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Cambial Variant in the Stem of *Antigonon leptopus* H. & A. (*Polygonaceae*)

By

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With 2 Figures

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Summary

RAO K. S. & RAJPUT K. S. 2000. Cambial variant in the stem of *Antigonon leptopus* H. & A. (*Polygonaceae*). – *Phyton* (Horn, Austria) 40 (1): 201-208, 2 figures. – English with German summary.

The stem of *Antigonon leptopus* H. & A. was composed of five to six successive cambial rings. Cambium was storied with axially elongated fusiform cambial cells and horizontally arranged ray cambial cells. Each cambial ring was functionally divided into fascicular and interfascicular regions; the former giving rise to xylem elements inside and phloem elements outside while the latter producing parenchyma cells on either side. New cambial rings were originated from cortical parenchyma after the cessation of cell divisions in the preceding ring. Prior to the initiation of new cambium, the interfascicular region of the previous cambium disappear while fascicular region maintained its radial arrangement. The nonfunctional phloem from the innermost cambial rings underwent obliteration. Xylem was composed of vessel elements, vascicentric tracheids, living fibres, axial and ray parenchyma cells. Vessels were dimorphic in nature with notably large and narrow vessel elements.

Zusammenfassung

RAO K. S. & RAJPUT K. S. 2000. Die Ausbildung des Kambiums im Stamm von *Antigonon leptopus* H. & A. (*Polygonaceae*). – *Phyton* (Horn, Austria) 40 (1): 201-208, 2 Abbildungen. – Englisch mit deutscher Zusammenfassung.

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Der Stamm von *Antigonon leptopus* H. & A. ist aus 5 bis 6 aufeinander folgenden Kambialringen zusammengesetzt. Das Kambium ist stockwerkartig aus axial verlängerten fusiformen Kambialzellen und horizontal angelegten Markstrahlkambialzellen aufgebaut. Jeder Kambialring ist funktionell in fasciculäre und interfasciculäre Bereiche gegliedert; die ersteren geben nach innen die Xylemelemente und die Phloemelemente nach außen hin ab, während die letzteren Parenchymzellen auf beiden Seiten bilden. Neue Kambialringe entstehen aus dem Rindenparenchym, nachdem die Zellteilungen im vorhergehenden Ring eingestellt wurden. Vor dem Beginn eines neuen Kambiums verschwindet der interfasciculäre Anteil des vorherigen Kambiums, wogegen der fasciculäre Teil seine radiale Anordnung behält. Das funktionslose Phloem des innersten Kambialringes wird vernichtet. Das Xylem ist aus Gefäßelementen, Tracheiden, lebenden Holzfasern, axialen und Holzstrahlparenchymzellen aufgebaut. Die Gefäße sind entweder bemerkenswert groß oder eng.

Introduction

In majority of gymnosperms and dicotyledons, a single vascular cambium functions throughout the life of the plant and brings about the increase in thickness of the main stem branches and roots. However, in some dicotyledons, especially in lianas, the first formed cambium functions only for a short duration and several additional cambia are differentiated in succession and behave identically to the first formed one. The cambia producing secondary vascular tissues in seed plants are by no means uniform in position, structure and mode of action. Many diverse types of cambial growth have been reported on the basis of their origin, structure and position (PHILIPSON & al. 1971). But relatively little attention has been paid to the cellular composition in scandent plants (CARLQUIST 1988) and the plants with abnormal secondary growth (RAO & RAJPUT 1998). SOLER-EDER 1908 reported the development of secondary meristem from parenchymatous portion of pericycle in the stem of *Antigonon*. This results in the development of new ring of vascular bundles to the outside of primary vascular ring. However, no detailed information is available regarding the structure of vascular cambium and histology of xylem derivatives. Therefore, the present study was aimed to examine the origin and function of cambial variant and development of xylem derivatives.

Materials and Methods

Samples measuring about 5 to 20 mm in diameter and 30 to 40 mm in length were collected from the main stem of *Antigonon leptopus* (*Polygonaceae*) growing in the M. S. University campus, Baroda and fixed immediately in FAA (BERLYN & MIKSCH 1976). Transverse and tangential longitudinal sections of 15 to 20 µm thick were obtained with a sliding microtome and stained with tannic acid-ferric chloride-lacmoid combination (CHEADLE & al. 1953). Length of fusiform cambial cell was measured directly from the tangential longitudinal sections and for vessel elements and xylem fibers, small pieces of stem were macerated with Jeffrey's fluid (BERLYN &

MIKSCH 1976). One hundred random measurements were taken for each element using an ocular micrometer scale to obtain the mean and standard deviation.

Results

Structure of cambium

The cambium is storied with axially elongated fusiform cambial cells and horizontally arranged ray cambial cells (Fig. 1A). In transverse view, fusiform cambial cells of the well-developed vascular bundles appear as tangentially flattened radial rows of 3–5 cells. In developing bundles they are more or less isodiametric and 2–3 layered in each radial file. Length and width of fusiform cambial cells range from 155–279 μm and 18–26 μm respectively. Cambial rays are uni-multiseriate, heterocellular and compound. Their height and width vary from 21–1800 μm and 18–340 μm respectively. Ray cambial cells appear more or less isodiametric ranging from 16–23 μm in diameter.

Development of vascular cambium and its derivatives

The young stem during primary growth is composed of five collateral vascular bundles (Figs. 1B, 2). These bundles are connected by interfascicular cambium and form a complete cambial ring. The cambium divides bidirectionally producing xylem centripetally and phloem centrifugally (Fig. 1C). However, xylem and phloem development remains restricted only to the fascicular sector of the cambium whereas interfascicular region differentiates into parenchyma cells on both sides, giving an impression that vascular bundles are embedded in parenchymatous tissue (Fig. 1C, D). The first cambium functions for a definite period and ceases to divide towards xylem side. After the cessation of xylem development, a new cambial ring originates from the cortical parenchyma, followed by similar pattern of cell division and differentiation like the previous cambium (Fig. 1E). At this stage, the interfascicular cambium of previous ring differentiates completely into parenchyma cells while the fascicular regions maintain its radial arrangement. From the newly developed cambium, the first derivative to differentiate is the sieve element (Fig. 1E) followed by thick walled xylem derivatives. The sieve tube elements from the inner rings begin to cease their function by extensive deposition of callose followed by obliteration of elements. The space formed by the obliteration of these sieve elements is replaced by the newly formed sieve elements and axial parenchyma cells which arise from the fascicular segment of the previous cambium (Fig. 1F).

Phloem remains functional in all the successive rings of vascular bundles owing to the replacement of nonfunctional phloem derivatives by addition of new elements. Compared with fusiform cambial cells, sieve elements are shorter measuring from 148–258 μm in length. Sieve plates

are simple on the slightly oblique to transverse end walls. Each sieve tube element is associated with a single companion cell.

Xylem is composed of vessel elements, vasicentric tracheids, nucleated fibers, and axial and ray parenchyma cells. Vessels are mostly solitary with simple perforation plate on the transverse end walls. The lateral wall pits are alternate, bordered and elliptic rather than round in which an alternate pattern intergrade with the scalariform pattern. Length and width of vessel elements vary from 73–155 μm and 80–265 μm respectively. Vessel lumen diameter, however, increases gradually from first formed to last form vessel elements in each vascular bundle.

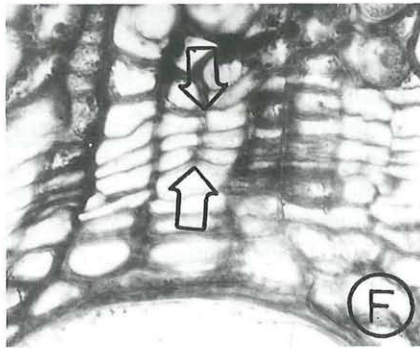
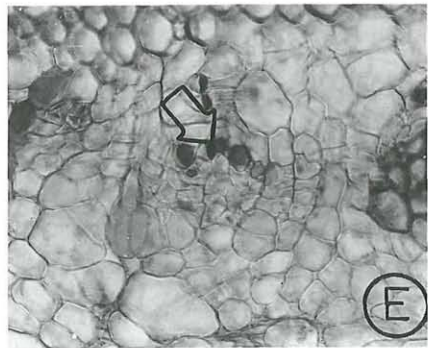
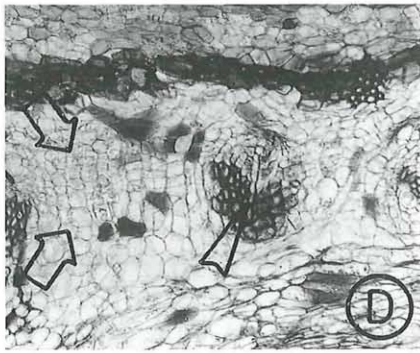
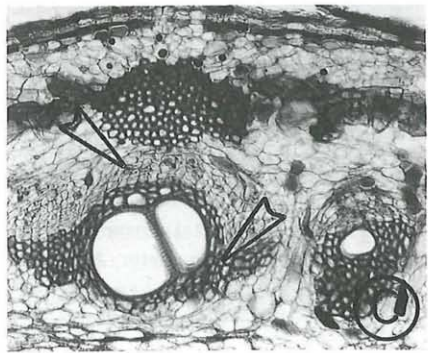
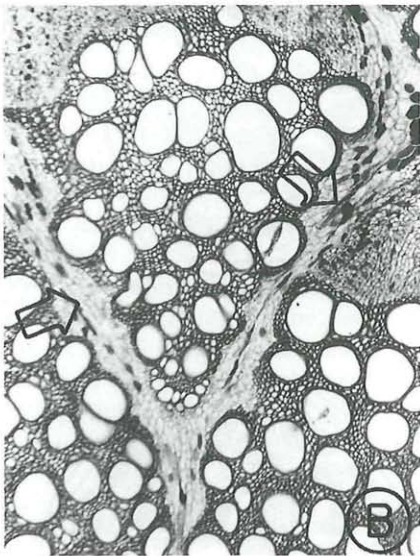
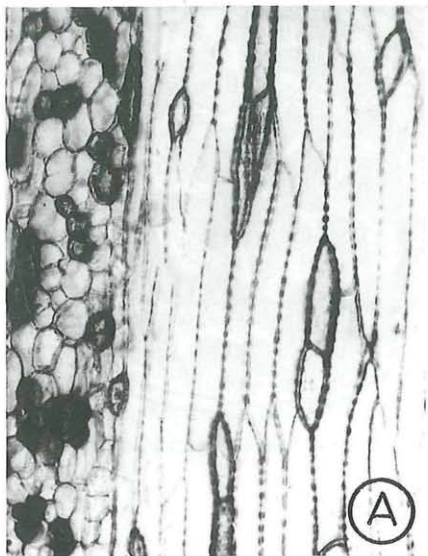
Xylem fibers are septate with slit-like simple pits and 2–4 times (395–578 μm) longer than the fusiform cambial cells. Fibers also retain nuclei in each compartment even after the deposition of secondary wall. The nuclei are oval to oblong and fusiform shaped, measuring from 4–7 μm and appear similar to the nuclei of axial and ray parenchyma cells of the xylem. The parenchyma cells differ from xylem fibers by being broader, shorter and having thinner walls. They also possessed large circular simple pits on both radial and tangential walls.

Discussion

Development of secondary meristem in *Antigonon* has already been studied by SOLEREDER 1908 but no detail information is given about its activity and development of vascular elements. Similar mode of cambial development is also noticed in *Rumex dentatus* another member of *Polygonaceae* (JOSHI 1931). Most of the studies on the cambial variant have focused on the various types of cambial activity but no attention has been paid on the behaviour of vascular cambium and development of its derivatives (RAJPUT & RAO 1998). Interestingly in *Antigonon*, the previous

Fig. 1. Tangential longitudinal (A) transverse view of cambium, xylem and phloem (B–F) of *Antigonon leptopus*.

- A: Nonstoried cambium with uni-multicellular cambial rays. X 150.
- B: Xylem structure. Arrowhead indicates ground parenchyma. X 25.
- C: Newly developed cambium with developing xylem and phloem from fascicular region. X110
- D: Development of xylem and phloem remains restricted to fascicular (arrowhead) region. Arrows indicate development of parenchyma cells on xylem and phloem side from the interfascicular region. X 115.
- E: Development of new cambium from cortical parenchyma cells. Note that phloem development starts first (arrow). X 240
- F: Unidirectional cell division and differentiation of phloem from the cambium of innermost vascular bundle. Note the anticlinal divisions and development of phloem (arrows). X 370



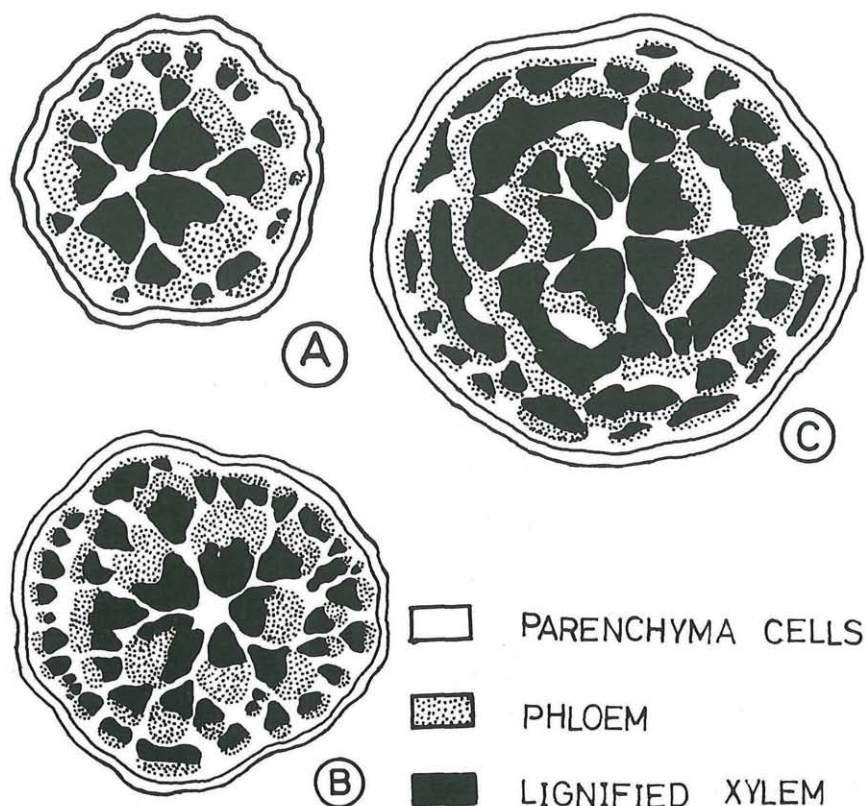


Fig. 2. Schematic diagram representing various stages of cambial variant and arrangement of lignified and unlignified xylem derivatives. (Stem diameter: A = 5 mm, B = 9 mm and C = 20 mm).

bidirectional cambium which ceases to divide soon after the formation of new cambial ring undergo unidirectional cell division, and differentiation occurs only towards the phloem side so as to fill the space formed by the obliteration of non functional phloem.

In *Antigonon*, xylem possesses notably wider and narrow vessel elements with a few intermediate in size. Occurrence of such vessel dimorphism is more prevalent in scandent species than in their nonscandent relatives (KLOTZ 1977, BAMBER 1984). Wide vessels offer low friction and conduct large volume of water per unit time. However in *Antigonon*, occurrence of wide vessels seems to be related with its greater capacity of spreading branches and maintaining full foliage even in summer.

Each ring of vascular bundles in *Antigonon* is ensheathed by parenchyma cells. Such parenchyma distribution permits vessel bearing seg-

ments to twist without fracture and enhancing stem flexibility (CARLQUIST 1985, SIEBER & KUCERA 1980). Occurrence of concentric parenchyma not only enhances the stem flexibility but also a water storage function (BAILEY 1962).

Fibers are the principal mechanical cells. The strength and several other properties of hard woods largely depend on their size and morphology. They are elongated sclerenchymatous dead cells mostly with lignified walls and narrow lumina. However, fibers sometime retain their living protoplast even after their secondary walls have been laid down (BAILEY 1953). Since, BAILEY's report, nucleated fibres have also been reported in some shrubs and sub-shrubs belonging to different families (FAHN & ARNON 1963, FAHN & LESHEM 1963, RAJPUT & RAO 1999). In the present study we report the occurrence of nucleated fibres in *Antigonon*. FAHN & LESHEM 1963 have considered that nucleated fibers in sub-shrubs and shrubs are associated with their diminishing supporting function. It seems true in case of present study, as *Antigonon* is scandent shrub.

Acknowledgements

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Corrigendum

Im vorigen Heft, Phytion 39 (2): 292 (1999) muß es im 4. Absatz von oben richtig heißen:

Anthophor: in einer Blüte zwischen Kelch und Krone entwickeltes Achsenstück.

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