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Monographic study of *Eichhornia crassipes* (Mart.) Solms

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Abstract
Eichhornia crassipes (Mart.) Solms (Water hyacinth) is an aquatic perennial macrophyte present through out of the world. It is considered as an invasive plant in India. It is used as fertilizer, animal feed, paper making and as fibre for energy production. The review contains taxonomic and anatomical study along with phytochemistry, pharmacological activities and economic uses.

Keywords: *Eichhornia crassipes*, invasive, phytochemistry, pharmacological activity, economic uses

Introduction
Water hyacinth (*Eichhornia crassipes* (Mart.) Solms) is a prolific free-floating aquatic macrophyte (Fig.-1), which is native to the tropical and sub-tropical South America and has proven to be a significant economic and ecological burden to several water bodies of India. According to Rao (1988) it was introduced in India as an ornamental plant for private ponds from Brazil and now it has invasive status [19]. It is efficiently utilized aquatic nutrients and solar energy for profuse biomass production and causing immeasurable environmental, social and economic difficulties [12]. It is found in lakes and estuaries, wetlands, marshes, ponds, dames, slow flowing rivers, streams and waterways in lower latitudes where growth is invigorating by the inflow of nutrient rich water from urban and agricultural runoff, deforestation, industrial waste and insufficient waste water treatment. Each plant produces thousands of seeds every year, these seeds will remain viable for next 28 years [20].

Fig 1: Water hyacinth

Vernacular Names

English	:	Water hyacinth
Hindi	:	Jal Kumbhi, Samudra sokh
Sanskrit	:	Jalakumbhi, Variparni
Tamil	:	Venkayattamarai

Classification

Kingdom	:	Plantae
Clade	:	Angiosperms
Clade	:	Monocots
Clade	:	Commelinids
Order	:	Commelinales
Family	:	Pontederiaceae
Genus	:	*Eichhornia*
Species	:	*E. crassipes*

Taxonomic Description
E. crassipes (Mart.) Solms in DC. Mon. Phan. 4: 527. 1882; Merr. Enum. 1: 200; FD. 338. -
Pontederia crassipes Mart. Nov. Gen. Sp. Pl. 1: 9, t. 4. 1823.
An erect free floating, aquatic, perennial; profusely rooting at nodes. Stolons spongy. Leaves 5–15 cm across, in rosette, broadly ovate-rhomboid, obtuse, cuneate to sub-cordate at base, shining; sheath, 4–8 cm long, membranous; petiole swollen into green bladders about the middle. Flowers are violet blue with dark purple and yellow colour on petals, in spikes with long peduncle; bracts 2; lower ones foliaceous with tubular sheath. Tepals 6; lower 3 small; upper 3 large. Stamens 6; unequal, inserted on the throat of perianth tube, exerted. 3-celled; style 3, connate, ovules many. Capsule oblong. Seeds minute, ribbed.

Anatomical Study
The fresh parts of the plant i.e. root, rhizome, leaves and petioles were collected and transverse sections of each was done manually for study.

Root
Root epiblema have single layered rectangular cells whereas hypodermis is composed of 1-2 layers of thick-walled cells.

Cortex is differentiated into 2 parts, i.e. outer and inner cortex. The outer cortex has air space with trabeculae or partitions of 4-5 layers of parenchyma cells. The inner cortex consists of 6-8 layers of parenchymatous cells. The stele is surrounded on the outside by single layered endodermis whereas casparian strips are not prominent. Single-layered pericycle is present under the endodermis. The stele consists of 7-10 xylem bundles alternating with phloem bundles. Each vascular bundle consists of a single metaxylem vessel surrounded smaller vessels. The root centre is occupied by sclerified parenchyma cells (Fig.2-A, C)

Rhizome

The epidermis has single layered compactly arranged rectangular cells. The cortex under the epidermis consists of 4-6 layers with air spaces. There is an inner portion of large air spaces separated from each other by a single cell layer of parenchyma. Air spaces are spherical. The vascular bundles of different sizes have dispersed in outer cortex surrounded by a patch of sclerenchyma and also present in the centre of rhizome. Xylem is V shaped and phloem is present in between the xylem arms (Fig.2- A, D).

Petiole/Stem

Epidermis is single layered and composed of parenchyma cells with no cuticle. The hexagonal air spaces are surrounded by bands of single layered parenchyma cells as shown in Vascular bundles are immersed in aerenchyma. Vascular bundles are embedded in outer parenchyma cells having a bundle cap of sclerenchyma cells. Each vascular bundle has xylem tissue consisting of tracheids, vessels, parenchyma cells and fibres. Phloem is composed of sieve tubes and companion cells. Sclereids were observed arising from aerenchyma cells projecting into air spaces. A few raphides were found in parenchyma cells (Fig.2- B, E).

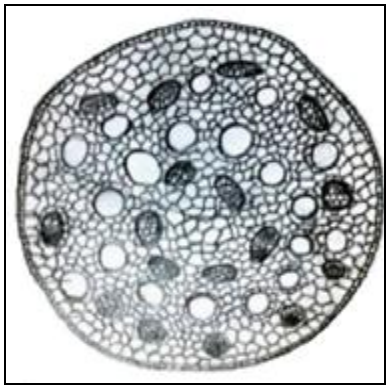
Leaves

Multi-layered epidermis shows parasitic type of stomata and lacking of Trichomes. A very thin cuticle is present outside the rectangular epidermal cells. Below the epidermis, mesophyll is differentiated into a palisade and spongy mesophyll. The spongy mesophyll consists of a large number of air spaces surrounded by thin walls full of chloroplast. Sclereids are observed in cells facing air spaces. Vascular bundles are of two types, i.e. smaller and larger vascular bundles. Smaller vascular bundles are present in both upper and lower epidermis side; some of them are in contact with the epidermis. Each vascular bundle is collateral with xylem towards the lower epidermis side and phloem towards the upper epidermis side. Tracheary elements consist of tracheids, vessels, and parenchyma cells. Tracheary elements in smaller bundles are thin-walled and without usual secondary thickenings. The phloem consists of sieve tubes and companion cells. Bundle sheath extensions are also observable in smaller bundles. Large vascular bundles are present in the leaf centre and extend from one end to the other of the leaf. Each vascular bundle is surrounded by a bundle sheath of parenchyma cells. Sclereids are present in the palisade cells, and also in air spaces (Fig.2- F, G).

A

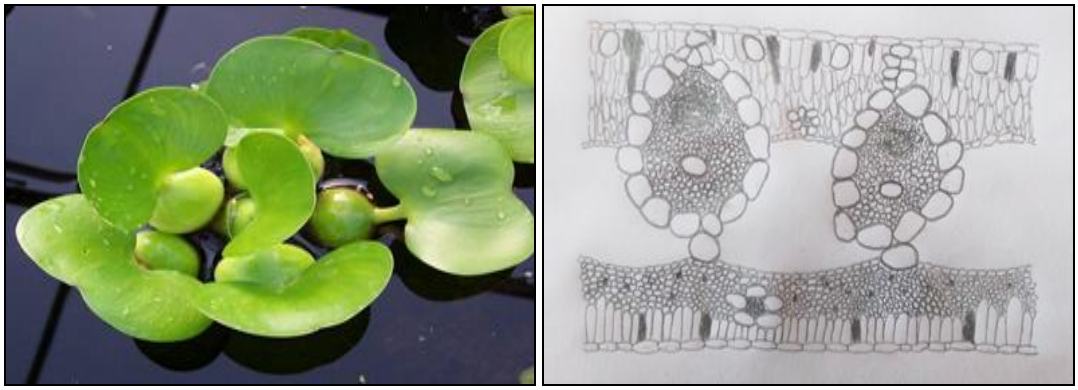
B

C



D

E



F G

Fig 2: (A) Plant showing root and rhizome, (B) Petiole, (C) T.S. of Root, (D) T.S. of Rhizome, (E) T.S. of Petiole, (F) Leaves, and (G) T.S. of Leaves

Phytochemistry

Water hyacinth possesses nutritionally important compounds like phenolics, alkaloids, terpenoids, sterols, glycosides and many other metabolites.

Pharmacological activities

Antimicrobial Activity- According to Zhou *et al.* (2009) [23], water hyacinth extract showed activity against *Staphylococcus aureus, Escherichia coli, Penicillium* and *Aspergillus niger*, but the activity depended on pH, concentration and action time [23]. Vadlapudi *et al.* (2010) [22] reported the methanolic extract of water hyacinth useful against *Alternaria alternata, Aspergillus flavus, Fusarium oxysporum, Rhizoctonia solani*, and *Xanthomonas compestries* [22].

Antioxidant Activity- Surendraraj *et al.* (2013) [21] described ethanolic extracts of flower, which contained the highest total phenolic content, were found to have high DPPH radical scavenging activity and reducing power. *E. crassipes*, an underutilized aquatic weed, could be a potential natural antioxidant source for food, feed, and pharmaceutical applications [21].

Wound Healing Activity- Ali *et al.* (2010) [2] reported the methanolic extract of water hyacinth leaves in the form of an ointment had better wound contraction ability in rats [1].

Antitumor Activity- A methanolic leaf extract of water hyacinth at different doses showed good response against B16F10 in vivo melanoma tumor bearing hybrid mice models [2].

Adsorbate- Water hyacinth efficiently removes a vast range of pollutants, from suspended materials, nutrients and organic matter to heavy metals [10, 18] and a low level of Zn, Cr, Cu, Cd, Pb, Ag and Ni [14].

Economic Uses- Water hyacinth can be effectively used to improve the livelihood of many people either for harvesting the plant or in other ways where it can be effectively utilized. Water hyacinth can be used in agriculture as a fertilizer, feed [16], paper making [13], bio-manure [15], a protein source for animal and possibly human nutrition, and as fibre for ruminants and for energy production [3]. Plant is used as carotene rich vegetable, green parts, inflorescence, cooked and eaten [5, 8, 11] and petioles as an antidiarrhoeic [6]. It is also used for the preparation of high caloric fuel (HCF) [9], cogeneration of H_2 and CH_4 [4], and liquid fuels [7]. Water hyacinth fiber is also used as a filler in the manufacture of natural rubber (STR20), where it increases the hardness and modulus of the products [17].

Conclusion

Eichhornia crassipes (Mart.) Solms (Water hyacinth), an aquatic perennial herb considered as an invasive plant in India. Plant have nutritionally important compounds like phenolics, alkaloids, terpenoids, sterols, glycosides and many other metabolites. It is used as fertilizer, animal feed, paper making, for preparation of high caloric fuel and as filler in manufacturing of natural rubber.

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