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Rayless Secondary Xylem of *Trianthema monogyna* *(Aizoaceae)*

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With 1 Figure

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Summary

RAO K. S. & RAJPUT K. S. 1998. Rayless secondary xylem of *Trianthema monogyna (Aizoaceae).* – Phyton (Horn, Austria) 37 (2): 161–166, with 1 figure. – English with German summary.

The stem of *Trianthema monogyna*, a common weed of tropics was composed of scanty rayless secondary vascular tissues produced by successive rings of cambium. The cambium was storied with only fusiform cambial cells. The absence of cambial ray cells led to the development of rayless secondary phloem and xylem. The xylem was composed of tracheids, vessel elements, axial parenchyma and fibres. The entire cambial zone between each successive ring of xylem and phloem underwent differentiation following the development of outermost new cambial ring. This made the cambium indistinguishable between xylem and phloem. Successive cambial rings originated from the outermost phloem parenchyma produced by the preceeding

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cambium. Vessel lumen diameter gradually increased from the inner to the outer ring of xylem. The radial width of each xylem increment gradually narrowed towards periphery of the stem. The structure of secondary xylem was described in detail in relation to the rayless condition.

Zusammenfassung

RAO K. S. & RAJPUT S. 1998. Strahlenloses sekundäres Xylem von *Trianthema monogyna (Aizoaceae)*. – Phyton (Horn, Austria) 37 (2): 161–166, 1 Abbildung. – Englisch mit deutscher Zusammenfassung.

Der Stamm von *Trianthema monogyna*, ein weitverbreitetes Unkraut der Tropen, wird von engen strahlenlosen sekundären Leitgeweben aufgebaut, welche als aufeinanderfolgende Ringe durch das Kambium gebildet werden. Das Kambium ist nur aus fusiformen Kambialzellen zusammengesetzt. Das Fehlen kambialer strahlenbildender Zellen führt zur Entwicklung eines strahlenlosen sekundären Phloems und Xylems. Das Xylem wird aus Tracheiden, Gefäßelementen und axialem Parenchym und Fasern aufgebaut. Die vollständige Kambialzone zwischen jedem aufeinanderfolgenden Ring des Xylems und Phloems unterliegt der Differenzierung gefolgt von der Entwicklung eines ganz außen gelegenen neuen Kambialringes. Dies führt dazu, daß das Kambium zwischen Xylem und Phloem nur schwer zu erkennen ist. Die aufeinanderfolgenden Kambialringe stammen vom äußersten Phloemparenchym, welches vom vorhergehenden Kambium erzeugt wurde. Gefäßinnendurchmesser nehmen ständig von innen zu den äußeren Kambialringen zu. Die radiale Weite von jedem Xylemzuwachs verschmälert sich gegen die Peripherie des Stammes hin. Die Struktur des sekundären Xylems wird im einzelnen in Bezug zur strahlenlosen Beschaffenheit beschrieben.

Introduction

Evolution has the fundamental role in the adaptation of plants to various environmental conditions. Probably in middle devonian, the vascular cambium evolved to cope with increasing crown weight and gravitational force (ZIMMERMANN & BROWN 1971). With the changing environment lateral meristem underwent various modifications to its mode of action resulting in the unidirectional differentiation of derivatives, development of successive cambia, production of medullary bundles and absence of rays. CARLQUIST 1970 concluded that anomalous growth is probably the result, in at least in some groups, of loss of normal cambial activity during evolution towards herbaceous mode of structure. However, MAHESHWARI 1930 reported the occurrence of successive cambia in *Trianthema* but nothing was mentioned on xylem structure. This paper reports the structure and rayless nature of xylem in *Trianthema monogyna*.

Materials and Methods

Stem pieces measuring about 8 mm in diameter were collected from *Trianthema monogyna* growing in M. S.University Campus, Vadodara in August 1995. Samples were immediately fixed in FAA and processed for microtomy by conventional method (BERLYN & MIKSCHE 1976). Transverse and tangential longitudinal stem sections of

10–12 μm thickness were stained with toluidine blue (SAKAI 1973) and tannic acid-ferric chloride Lacmoide combination (CHEADLE & al. 1953).

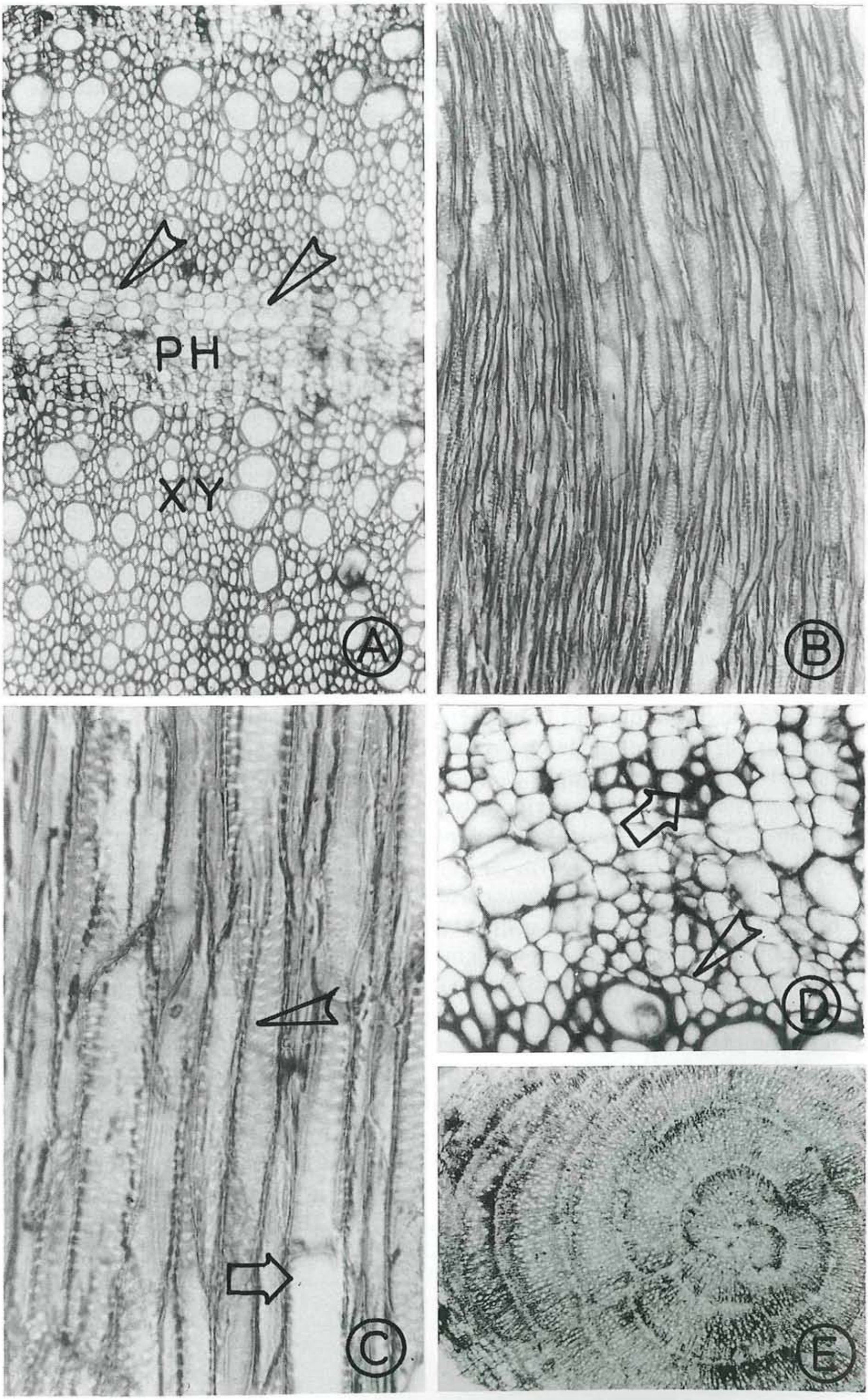
To obtain mean length and width of vessel elements and fibres small pieces of stem were macerated with Jeffrey's fluid (BERLYN & MIKSCHE 1976) at 55 to 60°C for 10–24 h. For each elements 100 random measurements were taken using an occular micrometer.

Results

Trianthema is a prostrate annual herb with spreading branches measuring 0.3–0.9 m in length. The stem, 3–8 mm in diameter produces alternate rings of xylem and phloem. The cambium is storied with vertically elongated fusiform cambial cells which are arranged in regular tires. The fusiform cambial cells are short, uninucleate with dense cytoplasm and beaded radial walls. The length and tangential width of fusiform cambial cells range from 110–115 μm and 13–18 μm respectively.

The stem possesses alternate bands of xylem and phloem produced by the activity of successive cambial rings (Fig. 1E). The first cambial ring functions for some time producing xylem centripetally and phloem centrifugally and then it ceases to divide. Before the new cambial ring is completely formed, all the fusiform cambial cells in the previous cambial zone undergo differentiation into phloem parenchyma and sieve tube elements thus leading to the disappearance of the cambial ring between the xylem and phloem (Fig. 1D). The new cambial ring originates from the outermost phloem parenchyma cells produced by the preceeding cambium (Fig. 1D). During the development of a new cambial ring the outermost 2–3 layers of phloem parenchyma cells become larger in size. Then the cells in one of these layers undergo periclinal divisions giving rise to a new cambial ring. The parenchyma cells centripetally adjacent to the new cambial ring appear to accumulate crystals which are later seen close to the inner face of the xylem ring.

The mature stem is composed of five successive rings of xylem which become narrower from the centre towards the periphery of the stem. The xylem is composed of tracheid elements, vessel elements, fibres and axial parenchyma cells. The length and width of vessel elements range from 120 to 180 μm and 20 to 40 μm respectively. Vessel elements have a simple perforation plate on transverse to slightly oblique end walls. The pits on the walls are bordered and arranged alternately. They are solitary but radial or tangential multiples of 2–3 vessel elements are also encountered. Tracheids with well developed alternate bordered pits are common (Fig. 1B and C) and are found distributed among the vessels and fibres. The elements to differentiate first from the new cambial ring are fibres followed by vessel elements. The length and width of fibres range from 380 to 460 μm and 13 to 23 μm respectively. Vessel lumen diameter increases gradually in each xylem increment.


PH
XY
A
B
C
D
E

The phloem is composed of sieve elements, companion cells and axial parenchyma cells. Each sieve element consists of a simple sieve plate on transverse to slightly oblique end walls. In all the successive rings of phloem sieve tube elements possess open sieve pores and remain functional. The xylem and phloem between two successive rings are separated by large crystal containing 2–3 layers of parenchymatous cells (Fig. 1A).

Discussion

Trianthema, a common weed of tropical India, shows anomalous secondary growth. The stem develops successive rings of cambium, each ring producing secondary xylem centripetally and phloem centrifugally. The vascular tissues are characterised by the absence of a radial system. Raylessness has also been reported in a few dicotyledonous taxa (BARGHOORN 1941, BOUREAU 1957, CARLQUIST 1970, PALIWAL & SRIVASTAVA 1969). Although raylessness is predominantly restricted to a tiny portion of the dicotyledonous group, generally it appears in plants having limited cambial activity (BARGHOORN 1941, CARLQUIST 1970) and the same has been confirmed in *Bougainvillea* by ESAU & CHEADLE 1969. In the present study also the extent of xylem produced by each successive cambial ring shows gradual reduction in centrifugal direction. Therefore, raylessness in *Trianthema* may be related to the limited cambial activity. Raylessness is also encountered in a group of plants in which woodiness is in the process of increasing rather than decreasing. This situation is reported in insular and tropical or subtropical areas where uniform climatic conditions permit more rarely indefinite accumulation of secondary xylem (CARLQUIST 1970). However, *Trianthema* as a tropical genus, shows continuous development of successive cambium throughout the year resulting in 3 to 5 rings of xylem and phloem.

The development of successive cambial rings in the stem of *Trianthema* is similar to that reported in *Boerhaavia diffusa* (MAHESHWARI 1930). Vascular rays play a key role in the radial transport of photosynthates and

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Fig. 1 A: Transverse view of two successive rings of rayless xylem. Arrowhead indicates crystalliferous parenchyma × 122.

B: Tangential view of xylem showing tracheids, vessels and fibres × 112.

C: Tangential view of xylem showing tracheids (arrowhead) and vessel elements (arrow) with bordered pits × 280

D: Transverse view of outermost xylem and phloem ring with completely differentiated cambium (arrowhead). Arrow indicates newly formed xylem elements from the recently developed cambium × 260.

E: Transverse view of stem showing successive rings of xylem and phloem. × 40.

(XY : Xylem, PH: Phloem)

serve as a bridge between the vertical and radial system. Though the raylessness is reported in the stems of a few species hitherto no information is available on the radial transport of materials between rayless xylem and phloem (PALIWAL & SRIVASTAVA 1969). Another interesting feature noticed in *Trianthema* is the differentiation of entire cambial zone cells into parenchyma cells resulting in the complete disappearance of the cambial ring. This makes both the xylem and phloem in direct contact to each other which may facilitate direct transfer of materials through symplastic and apoplastic pathways in the absence of a ray system.

Acknowledgement

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