Size correlations among cambial initials and their derivatives in *Haldina cordifolia* (Roxb.) Ridsdale

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Haldina cordifolia (Roxb.) Ridsdale (Rubiaceae) was selected for size correlation studies beween cambium and its derivative tissues- the phloem and xylem. The cambial organization was found non-storeyed type. The fusiform initials were tangentially elongated with long abruptly tapering ends and their walls have beaded appearance. The ray initials were rectangular and heterogeneous. The fusiform initials experience dimensional changes due to intrusive growth and shifting of their end walls during diffrentiation into elements of axial system in phloem and xylem. Vessel elements were short and broad (6-7 times) as compared to their progenitors. Fibres on both sides become 2 to 3 times longer than their initials. Ray initials did not undergo any marked change during their transformation into phloem and xylem rays.

Key-words - *Haldina cordifolia*, Cambium, Phloem, Xylem.

INTRODUCTION

BAILEY (1920, 1923) and Chattaway (1936) initiated the size variation analysis between cambium and its one or two derivative cell types in coniferales and dicotyledonous trees. Later Dinwoodie (1961), Philipson *et al.* (1971) and Butterfield (1973) have also examined the size variation of xylem elements and their mother cells on the same lines. Ghouse and Yunus (1975), Ghouse and Hashmi (1978), Anand *et al.* (1978), Sharma *et al.* (1979) and Paliwal and Yadav, (1999) have also analysed size variations among the components of cambium, phloem and xylem of some Indian tropical trees. The present investigation was also undertaken to explore the extent of dimensional change in cambial initials during their transformation into their derivative tissues.

MATERIAL AND METHOD

The samples of cambial tissue along with the bark and wood were collected from twigs as well as the main trunks (at chest height) of the two healthy trees of *Haldina cordifolia* in the third week of each month for one complete year. The species belongs to the family Rubiaceae and grows under natural climatic and edaphic conditions around Srinagar (Pauri-Garhwal) along the banks of river Alaknanda at an altitude of nearly 550m. above mean sea level, between 30°13'N latitude and 78°47'E longitude. Large samples were made into small ones and fixed in F.A.A. for 24 hours. Later, these were preserved in 70% alcohol. Sections were obtained on a Spensor's sliding microtome at 15-20µm thickness in transverse and tangential longitudinal planes. Staining was done following the technique outlined by Cheadle *et al.* (1953). Measurements of cambial initials and their derivatives, except vessel elements and fibres, were taken from both tangential longitudinal and transverse sections. The dimension of vessel elements and fibres were recorded after macerating the wood and bark separately. An average of 100 observations have been taken for each type of cambial initials and the elements derived from them.

OBSERVATION

Haldina cordifolia is a large, deciduous tree with a widely spread over crown and having orbicular, pubescent, leathery, 10-25 cm long, stalked leaves. The bark is grey and gets sloughed off in dentations. It occurs throughout the greater part of Burma, Pakistan and in the western Sub-Himalayan tract of India up to 1,000m above mean sea level.

The transectional view of the stem shows distinct outer layers of periderm which are followed by cortex, secondary phloem, vascular cambium, secondary xylem and pith. (Fig. 1A). In the mature phloem,

phloem rays and phloem parenchyma are of increased width. This feature can certainly be connected with the increase in the circumference of the twigs as well as the main trunk as a result of secondary thickening.

A cursory look at the wood suggests that *Haldina cordifolia* has non-storeyed type of cambium (Fig. 1B). The cambium comprises of long, vertically elongated fusiform initials and short, mostly, rectangular and heterogeneous ray initials. The fusiform initials are uni to multinucleate and each nucleus is provided with a single nucleolus. The nuclei of dormant cells are smaller with dense, dark grandular nuclear material as compared to the light and large sized nuclei of the active state. These are of various sizes and shapes from round to oval, elliptical, oblong to fusiform type in the initials of dormant and active periods of cambium. Average size of fusiform initials is 665.82 ±109.69x18.28±1.60µm in the twig and 683.94 ±97.20x21.25±1.55µm in the main trunk respectively. Ray initials are uni-, bi- to tri nucleate and arranged in uni, bi and rarely multiseriate fashion (Fig. 1, B). The dimension of cambial initals and their derivatives have been given in Table 1.

Functional phloem consists of sieve tube elements, companion cells, phloem parenchyma stands and phloem fibers in the axial system and ray parenchyma in the radial system. The sieve tube elements are generally devoid of dense contents except for the slime bodies in their lumen. Compound sieve plates, bearing 5-9 sieve areas in the twig and 6-12 in the main trunk are found at the ends of sieve tube element. Single or rarely two to three companion cells are associated with each sieve-tube elements. On an average, sieve tube elements in the twigs are shorter and narrower (482.41±112.70x17.69±2.05µm) whereas those of the main trunk are longer and broader (602.53±67.80x23.86±2.72µm). The axial parenchyma strands in phloem are vertically elongated, diffuse and have 3-5 compartments. Their size in the twigs as well as in the main trunk does not show any significant change round the year but they show some correlation with the active state or otherwise of the cambium. Their length was recorded to be highest at the time of dormancy or at the comparatively inactive period of the cambium. They possess dense protoplasm including starch grains and lipid droplets

Table 1. Size correlations among cambial initials and their derivatives in the twig and main trunk of *Haldina cordifolia*

Tissue and their elements	Twig		Main Trunk	
	Length (µm)	Width (µm)	Length (µm)	Width (µm)
Phloem				
Sieve-tube elements	482.41 ± 112.79	17.69 ± 2.05	602.58 ± 67.80	23.86 ± 2.72
Companion cells	378.50 ± 123.31	6.51 ± 1.42	486.81 ± 107.58	8.08 ± 0.83
Phloem parenchyma strands	626.53 ± 94.23	16.47 ± 2.72	640.82 ± 116.89	21.90 ± 2.65
Phloem fibres	1087.50 ± 217.22	18.64 ± 3.95	1146.73 ± 56.23	26.63 ± 1.09
Phloem ray cells	37.63 ± 4.66	24.59 ± 3.43	34.00 ± 4.01	25.28 ± 1.61
Cambium				
Fusiform initials	665.80 ± 109.69	18.28 ± 1.60	683.94 ± 97.20	21.25 ± 1.55
Ray initials	12.52 ± 1.92	19.54 ± 2.68	17.28 ± 2.55	24.12 ± 2.49
Xylem				
Vessel elements	734.00 ± 204.67	63.16 ± 13.97	811.20 ± 33.40	93.54 ± 17.43
Xylem parenchyma strands	650.91 ± 101.54	15.60 ± 1.92	654.66 ± 111.13	19.73 ± 1.02
Xylem fibres	1245.12 ± 260.46	19.65 ± 1.93	1974.45 ± 176.11	25.58 ± 3.06
Xylem ray cells	38.36 ± 4.86	17.34 ± 1.81	41.12 ± 4.25	24.63 ± 5.20

Values are the average of 1,200 elements for one year.

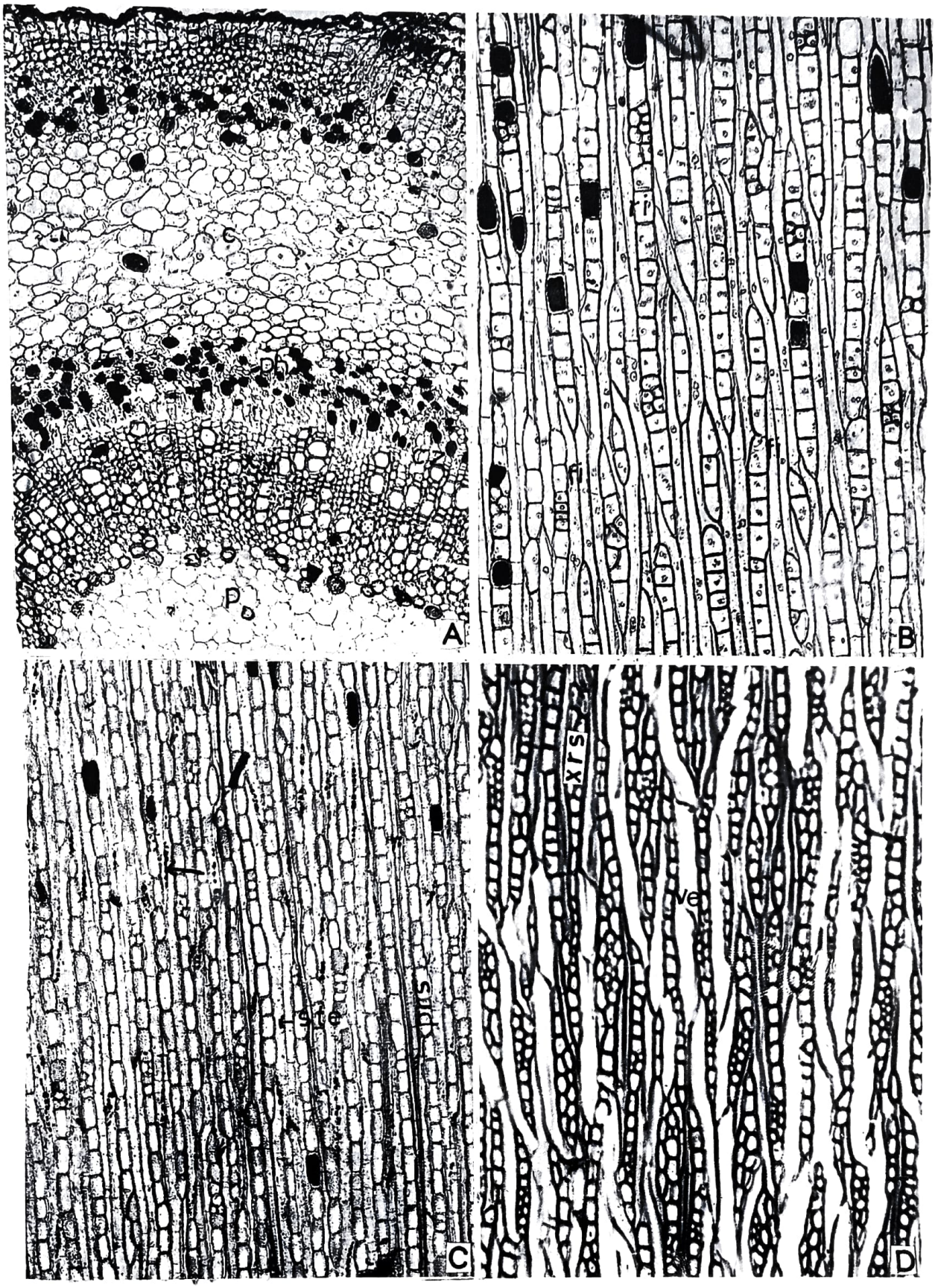


Fig. 1 (A-D) *Haldina cordifolia* (Roxb) Ridsdale. Organization and structure of phloem, cambium and xylem. (c, cortex; cz, cambium; fi, fusiform initial; p, pith; pd, periderm; ph, phloem; prs, phloem ray strand; ri, ray initial; ste, sieve-tube element; ve, vessel elements; xrs, xylem ray strand; xy, xylem.)

A. Microphotograph showing primary as well as secondary structure of stem in transectional view X120.

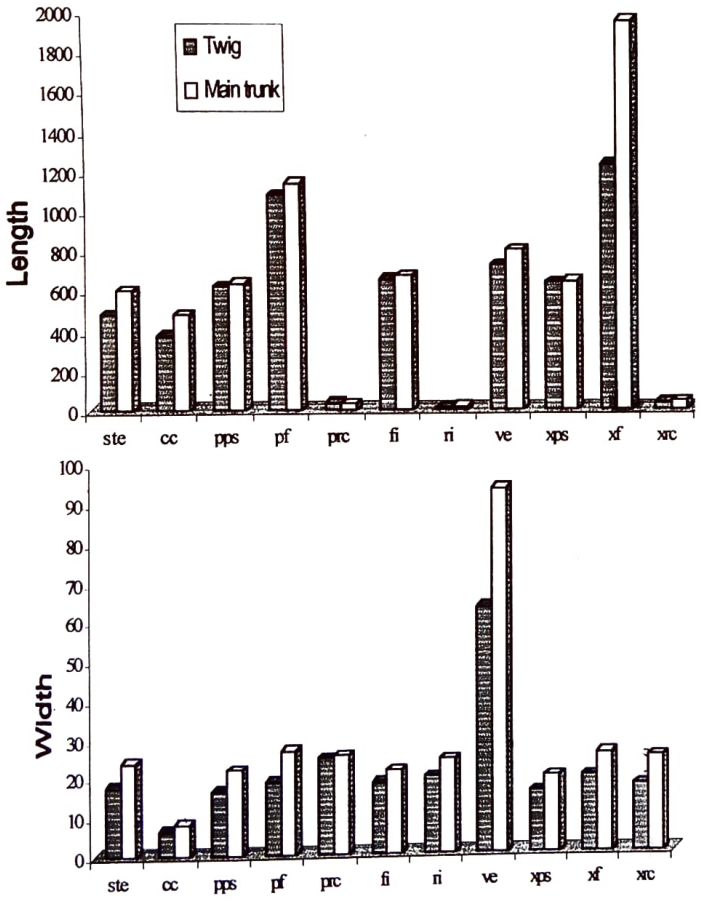
B. Microphotgraph showing non storeyed cambial organization and heterogeneous ray initials X100.

C. Microphotograph showing phloem organization X110.

D. Microphotograph showing xylem organization, small as well as large heterogeneous rays X80.

in their lumen which serve as storage tissues. The phloem fibres are aseptate, thick walled, narrow lumened and have tapered apices. Their average size is certainly more (1146.73±56.23x26.63±1.09µm) in main trunk as compared to same in twigs (1087.50±217.22 x 18.64±3.95µm). The ray cells are heterogeneous, rectangular, elongated, uninucleate, and are arranged mostly in uniseriate and a few in biseriate fashion (only in the middle region few isodiametric cells make them biseriate).

The secondary xylem (Fig. 1A) shows diffuse porous nature and indistinct zone of early and late wood. Xylem is made up of vessel elements, axial parenchyma, xylem fibres and ray parenchyma cells. The vessel elements appear small, angular to circular,



Histogram-1. *Haldiana cordifolia* (Roxb.) Ridsdale. Size correlation among cambial initials and their derivatives in twigs and main trunk. (cc, companion cells; fi, fusiform initials; pf, phloem fibres; pps, phloem parenchyma strands; prc, phloem ray cells; ri, ray initials; ste, sieve-tube elements; ve, vessel elements; xf, xylem fibres; xps, xylem parenchyma strands; xrc, xylem ray cells)

arranged solitarily or in a group of 2-3 forming a pore multiple. An aveage size of vessel elements is 734.00±204.67x63.16±13.97µm in twig and 811.20±33.40x93.54±17.43µm in the main trunk respectively. The axial parenchyma cells are distributed apotracheally and diffuse in aggregate. Each parenchyma strand has 3-7 compartments. The xylem fibers are thick walled and narrow lumened. Their average size is recorded more (1974.45± 76.11x25.53±3.06µm) in the main trunk as compared to the twigs (1245.12±260.46x19.65±1.93µm). Although their forerunners, the fusiform initials are more or less of the same length but their degree of elongation is different which may be due to the age factor. The minimum fibre elongation is noticed in the months of April and July, when first flush of cambial activity is in progress and at peak respectively. Xylem rays are heterogeneous and large. The cells in the middle region of bi- or multiseriaste rays are small, isodiametric, by which the width of the ray in the middle remains same as of the uniseriate tails (Fig. 1D). The length of uniseriate ends is more than the length of bi- or multiseriate region. The xylem rays are predominantly uni (65.10%), bi (34.70%) and rarely mutiseriate (0.20%).

DISCUSSION

It is fully borne out from data presented in Table 1 and Histogram 1 that all the derivatives of cambium undergo changes in their size after and during differentiation. For instance, the sieve-tube elements have been recorded shorter and these broaden only marginally or remain same in the width over the size of fusiform initials. Phloem and xylem parenchyma strands do not show any significant change and retain more or less similar size of their mother cells. The phloem and xylem fibres gain maximum elongation due to intrusive growth of all the components and become 1.5 to 3 times the length of fusiform initials. These results are in agreement with those of Bailey (1920), Chattaway (1936), Ghouse and Siddiqui (1976), Ghouse and Hashmi (1978), Anand *et al.* (1981) and Paliwal and Yadav (1999). Companion cells almost become half in length and 1/3 in width as compared to their progenitors.

The length of vessel elements shows much variation during their differentiation and maturation. On an average these exhibit slight elongation and an appreciable broadening (3-4.5 times) as compared to the size of fusiform initials. It might be due to pseudotranseverse anticlinal divisions of the fusiform initials followed by intrusive growth of the daughter cells. These observations fall within the range recorded by Sharma *et al.* (1979), Sharma (1980) and Singh (1981). As compared to the ray initials, phloem and xylem ray cells are 2 and 3 times longer in twigs and main trunk, respectively. Their width do not show any marked change over the width of their mother cells.

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