

ANATOMICAL STUDIES IN *SALVIA VIRIDIS* L. (LAMIACEAE)

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Abstract

Anatomical properties of two morphologically distinct forms (Form I: with violet coma and Form II: without coma or with white, green or pink coma) of *Salvia viridis* L. have been studied. The analysis provided here studying the cross-sections of root, stem, leaf, petiole, bract, calyx and corolla comprises the first detailed description for the species. The results are furnished with photographs and drawings. Although no anatomical differences were observed between the forms, *S. viridis* showed some differences from other *Salvia* species.

Introduction

Salvia L., the largest genus of the family Lamiaceae, represents an enormous and cosmopolitan assemblage of nearly 1000 species displaying a remarkable range of variation. Turkey is a major diversity centre for *Salvia* in Asia (Vural and Adıgüzel, 1996), with 90 species, 47 of which are endemic to this country.

Salvia viridis L. is the only annual species of *Salvia* in Turkey. There are several distinct forms based on coma features. In Turkey, the most frequent is that with a prominent violet coma consisting of sterile bracts (Form I). Specimens without coma or with white, green or pink coma (Form II) are less frequent (Hedge, 1982). Detail information on anatomical properties of *S. viridis* cannot be found in the existing literature. An attempt, therefore, has been taken to study the anatomy of *S. viridis* for the first time to elucidate its taxonomic implications.

Materials and Methods

Plant samples were collected from natural populations. Some of the samples were used for anatomical observations and some of them were dried as herbarium sample. The investigated forms were collected from the following locations: Form I: Samsun: Kalkanca, roadside, 900 m, 13.05.2003, Özdemir 034; and Form II: Manisa: Gölarmara, near lakeside, 79 m, 16.04.2005, Baran 020.

Anatomical studies were carried out on the samples kept in alcohol 70%. The parafin method was applied for preparing the cross-sections of root, stem, leaf, petiole, calyx and corolla (Algan, 1981). Results are presented with original drawings and photographs and

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in tables. No distinction is made between the two forms in data presentation since no difference was observed between them.

Results and Discussion

Root: Annual root of the species had a periderm 3-5-layered at the outermost of the cross-section. The fellem elements of this layer were dark coloured and crushed in places. Flattened parenchyma cells of cortex were located under periderm. Cortex parenchyma cells were 12-20-layered and gradually getting smaller towards the center. Cambium was not clear and rarely 1-2-layered under phloem. Pith was not parenchymatic since the center was filled with xylem. Diameter of trachea was enlarging towards the center. Pith rays were 1-3-layered (Fig. 1, Table 1).

Table 1. Measurements of different cells and tissues of *Salvia viridis*.

	Length (µm)		Width (µm)	
	Range	Mean ± SD	Range	Mean ± SD
Root				
Peridermis cell	10.6 - 42.4	25.2 ± 9.8	15.9 - 79.4	42.4 ± 21.7
Parenchyma cell	7.9 - 37.1	20.6 ± 12.6	7.9 - 68.8	34.7 ± 21.4
Pith ray			5.3 - 68.8	23.3 ± 18.4
Trachea cell			10.6 - 84.7	45.8 ± 33.6
Stem				
Epidermal cell	10.6 - 47.6	27.9 ± 11.9	10.6 - 58.2	23.3 ± 10.7
Parenchyma cell			10.6 - 58.2	34.4 ± 20.4
Trachea cell			5.3 - 47.6	26.8 ± 19.9
Pith cell			15.9 - 211.6	92.6 ± 78.0
Leaf				
Cuticle			5.3 - 7.9	6.6 ± 1.5
Adaxial epidermal cell	10.7 - 75.0	34.3 ± 19.6	16.1 - 96.4	53.0 ± 33.6
Abaxial epidermal cell	7.9 - 47.6	25.4 ± 15.6	7.9 - 79.4	33.3 ± 24.3
Mesophyll region			63.4 - 185.3	114.9 ± 39.6
Palisade region			44.9 - 105.9	67.5 ± 18.8
Spongy region			18.5 - 79.4	47.4 ± 20.8
Palisade cell	26.5 - 58.2	39.7 ± 11.7	10.6 - 26.5	17.5 ± 4.5
Spongy cell			10.6 - 31.8	19.3 ± 7.3

SD, Standard deviation.

Stem: Epidermal cells at the quadrangular stem were oval, squarish and nearly rectangular in the cross-section. At the corners of stem, there were collenchyma 2-5-layered under epidermal. Parenchyma was 5-7-layered consisting of oval or nearly circular cells. Vascular bundles at the corners were larger than the others. In the vascular bundles, phloem was located under sclerenchyma and a large xylem was located under

phloem. A very large pith was present at the centre of stem, so the vascular bundles were placed near the periphery of stem. Pith cells were parenchymatic (Figs 2A-B, Table 1).

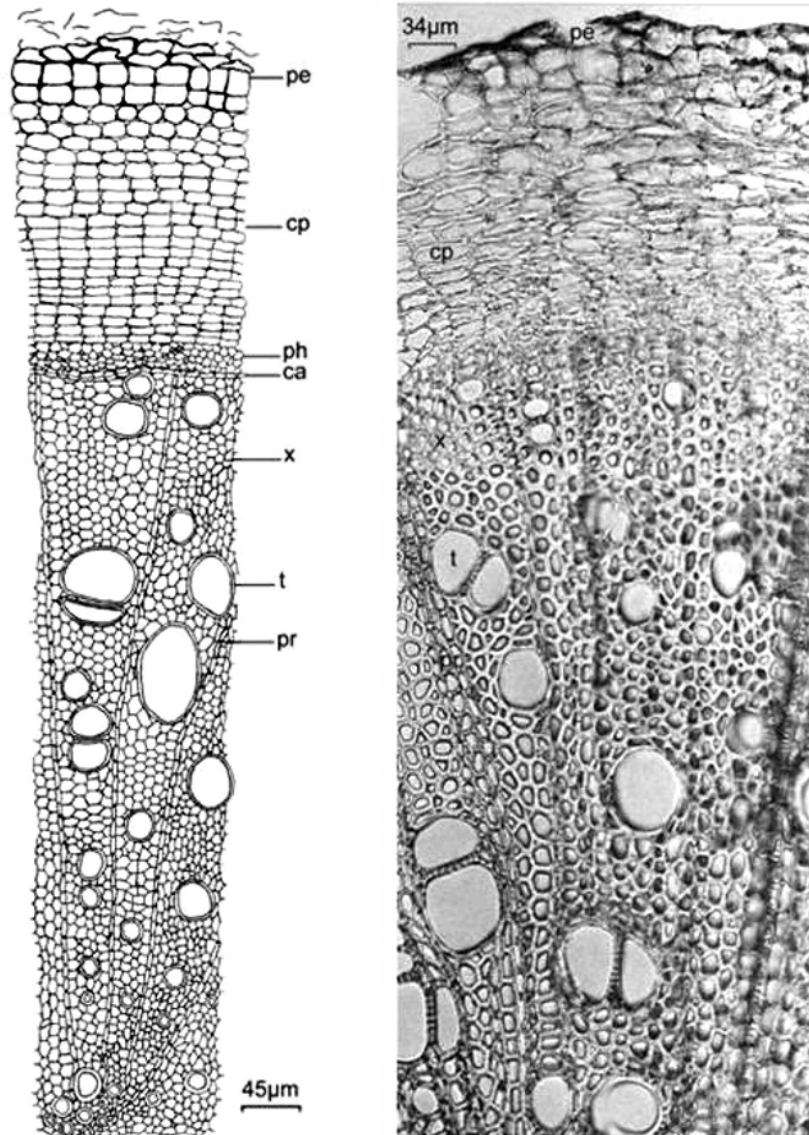


Fig. 1. The root sections of *Salvia viridis*. ca: cambium, cp: cortex parenchyma, p: pith, pe: peridermis, ph: phloem, pr: pith ray, t: trachea, x: xylem.

Leaf: Adaxial epidermal cells were larger than abaxial epidermal cells. Especially, epidermal cells at the region of median vein were larger than others. Leaf was bifacial. Palisade parenchyma was 1-2-layered. In the median vein of leaf, phloem and sclerenchyma surrounding it were clear and xylem rays were usually four. Epidermal

cells had sinuous walls in the superficial sections. Stomata were diacytic and present on both surface of leaf (Figs 2C-F, Table 1).

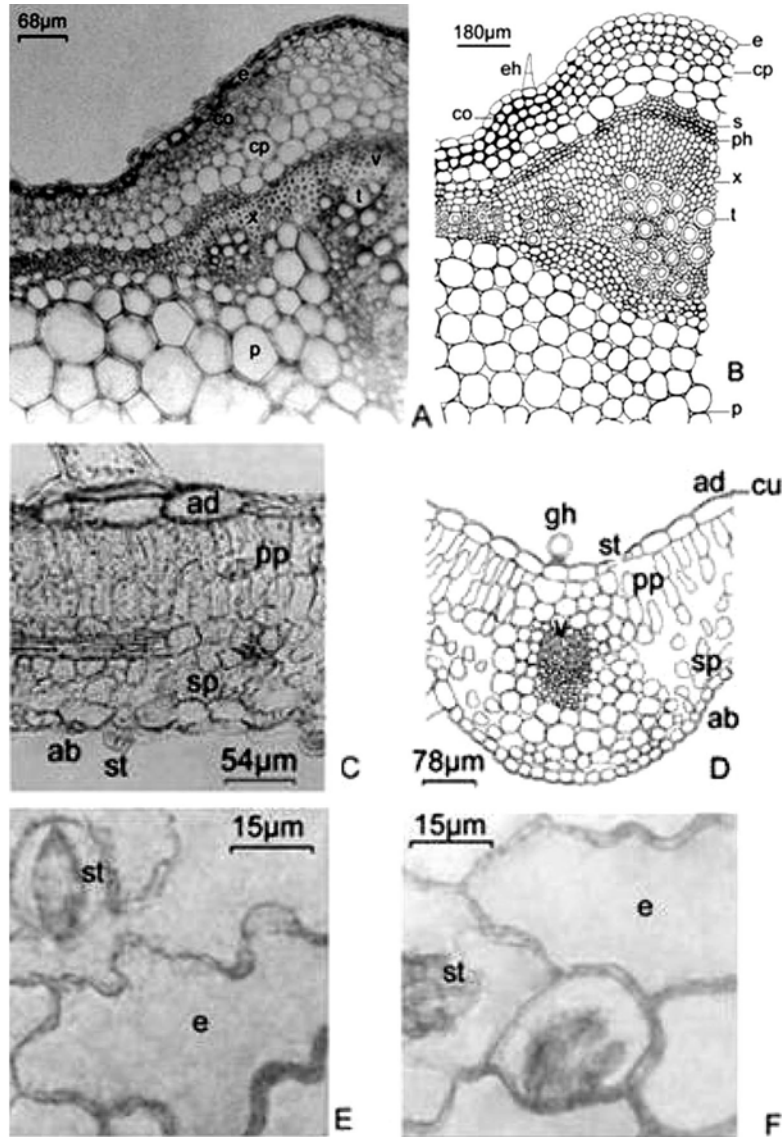


Fig. 2. The stem and leaf sections, and leaf surface of *Salvia viridis*. A-B. Stem sections; C-D. Leaf sections; E. Adaxial epidermis of leaf; F. Abaxial epidermis of leaf. ab: abaxial epidermis, ad: adaxial epidermis, co: collenchyma, cp: cortex parenchyma, cu: cuticle, e: epidermis, eh: eglandular hair, gh: glandular hair, p: pith, ph: phloem, pp: palisade parenchyma, s: sclerenchyma, sp: spongy parenchyma, st: stomata, t: trachea, v: vascular bundle, x: xylem.

Petiole: Single-layered epidermis consisted of oval or nearly circular cells in the cross-section of petiole. Parenchyma under epidermis was 5-10-layered consisting of circular cells. Parenchyma cells had clear intercellular spaces. Few-layered collenchyma

was located in places under epidermis. In the center of cross-section, there was a large single vascular bundle consisting of 31-37 xylem rays. This vascular bundle sometimes consisted of 2 or 3 lobes. In the cross-section, there were 2-4 small vascular bundles at the end of petiole. Vascular bundles were collateral (Figs 3A-D, Table 1).

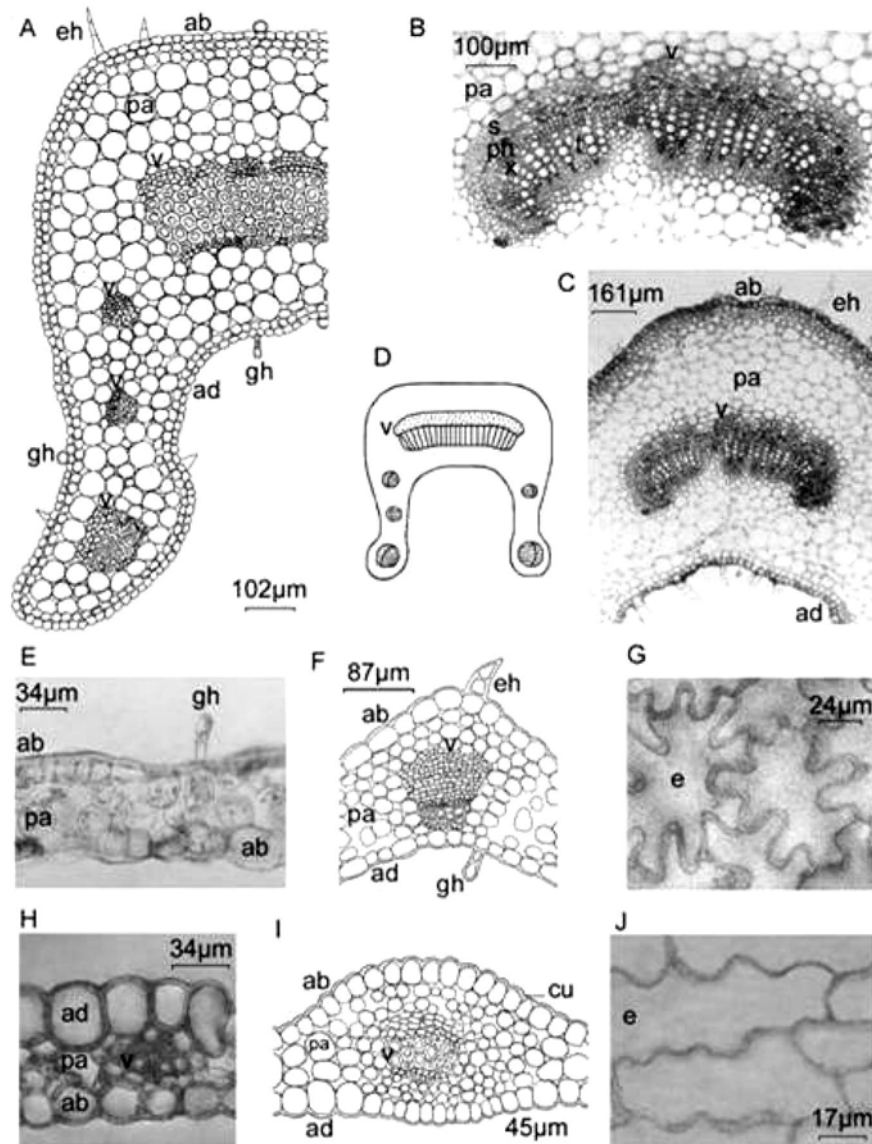


Fig. 3. The petiole, calyx and corolla sections of *Salvia viridis*. A-D. Petiole sections; E-G. Calyx sections; H-J. Corolla sections. ab: abaxial epidermis, ad: adaxial epidermis, cu: cuticle, e: epidermis, eh: eglanular hair, gh: glandular hair, pa: parenchyma, ph: phloem, pl: papilla, s: sclerenchyma, t: trachea, v: vascular bundle, x: xylem.

Bracts: Adaxial and abaxial epidermal cells of the bracts were nearly rectangular. Parenchyma cells between two epidermal layers were flattened and nearly rectangular.

Calyx: Parenchyma cells between epidermal layers were round, and had large intercellular spaces and a lot of chloroplasts. They were close together around vascular bundles. In vascular bundles, there was a large sclerenchyma on phloem. Epidermal cells of calyx had sinuous walls in the superficial section. Stomata were diacytic and present at epidermis (Figs 3E-G, Table 1).

Corolla: A thin cuticle was present on epidermis. The outer side of epidermal cells did not have papilla. Epidermal cells were oval, roundish or squarish. Parenchyma between two epidermal layers was 1-2-layered. A lot of vascular bundles were arranged in corolla circle. Epidermal cells of corolla had sinuous walls in the superficial section (Figs 3H-J, Table 1).

Pith rays of Lamiaceae family are 2-12 or more rowed and quite heterogeneous in structure (Metcalfé and Chalk, 1972). In *Salvia* species recorded in the literature, pith rays are 1-10-rowed and root center is filled with primary xylem (Çobanoğlu, 1988; Çobanoğlu *et al.*, 1992; Özdemir and Şenel, 1999). The root center of *S. forskahlei* L. has a large pith consisting of parenchymatic cells and the pith rays are 2-40-rowed (Özdemir and Şenel, 2001). Row number of pith rays can be used as a species-distinguishing feature, because it differs in every species.

The characteristic feature of Lamiaceae family is a quadrangular stem and a well-developed collenchyma, supporting tissue at the corners of stem (Metcalfé and Chalk, 1972). These features were seen in *S. viridis*. Woody stem of *S. forskahlei* has sclerenchyma groups upon the phloem and also a sclerenchymatic ring upon the sclerenchyma groups, but the herbaceous stem has only a sclerenchymatic ring (Özdemir and Şenel, 2001). The stem of *S. viridis* had clear sclerenchyma groups upon the phloem, but did not have any sclerenchymatic ring. Cambium in *Salvia* species examined is 2-3-layered or sometimes unclear (Çobanoğlu, 1988; Özdemir and Şenel, 1999, 2001). *S. viridis* exemplifies the latter type.

Leaf mesophyll of *Salvia* species is entirely parenchymatic and the median vein of leaf is surrounded by collenchyma (Metcalfé and Chalk, 1972). Lacunar collenchyma forming around intercellular spaces is present in *Salvia* genus (Yentür, 1995). This characteristic was found in *S. viridis*.

The arrangement of vascular bundles in the petiole of Lamiaceae is important in the point of taxonomy (Metcalfé and Chalk, 1972). Nakipoğlu and Oğuz (1990) separated the vascular bundles of seven *Salvia* species into two groups as those in the species with basal leaves and those in the species without basal leaves. According to this separation, the central vascular bundles of the species with basal leaves were divided, while those of the species without basal leaves were single, large and undivided. *Salvia argentea* L., a plant with basal leaves, had 4-7 central vascular bundles and 3-5 small bundles at each

end of petiole. Our finding corresponds with that of Nakipoğlu and Oğuz (1990), since *S. viridis* is a plant without basal leaves and the central vascular bundle of the petiole was single and undivided.

The analysis given in this account provides the first detailed description of anatomy of *S. viridis*. The two morphologically distinct forms (Forms I and II) of *S. viridis* showed no qualitative and quantitative differences in anatomy. Some anatomical differences, however, were identified between this species and other *Salvia* species reported in the literature. From the anatomical observations it could be concluded that the investigated forms of *S. viridis* belong to the same species showing morphological variations to some extent.

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