 and 25.17–27.49%. The soil samples had clayey-loamy structures (Table 3). While the N and organic matter contents were between 1.563–2.165% and 2.56–3.70%, the P and K contents were between 12–15 and 122–192 mg/kg. The Ca, Mg and Cu contents of soil samples ranged between 4692–6449, 179–347 and 1.10–1.80 mg/kg, while the Zn, Mn and Fe contents of soil samples ranged between 0.10–0.40, 11.20–13.60 and 4.60–8.20 mg/kg, respectively.

Soil Characteristics of *S. bifolia*

It is a widely distributed species in Turkey. Soil samples of this species were taken from five different locations (F1, F2, F3, F4 and F5) in Denizli, Muğla, Edirne, Samsun and Antalya. The $CaCO_3$, salinity values, pH values, organic matter, N, P and K contents of soil samples varied between 12.17–23.78%, 0.23–0.56%, 6.25–7.68, 3.12–7.52%, 1.550–2.870%, 12–20 and 278–495 mg/kg, respectively (Table 3). The Ca, Mg, Cu, Zn, Mn and Fe values were between 3210–3585, 187–332, 0.70–2.20, 0.30–0.70, 13.80–47.60 and 21.50–27.30 mg/kg, respectively.

Soil Characteristics of *S. leepii*

It is among the species that are endemic to Turkey. The soil samples of this species were obtained from two different localities (G1 and G2) in Elazığ and Erzincan. The pH values of soil samples were between 6.45 and 6.85. The $CaCO_3$ content varied from 2.20 to 2.77%. The salinity values were between 0.32 and 0.65%. The soils of two localities had clayey-loamy and loamy texture structure. The organic matter content was between 1.70 and 3.85% in soil samples. N content was between 2.310 and 2.840%. The P and K contents changed between 8–9 and 162–186 mg/kg. The Ca, Mg and Cu contents of soils varied from 3287 to 4125, 149 to 161 and 0.80 to 1.40 mg/kg, respectively. The Zn, Mn and Fe contents of soils were between 0.72–1.94, 3.38–5.12 and 8.20–9.62 mg/kg, respectively (Table 3).

Soil Characteristics of *S. siberica* subsp. *armena*

Soil samples of this taxon are based on only three different locations (H1, H2 and H3) in Sivas and Erzurum. It has limited distribution. But, it is not an endemic species for Turkey. The soil samples had clayey-loamy texture structure. The soils were slightly alkaline (7.52–7.92) and had low salinity content (0.20–0.47%). $CaCO_3$ content of the soils were at moderate levels (7.40–8.96%). The organic matter values were 1.40–2.98%. The nitrogen content was between 0.194 and 0.470% in the soil samples. The phosphorus content of soil samples changed from 8 to 10 mg/kg. On the other hand, potassium contents ranged from 149 to 256 mg/kg. Ca, Mg and Cu values were between 5148–5464, 174–205 and 0.30–0.70 mg/kg, Zn, Mn and Fe values were between 0.10–0.40, 3.80–4.40 and 2.60–4.70 mg/kg, respectively.

Soil Characteristics of *S. monanthos*

This taxon is a limited distributed species and its soil characteristics are based on two localities (K1 and K2) in Artvin and Trabzon. The pH values of soil samples were 6.50–7.15. The proportion of total salinity ranged from 0.25 to 0.49%. The content of $CaCO_3$ ranged from 0.53–1.66% in the soil where the species grows. The $CaCO_3$ content was at low levels. The texture of the soil was loamy. While the organic matter, N, P and K contents were 1.87–2.80%, 0.771–1.864%, 16–18 and 192–210 mg/kg, the Ca, Mg, Cu, Zn, Mn and Fe contents were 2980–3152, 330–358, 1.90–2.86, 1.33–1.45, 2.99–4.47 and 10.45–12.30 mg/kg, respectively (Table 3).

Soil Characteristics of *S. rosenii*

S. rosenii has a limited distribution. The soil samples for the taxa were taken from only two localities (L1 and L2) in Artvin. All soils had a loamy structure. The $CaCO_3$, pH, salinity, organic matter, N, P and K contents changed between 0.55–1.49%, 6.20–7.74, 0.34–0.58%, 4.50–6.59%, 2.061–2.250% 14–15 and 205–257 mg/kg, respectively. The Ca, Mg, Cu, Zn, Mn and Fe contents of soils varied from 2960 to 4114, 175 to 218, 1.20 to 2.70, 1.05 to 2.20, 14.22 to 25.20, 8.80 to 13.20 mg/kg, respectively (Table 3).

Statistical Analysis

According to the statistical analysis results of *S. ingridae, S. melaina, S. leepii ve S. mesopotamica*, a difference between K and N values of *S. ingridae* and *S. melaina* was seen ($H=8.46$, $p < 0.05$; $H=8.02$, $p<0.05$, respectively) (Fig. 1a and b). There is not any difference between the other ecological properties of these four taxa.

Compared to all soil analysis results of *S. siberica* subsp. *armena, S. bifolia, S. cilicica ve S. autumnalis,* we found a difference between N values of *S. siberica* subsp. *armena* and *S. bifolia*, those of *S. siberica* subsp. *armena* and *S. autumnalis*, those of *S. cilicica* and *S. autumnalis* ($H=11.79$, $p<0.05$). A difference was found between organic matter values of *S. autumnalis*, *S. siberica* subsp. *armena* and *S. bifolia* and those of *S. siberica* subsp. *armena* and *S. bifolia* ($H= 10.96$, $p<0.05$) (Fig. 2a, b), as well. There were differences between P, Ca and Cu values of *S. siberica* subsp. *armena* and *S bifolia*, those of *S. siberica* subsp. *armena* and those of *S. autumnalis, S. cilicica* and *S. autumnalis* ($H=13.29$, $p<0.05$; $H=13.61$, $p<0.05$; $H=11.59$, $p<0.05$), respectively (Fig. 2c, d and e). However, with respect to Cu values, a sole difference was observed between *S. cilicica* and *S. bifolia* ($H=11.59$, $p<0.05$). There is no other difference between the other soil properties of the two taxa. While differences between Zn values of *S. bifolia* and *S. autumnalis*; *S. siberica* subsp. *armena* and *S. cilicica*; *S. siberica* subsp. *armena* and S. *autumnalis*; *S. cilicica* and *S. autumnalis* were obtained ($H=14.56$, $p<0.05$) (Fig. 2f); differences between Mn and Fe values of *S. siberica* subsp. *armena* and *S. bifolia*; *S. siberica* subsp. *armena* and *S. autumnalis; S. cilicica* and *S. autumnalis* were obtained ($H=11.43$, $p<0.05$; $H=14.61$, $p<0.05$), respectively (Fig. 2g and h). No difference was observed between soil analysis results of *S. rosenii* and *S. monanthos*.

Discussion

In this paper, the ecological responses of ten *Scilla* taxa that grow naturally in Turkey were studied. These taxa are similar to each other morphologically (Table 2). In addition, similarities in the anatomical characters of these taxa were found by Kandemir *et al.* (2016).

The soil characteristics were examined in terms of their physical and chemical characteristics. All the investigated taxa prefer slightly saline, clayey-loamy and loamy soils (except, *S. rosenii* and *S. monanthos*). *S. rosenii* and *S. monanthos* grow only in loamy soils. Most taxa are distributed in extremely loamy soils where drainage is good. It was found that *Crocus pestalozzae* Boiss. (Kandemir, 2009), some *Iris* and *Crocus* taxa (Kandemir *et al*., 2011, 2012; Kandemir, 2016) and some geophyetes (Celik *et al*., 2004) prefer clayey-loamy and loamy soils. While the *S. autumnalis, S. cilicica, S. melaina, S. ingridae, S. mesopotamica* and *S. rosenii* grow usually in slightly alkali and neutral soils, *S. bifolia, S. leepii, S. siberica* subsp. *armena* and *S. monanthos* grow in slightly acidic and neutral soils. It is shown in Table 3 that some of the investigated *Scilla* taxa grow at moderate calcareous level

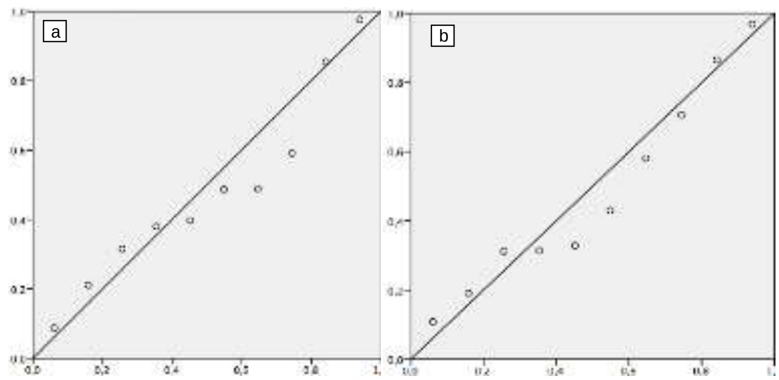

Fig. 1: Analysis graphs with respect to soil. (a) N, (b) K values of *S. ingridae*, *S. melaina*, *S. leepii* and *S. mesopotamica*

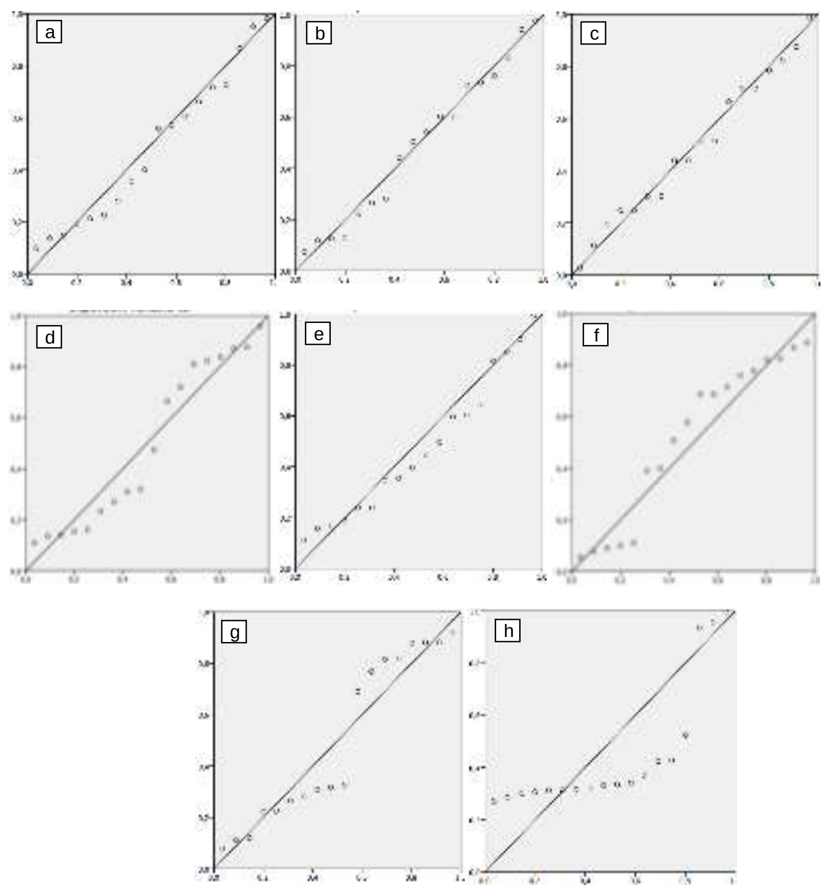

Fig. 2: Analysis graphs with respect to soil. (a)organic matter, (b) N, (c) K, (d) Ca, (e) Cu, (f) Zn, (g) Mn and (h) Fe values of *S. bifolia, S. cilicica, S. autumnalis* and *S. siberica* subsp. *armena*

(*S. autumnalis, S. bifolia, S. leepii* and *S. siberica* subsp. *armena*), some at high calcareous level (*S. cilicica, S. bifolia, S. ingridae, S. melaina* and *S. mesopotamica*) and some at low calcareous level (*S. monanthos* and *S. rosenii*). The findings were similar in other *Crocus* and *Iris* taxa by Kandemir *et al*. (2011, 2012) and in *Tulipa sylvestris, S. bifolia, Gagea bohemica* by Uysal *et al*. (2011).

S. autumnalis, S. bifolia, S. leepii S. mesopotamica, S. cilicica, and *S. rosenii* prefer soils that are rich in organic matter. Whereas *S. ingridae, S. melaina, S. siberica* subsp. *armena* and *S. monanthos* prefer moderate level of organic matter in soils. *S. autumnalis, S. ingridae, S. mesopotamica, S. bifolia and S. cilicica* are distributed in rich nitrogen soils. On the other hand, the *S. melaina, S. leepii, S. monanthos* and *S. rosenii* distribute at soils with moderate nitrogen levels. It was reported that *I. taochia* (Kandemir, 2006), *I. nezahatiae* (2016), *C. pestalozzae* (Kandemir, 2009) and some *Iris* taxa (Kandemir *et al*., 2011) grow in soils with rich and moderate levels of organic matter and nitrogen. The P contents of the soils of some of the taxa (*S. autumnalis*, *S. mesopotamica* and *S. bifolia*) are usually at sufficient levels. However, P contents in soils of *S. cilicica*, *S. ingridae*, *S. melaina S. leepii, S. monanthos, S rosenii* and *S. siberica* subsp. *armena* were found to be at deficient levels. This state may occur, because P is a rather phloem-immobile ion and stored in insoluable form (calcium-phosphate) in the soil. And, also in alkaline soils, pH affects the nutrient element intake of plants. In such soils, $CaCO_3$ contents increase and this increase causes low P contents. Therefore, plants can not get any benefit from P (Boerner, 1986; Stewart and Press, 1990).

Results showed that K, Cu, Mg, Mn, Fe and Ca contents are in sufficient amounts in all soil samples. It was reported by Kandemir *et al*. (2011, 2012) and Kandemir (2009) that K, Cu, Mg, Mn, Fe and Ca contents of soils where some *Crocus* and *Iris* taxa grow are generally enough. K is very phloem-mobile ion. From the Table 3, it is seen that Zn contents are low in all localities (except those of *S. autumnalis* and *S. rosenii*). Also, same researches found low values in Zn contents in some localities (Kandemir *et al*., 2011).

S. bifolia and *S. autumnalis* are morphologically different from other investigated *Scilla* taxa. In statistical analysis of this study, differences were found among N, organic matter, P, Ca, Cu, Zn, Cu values of *S. siberica* subsp. *armena* and *S. bifolia*, *S. cilicica* and *S. autumnalis*, *S. siberica* subsp. *armena* and *S. autumnalis*, *S. bifolia* and *S. autumnalis*. So, the two taxa are different from other *Scilla* taxa ecologically. This is because of the wide distribution of the *S. autumnalis* and *S. bifolia* and their exposure to various environmental and climatic factors. They grow generally in soils which have rich organic matters, N, Fe, Mg, K, Mn and high asidic and calcareous, moderate calcerous levels.

Yıldırım (2014a, 2014b) reported that taxa belonging to *Puschkinia* Adams and *Scilla* L. genus are close to each other both morphologically and phylogenetically. Specially, *S. bifolia, S. vardaria* and *P. bilgineri* are very similar morphologically. Morphologic similarities among these taxa may occur because of similar environmental conditions or common pollinators. Although these two genus originated from a common background, researchers do not prefer the morphological structures of these taxa are put into the same categories and added that the genus level of these two mentioned genus should be protected. *S. bifolia, S. vardaria* and *P. bilgineri* may be the species that enable a link to be formed between the *Puschkinia* and *Scilla* genus. On the other hand, these three taxa may be transitional taxa between the *Puschkinia* and *Scilla* genus. A more detailed study on these three taxa are required in order to confirm this.

A difference was seen between Cu and Zn values of *S. cilicica* and *S. bifolia*, *S. cilicica* and *S. siberica* subsp. *armena*, no other difference between the other ecological properties was seen. Therefore, *S. cilicica* and *S. siberica* subsp. *armena* are close taxa. Since a difference between ecological properties of *S. rosenii* and *S. monanthos* were not observed, these taxa were close to each other. Moreover, since little differences between the ecological properties (excluding difference between N and K values of *S. ingridae, S. melaina*) of *S. ingridae, S. melaina, S. leepii* and *S. mesopotamica* were observed, these four taxa were similar. The ecological reletionships between taxa were supported by the statistical analysis.

Conclusion

Based on ecologic characters, we suggest that (1) *S. ingridae*, *S. mesopotamica*, *S. leepii* and *S. melaina* are independent species with close relationships; (2) *S. monanthos* and *S. rosenii* are independent species with close relationships; (3), *S. siberica* subsp. *armena* and *S. cilicica* are close taxa; (4) *S. bifolia* and *S. autumnalis* are different taxa of *Scilla* genus. Also, the same state has been found in anatomic characters of investigated taxa by Kandemir *et al*. (2016).

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