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Soil-plant relations in the annual *Gypsophila* (Caryopyhllaceae) taxa of Turkey

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Abstract: The soil properties of the annual *Gypsophila* L. taxa of Turkey and their effects on plant morphology were investigated. The taxa studied were *Gypsophila heteropoda* Freyn & Sint., *G. parva* Barkoudah, *G. elegans* M.Bieb., *G. bitlisensis* Barkoudah, *G. viscosa* Murray, *G. antari* Post & Beauverd, *G. muralis* L., *G. tubulosa* (Jaub. & Spach) Boiss., *G. confertifolia* Hub.-Mor., and *G. pilosa* Hudson. The soils of the plant taxa were medium textured, sand or sandy-loam, saltless or a little salty, neutral, limy, rich in potassium and with very little phosphorous, and with medium levels of nitrogen and organic matter. *G. antari*, which had the greatest lime content, had the lowest number of leaves. *G. muralis* and *G. tubulosa* had the lowest saturation values and lime content but the greatest number of leaves. If the lime content increased, the development of roots decreased, and when the rate of sand increased, the development of roots increased. For *G. muralis*, phosphorus concentration, seed size, and salt content were negatively related to number of leaves. For *G. tubulosa* and *G. antari*, potassium and organic matter concentrations were negatively related to number of leaves. In *G. muralis*, salt content was positively related to calyx diameter and seed size. In *G. confertifolia*, organic matter content was positively correlated with height of the calyx, petal, and bract. It was observed that *G. pilosa*, *G. bitlisensis*, and *G. viscosa* species are also distributed in limeless steppe areas. The most important distribution areas of the species in Turkey are Sivas, Erzincan, Çankırı, Eskişehir, and Ankara.

Key words: *Gypsophila*, ecology, habitats, biodiversity, Turkey

1. Introduction

The family Caryophyllaceae, which is distributed generally in the hot and mild regions of the northern hemisphere, in the southern hemisphere, and in the Mediterranean region, shows great diversity with around 80 genera and 2100 species. It has a widespread geographical distribution as well as playing a significant part in the horticultural industry. The genus *Gypsophila* L., which has 126 species worldwide, shows distribution in the Irano-Turanian and Mediterranean regions (Williams, 1989; Sumaira et al., 2008; Korkmaz & Özçelik 2011b). Turkey is the one of the few rich countries in the world in terms of biological diversity and endemism; in this respect it is like an open-air museum. It is the gene centre of many cultivated plants and some important genera such as *Astragalus* L., *Verbascum* L., *Bolanthus* (Ser.) Reichb., *Ankyropetalum* Fenzl, and *Gypsophila* (Özçelik, 2000; Özçelik & Muca, 2010; Korkmaz & Özçelik 2011a). *Gypsophila*, the third biggest genus of the family Caryophyllaceae after *Silene* L. (147 taxa) and *Dianthus* L. (±70 species) in Turkey, has 60 taxa related to 56 species among 10 sections. The 36 species (64%) are endemic to Turkey (Huber-Morath, 1967; Davis et al., 1988; Ataşlar, 2001; Ataşlar & Ocak, 2005; Korkmaz & Özçelik, 2011a; Hamzaoğlu et al., 2011; Hamzaoğlu, 2012; Korkmaz & Özçelik, 2012). *Gypsophila* species in Turkey have a vertical distribution from 100 m to 2800 m and most of them have a horizontal distribution in the Irano-Turanian phytogeographical region (Korkmaz & Özçelik, 2012). Most of them are known from the type collection and some of them are relicts. *G. heteropoda* Freyn & Sint. subsp. *minutiflora* Bark., a rare and endemic taxon unique to Central Anatolia, is a species endangered on a global scale (Ekim et al., 2000; Özhatay et al., 2005). The genus is among our significant flora members because of the genetic centre's being in Turkey, the high endemism rate, the large number of species, and the high economic importance. Unfortunately, the biodiversity of this country is under the threat of some factors such as the industrialising agriculture and stockbreeding sector, erosion, fires, wood cutting, urbanisation, industrialisation, and excessive usage of pesticides. As a result of these, it is indicated by Ekim et al. (2000) that the generation of the 12 endemic species

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has become extinct (Özçelik, 2000). The populations of the *Gypsophila* taxa are also exposed to these pressure factors.

The name *Gypsophila*, which originates from the terms gypsum (gypsos) and phileo (loving), is given to a group of plant adapted to gypsum environments. Oligo-Miocene gypsum series are found around the Zara (Sivas) region as well as around Çankırı and Sivas in Central Anatolia. These areas are significant biodiversity centres in Turkey and must be protected.

Well-developed roots of some *Gypsophila*, *Akyropetalum*, and *Saponaria* L. species are called soaproot or soapwort. Six *Gypsophila* species are used to produce soaproot in Turkey (Koyuncu et al., 2008). This genus, referred to by Turkish people as Çöven, Çöven Otu, Helva Kökü, and Sabunotu is benefited from in various ways. The liquid obtained from the rhizomes of some species is added to halva in order to give crispness. It is also used in the production of ice-cream, liquor, and herby cheese (Korkmaz & Özçelik, 2011b). Moreover, some *Gypsophila* taxa are cultivated as ornamental plants (Huber-Morath, 1967). As it has good sparkling properties and saponin glycoside, it is used in soap and detergent production. It is also used in the cleaning of silk and other sensitive fabrics, in the production of medicine, and in metal polishing such as gold. It is of great importance in fire-extinguisher fabrication because of the sparkling property of the saponin (Korkmaz & Özçelik, 2011b). It is also stated that boron toxicity originating from the use of artificial fertiliser causes around 30% loss in the production of crops in agricultural areas and this loss can be recovered by growing some *Gypsophila* species (especially *G. sphaerocephala* Fenzl ex Tchihat.) in the same area (Babaoğlu et al., 2004).

There are many studies on different *Gypsophila* species. In situ and ex situ morphological characters and the seed germination of *Gypsophila trichotoma* Wend. under different conditions were examined by Kozuharova et al. (2011). It is an endangered medicinal plant within the Bulgarian flora and thus protected by the Law of Biodiversity. Comparatively good germination occurred only for seeds treated with gibberellic acid. With salty water germination was poor, but the percentage of seedlings was the highest. Baby's breath (*G. paniculata* L.) can withstand considerable variation in both temperature and moisture while being most aggressive in areas of low rainfall. It is commonly found in lightly grazed pastures, roadside ditches, hay fields, and abandoned fields. It spreads by seed and a single plant has an average of 13,700 seeds. Seeds are dispersed by wind and can travel great distances. It can also increase the number of stems per plant as the roots age and increase in diameter. Darwent and Coupland (1966) and Darwent (1975) stated that *G. paniculata* is used extensively by the flower industry in bouquets and as an ornamental in flower gardens. In Europe, the plant roots are used for different purposes because of their rich saponin content. Soil structure of the plant is fine or coarse textured, but fine textured soil retards root development. The centre of origin of the genus includes the Black Sea region, northern Iraq, and Iran. The general habitats are pastures, roadsides, and fields but *G. paniculata* grows on sandy, calcareous hills, and dry and stony places in Europe and Asia (Barkoudah, 1962). The floral structure suggests cross-pollination. The seeds show little or no dormancy. Heavy and continuous grazing can suppress the growth and prevent seedling. Darvent (1975) stated that Caryophyllaceae is called the pink family and *G. paniculata* is called baby's breath. The deep rooting habit of the species is very important for mature plants to withstand long drought periods. Root elongation is very rapid during the first 2 years. The seeds have no dormancy. Germination ranges between 91% and 97%. Wind is the most important agent of seed dispersal. Han et al. (1996) investigated the effect of some sealing materials on the growth and vitrification of *G. paniculata*. The habitat of *G. lepidioides* Boiss. was gypsum banks. The taxon was restricted to the gypsum steppe.

There are many studies on the saponin contents of the genus and their medicinal importance. Some *Gypsophila* species are used as an expectorant and diuretic in Turkey (Özdemir et al., 2010). Pauthe-Dayde et al. (1990) studied the production of triterpenoid saponins of some *Gypsophila* species in cultures (Gerrenova et al., 2010; Yao et al., 2011; Arslan et al., 2012) for medicinal purposes. According to Gerrenova et al. (2010), some type of saponins are considered the major bioactive components of drugs used for their anti-inflammatory, spermicidal (El Bayr & Nour, 1979; Primorac et al., 1985), hypocholesterolaemic, and antiviral activities. Moreover, saponins with an aldehyde function from *G. oldhamiana* Miq. exhibited cytotoxic activity against different human cancer cells (Bai et al., 2007).

Yao et al. (2011) stated that *G. paniculata* is a small perennial herb widely distributed in the northern regions of China. Its roots have been used to treat fever, consumptive disease, and infantile malnutrition syndrome in China. This study introduced 2 new saponins; they are antidiabetogenic oleanane-type triterpene oligoglycosides obtained from the roots. Arslan et al. (2012) studied a cytotoxic triterpenoid saponin of *G. pilulifera* Boiss. & Heldr. It was reported that the plant displayed significant cytotoxicity and can be used for combinatorial anticancer therapy.

Gerrenova et al. (2010) studied seed germination of some *Gypsophila* species and reported that high percentages of seed germination were observed for *G. glomerata* Pallas ex Adams and *G. viscosa*: 92% and 80%, respectively, followed by *G. paniculata* (72%) and *G. elegans* (51%). The seeds of *G. trichotoma* did not germinate satisfactorily. No effect of light on germination was observed, but after 20 days the lateral root initiation, growth, and number of lateral roots were markedly enhanced in light conditions.

The main aim of our study was to describe soil traits of annual *Gypsophila* taxa growing in Turkey and determine which traits of the plants are affected by soil characters. Furthermore, the distribution areas and the effects of the habitat traits on the species were investigated.

2. Materials and methods

This study was conducted on soil samples of 10 annual *Gypsophila* species (*G. heteropoda*, *G. parva* Bark., *G. elegas* Bieb., *G. bitlisesnsis* Bark., *G. viscosa* Murray, *G. antari* Post & Beauverd, *G. muralis* L., *G. tubulosa* (Jaub. & Spach) Boiss., *G. confertifolia* Hub.-Mor., and *G. pilosa* Hudson). Thirty-seven soil samples of these plants were collected from different localities and habitats in Turkey, as seen in Table 1.

The soil samples were taken from the natural habitats of distribution areas during the inflorescence period. After the part containing plant remains was removed from the soil surface approximately 1 kg of soil was taken from a depth between 0 and 30 cm and brought to the laboratory in polyethylene bags. Then the air-dried soil samples were made ready for analysis by sifting through a 2-mm mesh sieve. The analyses were conducted in the Soil Laboratory of Isparta General Provincial Directorate of Rural Services. The saturation % and constitution, salt %, pH, lime %, organic matter %, nitrogen (N) %, phosphorus (P), and potassium (K) kg/ha in the soil samples were determined according to the methods described by Tüzüner (1990) (total salt quantitation), Hindistan and İnceoğlu (1962) (determination of soil reaction (pH)), Çağlar (1949) (lime ($CaCO_3$) determination), Ülgen and Ateşalp (1972) (phosphorus (P_2O_5) determination), Doll and Lucas (1973) (potassium (K_2O) determination), Ülgen and Ateşalp (1972) (determination of organic matter), and Tüzüner (1990) (classification of the soils). In order to understand the effects of the soil traits on the morphological characters of plants, the results of the soil analyses were compared with the interspecies and intraspecies variations.

One-way ANOVA was used to assess the effects of soil traits on plant traits. Duncan's test was used to rank mean values. SPSS 10.01 was used for these tests. Our observations were interpreted and discussed in the light of previous research (Korkmaz & Özçelik, 2011b).

3. Results

Soil numbers, localities, and habitats of annual *Gypsophila* taxa distributed in Turkey are given in Table 1. The results of the soil analyses are shown in Table 2. Statistical analyses of the results of the soil analyses are given in Table 3. Soil classes of the annual *Gypsophila* taxa are given in Table 4. This table is prepared to describe the soil classes easily. The soil analyses' results are also shown in graphs (Figures 1–8) to facilitate expression of the results. Some evaluations and interpretations of the soil analysis results are detailed below.

Soil sample numbers of annual *Gypsophila* taxa are given in Tables 1 and 2. All of the *G. heteropoda* soils are in the medium textured (with saturation values of 40%–48%), loamy, and saltless classes. Their soil reaction (pH) values are in the slightly alkaline class. Sample 8 (Tavşanlı village, Hafik District, Sivas Province), in the limeless class, has the lowest lime content. Sample 25 is in the limy class and samples 7, 21, and 22 are in the medium lime class. Sample 1 (Polatlı District, Ankara Province) is in the high limy class. All of the samples are in the low phosphorous class. Samples 8 and 22 contain small concentrations of potassium; samples 1, 21, and 25 contain high concentrations; and sample 7 contains a very high concentration. All of the samples contain organic matter at various proportions from low to high. According to organic matter, sample 1 is in the small quantity class; sample 25 is in the medium quantity class; and samples 7, 21, and 22 are in the good quantity classes. The nitrogen contents of the soils vary from 0.020% to 0.099% (Tables 1, 2, 4).

Saturation values of the soil samples of *G. parva* ranged from 46% to 52% and fall in the medium textured soil class. Samples 17, 19, and 21 are in the loamy class and sample 14 is in the clayish loam class. Sample 16 is on the line dividing the 2 classes above. All of the soils are in the saltless class. Soil reaction values (7.83–7.98) are very close to each other, and they are in the slightly alkaline class. Samples 17, 19, and 21 are in the medium lime class and sample 14 is in the high lime class. All of the samples are in the low phosphorus class. In terms of potassium content, sample 19 is in the low class, samples 17 and 21 are in the sufficient class, and samples 14 and 16 are in the high class. The potassium concentration of sample 14 (from Çankırı) is much higher than that of the others. The quantity of organic matter is the factor that supports the development and ground-covering property. The examined samples contain medium, good, and high content of organic matter. The nitrogen content of the samples varies between 0.030% and 0.118%. Sample 17 of *G. parva* is 1 of the 2 samples that have the highest content of nitrogen (Tables 1, 2, 4).

The saturation values of samples 3 and 32 of *G. elegans* are 42% and 50%, respectively, in the medium textured class. Samples 32 and 3 are in the loam class but they are on the line dividing the loam and clayish loam classes. In terms of salt content (0.00% and 0.018%), sample 3 is

Table 1. Soil samples, localities, and natural habitats of annual *Gypsophila* taxa in Turkey.

Taxa	Soil number	Locality	Habitat
G. heteropoda	1	Ankara, Polatlı, Acıkır	Steppe
	7	Ankara–Çankırı highway, 10 km to Çankırı, surroundings of the railway station	Field side
	8	Sivas, Hafik, Tavşanlı village, vicinity of Tepeli	Limy slopes
	21	Between Çorum and İskilip, 10 km to İskilip	Steppe
	22	Sivas to Gürün, near Sivas	Steppe
	25	Sivas, 10 km from Sivas to Hafik	Field side
G. parva	14	Çankırı–Ankara highway, 13 km from Çankırı	Steppe
	16	Between Çankırı and Kalecik, 14 km to Kalecik	Steppe, hardened soils
	17	Between Çankırı and Kalecik, 14 km to Kalecik	Steppe, soft soils
	19	Between Çorum and İskilip, intersection of Dut and Kertme ways	Steppe
	21	Çorum to İskilip, 10 km from İskilip	Steppe
G. elegas	3	Ardahan, 25 km to Ardahan	Steppe
	32	Kars, Kars–Iğdır highway, 30 km to Digor	Alpinic steppe
G. bitlisesnsis	3	Ardahan, 25 km to Ardahan	Steppe
	10	Erzincan–Sivas highway, 4 km from Refahiye	Steppe
	11	Erzincan, vicinity of Sakaltutan Pass	Steppe
	13	Erzincan, vicinity of Sakaltutan Pass	Volcanic rocks
G. viscosa	12	Afyon–Ankara highway, 10 km to Sivrihisar	Steppe
	18	Kayseri to Pınarbaşı, 37 km to Pınarbaşı	Steppe
	26	Nevşehir, Ihlara, vicinity of Gülağaç	Steppe
	20	Nevşehir, Ihlara, vicinity of Gülağaç	Field and field sides
G. antari	23	Şanlıurfa, Akçakale, DSİ replantation area	Recreation place
	24	Şanlıurfa, Akçakale, near Suruç	Field side
G. muralis	27	Tekirdağ, Çorlu, Tekirdağ–İstanbul highway, Önerler village	Field and field side
	28	Tekirdağ, Çorlu, vicinity of Çorlu Vocational High School	Steppe
G. tubulosa	2	Denizli, Babadağ, 6 km from city centre	Hill slopes
	4	Ödemiş–Kiraz highway, 5 km from Ödemiş	Steppe
	5	Manisa, Kula–Güre highway, near the pass	Rocky places
	6	Manisa, between Kula and Alaşehir, 9 km from Kula	Steppe
	9	Denizli, Buldan, vicinity of the old Buldan way	Steppe
G. confertifolia	29	Burdur, Altınyayla (Dirmil) plateau of Dirmil	Alpinic steppe
	30	Burdur, Altınyayla–Fethiye highway, 7 km from Altınyayla	Hill slopes
	31	Muğla, Köyceğiz, Beyobası, vicinity of Süpürgelik tepe	Gaps of *Juniperus* forest
G. pilosa	15	Konya, Cihanbeyli–Yunak highway, 15 km to Yunak	Hill slopes
	12	Afyon–Ankara highway, 10 km to Sivrihisar	Steppe
	14	Çankırı–Ankara highway, 13 km from Çankırı	Steppe
	20	Nevşehir, Ihlara, near Gülağaç	Field side

Table 2. Soil analyses results of annual *Gypsophila* taxa in Turkey.

Taxa	Soil number	Saturation (%)	Salt (%)	Soil reaction (pH)	Lime (%)	Phosphorus (P_2O_5) (kg/ha)	Potassium (K_2O) (kg/ha)	Nitrogen (%)	Organic matter (%)
G. heteropoda	1	44	0.088	7.93	17.98	0.082	3.431	0.020	0.78
	7	48	0.088	8.00	9.17	0.082	8.234	0.076	3.01
	8	40	0.069	8.05	0.36	0.082	0.792	0.067	2.69
	21	46	0.066	7.91	14.02	0.082	3.167	0.099	3.95
	22	46	0.058	8.05	11.43	0.082	0.844	0.077	3.07
	25	40	0.048	7.91	4.49	0.123	1.900	0.047	1.87
G. parva	14	52	0.106	7.98	33.94	0.274	13.512	0.030	1.22
	16	50	0.060	7.92	19.92	0.082	4.328	0.085	3.41
	17	48	0.072	7.92	6.74	0.123	3.483	0.118	4.70
	19	48	0.039	7.83	13.28	0.082	1.689	0.069	2.74
	21	46	0.066	7.91	14.02	0.082	3.167	0.099	3.95
G. elegas	3	50	0.00	8.12	1.83	0.247	5.595	0.098	3.90
	32	42	0.018	7.92	27.12	0.136	2.504	0.028	1.16
G. bitlisesnsis	3	50	0.00	8.12	1.83	0.247	5.595	0.098	3.90
	10	42	0.000	8.18	2.56	0.123	0.844	0.053	2.13
	11	60	0.078	7.59	10.27	2.205	23.648	0.084	3.35
	13	48	0.038	8.15	2.20	0.123	1.319	0.017	0.68
G. viscosa	12	56	0.055	8.08	37.43	0.330	8.973	0.050	2.01
	18	50	0.054	7.91	2.95	0.165	1.583	0.113	4.50
	26	42	0.048	8.03	1.10	0.247	7.178	0.017	0.68
	20	40	0.059	8.00	4.05	0.247	4.645	0.050	1.98
G. antari	23	42	0.000	8.21	73.8	0.123	5.384	0.058	2.32
	24	42	0.042	7.9	45.38	0.330	15.095	0.052	2.09
G. muralis	27	40	0.000	5.97	1,45	0.824	2.533	0.017	0.68
	28	38	0.000	6,69	1.45	0.556	1.425	0.076	3.07
G. tubulosa	2	40	0.00	7.75	0.36	0.330	0.528	0.014	0.56
	4	50	0.00	7.25	0.36	1.030	3.695	0.048	1.90
	5	38	0.00	7.49	0,36	0.247	0.422	0.014	0.56
	6	42	0.00	7.18	6.23	0.247	0.792	0.012	0.46
	9	28	0.000	8.11	0.72	0.330	0.528	0.048	1.90
G. confertifolia	29	52	0.051	7.35	1.09	0.247	4.222	0.118	4.70
	30	54	0.028	7.26	1.09	0.165	2.850	0.090	3.62
	31	42	0.036	7.74	2.52	0.433	3.695	0.093	3.73
G. pilosa	15	54	0.000	6.70	1.47	0.701	3.272	0.082	3.29
	12	56	0.055	8.08	37.43	0.330	8.973	0.050	2.01
	14	52	0.106	7.98	33.94	0.274	13.512	0.030	1.22
	20	40	0.059	8.00	4.05	0.247	4.645	0.050	1.98

Table 3. Results of the statistical analyses (Mean ± SE and Minimum–Maximum) on the soils of annual *Gypsophila* taxa of Turkey.

Taxa	N	Saturation (%)	Salt (%)	pH	Lime (%)	Phosphorus (kg/ha)	Potassium (kg/ha)	Nitrogen (%)	Organic matter (%)
		Mean ± SE (Min.–Max.)							
P value		0.101	0.000	0.000	0.000	0.038	0.038	0.164	0.156
G. heteropoda	6	44.00 ± 1.37 (40.00–48.00)	$0.07^{c} \pm 0.01$ (0.05–0.09)	$7.98^{ab} \pm 0.03$ (7.91–8.05)	$9.58^{a} \pm 2.61$ (0.36–17.98)	0.089 ± 0.007 (0.082–0.123)	3.061 ± 1.130 (0.792–8.234)	0.06 ± 0.01 (0.02–0.10)	2.56 ± 0.45 (0.78–3.95)
G. parva	5	48.80 ± 1.02 (46.00–52.00)	$0.07^{c} \pm 0.01$ (0.04–0.11)	$7.91^{ab} \pm 0.02$ (7.83–7.98)	$17.58^{a} \pm 4.59$ (6.74–33.94)	0.129 ± 0.037 (0.082–0.274)	5.236 ± 2.112 (1.689–13.512)	0.08 ± 0.01 (0.03–0.12)	3.20 ± 0.59 (1.22–4.70)
G. elegans	2	46.00 ± 4.00 (42.00–50.00)	$0.01^{a} \pm 0.01$ (0.00–0.02)	$8.02^{ab} \pm 0.10$ (7.92–8.12)	$14.48^{a} \pm 12.65$ (1.83–27.12)	0.192 ± 0.056 (0.136–0.247)	4.050 ± 1.546 (2.504–5.595)	0.06 ± 0.04 (0.03–0.10)	2.53 ± 1.37 (1.16–3.90)
G. bitlisensis	4	50.00 ± 3.74 (42.00–60.00)	$0.03^{abc} \pm 0.02$ (0.00–0.08)	$8.01^{ab} \pm 0.14$ (7.59–8.18)	$4.22^{a} \pm 2.02$ (1.83–10.27)	0.675 ± 0.511 (0.123–2.205)	7.852 ± 5.373 (0.844–23.648)	0.06 ± 0.02 (0.02–0.10)	2.52 ± 0.71 (0.68–3.90)
G. viscosa	4	47.00 ± 3.70 (40.00–56.00)	$0.05^{bc} \pm 0.00$ (0.05–0.06)	$8.01^{ab} \pm 0.04$ (7.91–8.08)	$11.38^{a} \pm 8.70$ (1.10–37.43)	0.247 ± 0.034 (0.165–0.330)	5.595 ± 1.605 (1.583–8.973)	0.06 ± 0.02 (0.02–0.11)	2.29 ± 0.80 (0.68–4.50)
G. antari	2	42.00 ± 0.00 (42.00–42.00)	$0.02^{ab} \pm 0.02$ (0.00–0.04)	$8.06^{b} \pm 0.16$ (7.90–8.21)	$59.59^{b} \pm 14.21$ (45.38–73.80)	0.227 ± 0.104 (0.123–0.330)	10.240 ± 4.856 (5.384–15.095)	0.06 ± 0.00 (0.05–0.06)	2.21 ± 0.12 (2.09–2.32)
G. muralis	2	39.00 ± 1.00 (38.00–40.00)	$0.00^{a} \pm 0.00$ (0.00–0.00)	$6.33^{a} \pm 0.36$ (5.97–6.69)	$1.45^{a} \pm 0.00$ (1.45–1.45)	0.690 ± 0.134 (0.556–0.824)	1.979 ± 0.554 (1.425–2.533)	0.05 ± 0.03 (0.02–0.08)	1.88 ± 1.20 (0.68–3.07)
G. tubulosa	5	39.60 ± 3.54 (28.00–50.00)	$0.00^{a} \pm 0.00$ (0.00–0.00)	$7.56^{ab} \pm 0.17$ (7.18–8.11)	$1.61^{a} \pm 1.16$ (0.36–6.23)	0.437 ± 0.149 (0.247–1.030)	1.193 ± 0.628 (0.422–3.695)	0.03 ± 0.01 (0.01–0.05)	1.08 ± 0.34 (0.46–1.90)
G. confertifolia	3	49.33 ± 3.71 (42.00–54.00)	$0.04^{abc} \pm 0.01$ (0.03–0.05)	$7.45^{ab} \pm 0.15$ (7.26–7.74)	$1.57^{a} \pm 0.48$ (1.09–2.529)	0.282 ± 0.079 (0.165–0.433)	3.589 ± 0.400 (2.850–4.222)	0.10 ± 0.01 (0.09–0.12)	4.02 ± 0.34 (3.62–4.70)
G. pilosa	4	50.50 ± 3.59 (40.00–56.00)	$0.06^{bc} \pm 0.02$ (0.00–0.11)	$7.69^{ab} \pm 0.33$ (6.70–8.08)	$19.22^{a} \pm 9.55$ (1.47–37.43)	0.388 ± 0.106 (0.247–0.701)	7.601 ± 2.315 (3.272–13.512)	0.05 ± 0.01 (0.03–0.08)	2.13 ± 0.43 (1.22–3.29)
General	37	45.89 ± 1.07 (28.00–60.00)	0.04 ± 0.01 (0.00–0.11)	7.76 ± 0.08 (5.97–8.21)	12.12 ± 2.70 (0.36–73.80)	0.315 ± 0.063 (0.082–2.205)	4.811 ± 0.807 (0.422–23.648)	0.06 ± 0.01 (0.01–0.12)	2.43 ± 0.21 (0.46–4.70)

(The differences between the averages shown by the same letter are not significant at 0.05 levels for each trait thought to be significant.)

Table 4. Soil classes of annual *Gypsophila* taxa in Turkey.

Taxa	Soil texture (saturation %)	Salt (%)	pH (soil reaction)	Lime (%)	Phosphorus (kg/ha)	Potassium (kg/ha)	Organic matter (%)
G. heteropoda	medium	saltless	slightly alkaline	medium	low	high	low–high
G. parva	medium	saltless	slightly alkaline	medium	low	low–high	medium–high
G. elegans	medium	saltless	slightly alkaline	low	low	medium–high	low–good
G. bitlisensis	medium–thin	saltless	slightly alkaline	low	low	low–high	low–good
G. viscosa	medium	saltless	slightly alkaline	low	very low–low	low–high	low–high
G. antari	medium	saltless	slightly alkaline	very high	very low–low	high	medium
G. muralis	rough	saltless	medium acid, neutral	low	low, medium	low, medium	low–good
G. tubulosa	rough	saltless	neutral–slightly alkaline	limeless–medium	very low–high	very low–sufficient	low
G. confertifolia	medium–thin	saltless	neutral	low	very low	medium–high	good–high
G. pilosa	medium	saltless	slightly alkaline	limy–high	very low–medium	high	low–good
General (average)	medium (45.89)	saltless (0.04)	slightly alkaline (7.76)	medium (12.12)	very low (0.315)	low (4.811)	medium (2.43)

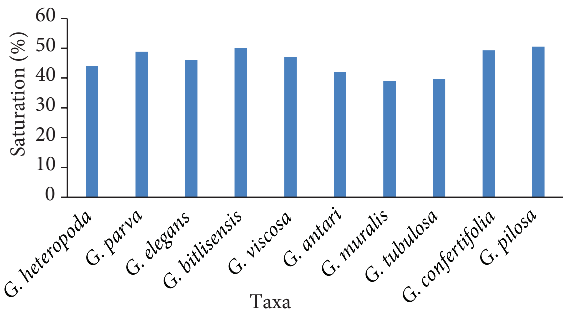

Figure 1. Saturation values of *Gypsophila* taxa.

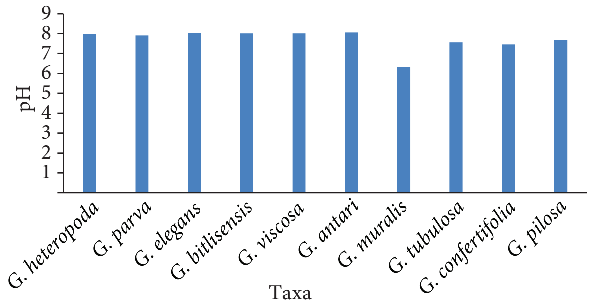

Figure 2. pH values of *Gypsophila* taxa.

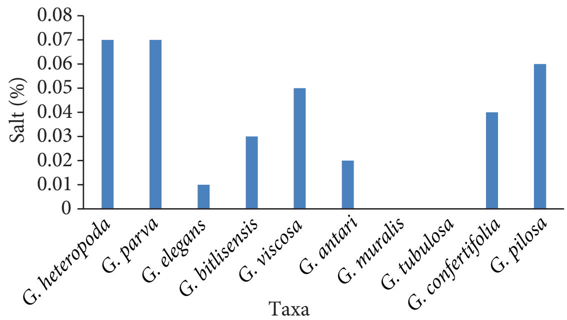

Figure 3. Salt contents of *Gypsophila* taxa.

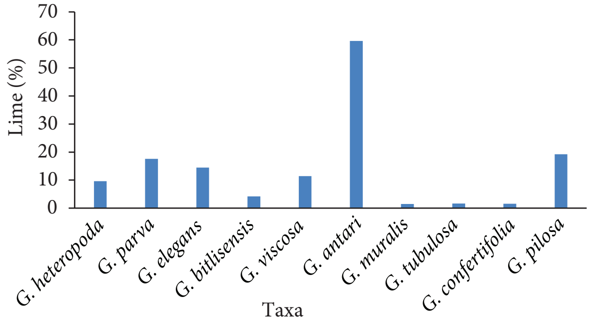

Figure 4. Lime contents of *Gypsophila* taxa.

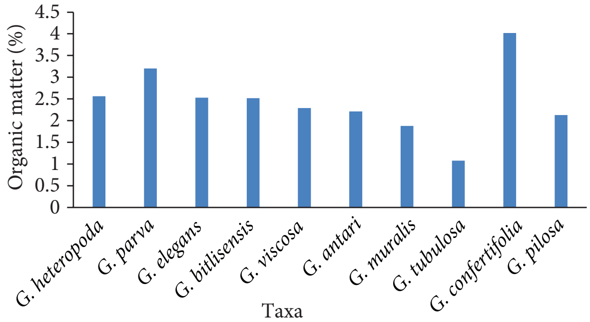

Figure 5. Organic matter contents of *Gypsophila* taxa.

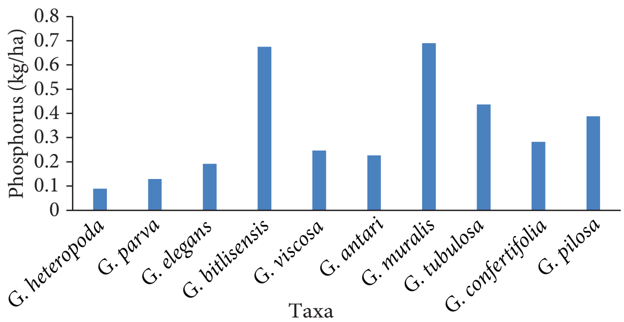

Figure 6. Phosphorus contents of *Gypsophila* taxa.

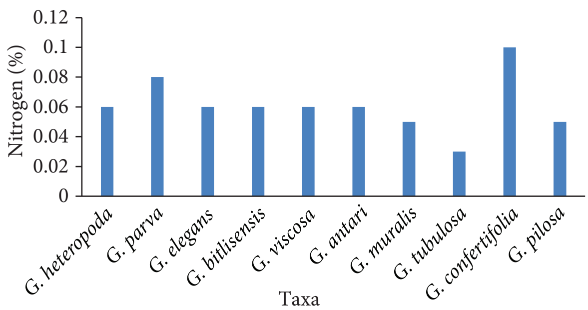

Figure 7. Nitrogen contents of *Gypsophila* taxa.

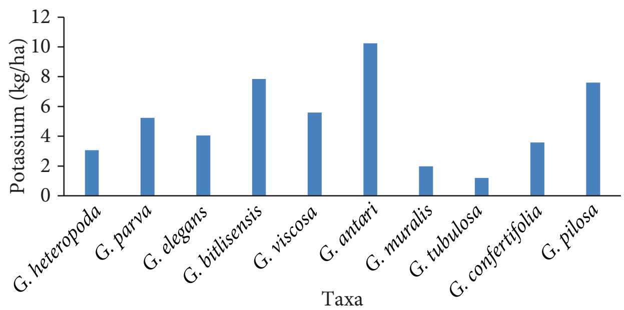

Figure 8. Potassium contents of *Gypsophila* taxa.

in the saltless class and sample 32 is in the slightly salty class. With regard to pH values (7.92 and 8.12), both of the samples are in the slightly alkaline class. According to lime content, sample 3 is in the low lime class and sample 32 is in the very high lime class. Both of the samples are in the low phosphorus class. With regard to potassium content, sample 32 is in the medium class and sample 3 is in the high class. According to organic matter concentrations (1.16% and 3.90%), sample 32 is in the low class and sample 3 is in the good class. The nitrogen concentrations of the samples are 0.028% and 0.098% (Tables 1, 2, 4).

The soil samples of *G. bitlisensis* numbered 3, 10, 11, and 13 are medium and thin textured. Samples 10 and 13 are in the loam class, sample 3 is on the line between the loam and clayish loam classes, and sample 11 is in the clayish loam class. All of the samples are in the saltless class. The pH values of all of the samples vary between 7.59 and 8.18 and they are considered in the slightly alkali class. Samples 3, 10, and 13 are in the low lime class, while sample 11 is in the medium lime class. In terms of phosphorus, samples 3, 10, and 13 are in the low class and sample 11 is in the very high class. With regard to potassium content, samples 10 and 13 are in the low class and samples 3 and 11 are in the high class. Sample 11 is noteworthy on account of its potassium content 4 times higher than that of the others. In terms of organic matter, samples 13 and 10 are in the medium quantity class and samples 3 and 11 are in the good quantity class. The nitrogen contents vary between 0.017% and 0.098%. Sample 11 of *G. bitlisensis* has the highest values of soil saturation (60%), phosphorus (22.05 kg/ha), and potassium (236.48 kg/ha) (Tables 1, 2, 4).

The saturation values of the soil samples of *G. viscosa* vary between 40% and 56%. They are medium textured. Samples 20 and 26 are in the loam class, sample 18 is on the line dividing the loam and clayish loam classes, and sample 26 is in the clayish loam class. Their pH values are around 8, and they have a slight alkaline property. In terms of salt values (0.048%–0.059%), they are in the saltless soil class. Samples 18, 20, and 26 are in the low lime class and sample 12 (from Sivrihisar) is in the very high lime class. In terms of phosphorus (between 0.165 and 0.330 kg/ha), 1 sample is in the very low class and the others are in the low class. With regard to potassium (1.583–8.973 kg/ha), sample 18 is in the low class and the other samples are in the high class. The organic matter contents vary from low to high. Sample 26 contains the lowest and sample 18 the highest quantity of organic matter. Their nitrogen quantities vary between 0.017% and 0.113% (Tables 1, 2, 4).

The soil samples of *G. antari* are medium textured and they are in the loamy sand classes. All of the samples are in the saltless soil class. They are in the slightly alkaline class, with pH values of 7.90–8.21. The samples are in the very high lime class (73.80% and 45.38%). In terms of phosphorus concentration, sample 23 is in the very low class and sample 24 is in the low class. In terms of potassium, both samples are in the high class. In terms of organic matter, they are in the medium class. The nitrogen content of the former is 0.052 and that of the latter is 0.058% (Table 1). Samples 23 and 24 of *G. antari* have the same saturation value (42%) as *G. viscosa* (Tables 1, 2, 4).

The soil sample numbers of *G. muralis* are 27 and 28. Their saturation values are 40% and 38% respectively. They are rough textured and in the loam class. Both of them are in the saltless class. They are in the medium acid and neutral classes, with pH values of 5.97 and 6.69. They are in the low class, with the same lime content (1.45%). In terms of phosphorus, sample 28 is in the low class and sample 27 in the medium class. With regard to potassium, they are in the classes of low and medium concentrations. According to their organic matter contents, sample 27 is in the very low class, whereas sample 28 is in the good class. Their nitrogen contents are 0.017% and 0.076% (Tables 1, 2, 4).

Sample 9 of *G. tubulosa* is rough textured and in the sand class. Samples 2, 5, and 6 are medium textured and in the loam class. Sample 4, on the line between medium and medium-thin textured soils, is in the loam and clayish loam classes. All samples whose salt contents are very low are in the saltless soil class. In terms of their pH values, samples 4, 5, and 6 are neutral and samples 2 and 9 are slightly alkaline. With the highest content of lime (6.23%), sample 6 is in the medium lime class. The others are in the limeless class. In terms of phosphorus, sample 4 is in the high class, samples 5 and 6 are in the very low class, and the other 2 samples are in the low class. Regarding potassium contents, sample 4 is in the sufficient class and the other 2 samples are in the very low class. In terms of their organic matter, samples 4 and 9 are in the low class and the others in the very low class. Their nitrogen contents vary between 0.012% and 0.048% (Tables 1, 2, 4).

Saturation of the soil samples of *G. confertifolia* species varies between 42% and 52%. Of these samples, 1 of them is in the medium texture class and the others are in the medium-thin texture class. Sample 32 is in the loam class and the others are in the clayish-loam class. All of them are in the saltless class. In terms of pH values, sample 31 is in the slightly alkaline class and the other 2 samples are in the neutral class. The lime amounts of samples 29 and 30 are the same (1.09%). Sample 31 has a higher lime content (2.52%). All of the samples are in the low lime class. Regarding phosphorus concentrations, samples 29 and 30 are in the very low class and sample 31 is in the low class. According to potassium contents, sample 30 is in the medium class, sample 31 is in the sufficient class, and sample 29 is in the high class. In terms of organic matter, samples 30 and 31 are in the good class and sample 29 is in the high class. Their nitrogen concentrations vary between 0.090% and 0.118% (Tables 1, 2, 4).

The saturation of *G. pilosa* soils ranges from 40% to 56%. Sample 20 is medium textured and the others are medium-thin textured. Sample 20 is in the loam class and the others are in the clayish-loam class. All of the samples are in the saltless class. In terms of their pH values, sample 15 is in the neutral class and the others are in the slightly alkaline class. Two samples (15 and 20) are in the limy class with their low content of lime. The other 2 samples (12 and 14), whose lime concentrations are 1.47% and 37.43%, respectively, are in the high lime class. In terms of phosphorus, samples 14 and 20 are in the very low class. Sample 12 is in the low class and sample 15 is in the medium class. With regard to potassium, except for sample 15, which is in the sufficient class, all of the samples are in the high class. The potassium concentration of sample 14 is much higher than that of the others. In terms of organic matter, samples 14 and 20 are in the low class, sample 12 is in the medium class, and sample 15 is in the good content class. The nitrogen contents of the samples vary between 0.03% and 0.082% (Tables 1, 2, 4).

There is no significant difference in the level of saturation concentration, phosphorus (kg/ha), potassium (kg/ha), nitrogen, or organic matter contents between the statistical averages of the analysed results of the soil samples ($P > 0.05$). However, there are significant differences in terms of salt, lime content, and pH values ($P < 0.001$) (Table 3).

In terms of soil saturation, the species generally grow in loamy soil types. However, the lime content averages of *G. bitlisensis* and *G. pilosa* are on the line between the loam and the clayish-loam classes. Soil samples of the other species are in the loam class (Tables 2, 4).

Although there are some differences among the averages of the statistical test results, all of the soil samples are in the saltless soil class. An aggregation is seen among the soils in terms of salinity. In the first group, which contains the soils of *G. elegans*, *G. bitlisensis*, *G. antari*, *G. muralis*, *G. tubulosa*, and *G. confertifolia*, there is no statistical difference among the averages ($P > 0.05$). The second group constitutes the soils of *G. heteropoda*, *G. parva*, *G. bitlisensis*, *G. viscosa*, *G. confertifolia*, and *G. pilosa*. No significant difference is seen among the averages for these species in terms of salinity ($P > 0.05$). In the third group, containing the soils of *G. muralis* and *G. tubulosa*, there is no salt in the soils. This may be related to the habitats of these species. The highest average in terms of salt content belongs to *G. heteropoda* and *G. parva* soils (Tables 3, 4; Figure 3).

Most of the *Gypsophila* taxa grow in soils that are slightly alkaline. In terms of the soil reaction (pH), a significant difference is noted between *G. muralis* and *G. antari* ($P < 0.05$). No significant difference is observed among the other species ($P > 0.05$). In terms of average pH values, the soils that belong to *G. muralis* are considered in the class of medium acid. The soils belonging to *G. confertifolia* are neutral. The averages of the other species are in the slightly alkaline soil class (Tables 3, 4; Figures 1, 2).

Gypsophila species (at various rates from low to higher amounts) grow in limy soils. In terms of lime, the soils of *G. antari* are statistically quite different from the others ($P < 0.05$). The averages of the lime contents of the species are very close to each other. *G. muralis*, *G. tubulosa*, and *G. confertifolia* grow in soils having a very low content of lime. The soil of *G. bitlisensis* is in the low lime class. The soils of *G. heteropoda*, *G. viscosa*, and *G. elegans* are in the medium lime class. The soils of *G. parva* and *G. pilosa*, including 15%–25% lime, are in the high lime class. *G. antari* soil, which has the highest average of lime (59.59 ± 14.21), is in the high lime class (Tables 2, 3, 4; Figure 4).

Gypsophila taxa generally grow in the soils with very low phosphorus concentrations. There is no significant difference among the phosphorus contents ($P > 0.05$). When the phosphorus averages of the soils are examined, the least amount is seen in *G. heteropoda* soils. *G. heteropoda*, *G. parva*, *G. elegans*, *G. viscosa*, *G. antari*, and *G. confertifolia* soils contain phosphorus at a very low level. *G. pilosa* and *G. tubulosa* soils have a low level of phosphorus and *G. muralis* and *G. bitlisensis* have a medium level of phosphorus, with the maximum concentration (Tables 3, 4; Figure 6).

Gypsophila taxa grow in soils that have high concentrations of potassium. In terms of potassium, there is no significant difference among the species according to the statistical tests ($P > 0.05$). When the averages are examined, it is seen that the species are in various classes. *G. tubulosa* (with the smallest average) and *G. muralis* soils are in the low potassium concentration class. There is no soil in the medium potassium class. The soils of *G. confertifolia* and *G. heteropoda* are in the sufficient potassium class. On the other hand, *G. elegans*, *G. parva*, *G. viscosa*, *G. pilosa*, *G. bitlisensis*, and *G. antari* soils are in the high concentration class. *G. antari* soil has the highest potassium concentration (Tables 3, 4; Figure 8).

Gypsophila taxa grow in soils that mostly have organic matter in the medium class. Therefore, in terms of organic matter, there is no significant difference among the soils of the species ($P > 0.05$). However, evaluation of the organic matter contents showed that *G. tubulosa* and *G. muralis* soils contain organic matter in the low class. *G. heteropoda*, *G. elegans*, *G. bitlisensis*, *G. viscosa*, *G. antari*, and *G. pilosa* soils are in the medium class. *G. parva* soils have organic matter in the good class, and *G. confertifolia* soil has organic matter in the high class. *G. tubulosa* and *G. confertifolia* soils have with the smallest and the highest averages of organic matter, respectively (Tables 3, 4; Figure 5).

Soils of annual *Gypsophila* taxa in Turkey generally have the properties of medium texture, sand or loamy-sand, neutral or slightly alkali, saltless or slight salty, and lime in medium or high amounts. In the habitats of the species, the dominant vegetation type is steppe. Because of this reason, plant species competitive or cooperative with *Gypsophila* are steppe plants. In these soils, the contents of N, P, and K (%) are generally low. The contents of organic matter show a great variability from lower to higher classes, related to the locality types. The soil samples have organic matter at poor, good, medium, and high levels (Table 4).

In order to understand the effects of soil properties on the morphological characters of annual *Gypsophila* species that were studied by Korkmaz and Özçelik (2011a), some comparisons were made within the interspecies and intraspecies variations of the soil analyses results.

When the effects of soil properties on the morphological characters are evaluated among the species, *G. antari*, with the highest rate of lime, has the lowest number of leaves. *G. muralis* and *G. tubulosa* have the lowest rate of lime but the greatest number of leaves. There is an inverse relation between lime content and number of leaves in these species. The seed of *G. muralis* is the largest but the concentration of phosphorus is the smallest. *G. heteropoda* and *G. parva*, which have the lowest concentration of phosphorus, have the greatest number of the flowers, both on the peduncle and on the plant. *G. tubulosa* has the lowest concentration of potassium but it has the greatest leaf number. *G. antari*, which has the highest potassium concentration, has the lowest leaf number. A negative correlation is seen between the potassium and organic matter contents with the number of leaves. Salt content, however, is positively correlated with calyx width and seed size in *G. muralis*. The content of organic matter and the number of the flowers are least in *G. tubulosa*. *G. confertifolia*, which has the highest level of organic matter, has calyx, petal, and bract heights at the highest level. A negative correlation is found between the content of organic matter and the number of leaves in *G. tubulosa*.

4. Discussion and conclusion

The studied soil samples of annual *Gypsophila* taxa are mostly medium textured (in sand and loamy-sand soil classes), their salt content is very low, they are generally slightly alkaline, and their lime content varies from low to very high. The P and K concentrations of the soil samples are generally low. The organic matter contents show a great variability related to the locality types and they vary from the low to the high classes. The dominant vegetation type is steppe in the habitats of the species.

With respect to soil structure, *G. muralis* and *G. tubulosa* differ from the other species with their rough texture. The soil reaction of sample 27 of *G. muralis* is a little different from that of the others with its medium acid character. In *G. viscosa* sample 12 (from Sivrihisar) is in the very high lime content class. For *G. bitlisensis* sample 11 is in the very high phosphorus content class and is noteworthy as its potassium content is 4 times higher than that of the others. In *G. parva* and *G. pilosa* the potassium concentration of sample 14 (from Çankırı) is much higher than that of the others. In *G. antari* both samples are in the high potassium class. The organic matter content is an important factor that supports the development and ground-covering property of the plants. The examined samples contain from medium to high content of organic matter (Tables 1, 2, 4; Figures 1, 2, 4–6, 8).

In order to understand the effects of soil properties on morphological characters some comparisons were made. *G. antari*, with the highest content of lime and highest concentration of potassium, has the lowest number of leaves. *G. muralis* and *G. tubulosa* have the lowest saturation values and lime content, but they have the highest number of leaves. The seed of *G. muralis* is the smallest, but this species has the greatest concentration of phosphorus. *G. heteropoda* and *G. parva*, which have the lowest concentration of phosphorus, have the highest number of flowers. *G. tubulosa* has the least concentration of potassium but it has the highest number of leaves. A negative correlation was observed between the content of salt, potassium, and organic matter and the number of leaves. Salt content is positively correlated with calyx width and seed size in *G. muralis*. Content of organic matter and number of flowers are lowest in *G. tubulosa*. *G. confertifolia*, which has the highest level of organic matter, has the calyx, petal, and the bract heights at the highest level. In *G. tubulosa* a negative correlation is found between the content of organic matter and number of leaves (Table 2; Figures 3–6, 8) (Korkmaz & Özçelik, 2011a).

The movement of air and water is easier in light soils. In sandy soils, plant roots reach the deep layer of soil easily. High amounts of clay and alluvium can prevent root development. For this reason, in coarse soils (sand, loam) plants that have the tap root system and in thin textured soils (clayish) plants that have the hairy root system can grow easily (Gökmen, 2007). Some plants species can be indicators of the environment where they exist or the soil where they grow. Species of *Gypsophila* are generally indicators of gypsum steppes and erosive areas. Ataşlar (2001) states that species of the genus *Gypsophila* are typical steppe plants and demonstrate a distribution on dry and calcareous rocks, serpentine rocks, and stony–sandy lands. It was claimed that some types of the species grow in soils that are loamy, slightly alkaline, limy, and deficient in topsoil. In our study, it was determined that the soils where annual *Gypsophila* taxa grow are generally loamy, with a slightly alkaline character, have lime at various contents (from the lowest to the highest), low phosphorus, much potassium, and medium organic matter. *Gypsophila* taxa that were analysed in both studies grow in loamy, saltless, slightly alkaline, and limy soils. It was stated that some taxa of the species grow in soils that are lacking in topsoil (Ataşlar, 2001). In our study, it was determined that annual taxa grow in soil that contains organic matter at the medium level. Moreover, as a result of our study, it was concluded that the taxa generally grow in soils that have low concentrations of phosphorus and potassium. There is very little information about the growing conditions of *Gypsophila* species in Turkey in Davis (1967) and Huber-Morath (1967a, 1967b), which are the most important studies about the species. Some ecological properties of some *Gypsophila* species distributed in western Turkey were examined by Ataşlar (2001) and some soil properties of *G. parva*, *G. viscosa*, *G. tubulosa*, and *G. pilosa* were given. It was stated that *Gypsophila* species grow in various habitats such as on dry slopes, in calcareous soils, in crevices, and on steppes, and that *G. tubulosa* is a maquis element and *G. pilosa* and *G. viscosa* are known as weeds in fields. It was also stated that these species prefer soils that are alkaline, limy, and with poor organic matter and their contents of nitrogen are 0.01%–0.29%, of phosphorus are 0.018–0.96 kg/ha, and of potassium are 1.08–27.10 kg/ha. These results are generally compatible with our findings except for the habitat of *G. tubulosa.* We did not observe *G. tubulosa* in maquis, but on hill slopes, in rocky places, and on steppes. Darwent and Coupland (1966) and Darwent (1975) stated that *G. paniculata* reduces the protein content of soil in fields. The results of the studies conducted on *Gypsophila* species show poor organic matter contents, supporting Darwent and Coupland (1966) and Darwent (1975).

Gypsophila species are widespread in arid and semiarid steppe areas. Korkmaz and Özçelik (2012) stated that most of them are therophytes and some species have a long flowering period. Vegetative development and seed germination of annual *Gypsophila* species are seen from March to June. Formation of the bud and flowers occurs in April–July and seed maturation is completed in May–August.

El Naggar (2004) studied the pollen and seed morphology of *G. pilosa.* We observed that it is a cosmopolitan and wild herb of many agricultural areas in Turkey. Güleryüz and Gökçeoğlu (1994) reported that nitrogen has a significant effect on competition among plants and excessive drought affects nitrogen formation negatively. *Onosma bracteosum* Hausskn. & Bornm. (Boraginaceae) is another endemic Irano-Turanian element and prefers sandy, loamy, and sandy limy soils. Our study results contribute to the results of the studies above in terms of lime, salt, organic matter, and nitrogen contents. Furthermore, *Gypsophila* species can adjust themselves to the summer drought with some adaptation such as depositing water in leaves and well developed and enlarged root systems. Sameh et al. (2011) stated that millions of hectares of arable land are too saline for agriculture. Halophytic plants are well adapted to salt and water stresses, which prevent the growth of most crops. Because of the rich biological diversity they have been regarded as a potential source of new crops (Akçin & Engin, 2005). In *Carthamus tinctorius* L. salinity decreases both germination and fertility and affects the development of seeds and roots negatively (Kaya et al., 2003). The osmotic potential increases, thus weakening the water inlet capacity of the plant. Salinity tolerances of plants depend on genetic and environmental factors. In addition, some elements such as the Cl and B have toxic effects on plants (Sönmez & Kaplan, 1997). Our study results and these results about salt content are consistent with each other. However, the higher salt content of some soil samples of *G. heteropoda* (1 and 7) and *G. parva* (14) show their higher tolerances to salinity. Sekmen et al. (2012) stated that salinity is a major limiting factor for plant productivity. Therefore, there is a need to select and characterise salt-tolerant plants. The aim of our study was to determine the responses of *G. oblanceolata* Bark., an endemic and endangered halophyte, to salt stress during germination and vegetative growth. It was found that salt stress decreased both the germination percentage and the activities of antioxidant enzymes. *G. oblanceolata* is a moderately salt-tolerant species at the vegetative stage. It was reported that variation in the soil type does not affect Ca content but increased salinity reduces the calcium level in plants (Sameh et al., 2011). Turkan and Demiral (2009) reported that, although the term salinity implies high concentration of salts in soil, NaCl constitutes the greatest part of soil salinity. Being natural inhabitants of highly saline soils, halophytes efficiently exclude salts from their roots and leaves and some can endure salts that are more than twice the concentration of seawater. Halophytes represent the best model species for future research to describe the salinity mechanisms (Turkan & Demiral, 2009).

Some *Gypsophila* species (particularly *G. sphaerocephala* and *G. perfoliata*) are boron hyperaccumulators. They hyperaccumulate boron from the soil to the upper organs of plants. Therefore, these plants should be used for boron mining by growing them in the same habitats. Boron toxicity originating from the usage of artificial fertiliser causes around 30% loss in crops and this loss can be recovered by growing some *Gypsophila* species in the same area (Babaoğlu et al., 2004). A low level of boron is necessary for development of plants but large amounts are toxic. Recently some species of *Gypsophila* from boron-rich soils in Turkey were shown to be remarkably tolerant to high levels of boron (Ünver et al., 2008). This indicates that some *Gypsophila* species have high tolerance to the toxic effects of boron.

Annual baby's breath (*G. elegans*) grows naturally in open and arid environments in south-eastern Europe and western Asia. It is naturalised in many geographical areas (Sinkkonen et al., 2008). This study indicated that very low levels of toxicant (Pb) may have a drastic effect on seedling and root development in fields.

Because of the increasing human population, studies and expenditures on soil usage and utilisation capacity to obtain the maximum output are increasing gradually. The provision of energy and material flow in nature, paving the way for the formation of vegetative biomass, and forming habitats for organisms living in it are among the significant functions of soil (Erdin, 1991).

Knowledge about the soil preferences of *Gypsophila* taxa, which are of great economic importance and have a natural distribution in Turkey and a high rate of endemism, is important for botanists and florists.

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