ANATOMICAL FEATURES OF *ASTER TRIPOLIUM* L. (ASTERACEAE) TO SALINE ENVIRONMENTS

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Summary
The article comprises histoanatomical characteristics of the root, stem and leaf in a halophyte plant species *Aster tripolium* L. The anatomical characteristics of the root, stem and leaf has been described and discussed. The results revealed that the anatomical structure of this plants especially the leaf justify its halophytic nature, even the plant has no secretory elements such as salt glands, hairs or other glandular structures on its leaves. The root has a secondary structure of the stele and an aerenchyma cortex. The stem possesses a secondary stucture (xylem tissue) generated by cambium zones activity. The strengthening of the stem is made up of phloem fibers, placed in periphloemic area of the stele. Remarkable are the leaf paracytic stomata apparatus envolved in the plant strategy in adaptation to soil salinity.
Key words: anatomy, blade, halophyte, vegetative organs, *Aster tripolium*

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Introduction

Halophytic plants are able to tolerate saline environments. Halophytes often show a diversity of structural and physiological adaptations that include suculent leaves with specialized "colorless", "window cells" that increase the plants capacity for salt accumulation. Other species have salt bladders, salt glands or hairs and multiple rows of hypodermis (probable with accumulation and storage role). Halophytes contrate salt in their tissues, moving it from the soil into and through the plant. Because salt connot be allowed to accumulate without limit, many halophytes have special surface glands and hair to remove NaCl from the underlying mesophyll cells and then actively secrete it on the leaf surface (Dickison, 2000). *Aster tripolium* L. (syn. *Tripolium pannonicum* (Jacq.) Dobrocz) is a plant that is native to Europe and is a member of Asteraceae family. *Aster tripolium* tends to be a short-lived perennial (Clapham *et al.*, 1962) plant, growing to 0.9 m and is typically found in marine settings or areas (marshes, estuaries etc.) with a high salt content (halophytic species). Like many other members of the aster family, this plant is known for its purple daisy-like flowers, flowering from July to October.

Fig. 1. *Aster tripolium* L.

Aster tripolium is also known by its common name, the sea aster. It hybridizes freely with other members of this genus (Brickell, 2007). The plant has culinary (stem and leaves) and medicinal (ophthalmic) uses. However *Aster tripolium* was known as a famine food in the Netherlands in harsh times. Today is a delicacy in the Netherlands and abroad. The germination, growth and quality of *Aster tripolium* L. was analysed to study cultivation of the wild leafy plant into a commercial vegetable (Wagenvoort *et al.*, 1989).

In literature are mentioned morphological (Watson & Dallwitz, 1991; Săvulescu, 1968) and mostly physiological studies of this plants but a study of the vegetative organs anatomy of *Aster tripolium* almost lack, knowing that the plant leaves have no secretive elements to excrete the salt accumulation in it tissues. The purposes of the paper was to show that the root, stem and leaf of this specie, exhibit certain anatomical features of interest and may contribute to a better understanding of it halophytic nature and mecanism of accumulation, moving and removing salt from the mesophyll.

Material and methods

The plant was collected from the Techirghiol Lake area in august 2011 and were fixed in FAA (formalin:glacial acetic acid:alcohol 5:5:90). Cross sections of the stem and leaf **(**lamina**)** were performed using the manual technique. The sections were stained with alum-carmine and iodine green. The samples were embedded in glycerin gelatin (Bercu & Jianu, 2003). Histological observations and micrographs were performed with a BIOROM –T bright field microscope, equipped with a TOPICA 6001A video camera.

Results and discussions

Cross sections of the root exhibit an intermediary structure. Externally is the rhizodermis, followed by an aerenchymatic cortex and the stele. The isodiametric rhizodermal cells possesses external thick walls (Figs. 1, 2).. Just bellow the rhizodermis, exodermis is present. It consists of a single layer of larger cells. comparatively with those of rhizodermis.

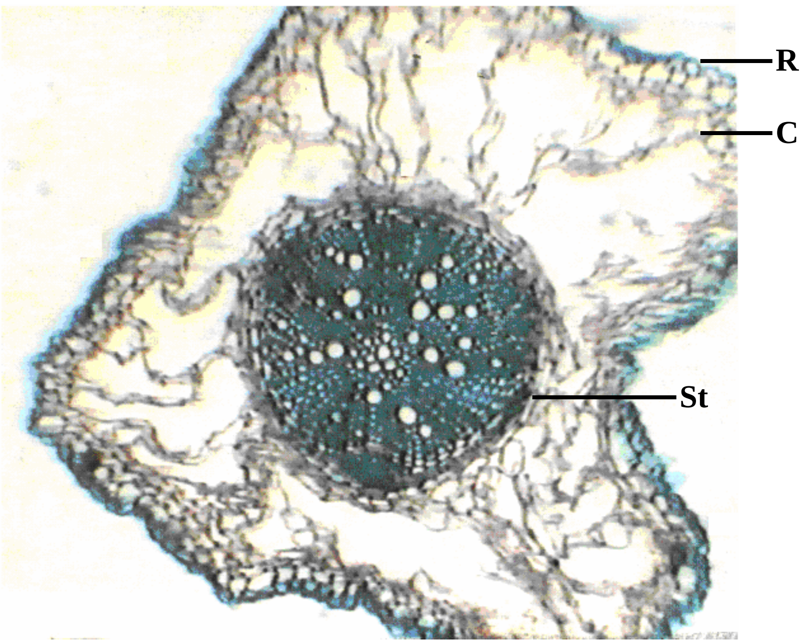

Fig. 1. Cross section of the root – ansamble (x 70): C- cortex, R- rhiyodermis, St- stele.

The cortex is represented by an aerenchyma tissue with large air chambers. The air chambers are separated by uniseriate cells named trabeculae (Batanouny, 1992) (Figs. 1, 2).

Centrally located is the stele surrounded by endodermis. The stele is represented by pericycle and conductive tissue. The xylem elements are separated by sclerenchyma pith rays. Phloem is poorly represented by some phloem vessels to the exterior part of the stele. Remarkable is the radial large xylem vessels arrangement, interconected by a sclerenchymatous parenchyma cells and xylem fibres with mechanical role (Figs. 1, 3).

The floem is poorly developed consisting of few floem vessels but some lignified elements, placed to the pericycle, are present. The pith, is centraly located and consists of cells with slightly lignified walls (Fig. 3).

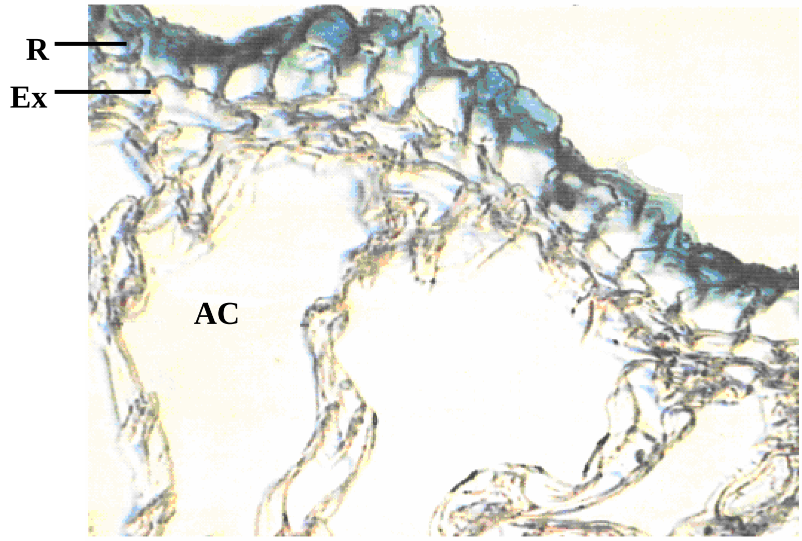

Fig. 2. Portion of the root in cross section with rhizodermis and cortex (x 224): AC- air chamber, Ex- exodermis, R- rhizodermis.

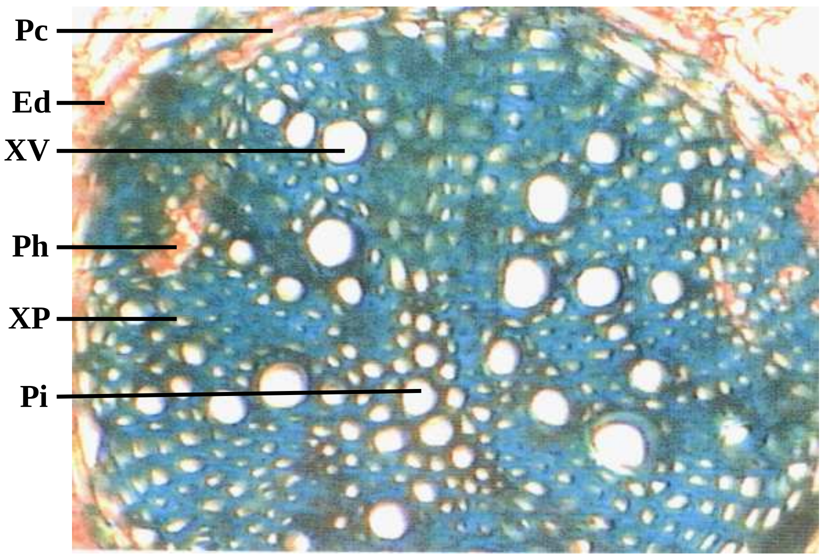

Fig. 3. The root stele - detail in cross section (x 224): Ed- endodermis,, Pc- pericycle, Ph- phloem, Pi- pith, XP- xylem parenchyma, XV- xylem vessels.

Cross setion of the stem exhibits a secondary structure of the xylem conductive tissue, due to the cambium zone activity. The unistratose epidermis is interruptured by the presence of stromata and covered by cuticle. Bellow the epidermis are 2-3 layers of chorenchyma cells. They are followed by a parenchymatic inner cortex with intercelluler spaces. Remarkable are the comunication spaces embedded in the cortex. (Fig. 4).

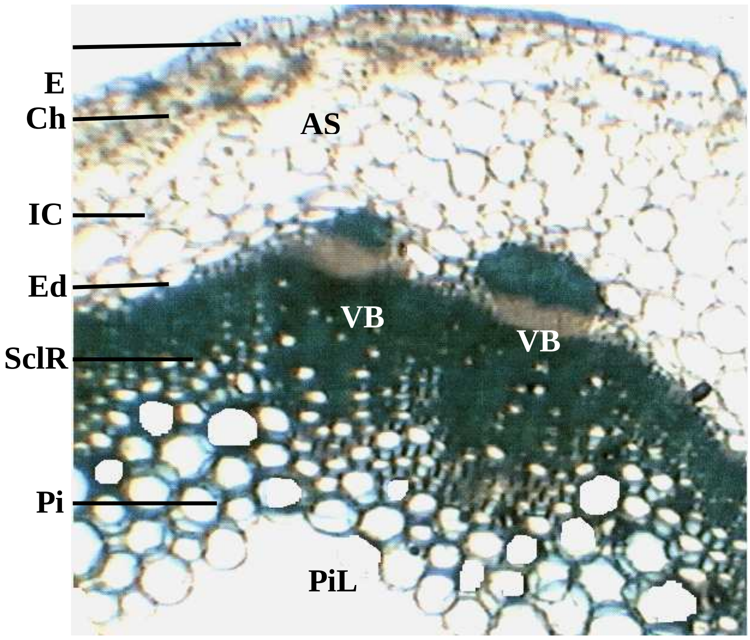

Fig. 4. Cross section of the stem (x 80): AS- air space, Ch- chlorenchyma, E- epidermis, Ed- endodermis, IC- inner cortex, Pi- pith, PiL- pith lacuna, SclR- sclerenchyma ray, VB- vascular bundle, X- xylem.

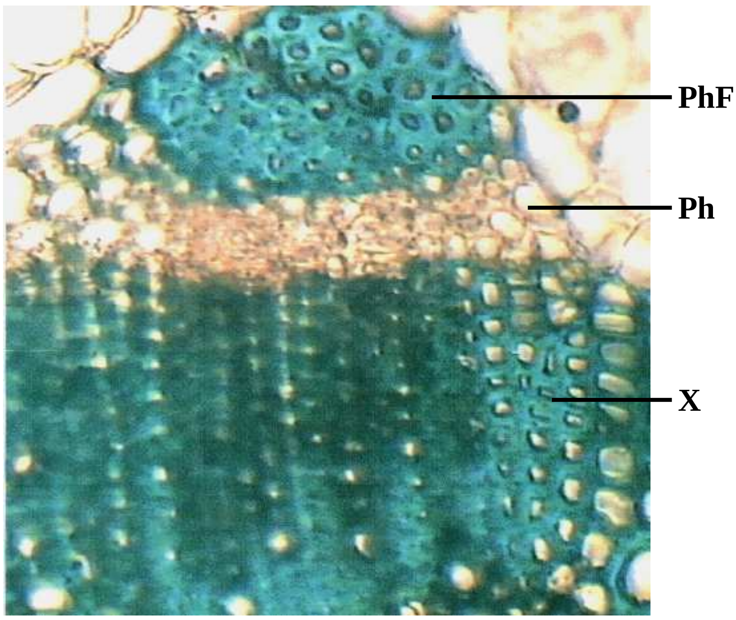

Fig. 5. A stele vascular bundle in cross section – detail (x 240): Ph- phloem, PhF- phloem fibres, X- xylem.

Cambium produced more xylem elements than phloem ones. Xylem consists of xylem vessels and a sclerencymatous parenchyma. Few primary xylem elements are present bellow the secondary xylem (Fig. 5).

The phloem tissue is poorly developed, represented by few phloem elements (Fig. 5).

The pith consists of parenchymatous thick-walled cells, disorganised to the centre in a large pith lacuna (Fig. 5).

The leaf such as other Asteraceae species (Bavaru & Bercu, 2002; Evert, 2006) in transection exhibits both epidermis (upper and lower epidermis) with cuticular ridges followed by a mesophyll with the palisade parenchyma found both below the upper epidermis and above the lower epidermis and a spongy parernchyma between them.

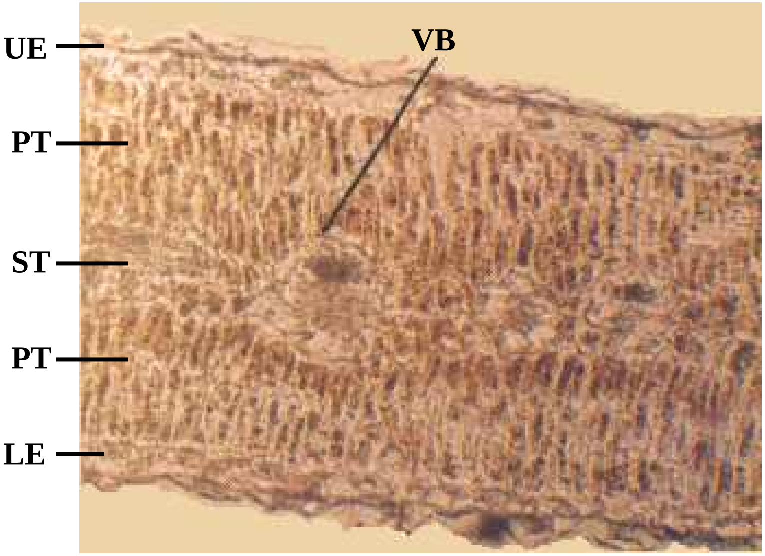

Fig. 6. Cross section of the leaf (x 90): LE- lower epidermis, PT- palisade tissue, ST- spongy tissue, UE- upper epidermis, VB- vascular bundles.

In the mesophyll the vascular system of the veins is embedded. The vascular bundles are collateral composed of large xylem vessels to the upper epidermis and phloem to the lower epidermis. The vascular bundles are surronded by parenchima sheats (Fig. 6).

The stoma apparatus, slightly embedded in the mesophyll, is of anomocytic type but mostly hemiparacytic type (one of the cells adiacent to one guard cell enclosing it and parallel to its long axis, the other guard cell having three or more normal epidermal cells surrounding it.) (Dilcher, 1974).. The epidermal cells are longer or shorter with straight walls (Figs. 7, 8).

The stoma apparatus have a great importance in the mechanisms of salt tolerance in *Aster tripolium*, a species which does not possess glands or other means of excreting salt. A new hypothesis is offered of the mechanism for controlling salt and water relations in this halophyte plant. It is suggested that when the capacity of the tissues to accumulate salt in cell vacuoles is exceeded, the concentration of Na^{+} ions in the apoplast around the guard cells begins to rise. This causes partial stomatal closure, reduces transpiration and increases water-use-efficiency. Therefore, the flow of salt into the leaves is reduced but growth (and the manufacture of the new photosynthates required to support it) can continue (Perera *et al.*, 1994).

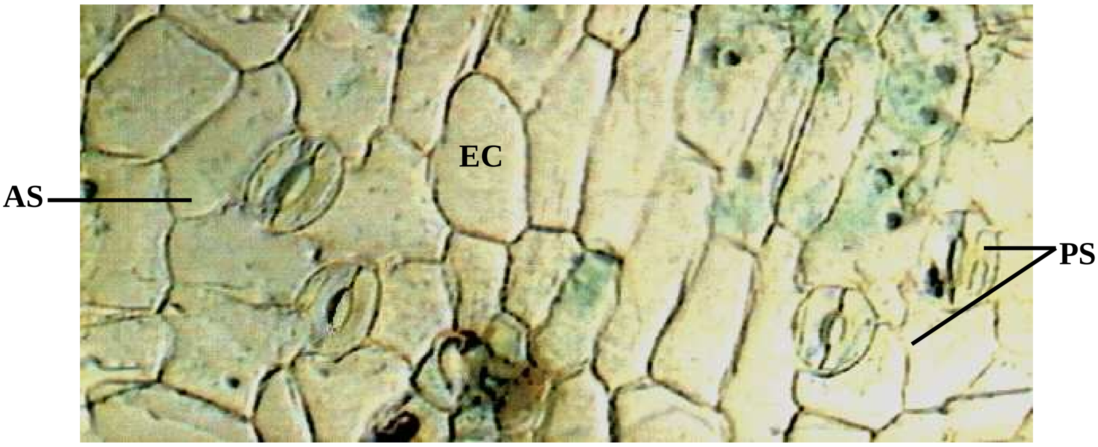

Fig. 7. Paradermal section of the adaxial epidermis (x 215): AS- anomocytic stoma, EC- epidermal cell, PS- parecytic stomata.

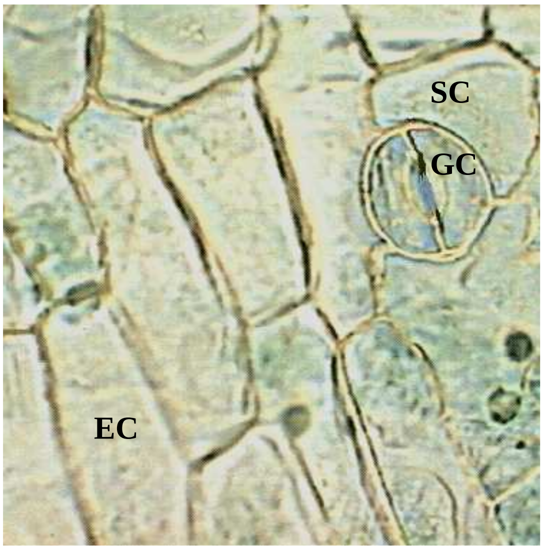

Fig. 8. Detail of the adaxial epidermis(x 440): EC- epidermal cell, GC- guard cell, SC- subsidiary cell.

Other Perera *et al*. (1995, 1997) studies report that increasing supplies of Ca^{2+} ions reduce the effect of salinity on stomatal conductance in the whole plant as well as in the isolated epidermis. This finding is consistent with the well established role of calcium in increasing resistance to salinity: in the presence of high calcium the plant can tolerate a greater salt intake, and hence there is a reduced need for transpiration to be restricted by partial stomatal closure. Ayala and O'Leary (1995) observed decreased stomatal conductance with increasing salinity that increased the transpiration rate at a low salinity level in *Salicornia bigelovii*. Lakshmi *et al*. (1996) reported a decrease in stomatal conductance in *Morus alba* under saline conditions.

Conclusions

Results indicate that the root, stem and leaf gets a specific structure of anatomical interest in accordance with *Aster tripolium* halophytic habitat. The root possesses a secondary structure with an aerenchyma cortex, surrounding the conductive tissues of the stele. The stem has a secondary structure of xylem conductive tissue. The leaf mesophyll is isobilateral with numerous veins embedded in it. Remarkable are the enlarged traheids terminating leaf veins endings. The lower epidermies possesses anomocytic and hemiparacytic stomata. The mechanical tissue is poor developed in the root, stem and leaf.

This halophytic plant *Aster tripolium* possess no glands or other means of excreting salt on the leaves, but it can tolerate a greater salt intake, and hence there is a reduced need for transpiration to be restricted by partial stomatal closure.

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