ACTA SOCIETATIS
BOTANICORUM POLONIAE
Vol. XLVIII, nr 1: 93—98
1979

Size correlations among cambial initials and their derivatives in *Polyalthia longifolia* Thw.

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(Received: March 2, 1978)

Abstract

The length and breadth of the cambial initials and their derivatives have been examined in *Polyalthia longifolia*, a tropical tree possessing non-storied cambium. Taking the average size of the initials and the elements originating from them, most of the sieve-tube elements have been found to be slightly shorter in length than the fusiform initials. On the other hand, a few of these are still shorter — almost half of the fusiform initials, due to transverse or somewhat oblique divisions in the sieve element mother cells. The vessel elements are slightly shorter but 5-6 times wider than the fusiform initials. The parenchyma strands, in phloem comprising cells storing starch or tannin (pps), in xylem accumulating starch only (ssps), are more or less equal to fusiform initials indicating that the xylem and phloem mother cells forming parenchyma cells have not undergone any major change except for transverse divisions. The individual vessel-associated parenchyma cells (v.a.p. cells) are wider but much shorter in length as compared to the starch-storing parenchyma cells (s.s.p. cells) indicating that more transverse divisions have occured in the strands of the former than those of the latter. Among all the cambial derivatives, the fibers exhibit maximum increase in length, due to intrusive growth. The ray parenchyma cells are slightly longer than the ray initials possibly due to the elongation of these initials during their transformation into vascular ray cells.

INTRODUCTION

Considerable information has become available during the past few decades on the various aspects like developmental changes, light and electron microscopic structure, physiology, and biochemistry of cambium and its derivatives in the woody taxa. Authors such as Bailey (1920), Chattaway (1936), Esau & Cheadle (1955), and Butterfield

(1972, 1973) have reported the seasonal variations in the size of cambial initials and the elements of the xylem and phloem tissues individually in a number of plants. Only limited attempts have, however, been made to establish the size relationship between cambial initials and the elements produced by them. The present communication aims to provide this information for *Polyalthia longifolia*, a common, evergreen tropical tree of Northern India.

MATERIAL AND METHODS

The material was collected from a tree growing at the Delhi University Campus. Small portions of bark, with intact wood, were cut off from a tree trunk 1.5 meters above the ground. Later, by using an electric saw and single-edge blades, blocks measuring 3.5 × 2.0 cms. were obtained. These were fixed in Craf III mixture for 24 hours. The slides were prepared following the schedule outlined by Cheadle et al. (1953).

Table 1

Average sizes* of cambial initials and their derivatives in *P. longifolia*

		Length (μm)	Breadth (μm)
Fusiform initials	A. CAMBIUM	404.8	18.3
Ray initials		44.2	24.3
Sieve-tube elements	B. PHLOEM	340.6	18.7
Companion cells		100.2	7.0
Axial parenchyma strands		399.9	18.4
Axial parenchyma cells		44.9	18.4
Ray parenchyma cells		61.1	27.9
Fibers		1068.7	15.2
Vessel elements	C. XYLEM	365.6	94.5
Vessel-associated parenchyma strand		452.2	33.2
Vessel-associated parenchyma cells		59.5	33.2
Starch-storing parenchyma strands		400.0	18.5
Starch-storing parenchyma cells		98.8	18.5
Ray parenchyma cells		62.2	24.7
Fibers		841.4	18.1

* Average of 250 values.

Measurements of fusiform initials and their derivatives, except for the vessel elements and fibers, were taken in both tangential longitudinal and transverse planes. The size of the vessel elements and fibers was recorded after macerating the bark and wood separately with concentrat-

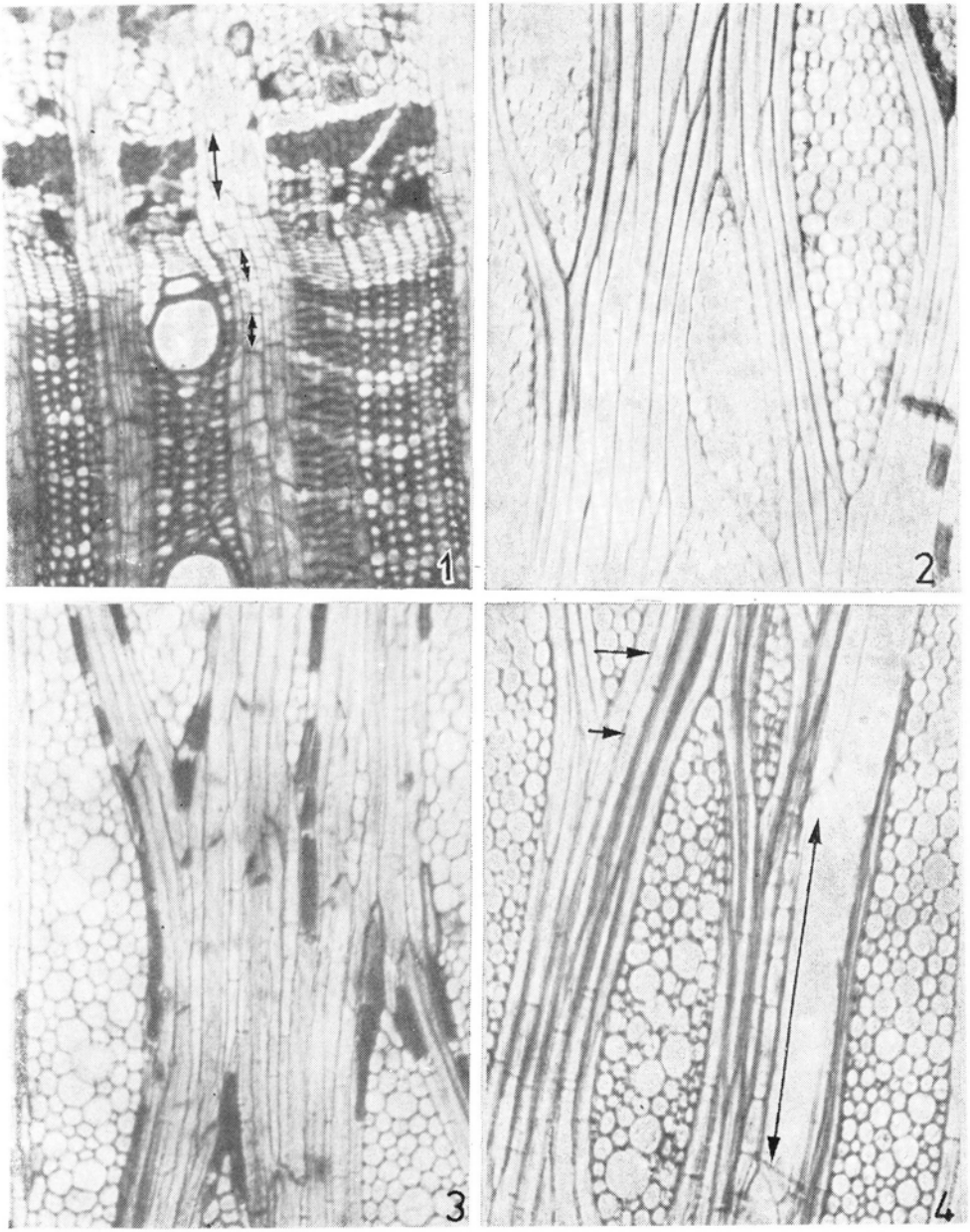

Fig. 1. Transverse section of stem showing initials and several layers of their immediate derivatives indicating its active state. × 154.

Fig. 2. Tangential longitudinal section of cambial region; mark the non-storied arrangement of the fusiform initials and heterogeneous ray initials. × 154.

Fig. 3. Tangential longitudinal section of phloem region; note the several cells of phloem parenchyma of a given strand exhibiting accumulation of tannin. × 154.

Fig. 4. Same as above in the xylem region; the difference between the organization of the vessels-associated parenchyma (v.a.p.) strand (along vertical, long arrow) and the starch-storing parenchyma (s.s.p.) strand (horizontal arrows). × 154.

ed nitric acid and potassium chlorate overnight and then staining with safranin after a thorough wash. An average of 250 readings has been taken for each type of initials and the elements derived from them.

OBSERVATIONS

P. longifolia has a non-storied cambium composed of fusiform initials with tapering apices and the ray initials which are nearly isodiametric and relatively small. In figure 1, initials and several layers of their immediate derivatives are seen (see also S c h m i d, 1976) indicating the active state of cambium. Fusiform initials are highly elongated, uninucleate with usual cytoplasmic contents (Fig. 2).

Phloem is made up of four types of cells: the sieve-tube elements, companion cells, phloem fibers, and phloem parenchyma. The sieve-tube elements possess simple sieve plates, located in a slightly oblique position. The sieve areas are usually surrounded by variable amounts of callose. Three to four companion cells with comparatively narrow lumen and dense cytoplasmic contents are associated with each sieve-tube element (Fig. 3). The phloem fibres, present in the form of alternating bands, are non-septate with pointed apices and a comparatively narrow lumen. The phloem parenchyma occurs in two patterns: the axial and ray system. The former comprises vertically elongated more or less spindle-shaped strands consisting of 7-9 cells which are of two types — starch-storing and tanniniferous. The cells of the other system are polygonal, arranged in multiseriate and heterogeneous rays. The sieve-tube elements vary in their length from nearly half to slightly shorter than fusiform initials but completely differentiated phloem fibers may acquire lengths up to four times than these. The axial parenchyma strands do not experience any appreciable size change. The cells of the ray parenchyma are longer than the ray initials.

Xylem is made up of the usual three types of cells: vessel elements, xylem fibers, and parenchyma cells. The vessel elements have lignified secondary wall and show pitted thickening (bordered pits) on their end walls with slightly oblique simple plates. The wood fibers, like the phloem fibers are elongated, non-septate with tapering apices. Their walls are highly lignified. Xylem parenchymatous tissue in the axial system consists of two quite distinct cell types: those of the first category belong to the cells of the storage parenchyma system, accumulating large quantities of starch (s.s.p. cells) whereas of the second to the specialized cells associated with the vessels (v.a.p. cells; Fig. 4). The parenchyma in the ray system produces multiseriate and heterogeneous rays. The vessel elements are slightly shorter but 5-6 times broader than the fusiform initials, whereas the completely differentiated wood fibres are

2-2.5 times longer than them. Each starch-storing parenchyma strand consists of four cells, whereas six to nine cells form the vessel-associated parenchyma strand. In xylem too, the ray parenchyma cells are longer than the ray initials.

DISCUSSION

It is obvious from the present investigation that except for the fibers and parenchyma cells, in general the size (particularly length) of the cambial initials corresponds to their derivatives (Fig. 5).

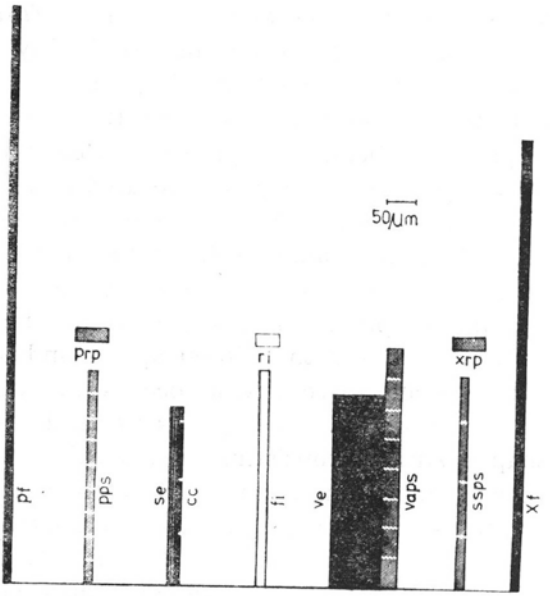

Fig. 5. Histograms showing proportionate size of the cambial initials to their derivatives

cc — companion cells; *fi* — fusiform initial; *pf* — phloem fiber; *pps* — phloem parenchyma strand (with 9 parenchyma cells); *prp* — phloem ray parenchyma cell; *ri* — ray initial; *se* — sieve-tube element; *ssps* — starch-storing parenchyma strand (with 4 parenchyma cells); *vaps* — vessel-associated parenchyma strand (with 8 parenchyma cells); *ve* — vessel element; *xf* — xylem fiber; *xrp* — xylem ray parenchyma cell.

Most of the sieve-tube elements are slightly shorter than the fusiform initials. It is probably due to the shift of oblique end walls of the latter to a more transverse position. On the other hand, a few of the sieve-tube elements are still shorter — nearly half of the length of fusiform initials indicating that transverse or somewhat oblique divisions occur in the sieve element mother cells. The latter results parallel with those of Esau and Cheadle (1955) for numerous species of the genera such as *Ailanthus, Asimina, Buxus, Cercidiphyllum, Clethra, Hypericum* and others (35 species out of 91 investigated) as well as Zahur (1959) for several dicotyledons.

A comparison of the length of fusiform initials and the vessel elements confirms the general affinity proposed by Bailey (1920) and Butterfield (1973). The slight decrease in the length of the vessel elements is due to the rearrangement of the end walls as the fusiform initials have tapering apices whereas the mature vessel elements possess slightly oblique end walls.

As already stated, the xylem parenchyma in axial system comprises two quite distinct cell types: the cells of the normal storage parenchyma and specialized cells associated with the vessels. Czaninski (1964, 1968) proposed a new nomenclature of the cells belonging to the latter category as 'vessel-associated cells', since according to him these have definite and distinct physiological relationship with tracheary system of the xylem. In a recent article, Czaninski (1977) has presented an elaborate analysis as well as electron microscopic details of their organization. In our own survey of a large number of tropical trees of India, drawn from the various families of the dicotyledons, we have found a remarkable range of their distribution and organization patterns — both within the same and different species. We are, therefore, in full agreement with this 'specialized' treatment but forward by Czaninski which is an attempt to rationalize future descriptions. We have, therefore, preferred to call them as vessel-associated parenchyma cells (or v.a.p. cells).

In both xylem and phloem, the size of the cells comprising storage parenchyma strands corresponds to those of the fusiform initials indicating that their progenitors have not undergone much size changes, except for transverse divisions, while forming them. As such, much shorter parenchyma cells are produced. The vessel-associated parenchyma strands have, on the other hand, gained both in length and width, suggesting that the xylem mother cells get elongated as well as laterally expanded at the time of the formation of their strands. The individual v.a.p. cells are, however, smaller but wider than the s.s.p. cells suggesting that more transverse divisions have occurred in the mother cells of the former.

The fibers are very much longer than the fusiform initials due to intrusive growth. These results correspond to those of Bailey (1920), Chattaway (1936), and Ghouse & Yunus (1975).

The enhanced length of the ray parenchyma cells over those of the ray initials is evidently due to their elongation during transformation.

Acknowledgments

The authors are grateful to the Head of Department of Botany for providing laboratory facilities. The work forms a part of the project "Organization, Ultrastructure and seasonal behaviour of cambium and phloem in some Indian trees sanctioned by the UGC, New Delhi to one of us (G.S.P.) and their financial support is gratefully acknowledged.

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Korelacje między wielkością komórek inicjalnych kambium a komórkami pochodnymi u Polyalthia longifolia Thw.

Streszczenie

Porównywano długość i szerokość komórek inicjalnych kambium drzewa tropikalnego *Polyalthia longifolia* Thw. z elementami komórek sitowych, naczyniowych i miękiszowych drewna. Stwierdzono, że rurki sitowe są krótsze, zaś naczynia, a zwłaszcza włókna drewna są znacznie dłuższe od inicjalnych komórek kambialnych.