Contribuţii Botanice, XLI, (2), **2006**
Grădina Botanică "Alexandru Borza"
Cluj-Napoca

HISTO-ANATOMY OF *OPUNTIA FICUS-INDICA* (L.) MILL.

Rodica BERCU
Facultea de Ştiinţe Naturale şi Agricole, Departamentul de Biologie,
Universitatea „Ovidius", str. Mamaia, nr. 124, **RO-900590 Constanţa**
e-mail: rodica bercu@yahoo.com

Abstract: The paper deals with the structural organization of the root and stem of *Opuntia ficus-indica* (L.) Mill. Present results revealed that the anatomical structure of this plant confirm the assimilatory and succulent nature of the plant, especially as concerning its water storage parenchyma, covering the major portion of the stem (cladode). The root is well developed, possesses a secondary structure which gives its strength. Remarkable is the presence of siliceous crystals and druses in the parenchyma cells and pith cells of the stem. The vascular system of the stele is represented by several collateral vascular bundles. The mechanical tissues are absent in the stem. One should note the presence of numerous spines and white lifeless hairs situated in the areoles of cladodes.

Key words: anatomy, root, cladode, spiny, *Opuntia ficus-indica*

Introduction

The cactaceous genus *Opuntia* originates from Mexic. *Opuntia ficus-indica* (L.) Mill. [syn.: *Cactus humifusa* Rafinesque 1820, *Opuntia vulgaris* P. Miller 1768, *O. caespitosa* Rafinesque 1830, *O. mesacantha* Rafinesque 1830, *O. italica* Tenore ex Pfeiffer 1837, *O. rafinesque* Engelmann 1856, *O. rafinesque* var. *minor* 1856 = *O. humifusa* var. *minor* (Engelmann) Crook & Mottram 1998, *O. fuscoatra* Engelmann 1857, *O. allariei* Griffiths 1909, *O. nemoralis* Griffiths 1913, *O. rubiflora* Griffiths 1916, *O. impedata* Small ex Brittton & Rose 1923, *O. calcicola* Wheery 1926, *O. cumulicola* Small 1933, *O. compressa* J. F. Macbr. var. compressa, var. *allairei* (Griffiths) Weniger, var. *fuscoatra* (Engelm.) Weniger and var. *microsperma* (Engelm. & Bigelow) L. D. Benson], known as indian fig or princkly pear, is an evergreen perennial plant growing up to 5 m by 5 m, with numerous minutely barbed glochids (hairs) that are easily dislodged when the plant is touched and they may stick into the skin. These glochids are difficult to be seen and removed and may cause considerable discomfort to animals and humans[10]. The indian fig is in leaf all year, in flower from June to September. The flowers are hermaphrodite being pollinated by insects. The purple or red fruits are 4-9 cm long,. Their red pulp contains many small seeds. The plant requires well-drained, light (sandy) and medium (loamy) soils with acidic, neutral or alkaline reaction. It cannot grow in the shade. The indian fig tolerate drought, strong winds but not maritime exposure [1, 11, 12].

Material and Methods

Cross sections of the root and stem of this cactus species were performed by using a rotary microtome. The samples were stained with alum-carmine, iodine green and safranine 1%. Observations were carried out with a BIOROM-T bright field microscope, equipped with a TOPICA-6001A video camera. The micrographs were obtained from the video camera connected to a computer.

Results and Discussions

Cross sections of the root of *Opuntia ficus-indica* exhibit the cork, secondary cortex and the stele as usual in other cacti [3, 4]. The outermost layers of flattened cells (3-4 layers)

correspond to the cork, followed by the one-layered phellogen and 2-3 layers of parenchyma cells belonging to the secondary cortex (Fig. 1a).

The stele consists of five conducting tissue bundles separated by large medullar rays. Each vascular bundle consists of secondary phloem (few sieve cells, companion cells and phloem parenchyma) and well developed secondary xylem (xylem vessels and xylem parenchyma). Few small primary xylem vessels are present towards the pith zone. The centrally located pith consists of few parenchyma cells with storing role (Figs. 1a, b). The cambium zone is not distinct.

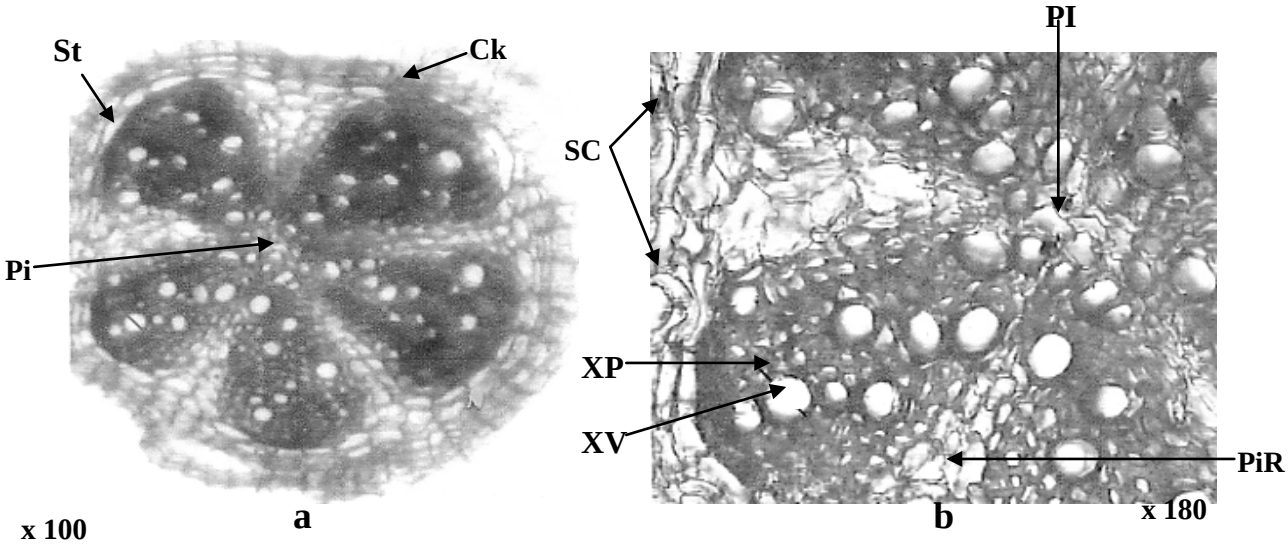

Fig. 1: Cross section of the root. General view (A). Detail of the stele (B): Ck- cork, Ph- phloem, Pi- pith, PiR- pith ray, St- stele, SC- secondary cortex, XP- xylem parenchyma, XV- xylem vessel (orig.).

The assimilatory stem (cladode), in cross section, reveals that the epidermis consists of single cell layer, covered by the cuticle showing supplementary waxy coating. The continuity of epidermis is interrupted by the presence of stomata and zones which will generate caduceus cauline structures. In its areoles, there are groups of 3-4 spines (glochids) and numerous small soft white, tortuous hairs (woolly hairs, tomentose) (Figs. 2a, b). Each spine possesses thickened base, vigorous body and slightly sharp rounded tip (Fig. 4c). Anatomically, it consists of thick-walled epidermal cells, followed by 3-4 layers of sclerenchymatous cells and a centrally located conducting tissue bundle joining the stem vascular system. The first three basal cells of the small white hairs are large and more or less trapezoidal in lateral view, followed by two thin, elongated cells. The sharp-tipped terminal cell of the hair is shorter and more elongated. (Figs. 4a, b).

As a result of accommodation of the species to special environmental conditions, the subulate leaves had gradually been changed into spines. The leaves became thinner and thinner, sharp-tipped, cylindrical and early caduceus due to the sclerization of the sub epidermal cells (Figs. 3, a-e).

Under the epidermis two layers of small hypodermal, chlorenchyma cells are present, followed by the water storage parenchyma. This aquiferous tissue consists of large, polygonal parenchyma cells (Fig. 2a). For this reason, some authors [2, 8] do not consider cacti as xerophytes. They are able to retain considerable amount of water in their body, an adaptation allowing them to live in dry areas.

It should also be mentioned the presence of siliceous crystals in the parenchyma tissues of cacti [6, 7] (Fig. 2a). The poorly developed stele is embedded in a ground tissue and consists of 8-10 radially arranged collateral vascular bundles, unequal in size, separated by large pith rays. The pith is formed from large polygonal parenchyma cells containing siliceous crystals and druses (Fig. 2b).

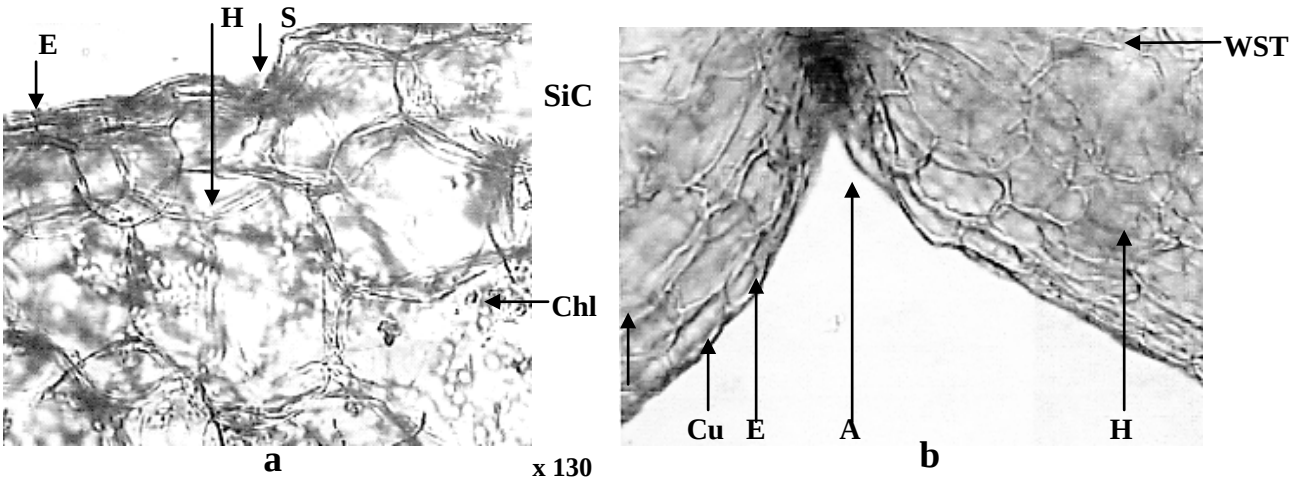

Fig. 2: Cross section of the cladode. Portion of cladode with epidermis and cortex (A). Portion with areole (B): A- areole, Chl- chloroplasts, Cu- cuticle, E- epidermis, H- hypodermis, S- stoma, SiC- siliceous crystals, WST- water storage tissue (orig.).

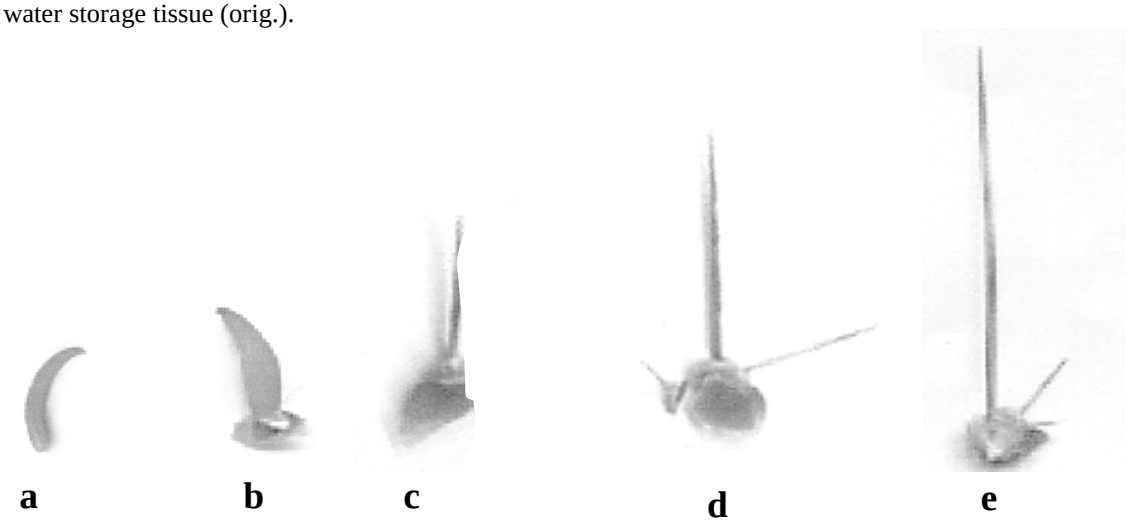

Fig. 3: Leaves (a, b) and spines (c-e) (orig.).

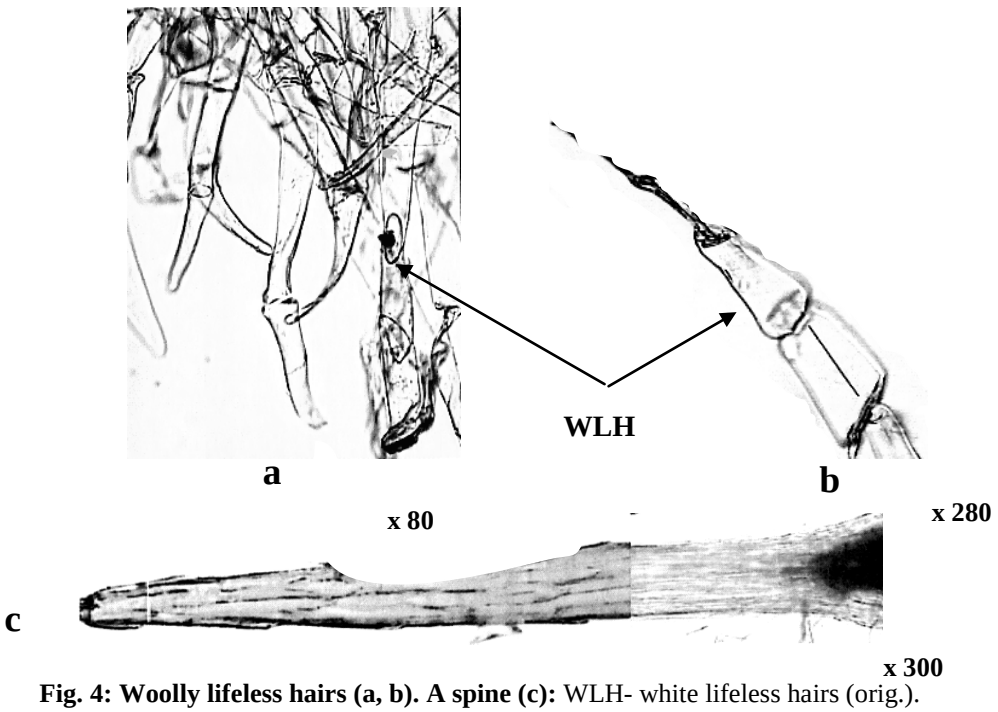

Fig. 4: Woolly lifeless hairs (a, b). A spine (c): WLH- white lifeless hairs (orig.).

The epidermis, in grazing sections, discloses the stoma of paracytic type, such as many other cacti [3-5]. Note the presence of four subsidiary cells oriented parallel with the long axis of the stomata. The epidermal cells have rectangular walls (Fig. 5) [8].

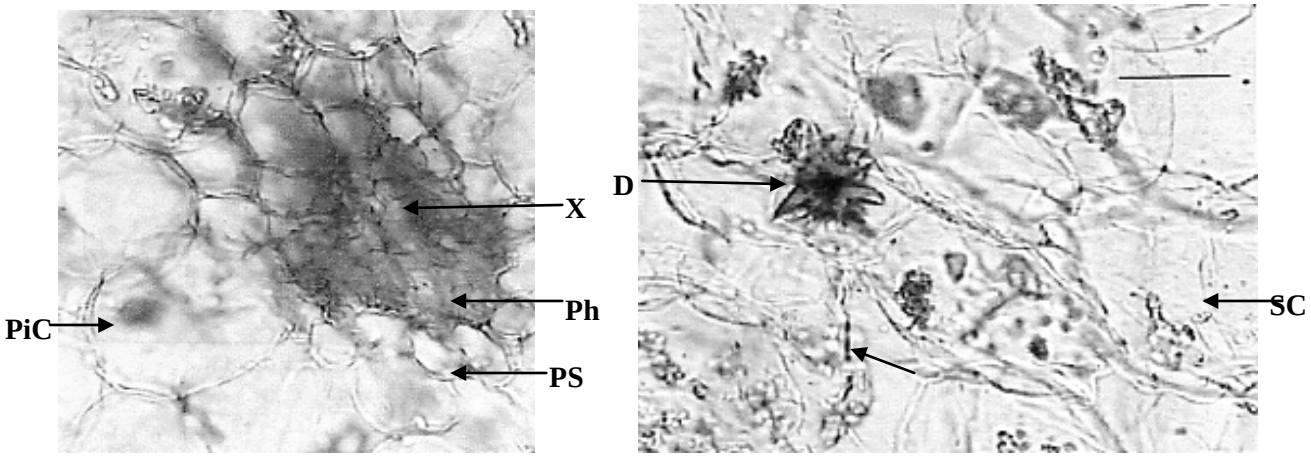

Fig. 5: Cross section of the cladode. A pith portion (a) and a vascular bundle in transversal section (b): D- druses, Ph- phloem, PS- parenchyma sheath, SC- siliceous crystals, SG- starch grains, X- xylem (originals).

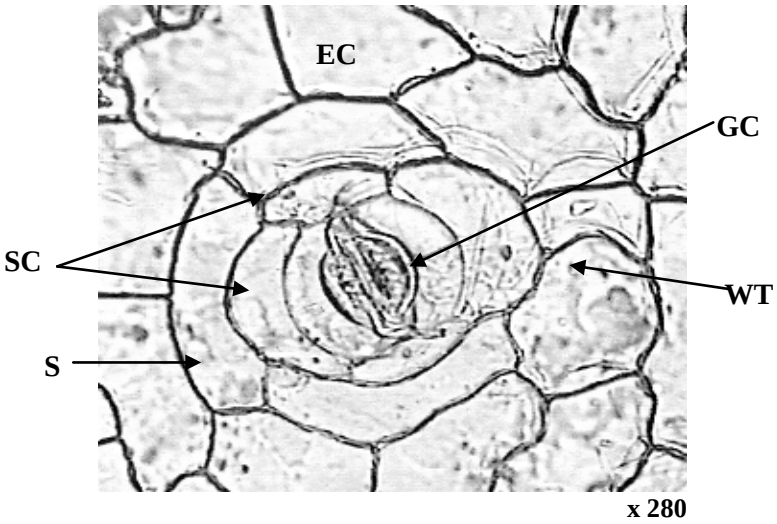

Fig. 6: Portion of the stem epidermis in grazing section. EC- epidermal cell, GC- guard cell, S- stoma, SC- subsidiary cells, WT- wax thickenings (orig.).

Conclusions

The present results indicate that the root vascular system is well developed possessing a well defined secondary structure. The epidermal cells of the stem are closely arranged and thick-walled. Their thick outer surface cuticle is covered by waxy deposits. The thickness of accumulation is directly proportional to the xeric condition. Note the presence of paracytic type stomata distributed among the epidermal cells. Only thin spines and white lifeless protective hairs are present. The stem cortex is differentiated into two regions: the chlorenchyma region (with photosynthetic role) and the parenchyma region containing mucilaginous substances allowing water storage. Note the presence of siliceous crystals and druses in the stem cortex and pith. The vascular tissue is poorly developed consisting of a low number of collateral vascular bundles in a radial arrangement, protected by a parenchyma sheath. Mechanical tissues are

absent. *Opuntia ficus-indica* presents a structural organization considerable anatomical interest, in accordance with it succulent, fleshy and xeric nature.

REFERENCES

1. Anderson, F.E., 2001, *The Cactus family*, Timber Press, Inc., Oregon: 18, 123-127, 227-230.
2. Batanouny, K.H., 1992, *Plant Anatomy. A Textbook of Botany*, Univ. Press, Cairo: 239-246.
3. Bercu, R., Bavaru, E., 2004, Anatomical aspects of *Disocactus ackermannii* (Haw.) Barthlott 1991 (Cactaceae), *Lucrări ştiinţifice – Agricultură*, Univ. Şt. Agr. şi Med. Vet. a Banatului, Ed. EUROBIT, Timişoara, **36**: 486-490.
4. Bercu R., 2005. Anatomy of *Austrocylindropuntia subulata* (Muehl.) Backeb. (*Cactaceae*), *Contr. Bot.*, **1l**: 209-214.
5. Bercu, R., 2006, Structural organization of *Rhipsalidopsis rosea* Backbr. (Cactaceae), Lucrări ştiinţifice - Agricultură, Univ. Şt. Agr. şi Med. Vet. a Banatului, Timişoara, **38**: 325-328.
6. Bobîrnac, B., Copăcescu, S.V., Grigoraş, V., 1984, *Cactuşi*, Ed. Scrisul Românesc, Craiova.
7. Copăcescu, S.V., 2001, *Cactuşii* (monografie), Ed. Ceres, Bucureşti; 39-45; 73-89, 467.
8. Dilcher, D.L, 1974, Approaches to the identification Angiosperm leaf remains, *Bot. Rev.* **40**: 42-47, 86-103.
9. Gibson, A., Nobel, P.S., 1986, *The Cactus Primer*, Cambridge Mass. Harvard Univ. Press: 4-7.
10. Huxley, A., 1972, *House Plants, Cacti and Succulents*. London: Hamlyn Publ. Group: 65-72.
11. Lubermann, M., 1997, *Cactus and Succulents*, Chronicle Book, San Francisco, CA 94105: 12-25, 63-65.
12. *** *Encyclopedia of Cacti and Succulents*, 2005, vol. 4.,2 CD-Rom.

HISTO-ANATOMIA SPECIEI *OPUNTIA FICUS-INDICA* (L.) MILL.

(Rezumat)

Lucrarea aduce contribuţii la cunoaşterea anatomiei speciilor care aparţin familiei *Cactaceae*, prezentând structura organelor vegetative ale speciei. *Opuntia ficus-indica* (L.) Mill. este o plantă ornamentală la noi, ca majoritatea cactaceelor [9, 10], originară din America de Sud (Mexic) şi are aspect arbustiv ce poate atinge 5 m înălţime, cu numeroase glohidii [10]. Florile sunt hermafrodite şi sunt polenizate de insecte. Specia preferă lumină intensă, soluri uscate acide, neutre sau alcaline. Fructele sunt roşii atingând 4-9 cm lungime [1, 10, 11, 12].

Pe secţiune transversală rădăcina prezintă o structură tipic secundară (Fig. 1a, b), cum au cele mai multe dintre cactacee, cu rol şi în consolidarea rădăcinii [3, 4, 5].

Secţiunile transversale prin cladodiu înfăţişează, la exterior, epiderma unistratificată, întreruptă în dreptul areolei cu spini, urmată de hipodermă. Din loc în loc se observă stomate (Fig. 2a, b). În areole se găsesc 3-4 spini şi peri lânaţi. Spinii prezintă o bază groasă, cu corpul viguros şi vârful uşor rotunjit (Fig.. 4c) Anatomic spinii au apărut în urma unui proces accentuat de sclerificare a straturilor subepidermale (Fig. 3a-e) [6, 7, 9]. Perii lânaţi prezintă celule bazale lăţite, trapezoidale, urmate de două celule alungite. Celula din vârf este ascuţită, asemănătoare unui vârf de seringă (Fig. 4a, b).

Sub epidermă se observă 2-3 straturi de celule clorenchimatice, urmate de parenchimul acvifer [2]. Se remarcă, în celulele acestui ţesut prezenţa cristalelor de siliciu. Stelul, pe secţiunile analizate, este alcătuit din 8-10 fascicule vasculare colaterale, aşezate circular, aflate în diferite stadii de dezvoltare (Fig. 5a). Măduva, situată central, este formată din celule parenchimatice în care se depun substanţe de rezervă, cristale de siliciu şi druze (Fig. 5b). Epiderma, pe secţiune tangenţială, prezintă celule epidermale rectangulare şi stomate de tip paracitic (Fig. 6) [8].

Caracterele anatomice ale acestei specii justifică natura sa de plantă suculentă, în special, prin prezenţa ţesutului acvifer (care ocupă cea mai mare parte din structura tulpinii), cu rol de depozitare a apei., ca rezultat al adaptării sale la mediul în care habitează. Se remarcă lipsa ţesutului mecanic din structura tulpinii. Prin caracterele sale anatomice, specifice (cutícula epidermală groasă, cerificată, slaba dezvoltare a ţesutului mecanic şi a elementelor vasculare, reducerea cortexului în tulpină, frunzele transformate în spini etc.) specia este perfect adaptată condiţiilor xerofitice de mediu.