Journal of Applied Biological Sciences 4 (2): 33-37, 2010
ISSN: 1307-1130, E-ISSN: 2146-0108, www.nobel.gen.tr

Anatomical and Ecological Investigations on Some Salvia L. (Lamiaceae) Species Growing Naturally in the Vicinity of Balıkesir

Rıdvan POLAT[1] Fatih SATIL[1] Selami SELVİ[2]

[1]Balıkesir University, Science and Arts Faculty, Department of Biology, Çağış Campus 10145 Balıkesir-TÜRKİYE

[2]Balıkesir University, Altınoluk Vocational High School, 10870 Edremit, Balıkesir-TÜRKİYE

Corresponding Author
e-mail: rpolat10@hotmail.com

Received : May 25, 2010
Accepted : August 05, 2010

Abstract

This study proposes to present a comparative analysis of the anatomical and ecological characteristics of three Salvia L. species (*S. argentea, S. aethiopsis, S. viridis*) collected from various localities of Balıkesir province. The only *S. viridis* is an annual. Anatomical examination was made of cross sections obtained from stems and leaves, in addition to examining leaf surface sections to determine stoma type. All anatomical sections obtained were photographed. While the stem anatomies of all species generally resembled one another we did not observe sclerenchyma tissue in the *S. viridis.* Ecological investigation included physical (texture, pH, lime ($CaCO_3$), total salt) and chemical (N, P, K, organic matter) analysis of soil samples taken from the various localities. In general the structure of the soil over which the species had spread showed similarity.

Keywords: Anatomy, Balıkesir, Ecology, Lamiaceae, *Salvia.*

INTRODUCTION

Turkey is regarded as an important gene centre for the Lamiaceae family which is represented in Turkey by 47 genera [1,2,3]. *Salvia* is one of the large genus of Lamiaceae family. Turkey is a major diversity centre for *Salvia* in Asia [4]. This genus is repesented in Turkey by 95 species. The ratio of endemism in the genus *Salvia* in Turkey is ca. 50 % [2,4-7].

Salvia species are an important group of useful plants. Several species of *Salvia* are used in folk medicine as antiseptics, astringents and spasmolytics. Many studies have shown the antioxidant, antimicrobial and antiviral activities of some *Salvia* species. The antibacterial, antituberculous and antiphlogistic activities of the constituents of *Salvia* species are well-established [8]. Besides medicinal value, *Salvia* species are also grown in parks and gardens as ornamental plants [9].

Detailed studies on the anatomy and especially ecology of this genus are limited. Recent studies have been done on the anatomical structure of the some Salvia species [10-13]. Kaya et al. [14] reported morphological, anatomical and palynological characteristics of Salvia halophila. Also, Kaya & Aksakal [15] studied the morphological and autecological properties of Salvia rosifolia grown in Erzurum and its environs in Turkey. Kahraman et al. [16] studied on morphological, anatomical and palynological characteristics of *Salvia glutinosa* L. and *S.staminea.*

Detail information on anatomical and especially ecological properties of 3 *Salvia* species have not been studied. There are only anatomical studies on *S. viridis* [17]. Therefore, the purpose of this paper was to investigate the anatomical and ecological properties of *S. viridis, S. aethiopsis* and *S. argentea*. We think that presented differences will provide useful information would be beneficial to botanists who will make biosystematical and revision studies in the future.

MATERIAL AND METHOD

Salvia species studied were collected from natural populations within the vicinity of Balikesir. Voucher specimens are deposited in the Herbarium of the Faculty of Arts and Sciences of Balıkesir University. Collecting localities for the examined speciments are given in Table I.

For bright-field microscopy, specimens of both fresh and fixed material were prepared. Suitable sections prepared from the specimens in 70% EtOH were used

Table 1. Localities of the examined *Salvia* taxa from Balıkesir.

Species	Collection data and collector number
S. viridis	B1 Balıkesir: 4 km from Balıkesir to İzmir road, roadsides, 350 m, 17.07.2004, RP 101.
S. aethiopsis	B1 Balıkesir: 20 km from Balıkesir to Bigadic road, roadsides, 420 m, 12.08.2003, RP 72.
S. argentea	B1 Balıkesir: İvrindi, Madra mountain, 610 m, 13.07.2004, RP 92.

for anatomical studies under the microscope. Transverse sections stem and leaves and surface of leaves were prepared manually and were stained with Sartur reagent [18] Then, the sections were mounted in glycerin-gelatin [19]. Olympus BX51 microscope with DIC (Differential Interference Contrast) was used for anatomical investigations. Also, Nikon Eclipse E 600 research microscope with drawing tube was used for anatomical drawings.

Soil samples were collected from 5 different localities during generative growth period at a depth of between 0-25 cm. The chemical analysis of soil samples was made in the laboratory of the Agriculture and Rural Affairs Directorate of Balikesir. The texture, total salt, pH, lime ($CaCO_3$), P ($P2O_5$), K (K_2O) and organic matter were determinate. Organic matter was determinated by the Walkey-Black method and N% by Kjeldahl's method, P% by ammonium molibdate-tin chloride method and K% by flame photometer. The analysis of soil samples were evaluated according to Kaçar [20].

Anatomical Properties

Stem Anatomical Characteristics

The stem cross-sections of *S. viridis, S. aethiopsis* and *S. argentea* bear a remarkable resemblance to one another. Stem is quadri-angular. The upper and lower walls of the epidermis are covered with a thick cuticle and they are thicker than the lateral walls. There are glandular and eglandular hairs on epidermis. Eglandular hairs are 1-4 (-5) celled, straight or curved and covered with a thick cuticle. The glandular hairs are of two main type; capitate and peltate (Lamiaceae type). Capitate hairs have unicellular head and unicellular-multicellular stalk. Peltate hairs are rare. They have 4 central and 8 peripheral cells. Collenchyma is in corner while in between corner is 2–3 layers and located under epidermis. Parenchymatic cortex is 3–9 layers and located under collenchyma. Also; cortex cells includes dense ergastic matter. The single-layered endodermis cells are long and flattened, under which lies pericycle. Vascular bundles at the corners were larger than the others. There is a sclerenchymatous sheath on the phloem but there is not S. viridis. The cambium is not observed. The pith is large and consists of paranchymatous cells (Figures 1, 2, 3).

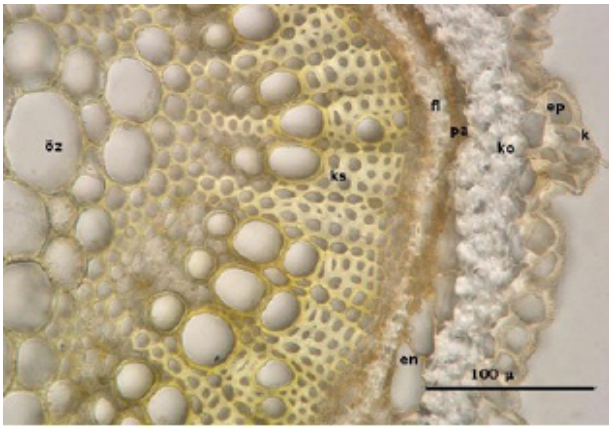

Figure 1. Cross-section of S. viridis stem (k: cuticle, ep: epidermis, ko: collenchyma, en: endodermis, pa: paprenchyma, fl: phloem, ks: xylem, öz: pith).

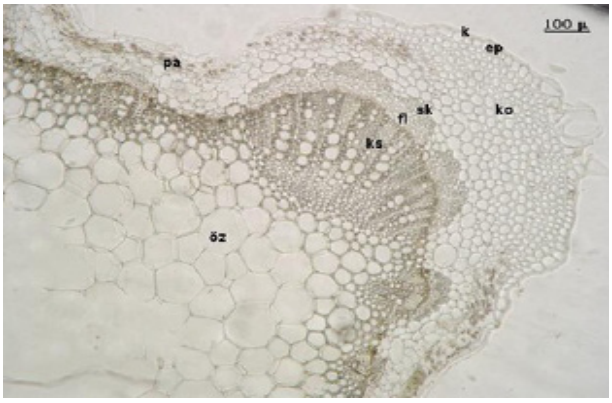

Figure 2. Cross-section of S. argentea stem (k: cuticle, ep: epidermis, ko: collenchyma, sk: sclerenchyma, pa: parenchyma, fl: phloem, ks: xylem, öz: pith).

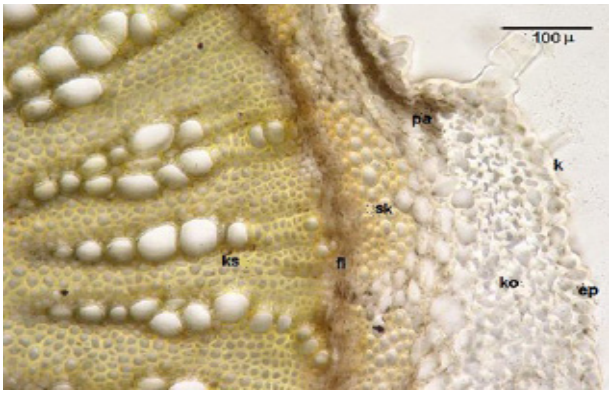

Figure 3. Cross-section of S. aethiopsis stem (k: cuticle, ep: epidermis, ko: collenchyma, sk: sclerenchyma, pa: parenchyma, fl: phloem, ks: xylem).

Leaf Anatomical Characteristics

The leaf cross-sections of *S. viridis*, *S. aethiopsis* and *S. argentea* bear a remarkable resemblance to one another. There was a single layered epidermis on both adaxial and abaxial surface of leaf. Epidermal cells were oval, squarish or nearly rectangular in the cross-section. It was covered with a thick cuticle. Glandular and eglandular hair were present on both upper and lower epidermis. Eglandular trichomes are 1-5 (-7) celled with cuticular micropapillae and unbranched. Multicellular hairs are more abundant. There are 2 types of glandular hairs: Capitate type and peltate type. The glandular hairs are of two main type; capitate and peltate (Lamiaceae type). Capitate hairs have unicellular head and unicellular-multicellular stalk. Peltate hairs are rare. They have 4 central and 8 peripheral cells. Peltate hairs are usually sinked toward the epidermis. Stoma cells were present both adaxial and abaxial epidermis. Stoma type was diacytic. Leaf was bifacial. Palisade parenchyma was 2–4 layered and spongy parenchyma 3–4 layered. Palisade and spongy parenchyma cells had a lot of chloroplast. Vascular bundle structure is collateral type. The sclerenchyma tissue is well developed above the phloem and below the xylem. There is angular collenchyma 2–3 layered under the epidermis of the median vein. (Figures 4,5,6).

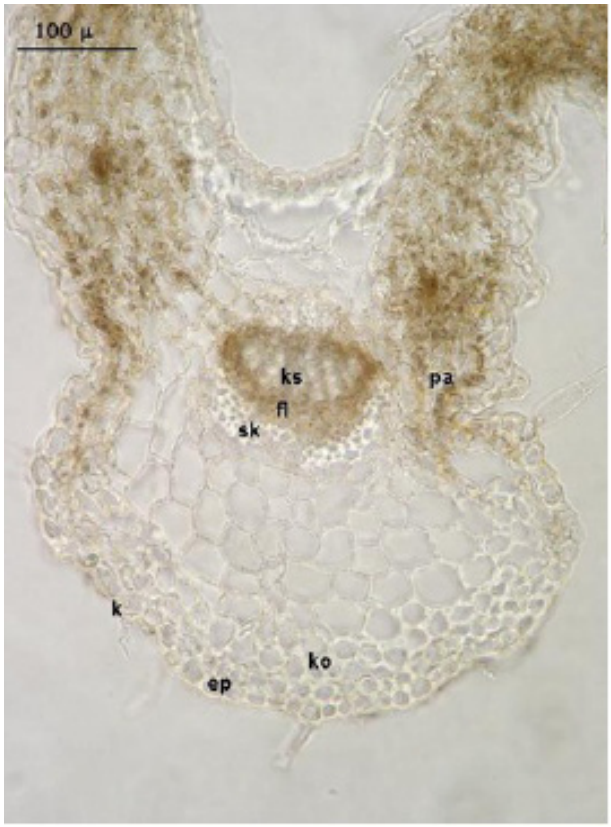

Figure 4. Cross-section of S. viridis leaf (ep: epidermis, k:cuticle, ko: collenchyma, pa: parenchyma, sk: sclerenchyma, fl: phloem, ks: xylem).

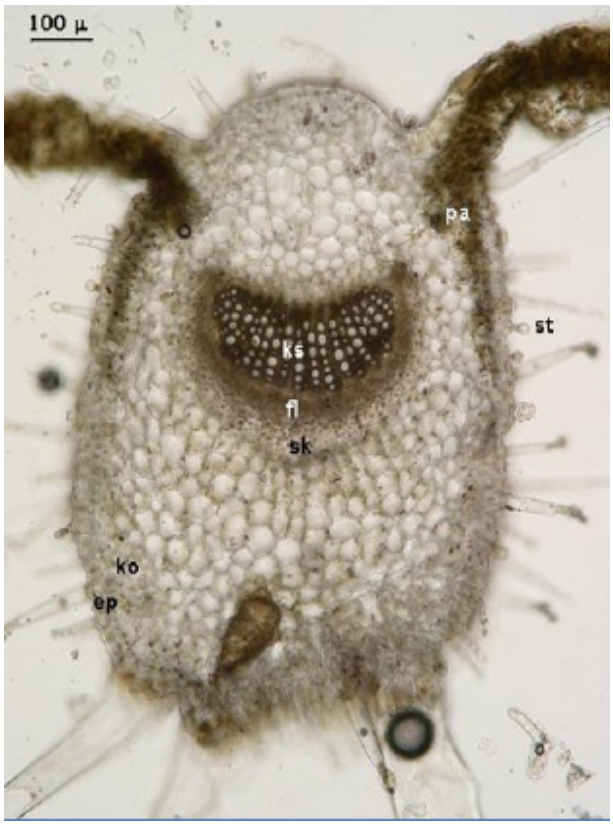

Figure 5. Cross-section of *S. argentea* leaf (ep: epidermis, ko: collenchyma, pa: parenchyma, st: glandular hair, sk: sclerenchyma, fl: phloem, ks: xylem).

Figure 6. Cross-section of S. aethiopsis leaf (k: cuticle, ep: epidermis, ko: collenchyma, pa: parenchyma, sk: sclerenchyma, fl: phloem, ks: xylem).

Ecological Properties Distribution

In the field observations carried out in different localities, *Salvia viridis* cover a wide area, however, it has been seen that other species show a considerably poor population. In the studying areas, steppe vegetation is widespread also, different habitat types are observed. This habitat types are igneous, limestone slopes, fallow fields and roadside banks.

Table 2. Conclusions soil analyses of *Salvia* taxa.

Taxa	Texture	Total salt %	pH %	$CaCO_3$ %	P %	K %	Org. Mat. %
S. viridis	Clayey-loamy	0.18	6.87	-	2.29	241.5	2.73
S. aethiopsis	Loamy	0.15	7.29	-	0.69	276	2.11
S. argentea	Clayey	0.07	7.34	-	12.59	209.3	5.19

Soil Analysis Results

This species generally prefers clayey-loamy, loamy and clayey soils. According to the results presented in Table 2, pH values were between 6.87 and 7.34. Soils are showed that Calcium carbonate ($CaCO_3$) wasn't involved. Total salts were between 0.07 and 0.18%. The organic matter concentration of *S. argentea* was 5.19, however; *S. viridis* and *S. aethiopsis* were respectively 2.11 and 2.73. The phosphorus concentration of *S. argentea* is 12.59 and considering other two species were very rich. Potassium concentration of three species were between 209.3 and 276.

DISCUSSION

In this study, we investigated the anatomical and ecological properties of *S. viridis, S. aethiopsis* and *S. argentea.* The characteristic feature of Lamiaceae family is a quadrangular stem and a well developed collenchyma, supporting tissue at the corners of stem [21]. These features were seen in three *Salvia* species.

The stem of *S. aethiopsis* and *S. argentea* have sclerenchyma groups upon the phloem, but the the herbaceous stem of *S. viridis* has not a sclerenchymatic groups (Table 3). However, according to Özdemir and Şenel [11] the herbaceous stem of *S. viridis* has clear sclerenchyma groups upon the phloem. Also, there is sclerenchymatic groups on the phloem of stem cross sections of the *S. sclarea* [10].

Studied three *Salvia* species exhibit difference in collenchyma and phloem thickness in stem. The phloem is the thickest in *S. viridis.* However, the collenchyma is the thinnest in *S. viridis* (Table 3).

Leaf mesophyll of Salvia species is entirely parenchymatic and the median vein of leaf is surrounded by collenchyma [21]. Lacunar collenchyma forming around intercellular spaces is present in *Salvia* genus [22]. This characteristic was found in studied *Salvia* species. The vascular bundle is surrounded by a distinguishable bundle sheath in *S. viridis.* But the bundle sheath is indistinguishable in *S. aethiopsis* and *S. argentea.*

The nonglandular hairs are uni or multicellular, with cuticular micropapillae, unbranched and consisting of elongated cells in stem and leaf. The glandular hairs are of two main type in stem and leaf; capitate and peltate. The capitate hairs are quite simple in morphology. Capitate hairs have unicellular head and uni or multicellular stalk (Table 3). Baran et al. [23] examined the anatomical structure of the glandular trichomes in *S. argentea* and reported that capitate glandular trichomes forming a base 1–7 celled, a stalk 1–5 celled or no stalk and a head uni-or bicellular had various types. In our samples, *S. argentea* has peltate trichomes, with 4 cells in the center and 8 cells at the periphery. They have 1–4, central and 8–10, 12, peripheral cells in study of Baran et al. [23].

According to soil analysis results, organic material levels in the soil of the *S. argentea* and *S. aethiopsis* was high while that of the S. viridis was average. As for texture, the *S. viridis* seemed to prefer clayey-loamy and clayey soils while the S. aethiopsis seemed to prefer loamy, and the S. argentea to prefer clayey soils. *S. viridis* seemed to thrive in slightly salty soil while the other two species preferred saltless soil. The pH of soils

Table 3: The comparison of anatomical characteristics of studied Salvia species

	Stem					Leaf			
	Eglandular tichome	Capitate trichome	Collenchyma	Phloem	Sclerenchyma	Bundle sheath	Eglandular tichome	Capitate trichome	Phloem
S. viridis	1-5 celled	unicellular head and stalk	2-4 layered	3-5 layered	absent	distinguishable	1-3 (4) celled	unicellular head and stalk	3-4 layered
S. aethiopsis	1-4 celled	unicellular head and uni-two celled stalk	3-7 layered	2-4 layered	3-5 layered	indistinguishable	1-5 celled	unicellular head and uni-two celled stalk	3-6 layered
S. argentea	1-5 celled	unicellular head and uni-three celled stalk	8-10 layered	2-3 layered	3-5 layered	indistinguishable	1-4 (7) celled	unicellular head and uni-three celled stalk	4-5 layered

for all three species were neutral. Lime ($CaCO_3$) was absent. The phosphorus value was quite high for the *S. argentea*, while very low levels were seen for the other two (Table 2).

In their ecological studies, Kaya and Aksakal [15] found that the *S. rosifolia* species prefered neutral and alkaline soils, saltless and low-salt soils that were sandy-loamy or sandy-clayey. This species also prefered soils high in phosphorus, calcium carbonate, and organic matter. We obtained results similar to these in our study as well, except for one characteristic difference, and that is the preference for clayey, loamy, and clayey-loamy soil types.

Soil samples from a study carried out by Nakipoğlu [9] proved to be, in contrast to our results, slightly alkaline (7.55) for the *S. argentea*, while similar to our results soils for the *S. viridis* registered as neutral (7.15) (Table 2).

Yücel and Altınöz [24] work on the *S. wiedemannii's* ecological characteristics revealed its soils to be neutral and alkaline; its sandy, clayey soil structures to have a high moisture retention capacity, and its soils to be otherwise saltless and shallow. Our fieldwork produced one different result; the *S. wiedemannii* was seen to thrive on sandy soils with a pH between 7.7 and 8.32, and with organic matter between 0.43% and 4.01%, P levels at 0.01% - 0.27% and K at 0.27% - 1.85%. From the perspective of these findings we may conclude that there is little difference in soil types between samples taken for the species in this study and those for the *S. wiedemannii.*

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