

Stem Anatomy of Selected True Mangrove Species in Kerala

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ABSTRACT

The present studies were carried out the anatomical features of selected true mangroves in Kerala. In *Avicennia marina*, *Avicennia officinalis* and *Excoecaria agallocha* the presence of phloem seen as islands it gives an impression of growth rings. In both the species of *Acanthus* frequently associated sclereids in phloem and large vessel compare to other species and helical thickening were present. Among Rhizophoraceae all members showed homogeneity in characters like scalariform perforation plates, air cavities in cortex, presence of sclereids, multicellular heterogenous rays and presence of crystalliferous cells. Inter-vessel pitting of all the members were alternate except Rhizophoraceae, it possess scalariform pitting.

Keywords: Mangroves, Anatomy, Diffuse Porous Wood, Sclereids.

I. INTRODUCTION

Mangroves are halophytes occurring in saline marshy places. The word mangrove is a combination of Portuguese word “Mangue” and English word “Grove”. The new term to the mangroves i.e., “mangal” for mangrove community and “mangrove” for individual species. Mangroves are salt tolerant plants of tropical and subtropical intertidal regions of the world. The regions where these plants occur are termed as “mangrove ecosystem”^[1].

In the mangrove ecosystem, where tides and coastal currents bring unremitting variation to the forest plants and animals adopt continuously to changing, chemical, physical and biological characteristics of their environment. Within these ecosystem the individual plants and animals, the soil microbial populations and the physical environment are linked by processes by which a continuous exchange and assimilation of energy occurs^[2].

Researchers on wood anatomy of the mangroves can date back to the previous century. Representative work includes investigation on the wood structure of mangrove species in Philippines and dealt with wood structure of some mangrove species of Rhizophoraceae. Vessel characteristics of some Javan mangrove species.

In addition, other reports were also published on wood structure of selected mangrove species^[3,4,5,6,7,8,9] and stem anatomy of true mangrove species in Sunderbans.^[10,11,12,13]

II. MATERIALS AND METHODS

The study was conducted for characterizing anatomical features of 15 mangrove species seen in Kerala. The species were *Aegiceras corniculata*, *Acanthus ilicifolius*, *Acanthus ebracteatus*, *Avicennia marina*, *Avicennia officinalis*, *Bruguiera cylindrica*, *Bruguiera gymnorhiza*, *Bruguiera sexangula*, *Excoecaria agallocha*, *Kandelia candel*, *Rhizophora mucronata*, *Rhizophora aapiculata*, *Sonneratia alba*, *Sonneratia caseolaris*, and *Lumintzera recemosa*.

Stem samples were collected from the selected species, which are distributed in the mangroves of intertidal zones of Kerala. The plant materials were authenticated from Botanical Survey of India and herbarium deposited in Calicut University Herbarium with voucher number 6918 to 6931. Thin sections were made and sections were immersed in water to avoid air bubbles. Stem transverse section, transverse longitudinal section and radial longitudinal sections were made and stained with Toluidine blue O and mounted in 50% glycerine. The slides analysed by trilocular compound microscope

model number 10093409 and imaged by using the camera Olympus E-PL3.

III. RESULTS

In *Lumnitzera recemosa*, stem showing well developed periderm in the outer region. The phelloderm comprises two to four layers of radially flattened cells. The crystalliferous cells were predominately seen along with the periderm. The secondary xylem vessels were medium sized and numerous in numbers. Vessels four to several cells of radial multiples. Outer to the secondary phloem some of the cells were secretory cells with yellow contents. The stele transverse with narrow and elongated medullary ray parenchyma. Phloem also consists of numerous crystalliferous cells. Phloem contains islands of sclerenchyma elements were transversely oriented. A ring of inter xylary phloem were present in between xylem and pith. The pith composed of thin walled parenchyma cell. In TLS intervascular pitting alternate. Numerous fibers present with simple pits. The tangential walls of fibers showing simple pits with moderate thickness. In RLS, the wood showing vessels with annular and spiral thickening. The rays were uniseriate in nature, cells square and upright. The gummy deposits were observed in the cells. (Plate A).

In *Sonneratia alba*, stem showing well developed periderm in the outer region. The phelloderm comprises two to four layers of radially flattened cells. Cortex multilayered and consists of phenolics. Xylem vessels were medium sized and numerous more or less evenly distributed, solitary and in radial multiples. The vessel lines distinct. The wide pith composed of thin walled parenchyma cell and was deposited with phenolics and brachysclereids. In TLS, intervascular pitting alternate. Vessels cylindrical in outline with simple perforation plate. Rays were uniseriate and homogenous with median length. The long fibers were septate with simple pits. In RLS, xylem shows vessels with annular and spiral thickening. Ray cells square and upright with medium length (Plate B).

In *Sonneratia caseolaris*, stem showing well developed periderm with lenticels. The phelloderm comprises two to four layers of radially-flattened cells. The cortex was parenchymatous and consists of numerous air cavities and phenolic depositions. Xylem vessels were moderately larger, numerous radial multiples appear as

2-4, and solitary and vessel lines were conspicuous with medullary ray. Distinct type of fibers seen around the vessels were noted and is untapered, thin walled with intercellular spaces. In TLS, vessels were cylindrical in outline with simple perforation plate and wider in size. Vessel lines were conspicuous with medullary ray. Intervascular pitting alternate. Rays were uniseriate and homogenous with median length. The long fibers were septate with simple pits and wider. In RLS, xylem shows vessels with annular and spiral thickening. Ray cells were square and upright. The cells were dark with gummy deposits and square cells contain solitary crystals (Plate C).

In *Bruguiera cylindrica*, epidermis is highly ridged with thick cuticle. The cortex were thick, multilayered and parenchymatous. The cells of cortex and pith were deposited with phenols and sclereids. Stem shows secondary growth. Xylem vessels were small, distinct and numerous. There were evenly distributed, in short radial multiples appear of 2-3 and open with inconspicuous vessel line. The continuous rings of phloem were present. The outer zone of cells was development with phloem fibers. Moderately large pith with parenchyma cells. In TLS, vessels were cylindrical in outline with scalariform perforation plate and wider in size. Vessel lines were conspicuous with medullary ray. Intervascular pitting scalariform. In RLS, xylem shows vessels with scalariform thickening. Rays were biseriate and heterogenous. The long fibers were septate with simple pits and thick walls (Plate D).

In *Bruguiera gymnorrhiza*, stem showing well developed periderm. The phelloderm comprises radially flattened cells. Vessels moderately numerous evenly distributed, solitary in short radial multiples appear of 2-3, vessel line conspicuous. The continuous rings of phloem were present. The outer zone of cells was development with phloem fibers. In TLS, vessels were cylindrical in outline with scalariform perforation plate and wider in size. Vessel lines were conspicuous with medullary ray. Intervascular pitting scalariform. In RLS, xylem shows vessels with scalariform thickening. Rays were moderately broad, multiseriate and heterogenous. The xylem fibers were narrow and thick (Plate E).

In *Bruguiera sexangula*, stem showing epidermis consists of thick cuticle. The cortex showing outer collenchymatous and inner aerenchymatous cells.

Vessels were moderately small, distinct, randomly distributed and less in number. The vessel elements were in short radial multiples of 2-3 vessel line were distinct. The continuous rings of phloem were present. Fiber distribution were in xylem are wider. Brachey sclereids associated with phloem. Numerous crystalliferous cells were present in cortex, phloem, and pith. Phloem was smaller and is evenly distributed. In TLS, vessels were cylindrical in outline with scalariform perforation plate and wider in size. Vessel lines were conspicuous with medullary ray. Intervascular pitting scalariform. In RLS, xylem shows vessels with scalariform thickening. Rays were moderately broad and multiseriate and heterogenous. The xylem fibers were narrow and thick (Plate F).

In *Kandelia candel*, stem showing epidermis was bilayered, wavy and highly cutinized. Cortex multilayered and consists of crystalliferous cells and phenolics. Vessels elements were small moderately numerous, evenly distributed, solitary and in short radial multiples appear of 2-5. The vessel lines were inconspicuous. The continuous rings of phloem were present. The outer zone of cells was development with sclereids. Pith composed of thin walled parenchyma with crystalliferous cells. In TLS, vessels were cylindrical in outline with scalariform perforation plate and wider in size. Long tail or ligule like structures were present at the end wall of vessel element. Intervascular pitting scalariform. In RLS, xylem shows vessels with scalariform thickening. Rays were moderately broad and multiseriate, upright and heterogenous. The xylem fibers were long, slender and unseptate (Plate G).

In *Rhizophora apiculata*, stem showing cork warts were observed outer to the periderm with lenticular opening. Phelloderm multilayered. The cortical tissue was observed with high phenolic depositions and large sclereids. Inter fascicular parenchyma were distributed between the early and late formed vascular tissues. Uniseriate epidermises were highly cutinized. The cortex were multilayered and parenchyma with air cavities. Vessels elements were large, moderately numerous, evenly distributed, solitary and in short radial multiples appear of 2-3 and round in outline. The vessel lines were inconspicuous. The continuous rings of phloem were present. The outer zone of cells was development with sclereids. Pith composed of thin walled parenchyma with crystalliferous cells and

phenolics. In TLS, vessels were cylindrical in outline with scalariform perforation plate and wider in size. Intervascular pitting scalariform. In RLS, xylem shows vessels with scalariform thickening. Rays were moderately broad and multiseriate, upright and heterogenous. The xylem fibers were long, slender and unseptate (Plate H).

In *Rhizophora mucronata*, stem showing the outer rim of stem with multilayered cork. The phelloderm comprises two to four layers of radially flattened cells. The cortex were multilayered and parenchyma with air cavities. Vessels elements were large, moderately numerous, evenly distributed, solitary and in short radial multiples appear of 2-3 and round in outline. Pith composed of thin walled parenchyma with crystalliferous cells, phenolics. In TLS, vessels were cylindrical in outline with scalariform perforation plate and wider in size. Intervascular pitting scalariform narrow, crowded extending complete across the wall. In RLS xylem shows vessels with scalariform thickening. Rays were moderately broad and multiseriate, upright and heterogenous. Vertical or obliquely elongated pits in ray cell wall. The xylem fibers were long, slender and unseptate (Plate I).

In *Aegiceras corniculatum*, stem showing periderm. The phelloderm comprises two to four layers of radially flattened cells. Cortex multilayered broad made up of parenchyma, chlorenchyma. The cells were deposited with sclereids. Polygonal, thin walled parenchyma cells were deposited with tannin, phenol and sclereids. Vessels were moderately small irregular groups, numerous with radial and tangential pattern and round to angular in outline. Vessel lines were irregular and distinct. The parenchymatous pith were deposited with tannin, and sclereids. In TLS, vessel cylindrical in nature with alternate inter- vessel pitting and simple perforation plate. Fibers non septate with simple pits on lateral walls. Moderately thick walled. Storied arrangement of fibers. In RLS, vessel showed spiral and annular thickening. Rays composed of mixed procumbent and square cells. Rays were uniseriate, square cells, homogenous and moderately broad to fine (Plate J).

In *Excoecaria agallocha*, stem showed presence of cork. The phelloderm comprises two to four layers of radially flattened cells. Cortex were multilayered with made up of parenchyma, chlorenchyma. Brachy sclereids seen in

outer cortex. Continuous layer of sclerenchyma were present. Vessels were moderately large, less in number, visible solitary. Rarely radial multiples of two and uneven distribution. In TLS, vessel cylindrical in outline with simple perforation plate. Inter-vessel pitting alternate. Fibers septate moderately thin walled with simple perforation and medium length. In RLS, xylem showing spiral thickening. Rays were upright, uniseriate and homogenous (Plate K).

In *Acanthus ebracteatus*, stem showing periderm. The phelloderm comprises two to four layers of radially flattened cells. Cortex multilayered broad made up of parenchyma, chlorenchyma. The cells were deposited with sclereids. Polygonal, thin walled parenchyma cells were deposited with tannin, phenol and sclereids. Vessels were moderately small irregular groups, numerous with radial and tangential pattern and round to angular in outline. Vessel lines were irregular and distinct. The parenchymatous pith were deposited with tannin, and sclereids. In TLS, vessel cylindrical in nature with alternate inter-vessel pitting and simple perforation plate. Fibers non septate with simple pits on lateral walls. Moderately thick walled. Storied arrangement of fibers. In RLS, vessel showed spiral and annular thickening. Rays composed of mixed procumbent and square cells. Rays were uniseriate, square cells, homogenous and moderately broad to fine (Plate L).

In *Acanthus ilicifolius*, stem showing uni layered epidermis with thin film of cuticle. The cortex was multilayered with compactly arranged parenchyma cells. Outer cortex with thin walled parenchyma cells having tannin and phenolics. In between the outer and inner cortex, the parenchyma cells were oriented with thick inner walls. Solitary sclereids were present in the cortex. The cells were deposited with tannins. Vessels were less in number, distinct and solitary with circular outline. Vessel lines were distinct. The stele transverse with narrow and elongated medullary ray parenchyma. Phloem contains sclereids. Inter xylary phloem were present in between xylem and pith. The rays were uniseriate in nature. In TLS, vessels cylindrical in nature. Intervascular pitting alternate with simple perforation plate. Rays were uniseriate, upright, square cells and homogenous. Fibers were long and wide septate with simple pits. In RLS, the wood showing vessels with annular and helical thickening. Ray cells square and upright. (Plate M).

In *Avicennia marina*, stem showing unilayered epidermis with thin film of cuticle. The cortex was multilayered with outer chlorenchyma and inner parenchyma cells with air spaces. Solitary sclereids were present in the cortex. Vessels elements were medium sized, numerous solitary and round in outline. Vessel lines were indistinct. The stele transverse with narrow and elongated medullary ray parenchyma. Phloem contains sclereids. Intra xylary phloem was present in between xylem and pith. The wide pith composed of thin walled parenchyma cell. In TLS, vessels cylindrical in nature. Intervascular pitting alternate with simple perforation plate. Rays were uniseriate, upright, square cells and homogenous. Fibers were long and wide septate with simple pits. In RLS, the wood showing vessels with annular and helical thickening. Ray cells square and upright. The gummy deposits were observed in the ray cells (Plate N).

In *Avicennia officinalis*, stem showing unilayered epidermis with thin film of cuticle. The mature stem showing well developed cork with lenticels and demarcated with cork warts. The phelloderm comprises two to four layers of radially flattened cells. The cortex is heterogenous with chlorenchyma, aerenchyma and parenchyma. The thin walled parenchyma cells were deposited with sclereids. Vessels were large and distinct, evenly distributed in short radial multiples of 2 to 3. Phloem developed in abnormal level. The island of phloem distributed between the secondary xylem elements. In addition to the early formed phloem, outer to the secondary xylem there are rings of phloem were developed transverse with patches of bast fibers. Pith composed of thin walled parenchyma with varying size and shape. In TLS vessel cylindrical in nature with alternate inter-vessel pitting alternate; it is small and minute. Perforation plates simple. Medullary rays multiseriate. Fibers non septate. In RLS xylem showed spiral thickening. Rays were extremely fine, closely spaced and uniformly distributed uni or biseriate and heterogeneous (Plate O).

IV. DISCUSSION

In Acanthaceae both the species have secondary phloem frequently characterized by islands of sclereids elements compare with other species. Solitary sclereids scattered in the cortex that were seen around phloem cells. In Avicenniaceae *A. marina* and *A. officinalis* presence of phloem seen as islands it gives an impression of growth rings.^[15] Numerous non-glandular trichomes present in epidermal region. Variation in wood density of *A. marina* investigated such as variation in xylem vessel size, fiber wall thickness and proportion of the phloem within the wood contributed to the variation in wood density and how these characters are related to growth rate. The large xylem vessels and high growth rate directly correlated with high wood density because of numerous numbers of fibers associated with the vessels^[14].

In Myrsinaceae, *A. corniculata* showed continuous sclerenchyma bands in the outer region of phloem. *A. corniculatum* differs from other species because it has short vessel elements and uniseriate rays with exclusively procumbent and upright ray cells and its contains numerous tannin cells. In Euphorbiaceae, *E. agallocha* consists of continuous bands of sclereids in the cortex and bands of phloem showed ring like appearance. In Combretaceae, *L. recemosa*, crystalliferous cells found in the cork region.

In Sonnerataceae, *S. caseolaris* and *S. alba* have mucilage cavities in pith.^[15] Vessels mostly radial multiples of two.

In Rhizophoraceae stem anatomy showed some common characters like presence of sclereids in cortex and phloem, presence of cork warts, multi seriate rays, scalariform thickening and long vessels. *B. gymnorhiza* showed uniseriate rays also studied vessel characters and water transport systems in *A. marina* and *R. mucronata*.^[16]

V. CONCLUSION

Mangroves with stand unique environment, which different from normal terrestrial plants in plant parts like leaf, stem, root and reproductive structures. Plant group showing different modification in morphological, anatomical and physiological aspects to survive the stress environment. In this study anatomical structures with its functional modifications different from semi mangroves and back mangals. Presence of air cavities

and sclereids in cortex, numerous vessels, perforation plates, inter- vessel pits helps to their existence.

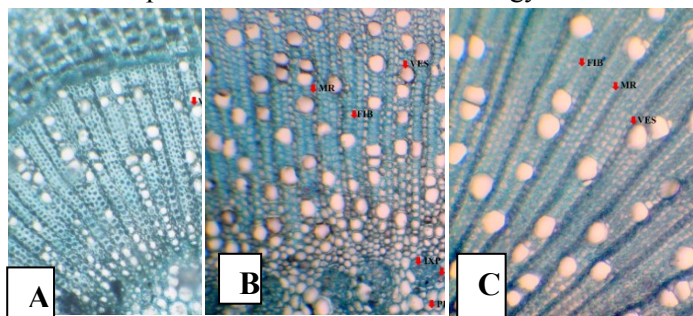
VI. ACKNOWLEDGEMENT

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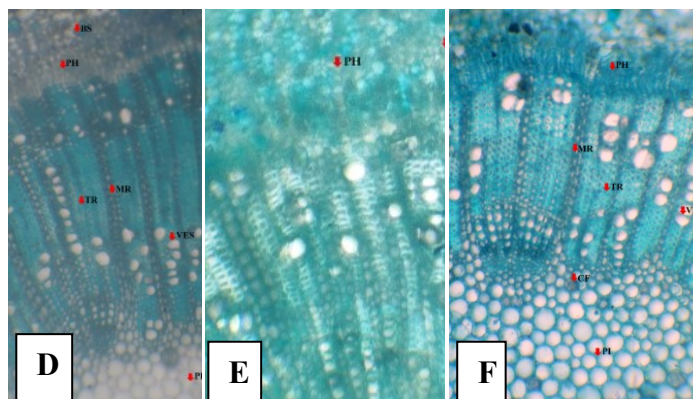
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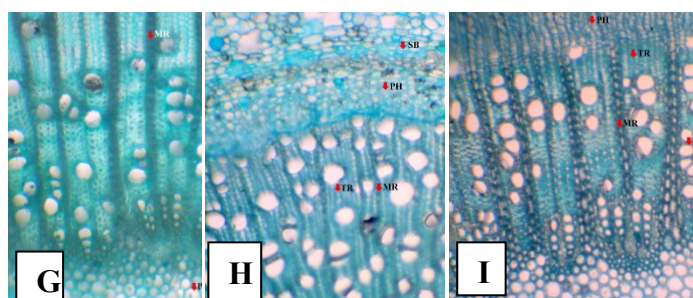
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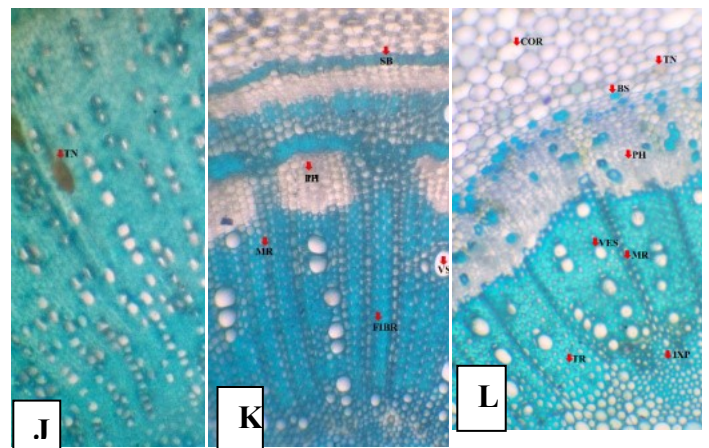
L. recemosa *S. alba* *S. caseolaris*



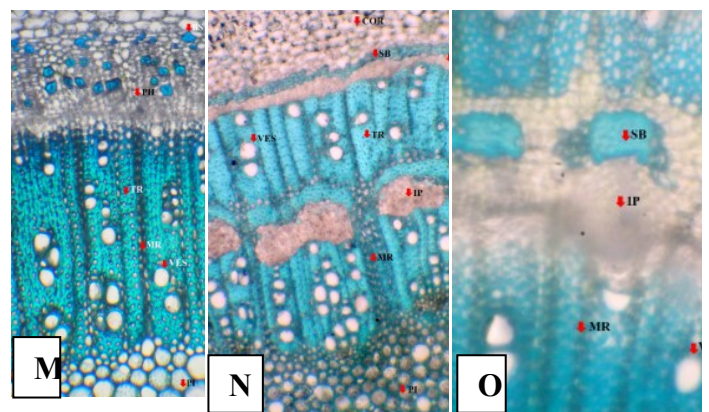
B. cylindrica *B. gymnorrhiza* *B. sexangla*



K. candel *R. apiculata* *R. mucronata*



A. corniculatum *E. agallocha* *A. ebracteatus*



A. ilicifolius *A. marina* *A. officinalis*

Fig-1. Stem anatomy of true mangrove species.

TN- Tannin, FIB- Fiber, XY-Xylem, MR- Medullary ray, VES-Vessel, BS- Brachy sclereids, PH- Phloem, SCL-Sclerenchyma, SB-Sclerenchyma bands, IP-Included phloem, TR-Tracheids, PI-Pith, COR-Cortex, PH-Phloem, CF-Crystalliferous cells, PL-Phenol, IXP-Intraxylary phloem, BS- Brachysclereids.