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Research Article

THE STEM-NODE-LEAF CONTINUUM IN SOME MEMBERS OF ASTERACEAE

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ABSTRACT

Vasculature was traced through internode, node and petiole/rachis in *Helianthus annuus; Tagetes erecta; Xanthium strumarium* and in *Zinnia elegans.* The arrangements of leaves are different in the four species of Asteraceae. In *Helianthus annuus* the upper part of plant shows alternate phyllotaxy and lower part shows opposite decussate arrangement whereas in *T. erecta* the lower part of plant shows alternate phyllotaxy and upper part of plant shows opposite phyllotaxy. In *X. strumarium* the arrangement of leaves are alternate. In *Z. elegans* the lower nodes have opposite decussate arrangement whereas the upper nodes bear whorl of three leaves. Some variations are observed at the nodal region due to the arrangement of leaves. In all the four species, the node has trilacunar three trace condition. The three traces enter into the base of petiole/rachis separately in all the four species.

Keywords: *Helianthus annuus; Tagetes erecta; Xanthium strumarium; Zinnia elegans; Stem-Node-Leaf Continuum; Trilacunar Three Trace Node*

INTRODUCTION

The Asteraceae family with more than 1,600 genera and around 24,000 species (Shi *et al.,* 2011) are categorized as the largest family of vascular plants. In Asteraceae family the arrangement of leaves on the stem may be opposite, alternate or less commonly whorled. Howard (1962) stated that the petiolar anatomy is very useful in generic level and in few cases also at the specific level. Howard (1974), Sharma and Pillai (1982), Larson (1984), Sharma and Pillai (1985), Dubey *et al.,* (1990) and others have emphasised the importance of study of vasculature through internode and leaf. Stem-node leaf continuums in paripinnate leaves have been studied by Sharma and Pillai (1982), Pillai and Sharma (1984) and Dubey *et al.,* (1990) which indicate significant clues towards phylogenetic importance of petiolar anatomy. The data on number of gaps and number of leaf traces and the details of petiole in *H. annuus; T. erecta; X. strumarium; Z. elegans* are presented here.

MATERIALS AND METHODS

For the study of nodal anatomy the internodes, nodes and leaves were collected from mature plants of *Helianthus annuus* (L.), *Tagetes erecta* (L.), *Xanthium strumarium* (L.) and *Zinnia elegans* (Jacq.) and fixed in FAA and maintained in 70% ethanol. The materials were dehydrated through TBA series and embedded in paraffin.

Serial transverse sections of internode, node and petiole/rachis were cut at 8-12 micro metre and affixed to the slides using Haupt's (Johansen, 1940) adhesive. Dried sections passed through down and up xylene series and stained with safranin – light green combinations. Microphotographs were taken using Nikon's microscope.

RESULTS

The four species of Asteraceae family showed different patterns of arrangement of leaves on the stem. In *H. annuus* the erect, herbaceous and branched plant bears simple leaves, which were arranged in alternate phyllotaxy at upper nodes and in opposite decussate manner at lower few nodes. Leaves are petiolate with reticulate venation.

In *T. erecta* the erect herbaceous stem bears pinnately compound leaves. In lower part of plant the leaves are alternate and in upper part of plant they are opposite. The oblong leaflets with toothed margins are arranged in pairs on the rachis.
In *X. stramarium* the erect and rough stem covered with short hairs bears ovate to sub-orbicular leaves having toothed margins. The arrangement of leaves is alternate.
In *Z. elegans* there are two types of phyllotaxy. The upper few nodes showed whorl of three leaves each whereas lower ones had opposite decussate arrangement. The stem is erect, branched and hairy.

Figure 1 (A-K): Showing general morphological features
Figures (A-C): *H. annuus;* A, habit of plant; B, twig showing alternate phyllotaxy; C, hairs on surface of stem, branch and petiole
Figures (D-F): *T. erecta*; D, habit of plant; E, twig showing opposite phyllotaxy; F, vegetative branch showing alternate phyllotaxy
Figures (G-H): *X. strumarium;* G, habit of plant; H, flowering twig with fruits and showing alternate phyllotaxy
Figures (I-K): *Z. elegans;* I, habit of plant; J, K, vegetative and flowering twigs showing phyllotaxy

The Nodal Anatomy

In *H. annuus* two bundles placed opposite to each other in the axis stele become larger than the remaining bundles of stele. These larger bundles leave the stele as two medians of the two opposite leaves. Simultaneously the four smaller bundles, from the axis two on either sides of each median, also leave the stele as two laterals to each leaf. Out of the two laterals to one leaf, one leave slightly at lower level than the other. The node is of trilacunar three trace type in *H. annuus.*

The three traces to a leaf enter the petiole as separate bundles. The three bundles at higher levels supply the midrib and lamina of the leaf.

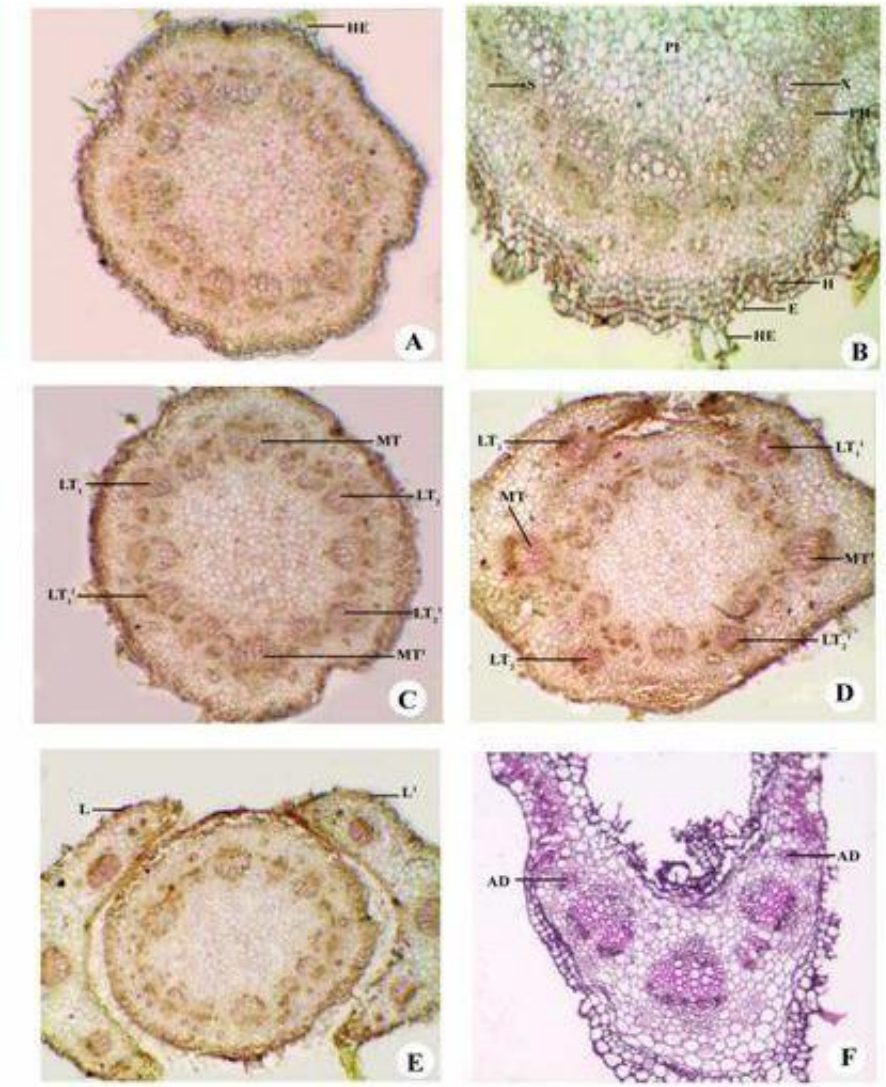

Figure 2 (A-F): Transverse sections through internode, node and petiole of *H. annuus.*

Figures (A,B): Internodal anatomy (X40, X100); C,D: different stages of departure of median and lateral traces to two opposite leaves (X40); E: nodal and internodal regions showing leaf vasculature in the first node leaves and preparation of traces to second node leaves (X100); F: petiole vasculature (X100)

C – Cortex; E – Epidermis; H – Hypodermis; HE – Hair; LT – Lateral trace; MT – Median trace; PH – Phloem; PI – Pith; S – Sclerenchymatous pericycle; MT, LT_1, LT_2 – Median and lateral traces of one leaf; MT, LT_1^1, LT_2^1 – Median and lateral traces of second leaf; L, L^1 – Two leaves of a node; AD – Adaxial vascular branch

Tagetes erecta: In *T. erecta* six leaf traces, three lateral traces on one side and three on the other side, are seen at the nodes where the leaves are opposite in arrangement. Out of the six traces, in nodes with opposite phyllotaxy, two laterals on one side depart at almost the same level followed by the two laterals on the other side. This is followed by departure of the median traces of the two leaves. The lateral gaps are immediately filled by fresh procambium differentiation whereas the median gaps are filled only after departure of the axillary bud supply. The two laterals of each leaf travel in the cortex and enter the base of leaf separately along with the median of the leaf. The outline of the base of leaf is semilunar with two flaps on the adaxial sides. These flaps continue to enlarge on either sides of the lamina. The three traces remain separate and represent the vasculature of the two lateral veins and midrib of the leaf lamina.

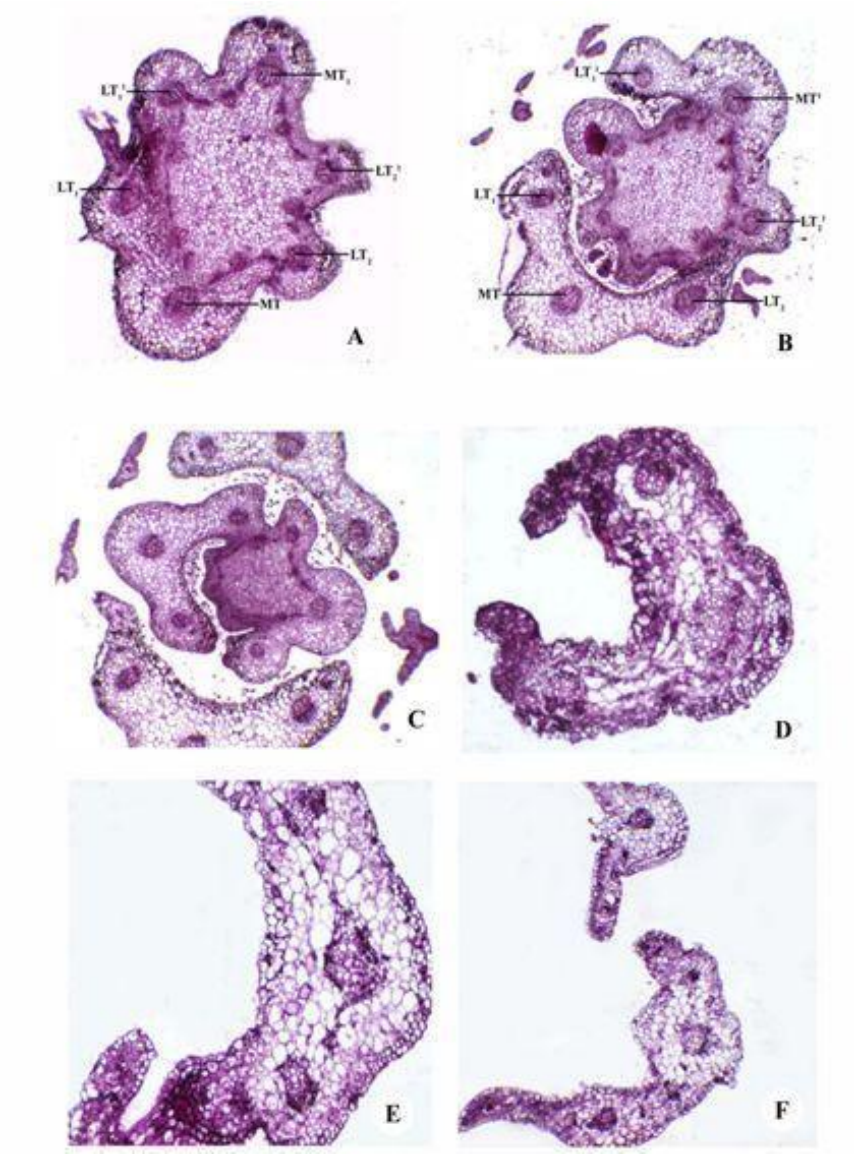

Figure 3 (A-F): Transverse sections through internode, node and petiole and lamina of *T. erecta* Figures A,B: Different stages of departure of median and lateral traces to the two leaves of a node (X40); C, two nodes with alternate phyllotaxy (X40); D, Petiole vasculature (X100); E,F, Lamina vasculature (X100).

MT, LT_1, LT_2 – Median and lateral traces of one leaf
MT, LT_1^1, LT_2^1 – Median and lateral traces to second leaf

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X. strumarium: The node is trilacunar three trace type. The two laterals depart one by one followed by the median trace (MT). The lateral gaps are immediately filled with procambial tissue. The median gap is filled only after departure of the axillary bud supply. The vasculatures of each lateral trace along with that of the median enter the base of petiole separately.

At higher levels two small bundles from abaxial sides of laterals separate and become part of the petiolar vasculature. Adaxially differentiating vascular tissue is seen at higher levels and as the petiole approaches the lamina its vasculature is represented by one adaxial, one abaxial and two lateral large bundles. These four bundles are alternated by small intrafasicular vascular groups.

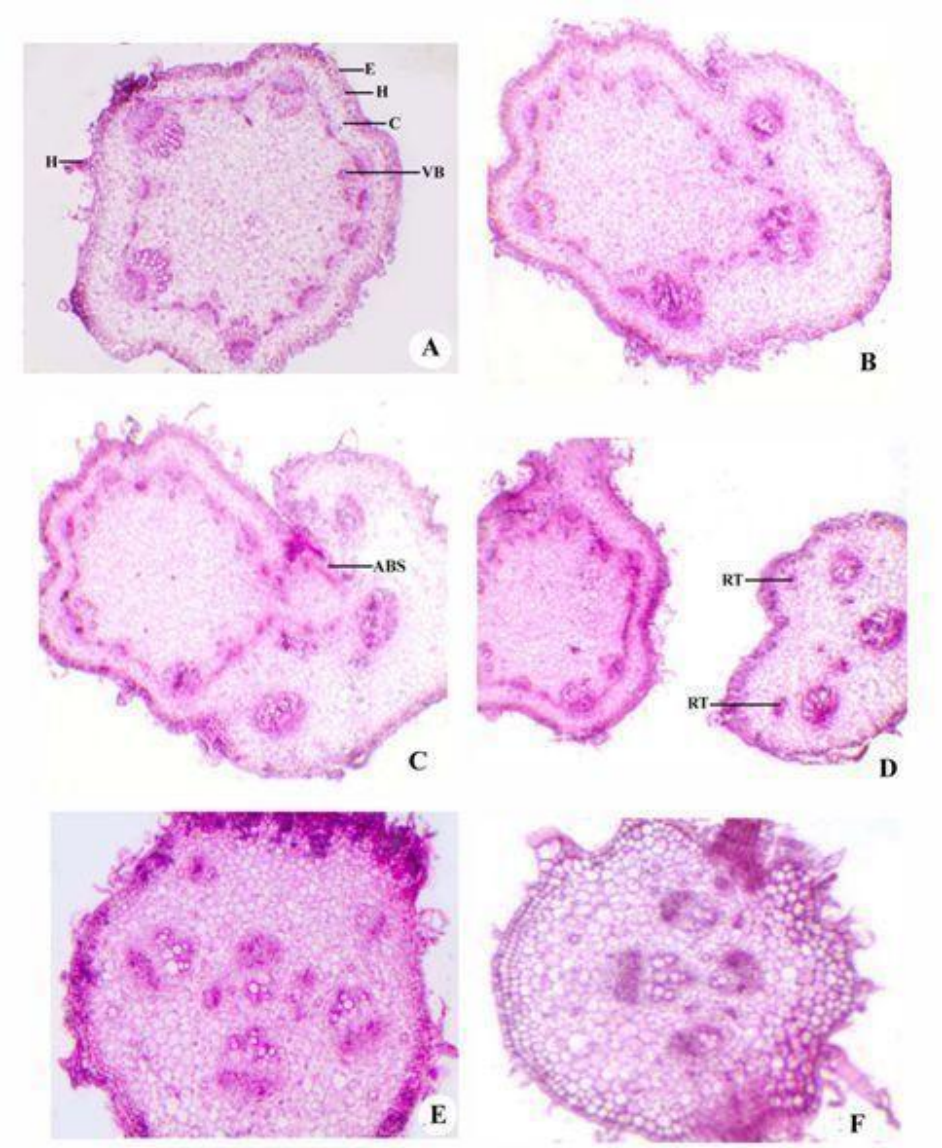

Figure 4(A-F): Transverse sections through internode, node and petiole and lamina of *X. strumarium.*

Figure A: Internodal structure (X100); B,C: (departure of median and lateral traces to a leaf (X100)); D,E: Petiole vasculature (X40; X100); F (Lamina vasculature) X 100.

ABS – Axillary bud supply; C – Cortex; E – Epidermis; H – Hypodermis; VB – Vascular bundle; MT, LT_1, LT_2 – Median and lateral traces.

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Z. elegans: The nodes with both opposite and whorled leaves are of trilacunar three trace types. Laterals (4 in case of opposite leaves and six in case of whorled leaves) depart almost at the same level. Similarly medians (two in opposite and three in whorled ones) depart simultaneously. The three traces (one median and two laterals) of each leaf travel for some distance in the cortex and enter into the base of lamina directly (as petioles are absent). The laterals supply the lamina whereas the median becomes part of mid vein.

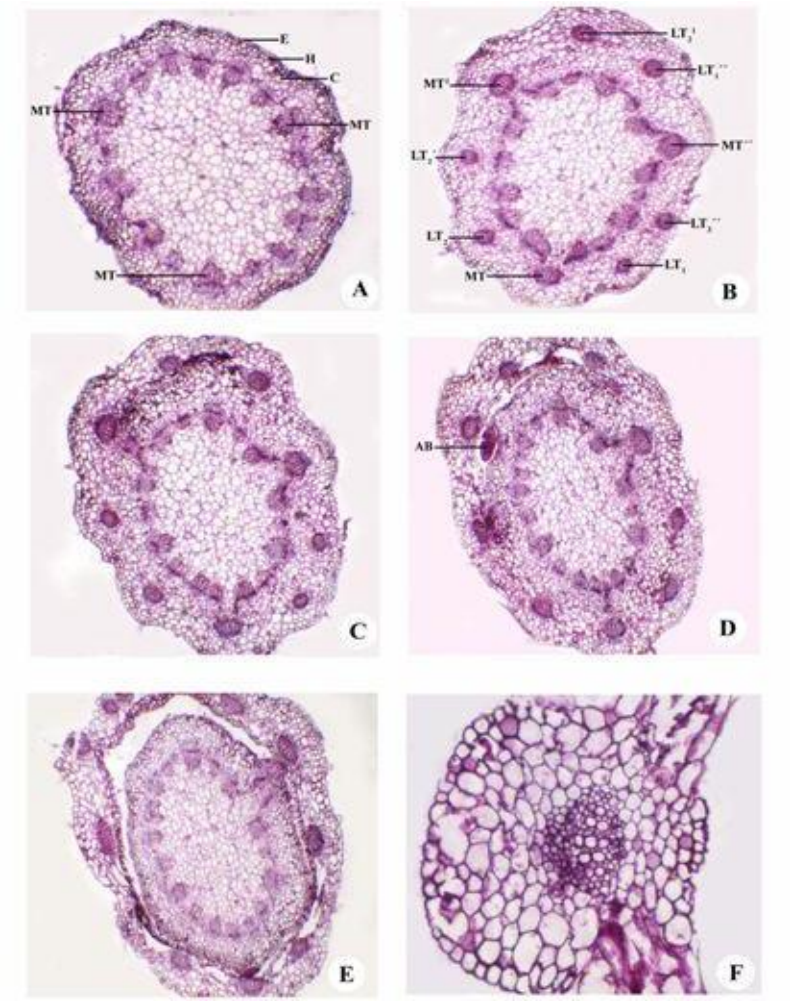

Figure 5(A-F): Transverse sections through internode and node in *Z. elegans.*

Figure A: Internodal anatomy with identification of three median traces for three leaves of a whorl (X40); B,C: Nodal regions showing departure of median and lateral (two to each leaf) traces for three leaves of a whorl (X40); D,E: node and internode above nodal region showing vasculature (X40); F: Lamina vasculature (X100)

C – Cortex; E – Epidermis; H – Hypodermis; AB – Axillary bud
MT, LT_1, LT_2 – Median and two lateral traces to one leaf
MT, LT_1^1, LT_2^1 – Median and two lateral traces to second leaf
MT'', LT_1'', LT_2'' – Median and two lateral traces to third leaf

DISCUSSION

All the four species of Asteraceae family showed the trilacunar three trace nodal condition. In *Helianthus* lower few nodes showed opposite decussate phyllotaxy while upper few nodes showed alternate phyllotaxy. In *Tagetes* lower few nodes showed alternate phyllotaxy while upper nodes showed opposite

phyllotaxy and *Zinnia* showed opposite and the whorled arrangements. Sinnott (1914) observed that trilacunar nodes occurred in majority of dicotyledons. Howard (1970) stated that multilacunar nodes were relatively uncommon in dicotyledonous families but were found in members of primitive orders such as Magnoliales, Piperales and advanced orders such as Umbelales and Asterales. But all Asteraceae members studied here are not in accord with Howard's observations as the four Asteraceae species studied here exhibited trilacunar three trace nodal condition. Sinnott (1914) considered trilacunar three trace type as the basic type while Ozenda (1949) and Marsden and Bailey (1955) and Canright (1955) considered unilacunar two trace nodes as primitive.

Nodal anatomical studies provide one of the most reliable evidences for classification and possibly for phylogenetic studies. Dickison (1969, 1980) suggested that the trilacunar three trace pattern is the ancestral type from which the multilacunar condition evolved by amplification in the number of lateral traces. On the basis of floral and other characters the family Asteraceae has long been considered to be an evolved taxon but the nodal condition studied here are not in support of this.

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