Anatomical aspects of *Salsola kali* subsp. *ruthenica* (*Chenopodiaceae*)

Rodica Bercu & Elena Bavaru

Department of Vegetal Biology, Faculty of Natural Sciences, Ovidius University, 124, Mamaia St., 900527 Constantza, Romania, e-mail: rodicabercu@yahoo.com

Received: June 3, 2003 ▷ Accepted: July 10, 2003

Abstract. The article comprises an investigation of the root, stem and leaf anatomy of *Salsola kali* subsp. *ruthenica* (*Chenopodiaceae*) from the Dobroudzha region (Romania). The anatomical characteristics of the vegetative organs of the species have been described and discussed. The young root has a primary diarch structure, whereas the mature root possesses a typically secondary structure. The stem possesses primary structure and the leaf is differentiated into chlorenchyma and parenchyma tissues. The stem vascular system, composed of xylem and phloem, forms a circular ring around the stem. The leaf vascular system is represented by a few poorly developed close collateral bundles. An apical view of the blade epidermis discloses paracytic stomata characteristic of *Chenopodiaceae*. The anatomy of the vegetative organs of the species exhibits characteristic features in accordance with its harsh habit.

Key words: anatomy, leaf, root, *Salsola kali* subsp. *ruthenica*, stem

Introduction

Genus *Salsola* L. (*Chenopodiaceae*) comprises worldwide as many as 150 species, both with herbaceous and shrubby members (Willis 1973). It is a noxious bushy summer annual, with rigid branches and reduced, stiff, prickly upper stem leaves (bracts) at maturity (Forbes & Allred 1999). In the Dobroudzha region (Romania), *S. kali* subsp. *ruthenica* (Iljin) Soó (syn. *S. pestifer* A. Nelson, *S. ruthenica* Iljin), known as a prickly saltwort, grows particularly in the littoral area (Constanza, Năvodari, Agigea, Mangalia), but all over Romania it is spread in halophytic areas (Morariu 1952).

Studies into the anatomy of the species are almost lacking in literature. Our purpose was to show that the root, stem and leaves of this plant exhibit certain interesting anatomical features in accordance with its slightly halophytic habit.

Material and methods

The plant materials were collected at the Black Sea Coast, the South Constantza zone. Small pieces of the material were fixed in FAA (formalin:glacial acetic acid:alcohol 70 % = 5:5:90). Cross sections were clarified with chloral hydrate and stained with alum-carmine and iodine green, and embedded in glycerine gelatine. The blade tangent sections were stained with 1 % saphranin. The observations and microphotographs were performed with a BIOROM-T bright field microscope, equipped with a TOPICA-6001A video camera. The microphotographs were obtained after downloading from the video camera on a computer.

Results and discussion

In the first stage of vegetation the root has a primary diarch structure (Plate I, Fig. 1). The cortex consists of 3–4 layers of large parenchyma cells. Endodermis consists of layer of cells. The vascular system is composed of phloem and xylem bundles surrounded by pericycle. The cambium is differentiated from the parenchyma cells, placed on the inner side of the phloem bundles and on the outer side of the xylem bundles. It has a sinuous shape from the beginning. The cambium produces more secondary xylem elements on the inner side and few secondary phloem elements on the outer side of the root (Plate I, Figs 1, 2). The diarch character of the root primary structure is characteristic also to other *Chenopodiaceae* such as *Atriplex tatarica*, *Kochia scoparia*, *Spinacia oleracea* (Phillips & Launchbaugh 1958; Zanovschi & Toma 1985).

During the period of vegetation the root acquires an early secondary structure (Plate I, Figs 3, 4). The outermost layer of compactly arranged thin-walled cells – the epidermis – is sporadically ruptured and replaced by cork just bellow. It is followed by phellogen – a single layer of thin-walled, radially flattened in shape and compactly arranged cells – and phelloderm (secondary cortex). The slightly suberized cork cells are compactly packed, without intercellular spaces. The phelloderm consists of isodiametric parenchyma cells. Intercellular spaces are found between them (Plate I, Figs 3, 4).

Similarly to other dicots roots (Tarnavschi & al. 1974; Andrei 1978; Şerbănescu-Jitariu 1980; Essau 1988; Batanouny 1992; Bavaru & Bercu 2002), the circular ring of the cambium produces a secondary xylem on the inner side and a secondary phloem on the outer side. Packets of sclerenchyma fibres are produced at each peripheral phloem bundle (Plate I, Fig. 4). The secondary phloem comprises sieve elements, companion cells, phloem parenchyma (mostly at the peripheral region), alternating with phloem fibers. Similarly to other species of *Chenopodiaceae* (Zanovschi & Toma 1985), the centrally located secondary xylem elements, found in the root of *S. kali* subsp. *ruthenica* consist of packed radial layers of xylem vessels placed into a sclerenchymatous parenchyma (xylem parenchyma) (Plate I, Figs 3, 4). Primary xylem elements are present in the centre of the root.

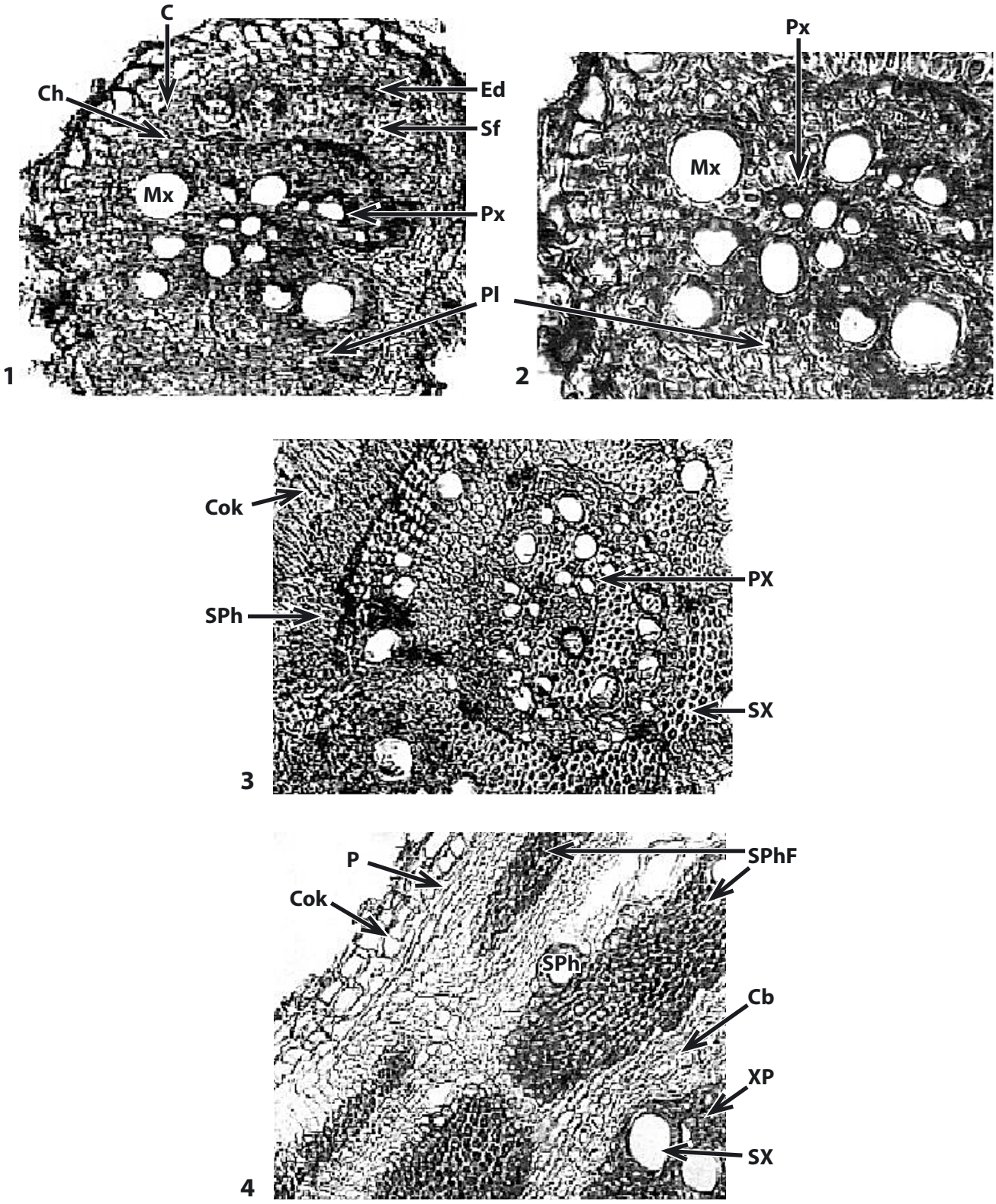
The stem of *S. kali* subsp. *ruthenica*, as Ciobanu (1971), Zanovschi & Toma (1985) and Essau (1988) reported for other *Chenopodiaceae* annual species (*K. scoparia*, *S. oleracea*), has a specific structure of anatomical interest. The stem has nine crests (Plate II, Fig. 1). The epidermis, the outermost layer of cells, is covered by a thick cuticle. The cortex can be roughly divided into an outer and inner region (Plate II, Figs 1, 2, 3). The palisade cells of the outer region are compactly arranged and contain numerous chloroplasts. The inner region of parenchyma cells covers almost the entire central portion of the stem. The continuity of the outer region is interrupted by large collenchyma cells placed in the crests (Plate II, Figs 1, 3). The inner layers are composed of loosely arranged cells. The endodermis is composed of one layer of parenchyma cells. Pericycle is well developed and lies beneath the endodermis. It consists of 2–3 layers of sclerenchyma cells (Plate II, Fig. 4).

The vascular elements (xylem and phloem) form compact and conjoined tissues (Plate II, Fig. 4). The larger xylem elements face the periphery, whereas the smaller xylem elements face the pith region. The pith is made up of a large number of rounded cells, which are loosely arranged, enclosing intercellular spaces (Plate II, Fig. 4).

A cross section of the sessile filiform leaf exhibits a more or less elliptically shaped blade (Plate III, Fig. 1). The epidermis consists of one layer of cells, covered externally by a thick cuticle. The heterogeneous mesophyll is differentiated into a chlorenchyma (palisade) region and a parenchyma (spongy) region (Plate III, Figs 1, 2, 4). The palisade region is interrupted by slightly sclerenchymatous cells on the margins (Plate III, Fig. 4). The vascular system is represented by a large close collateral bundle (of the midrib) in the center and two small vascular bundles on the peripheral sides composed of xylem and phloem. Xylem is presented on the upper side, whereas phloem is presented at the lower side. The large vascular bundle is characterized by the presence of a parenchymatous sheath (Plate III, Fig. 3). The small bundles consist of few xylem and phloem elements (Plate III, Fig. 4). The continuity of the epidermis is broken by paracytic stomata (Dilcher 1974; Deliu 1993) (Plate III, Fig. 5).

In the stem cortex and in the leaves of some *Chenopodiaceae* species, such as *K. scoparia* (with the same histological elements as *S. kali* subsp. *ruthenica*), Dickie & al. (1989) noticed a high concentration of soluble calcium oxalate which could cause chronic oxalate poisoning (alkalosis) in cattle. Such ergastic inclusions are absent in the stem and leaves of *S. kali* subsp. *ruthenica*.

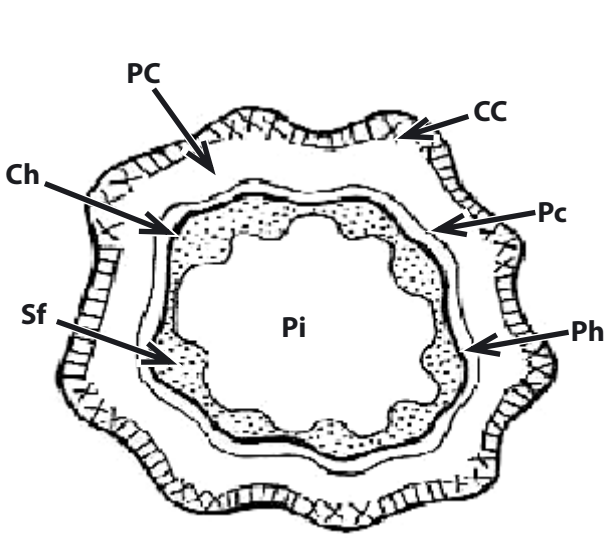
Plate I



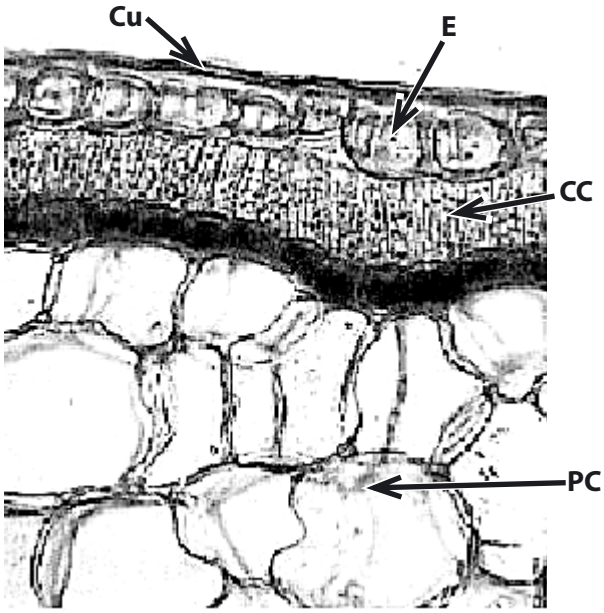
Figs 1-2. Cross section of the first stages root development: **1,** general view (×80); **2,** the stele (×240).

Figs 3-4. Cross section of the root secondary structure: **3,** the stele (×120); **4,** portion with cork, phelloderm and secondary phloem (×310): **C** – cortex; **Cb** – cambium; **Cok** – cork; **P** – phellogen; **Pl** – phloem; **PhF** – phloem fibre; **PX** – primary xylem; **SC** – secondary cortex; **SPh** – secondary phloem; **SX** – secondary xylem; **XP** – xylem parenchyma (Orig.).

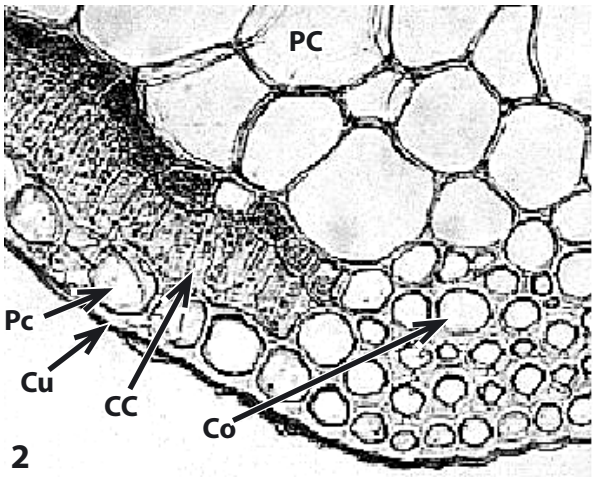
Plate II



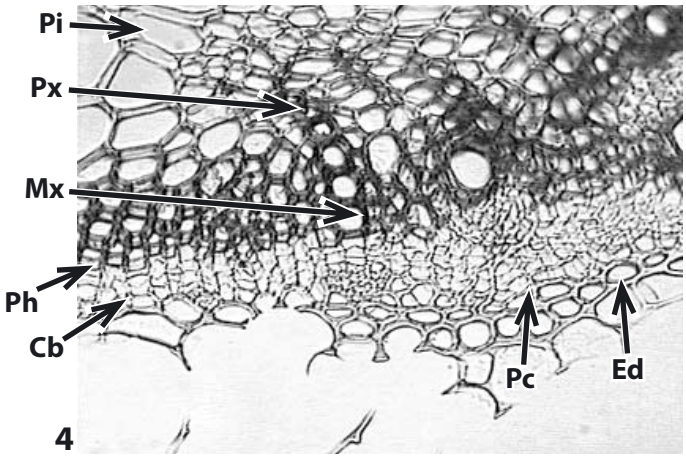
1



2



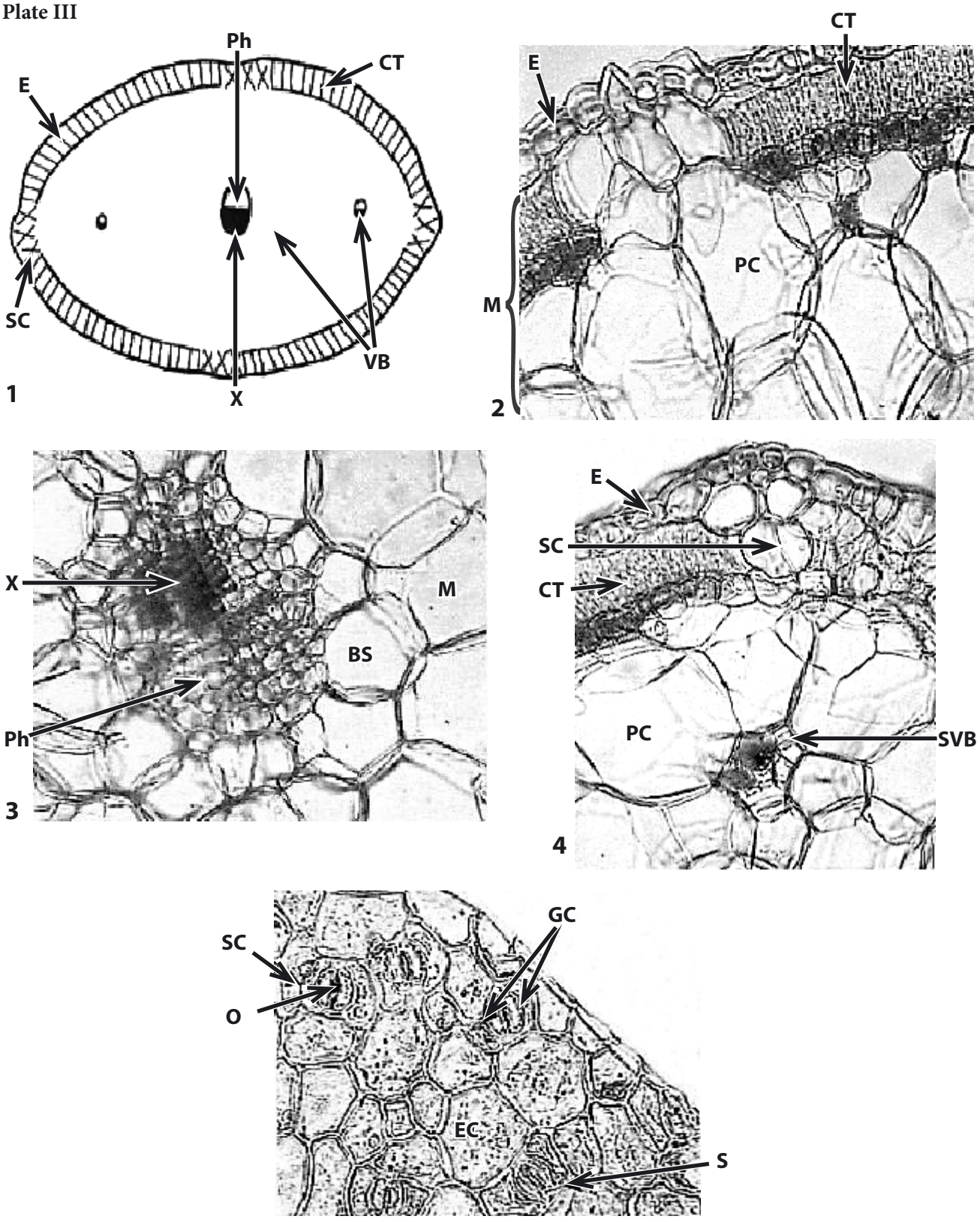
2



4

Figs 1-4. Cross section of the stem (×270): **1**, diagram showing the stem structure; **2-3,** portions with epidermis and cortex; **4,** portion of the central cylinder: **Cb** – cambium; **Co** – collenchyma; **Cu** – cuticle; **CC** – chlorenchyma cortex; **E** – epidermis; **Ed** – endodermis; **Mx** – metaxylem; **Pc** – pericycle; **Ph** – phloem; **Pi** – pith; **Px** – protoxylem; **PC** – parenchyma cell; **X** – xylem (Orig.).

Plate III



Figs. 1-4. Cross section of the leaf: **1,** diagram showing the leaf structure; **2,** portion with epidermis and mesophyll (×300); **3,** the large vascular bundle (×460); **4,** the small vascular bundle (×300): **BS –** bundle sheath; **CT** – chlorenchyma tissue; **E –** epidermis with cuticle; **M** – mesophyll; **Ph** – phloem; **PC** – parenchyma cell; **SC** – schlerenchymatous cells; **SVB** – small vascular bundle; **VB** – vascular bundles; **X** – xylem (Orig.).

Fig. 5. Tangent section of the blade (×360): **EC** – epidermal cell; **GC** – guard cell; **O** – ostiole; **S** – stoma; **SC** – subsidiary cells (Orig.).

Conclusions

The results have revealed dicots and certain halophytic characters of *S. kali* subsp. *ruthenica* vegetative organs, such as the typically secondary structure of the mature root, deriving from the primary one (in the first stage of the plant life). Cross sections of the stem (except of the vascular system) and leaf have shown almost the same structure, especially of the cortex. In both vegetative organs the cortex is differentiated into chlorenchyma with assimilatory function and parenchyma tissue. A number of collenchymatous cells are arranged on the stem crests, whereas sclerenchimatous cells are present on the leaf margins. The vascular system (xylem and phloem) of the stem forms compact tissue, whereas in the leaves it forms poorly developed close and collateral bundles.

The homogeneous leaf has a well-developed mesophyll (especially the "spongy" one). The stem and leaf epidermis are covered with a thick layer of cuticle as a protection from the harsh conditions on the seashore. The paracytic stomata type found in the stem and leaf is a characteristic feature of the *Chenopodiaceae* species.

The specific anatomical features of *S. kali* subsp. *ruthenica* root, stem and leaves prove that this species is well adapted to the harsh conditions on the (usually) shingle shores it grows on.

References

Andrei, M. 1978. Anatomy of Plants. Didactics and Pedagogic Publishing House, Bucharest (in Romanian).

Batanouny, K. H. 1992. Plant Anatomy. A Textbook of Botany, Univ. Press, Cairo.

Bavaru, A. & Bercu, R. 2002. Morphology and Anatomy of Plants. Ex Ponto, Constanţa (in Romanian).

Ciobanu, **I.** 1971. Morphology of Plants. Ed. 2. Didactics and Pedagogic Publishing House, Bucharest (in Romanian).

Deliu, C. 1993. Morphology and Anatomy of Plants. Vol. **1**. "Babeş-Bolyai" Univ. Press, Cluj-Napoca (in Romanian).

Dickie, C. W., Gerlach, M. L. & Hamar, D. W. 1989. *Kochia scoparia* oxalate content. – Vet. Hum. Toxicol., **31**(3):240-241.

Dilcher, D. 1974. Aproaches to the identification of the angiosperm leaf remains. – Bot. Rev., **40**: 24-103.

Essau, K. 1988. Plant Anatomy. Ed. 3. John Wiley & Sons, Inc., New York.

Forbes, A. C. & Allred, K. W. 1999. An investigation of *Salsola* L. (*Chenopodiaceae*) in New Mexico. – New Mexico Bot., **12**: 2-9.

Morariu, I. 1952. *Salsola* L. – In: **Săvulescu, T.** (ed.), Fl. Reipubl. Popularis Romanicae. Vol. **1**, pp. 577-581. Editio Acad. Reipubl. Popularis Romanicae, Bucharest (in Romanian).

Phillips, W. M. & Launchbaugh, J. L. 1958. Prelminary studies of the root system of *Kochia scoparia* at Hays, Kansas. – Weeds, **6**(1): 19-23.

Şerbănescu-Jitariu, G. & Toma, C. 1980. Morphology and Anatomy of Plants. Didactics and Pedagogic Publishing House, Bucharest (in Romanian).

Tarnavschi, T. I., Şerănescu-Jitariu, G., Rădulescu-Mitroiu, N. & Rădulescu, D. 1974. Practicum of Vegetal Morphology and Anatomy. Univ. Printing Works, Bucharest (in Romanian).

Willis, J. C. 1973. A Dictionary of the flowering plants and ferns. Cambridge Univ. Press, Cabmridge.

Zanovschi, T. I. & Toma, C. 1985. Culture Plants Anatomy. Ceres, Bucharest (in Romanian).