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The Morphological and Autecological Properties of *Salvia rosifolia* Sm. (Lamiaceae) Grown in Erzurum and its Environs in Turkey

Yusuf Kaya and Ozkan Aksakal
Department of Biology, Faculty of Arts and Sciences, Atatürk University, Erzurum, 25240, Turkey

Abstract: The aim of this study was to determine the morphological and autecological characteristics of *Salvia rosifolia* Sm. which is an endemic plant (Lamiaceae) distributed in Erzurum and its environs. Morphologically, it was observed that the species had a perennial root system, the herbaceous stem was ascending, unbranched, leaves pinnatisect, oblong-eliptic, glandular and eglandular hairs were present on the both surface of leaves. Bracts were ovate-acuminate and bracteols lanceolate. It was observed that calyx was campanulate and corolla bilabiate and also species contained two A type of stamen. Ecologically, the chemical and physical analysis was carried out on soil and plant samples collected from 22 different localities in Erzurum and its environs. Present results showed that the plant generally prefers loamy, sandy-loamy and sandy-clayey-loam textural soils, with a slightly alkaline or neutral pH. They also preferred non-saline or slightly saline soils which were both medium and rich calcium carbonate. The result obtained from soil and plant analyses were evaluated statistically and it was found that there was a relation between the quantities of phosphorus, nitrogen and potassium and plant abundance and distribution.

Key words: Autecology, morphology, *Salvia rosifolia*

INTRODUCTION

The genus *Salvia* has roughly 900 species, thus being by far the largest genus within the Lamiaceae of worldwide occurrence (Kandemir, 2003). The two largest center of genus are in America and in South-West Asia. There are 87 *Salvia* species growing naturally in Turkey, half of which are endemic (Hedge, 1982). In Turkey they grow between an altitude 1-3350 m (Vural and Adigüzel, 1996). In various studies *Salvia* has been shown to be the most potent natural antioxidant of the common species (Wang *et al*., 1998). *Salvia* species contain monoterpenes with antiseptic characteristics (Nakipoğlu, 1993). Many *Salvia* species their essential oils are commonly used in the food, drug, cosmetic and perfumery industries (Nakipoğlu, 2002). They are well known among people and widely used as flavouring or fragrances and for medicinal purposes in the several regions of the world (Özcan *et al*., 2003). The leaves of *Salvia* species are also used as tea. In addition, *Salvia* species are grown in parks and gardens as ornamental plants (Nakipoğlu, 1993). Studies on autecology this genus very limited or not. For an understanding of the biological characteristics of a species, it is important to have knowledge of its habitats (Doğan and Mert, 1998; Doğan, 2001). No morphological and autecological studies have been done on *Salvia rosifolia* Sm (Lamiaceae), an endemic species, in Turkey. Therefore, the purpose of this study is to investigate the morphological and autecological features of *Salvia rosifolia*.

MATERIALS AND METHODS

The specimens of *Salvia rosifolia* Hedge were collected from 22 different localities in Erzurum and its environs (Fig. 1) during flowering and identified with the help of Flora of Turkey and the Aegean Islands (Davis, 1988). All the specimens *Salvia longipedicellata* were deposited in the Ata Herbarium (Department of Biology, Faculty of Arts and Sciences at Atatürk University). Herbarium and fresh samples were used for morphological features, biometric measurements and autecological features.

Soil samples were collected from 0-30 cm depth, brought to the laboratory. They were left under laboratory conditions and air-dried. The dried soil samples were ground, passed through a 2 mm sieve and subjected to analysis. The texture determined according to the method of Gee and Bauder (1986). Total soluble salts, calcium carbonate ($CaCO_3$) and organic matter were determined according to the method of Öztürk *et al*. (1997). The pH values were determined using soil samples saturated with

Corresponding Author: Yusuf Kaya, Department of Biology, Faculty of Arts and Sciences, Atatürk University, Erzurum, 25240, Turkey

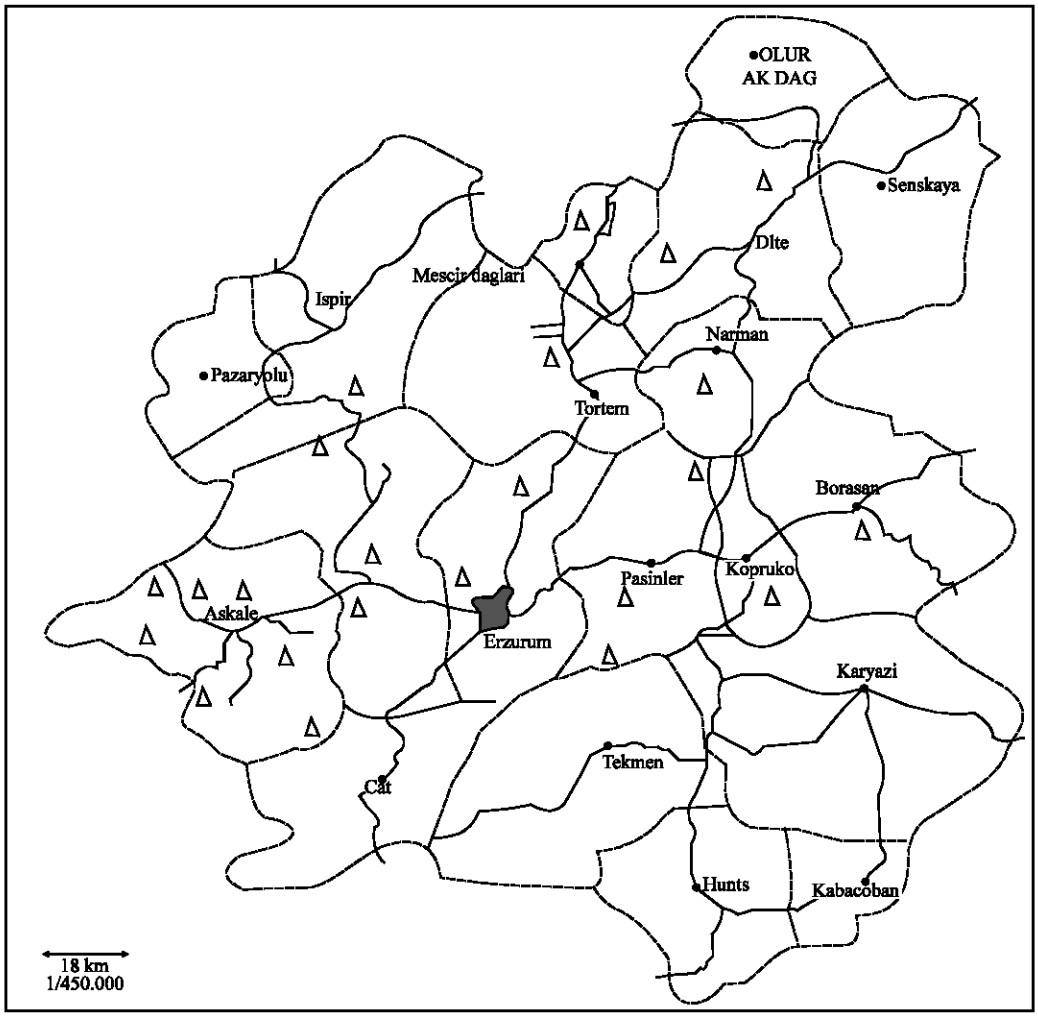

Fig. 1: Localities of stations *Salvia rosifolia* samples were collected (●: *S. rosifolia*)

distilled water (Mclean, 1982). The N, P and K contents were determined according to the method outlined in Kjeldahl, described by Hewetson (1951). The total phosphorus was determined with a spectrophotometer at a wavelength of 436 nm. The total potassium was determined with a flame photometer (Perkin elmer Atomic absorbsion spectrophotometer 360). The Fe, Zn, Mn was determined according to the method of (Lidsay and Norwell, 1969) and measured Perkin elmer Atomic Absorbtion Spectrophotometer 360.

The above ground parts (stem, leaves and flowers) of the plants were collected from different localities in the flowering period (June-August), dried at 80°C in an oven for 24 h, ground with a commercial blender and prepared for analysis. Total nitrogen was determined according to AOAC (1990), method phosphorus was determined by spectrophotometer and potassium, calcium and sodium were determined by flame photometer according to the methods outlined in detail by AOAC (1990). Result of soils and plant samples were statically tested and regression curves and correlation coefficients obtained.

RESULTS AND DISCUSSION

Morphological properties of *Salvia rosifolia* Sm

Root: The top root of the taxon is 28-65 cm length. In generally dense dark-brown hard barks surrounds the root. A lot of lateral root occurred from this main root.

Stem: The perennial herbaceous stem is ascending or suffruticose and branched or not, lower parts cover with old petiols. The stem is 23-72 cm long and 1.5-5.5 cm width. The stem surface is covered by densely glandular and eglandular hairs (Fig. 3). The stem color is light brown or brown-green at basal, green colored at upper in flowering period and dark violet colored in fruiting period.

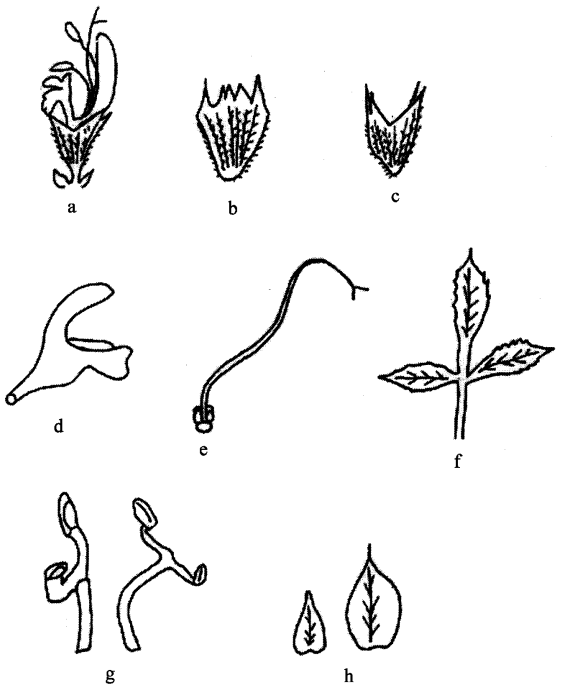

Fig. 2: The flower segments of *Salvia rosifolia*: (a) longitudinal view of flower, (b-c) calyx, (d) corolla, (e) pistil, (f) venation of leaf, (g) stamens and (h) bracts (Scale: 1 cm)

Leaf: Leaves are pinnatisect with an oblong elliptic terminal segment. Glandular and eglandular hairs are present on both the upper and the lower of leaves. It is found two pairs leaves at lateral segments (Fig. 2f). The petiole is 6.6-30 mm, glandular and eglandular hairs are present at the surface of petiole (Fig. 3a, c-d). The leaves are dark-green at basal, violet green at upper in flowering period.

Flower: Inflorescence is paniculate, flowers are zygomorphic symmetric (Fig. 2a). The flowers are arranged verticillately on plant and 4-14 flowers are present at verticillasters, rarely terminal verticillasters ending with 1 flower. Flowers are at the base of bracts. Bracts are ovate, acuminate and green-violet colored. Bracts are 3-5.5×6.5-13.5 mm (Fig. 2h). Bracteols are lanseolate in shape and 1-3×4-12 mm length. Pedicel is 5.5-9.3 mm length. The upper lip of calyx is tridentate and lower lip is bidentate. The shape of the calyx is campanulate (Fig. 2b-c). Calyx has numerous sessile glands (Fig. 3b). The calyx is 10.1-15 mm long and the color of the calyx lilac-green. Corolla is 18.3-27.3 mm length. Upper lip is lilac, lower lip is pink-violet. The lower part of corolla tube is annulate. The upper lip is straight in shape (Fig. 2d).

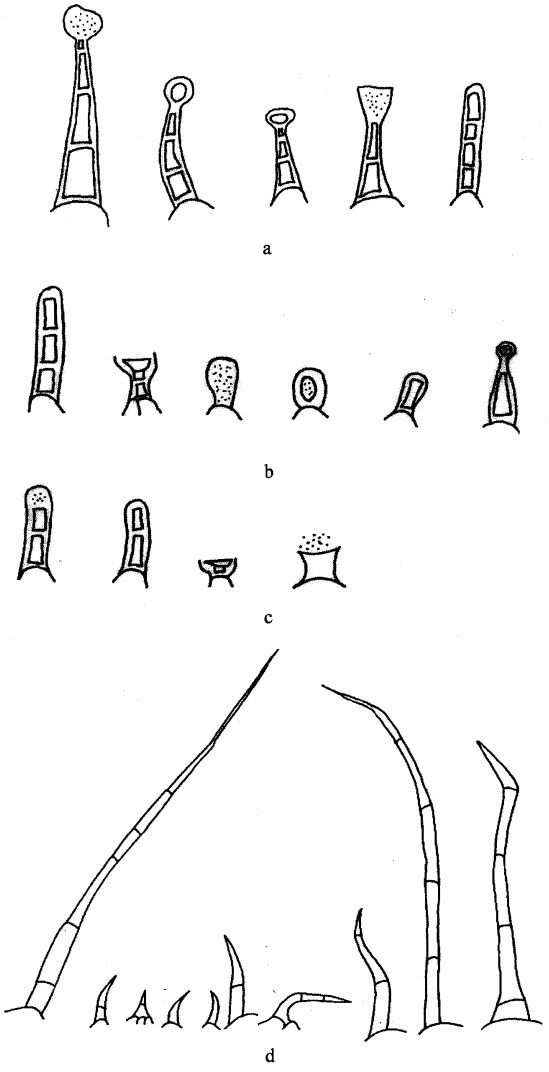

Fig. 3: Glandular and eglandular hairs in different parts of *Salvia rosifolia* (a-c). Capitate hairs (Glandular) and (d) Eglandular hairs

Stamens are A type (Fig. 2g) and include within corolla. The filament is 6-11.5 mm length and anther is 1.7-3 mm length and yellow colored. The stigma has two parts and each parts are violet colored (Fig. 2e). The style is 18-27.2 mm long. Fruit type is nutlet. Seed is colored dark-brown and rounded as trigonous and 2.2×3 mm in length.

Physical analysis of the soils: It was found that 45.45% of the soils were loamy, 18.18% sandy-clayey-loam, 27.27% sandy-loam, 4.5% clayey-loam and 4.5% were silt-loam in texture (Table 1). This indicate that the plant generally prefers loamy and sandy-loam soils. Salvia wiedemannii growing in Middle East Anatolia has also been reported

Table 1: Physical and chemical analysis of the soil of *Salvia rosifolia*

Locality	Sand (%)	Clay (%)	Silt (%)	Texture	pH	Salts (%)	Ec 10^3 mmhos cm^{-1}	$CaCO_3$ (%)	Org.Mat. (%)
1	51.90	20.20	27.90	Sandy-clayey-loam	7.3	0.028	0.72	12.60	5.42
2	29.20	20.90	49.90	Loamy	7.8	0.016	0.39	30.00	0.07
3	47.90	16.80	35.30	Loamy	7.5	0.012	0.30	45.80	1.33
4	39.60	27.10	33.30	Clayey-loam	7.8	0.024	0.44	29.80	0.35
5	61.80	19.60	18.60	Sandy-loam	7.4	0.022	0.62	16.40	3.32
6	23.00	23.00	54.00	Sandy-clayey-loam	7.8	0.014	0.31	36.80	0.06
7	41.70	25.10	33.20	Loamy	8.0	0.017	0.41	30.60	0.40
8	45.80	16.70	37.50	Loamy	7.8	0.013	0.29	53.80	0.70
9	35.40	23.00	41.60	Loamy	7.8	0.02	0.49	45.30	1.08
10	39.60	20.90	39.50	Loamy	7.9	0.012	0.32	40.30	1.26
11	52.10	10.50	37.40	Sandy-loam	7.0	0.029	0.83	15.30	2.10
12	60.40	27.10	9.80	Sandy-clayey-loam	7.8	0.008	0.29	11.80	0.52
13	29.20	16.80	54.00	Silt-loam	7.7	-	-	25.60	1.43
14	52.10	16.70	31.20	Sandy-loam	7.5	0.022	0.35	26.10	1.05
15	64.50	12.60	22.90	Sandy-loam	7.2	0.053	0.46	13.40	1.22
16	39.60	23.00	37.40	Loamy	7.9	0.013	0.28	30.30	0.77
17	56.40	9.20	34.40	Sandy-loam	7.9	0.161	3.45	9.90	5.59
18	54.70	15.60	29.70	Sandy-loam	7.9	0.014	0.36	20.00	4.89
19	44.10	11.20	44.70	Loamy	7.6	0.023	0.44	17.90	4.65
20	44.80	23.40	31.80	Loamy	7.9	0.017	0.40	11.40	1.66
21	45.30	17.30	37.40	Loamy	7.8	0.041	0.45	29.50	2.55
22	51.40	26.60	22.00	Sandy-clayey-loam	7.8	0.01	0.25	38.20	1.10
Min.	23.00	9.20	9.80		7.0	0.008	0.25	9.90	0.06
Max.	64.50	27.10	54.00		8.0	0.161	3.45	53.80	5.59
Mean	45.90	19.20	34.70		7.7	0.027	0.56	26.80	1.88
SD	10.86	5.37	10.80		0.3	0.032	0.677	12.71	1.752

to prefer same soils (Altınöz, 1997). The soils on which *S. rosifolia* grows have pH values of 6.95-8.01 (Table 1). According to soil analysis data the plant prefers 22.30% neutral, 77.27 slightly alkaline. A preference for slightly to moderately alkaline soils resembles the behaviour of *Salvia wiedemannii* distributed in the near region (Altınöz, 1997).

The calcium carbonate content of the soils of *S. rosifolia* varies from 9.9-53.8%. Accordingly plant grows that 22.72% medium, 59.09% very rich $CaCO_3$ and 18.18% rich $CaCO_3$ (Table 1). It can be seen that this plant generally prefers calcareous soils. Also, *Salvia wiedemannii* distributed in near region prefer soils moderately rich and rich in calcium carbonate content. The organic matter of these soils varies from 0.06-5.59%. These soils contain very poor (31.81%), poor (36.36%), rich (27.27%), medium (9.09%) and moderately rich (4.54%) in organic matter (Table 1). The salinity values of Soil of *S. rosifolia* vary from 0.008 to 0.161% (Table 1). These soils are non-saline in general (Tüzüner, 1990). A comparison of our data with those of other researchers (Çirik and Seçmen, 1990; Altınöz, 1997) reveals that *Saliva rosifolia* and the other species *Salvia kronenburgii* Rech. Fil, *Salvia wiedemannii* distributed in the near region occupy non-saline soils.

Chemical analysis of soils: The nitrogen contents of *S. rosifolia* varies from, 0.01 to 0.28% (Table 2). Accordingly 36.36% of the soils are poor, 27.27% are moderate, 9.9% sufficient and 27.27% rich in nitrogen. The phosphorus contents of the *Salvia rosifolia* Sm soil samples are given in (Table 2). 31.81% of the soils are very rich in phosphorus, 22.72% rich in phosphorus, 27.27% medium and 9.09% very poor and poor phosphorus. The species prefer varying phosphorus soils. Potassium values were 54.54% sufficient potassium, 45.46% rich potassium of the soils (Table 2). On the other hand, the soils of the species *Origanum onites* belongs to same family and spreaded in near regions were determined rich in nitrogen and phosphorus, but not in potassium (Gönüz and Özörgücü, 1999).

Chemical analysis of the plants: The chemical analysis of plant, showed that the contend of nitrogen, phosphorus, potassium, calcium and sodium were varied from 1.08 to 2.80; 0.05 to 0.27; 1.38 to 2.51; 0.70 to 1.60 and 0.02 to 0.2, respectively (Table 3). These values were found to be in accordance with the limits reported before (Kaçar, 1972; Johnson and Ulrich, 1959; Chapman, 1967).

Statistical evaluation of the soil and plant analysis result: *Salvia rosifolia* the statistical evaluation of the results between the pH, $CaCO_3$, organic matter, Salt, phosphorus, potassium, calcium, sodium, magnesium, iron, manganese and zinc content of the soils and nitrogen, phosphorus, potassium, calcium, sodium of the plants. From the regression analysis four relevant correlations were obtained, three of these negative and one positive correlation. The latter were observed between calcium carbonate and nitrogen, salt and calcium, salt and sodium,

Table 2: Physical and chemical analysis of the soil of *Salvia rosifolia*

Locality	N (%)	P (ppm)	K me/100 g soil	Ca me/100 g soil	Na me/100 g soil	Mg me/100 g soil	Fe (ppm)	Mn (ppm)	Zn (ppm)
1	0.27	7.20	1.65	13.33	0.16	2.39	0.81	13.97	2.18
2	0.01	8.60	1.53	10.98	0.53	2.56	1.49	3.77	2.48
3	0.07	10.30	0.67	12.84	0.50	2.16	0.65	9.40	0.59
4	0.02	2.30	1.80	13.14	0.53	2.48	0.81	5.66	1.68
5	0.17	10.70	1.49	10.47	0.35	2.20	1.10	14.16	2.33
6	0.01	3.20	1.54	13.66	0.42	2.52	1.40	2.83	1.39
7	0.02	6.80	1.65	11.96	0.88	2.13	1.34	2.83	1.62
8	0.04	6.20	1.38	13.33	0.18	2.16	0.42	3.40	0.61
9	0.05	10.60	1.57	13.66	0.44	2.36	0.42	8.68	1.33
10	0.06	11.90	1.65	12.84	0.50	2.68	0.51	6.04	0.57
11	0.11	8.30	1.12	13.95	0.27	2.40	0.89	10.88	1.00
12	0.03	19.70	0.67	10.82	0.42	2.08	0.71	7.55	0.51
13	0.06	16.80	0.69	12.99	0.65	2.00	0.81	7.17	0.93
14	0.06	1.80	1.27	9.87	0.26	2.20	0.56	8.68	0.50
15	0.06	15.70	0.51	11.76	0.27	2.12	0.98	16.05	1.62
16	0.04	19.00	0.81	14.01	0.70	2.44	0.36	7.55	0.32
17	0.28	14.60	1.65	12.84	0.85	2.80	0.86	18.40	2.38
18	0.25	11.30	1.65	10.78	0.19	2.12	1.19	11.33	2.30
19	0.23	26.10	1.47	13.16	0.22	2.08	0.83	12.77	0.71
20	0.18	13.30	1.24	12.60	0.39	2.56	0.80	6.60	0.53
21	0.13	6.90	1.44	13.50	0.50	2.68	0.77	7.36	1.82
22	0.04	5.70	1.71	15.05	0.32	2.24	0.51	9.10	1.09
Min.	0.01	1.80	0.51	9.87	0.16	2.00	0.36	2.83	0.32
Max.	0.28	26.10	1.80	15.05	0.88	2.80	1.49	18.40	2.48
Mean	0.09	10.70	1.32	12.60	0.43	2.33	0.82	8.82	1.29
SD	0.09	6.08	0.399	1.328	0.203	0.23	0.31	4.27	0.72

Table 3: Chemical analysis of *S. rosifolia* Sm

Locality	N (%)	P (%)	K (%)	Ca (%)	Na (%)
1	2.315	0.22	1.94	1.10	0.06
2	1.725	0.17	2.49	0.70	0.04
3	1.736	0.185	1.60	1.12	0.06
4	2.80	0.259	1.96	0.70	0.12
5	2.38	0.163	1.46	0.94	0.06
6	1.08	0.156	1.91	0.92	0.04
7	2.10	0.085	1.38	1.46	0.08
8	1.90	0.276	1.85	0.94	0.12
9	1.47	0.113	2.51	1.02	0.02
10	2.055	0.202	2.04	1.12	0.08
11	1.10	0.09	1.90	1.10	0.04
12	2.53	0.05	1.96	1.18	0.12
13	2.40	0.19	2.04	0.72	0.06
14	2.11	0.17	1.64	0.84	0.10
15	2.226	0.258	1.56	0.76	0.06
16	1.22	0.194	1.83	1.60	0.04
17	2.36	0.175	1.90	0.70	0.20
18	1.83	0.225	2.00	1.18	0.06
19	2.625	0.148	2.14	1.10	0.08
20	2.36	0.08	1.68	1.44	0.14
21	1.30	0.11	1.44	0.94	0.12
22	1.745	0.242	1.90	1.16	0.06
Min.	1.08	0.05	1.38	0.70	0.02
Max.	2.80	0.276	2.51	1.60	0.20
Mean	1.971	0.17	1.86	1.03	0.08
SD	0.503	0.063	0.294	0.252	0.423

zinc and calcium. No other relevant correlations were obtained. Regression curves and correlations coefficients showed that negative correlations exist between soil calcium carbonate and plant nitrogen (R^2 = 0.18, R = 0.42) (Table 4, Fig. 4); soil salt and plant calcium (R^2 = 0.18, R = 0.43) (Table 4, Fig. 5); and soil zinc and plant calcium (R^2: 0.18, R: 0.42) (Table 4, Fig. 7). But a positive

Table 4: Regression analysis between different parameters in *Salvia rosifolia*

Soil sample	Parameter	Plant N	Plant Ca	Plant Na
Soil $CaCO_3$	Multiple R	0.4258		
	R Square	0.1813		
	Adjusted R Square	0.1404		
	Standard Error	0.4665		
Soil salt	Multiple R		0.4329	0.6003
	R Square		0.1874	0.3604
	Adjusted R Square		0.1446	0.3267
	Standard Error		0.2298	0.0353
Soil zinc	Multiple R		0.4281	
	R Square		0.1833	
	Adjusted R square		0.1424	
	Standard Error		0.2338	

correlation exist between soil salt and plant sodium (R^2: 0.36, R: 0.60) (Table 4, Fig. 6) was obtained. Since the probability values of the soil calcium carbonate-plant nitrogen, soil salt-plant calcium and soil zinc-plant calcium in *S. rosifolia Sm* correlations were less than 0.05, the correlation coefficients and models were significant (İkiz *et al*., 1996) and a reliable correlation exist between soil salt-plant sodium. In terms of percentage r^2-values the soils of this plant appear to be poor in nutrients.

It was determined that morphological characters such as type of stamen, properties of glandular and eglandular hairs, shape of corolla and calyx structure of bract have taxonomical value. As regards results presented here, the morphological properties of *S. rosifolia* Sm showed some similarities and differences compared to other findings in the Flora of Turkey.

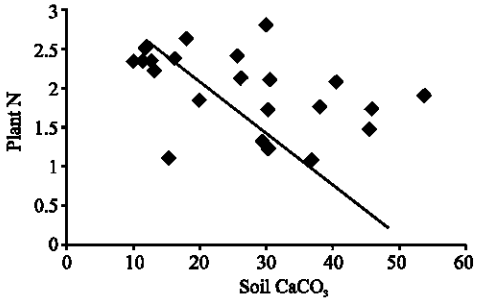

Fig. 4: Regression analysis of plant nitrogen and soil $CaCO_3$ in *S. rosifolia*

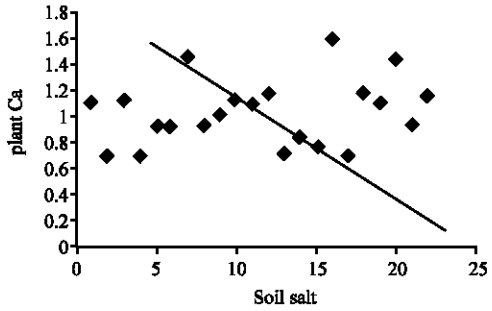

Fig. 5: Regression analysis of plant calcium and soil salt in *S. rosifolia*

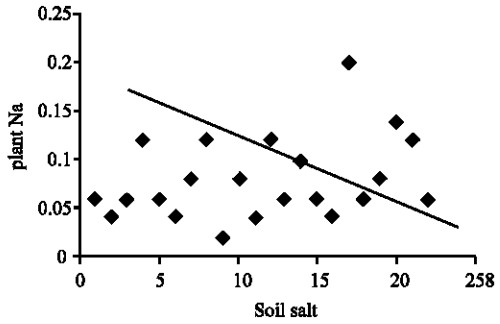

Fig. 6: Regression analysis of plant sodium and soil salt in *S. rosifolia*

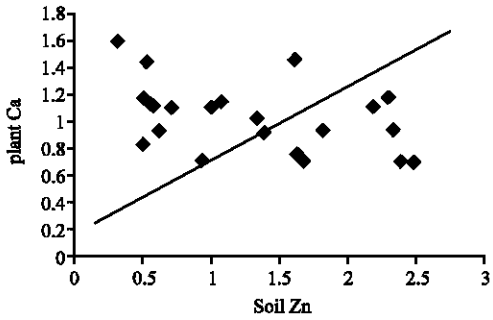

Fig. 7: Regression analysis of plant calcium and soil zinc in *S. rosifolia*

Very few ecological studies have been conducted on Lamiaceae family especially *Salvia* sp. in Turkey which are used as pharmaceuticals, ornamental, tea etc. Therefore, we investigated ecological properties of *S. rosifolia.*

REFERENCES

AOAC., 1990. Official Methods of Analysis of the Association of Official Analytical Chemists. Washington DC.

Altınöz, N., 1997. Salvia wiedemannii Boiss.'in ekolojik özellikleri. Anadolu Üniv. Fen Bilimleri Enstitüsü 69. Eskişehir.

Chapman, H.D., 1967. Plant analysis values suggestive of nutrient status of selected plants. Soil Testing and Plant Anal., 2: 77-91.

Çiriğ, N. and Ö. Seçmen, 1990. *Salvia kronenburgii* Rec. Fil tütü üzerinde morfolojik taksonomik ve ekolojik çalışmalar. X. Ulusal Biyoloji Kongresi 18-20 Temmuz 1990. Erzurum.

Davis, P.H., 1988. Flora of Turkey and the East Aegean Islands (Supplement). Vol. 1-10. Edinburgh University Press, 11: 4-124.

Doğan, Y. and H.H. Mert, 1998. An autecological study on the v*itex agnus-castus* L. (Verbenaceae) distributed in West Anatolia. Tr. J. Bot., 22: 327-334.

Doğan, Y., 2001. A study on the autecology of *Reseda lutea* L. (Resedaceae) distributed in western Anatolia. Turk. J. Bot., 25: 137-148.

Gee, G.W. and J.W. Bauder, 1986. Particle-Size Analysis. Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods. 2nd Edn. Agronomy No. 9 Part 2. Edition, pp: 383-441.

Gönüz, A. and B. Özörgücü, 1999. An investigation on the morphology, anatomy and ecology of *Origanum onites* L. Tr. J. Bot., 23: 19-32.

Hedge, I.C., 1982. *Salvia* L. In: Flora of Turkey and the East Aegean Islands. Davis, P.H. (Ed.) University. Press, 7: 400-461.

Hewetson, C.E., 1951. Ecology of *Tectona grandis.* Modros for College, Mag., 27: 101-108.

Johnson, C.M. and A. Ulrich, 1959. Analytic methods for use in plant analysis. California: Agricultural Experiment Station Bulletin, pp: 766.

Kaçar, B., 1972. Bitki ve toprağın kimyasal analizleri. 2. Bitki Analizleri. Ankara: Ankara Üniversitesi Ziraat Fakültesi Yayınları 453. Uygulama Klavuzu: 155. Ankara Üniv. Basımevi.

Kandemir, N., 2003. The morphological, anatomical and karyological properties of endemic S*alvia hypargeia* Fich. and Mey. (Lamiaceae) in Turkey. Pak. J. Bot., 35: 19-236.

Lidsay, W.L. and W.A. Norvell, 1969. Development of a DTPA soil test for Zn, Fe, Mn and Cu. Soil Sci. Soc. Am. J., 42: 421-428.

Mclean, E.O., 1982. Soil pH and lime requirement. Methods of soil analysis. Part 2. Chemical and Microbiological Properties. 2nd Edn. Agronomy No. 9 Part 2. Edition. pp: 199-224.

Nakipoğlu, M., 1993. Türkye' nin bazı *Salvia* L. türleri üzerinde karyolojik araþtýrmalar I. *S. fruticosa* L., *S. tomentosa* Mill. *S. officinalis* L. *S. smyrnaea* Boiss. (Lamiaceae). Doğa. Tr. J. Bot., 17: 21-25.

Nakipoğlu, M., 2002. The classification of the *Salvia* L. (Labiatae) species distributed in West Anatolia according to phenolic compounds. Turk. J. Bot., 26: 103-108.

Özcan, M., O. Tzakou and M. Couladis, 2003. Essential oil composition of Turkish herbal tea (*Salvia aucheri* Bentham var. *canescens* Boiss. and Heldr.). Flavour Fragr. J., 18: 325-327.

Öztürk, M., M. Pirdal and F. Özdemir, 1997. Bitki ekolojisi uygulamaları. Ege Üniv. Fen Fak Kitaplar Serisi No: 157, İzmir: Ege Üniv. Basımevi.

Tüzüner, A., 1990. Toprak ve su analiz laboratuvarları el kitabı. Tarım Orman ve Köy İşleri Bakanlığı, Köy Hizmetleri Genel Müdürlüğü, 375, Ankara.

Vural, M. and N. Adıgüzel, 1996. A new species from central Anatolia: *Salvia aytachii*, M. Vural et N. Adıgüzel (Labiatae). Tr. J. Bot., 20: 531-534.

Wang, M., J. Li, M. Rangarajan, Y. Shao and E. Lavoie, 1998. Antioxidative phenolic compounds from sage (*Salvia officinalis*). J. Agric. Food Chem., 46: 4869-4873.