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Developmental and Dimensional Changes in the Cambial Fusiform Initials of *Holoptelea integrifolia* (ROXB.) PLANCH.

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Abstract. Divisional activity, intrusive growth of the cell wall and loss of fusiform initials have been studied in *Holoptelea integrifolia*. The dimensional changes in relation to mean length, length frequency, mean width and length variation in relation to fibre length have also been analysed.

Additional index words: Cambial activity; intrusive growth; loss of initials.

The structural studies on cambium of tropical trees are insufficient, compared to the extensive literature available on the cambial structure in temperate species (see GHOUSE and HASHMI 1977). RAO and DAVE (1985a) pointed out that ".... the prevailing information on developmental changes in cambium has been obtained mostly by an analysis of secondary xylem and phloem which may not authenticate the structural and developmental changes in the cambial initials itself". Similarly, although a number of papers have appeared dealing with the variation in size of xylem and phloem fibers in some tropical trees (see KHAN *et al.* 1979), attempts to correlate the size of cambial derivatives to that of cambial initials have been relatively few. AJMAL *et al.* (1985) analysed the size correlations between fusiform cambial initials and xylem derivatives in 10 species of *Eucalyptus*.

The present study was undertaken in continuation of the earlier studies on the developmental changes in the fusiform cambial cells of three angiosperm trees by RAO and DAVE (1985a) and on the cambial activities of *Holoptelea integrifolia* by RAO and DAVE (1985b).

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MATERIAL AND METHODS

Periodic collections of cambial tissue together with the outer wood and inner phloem were carried out from trees of *H. integrifolia* (ROXB.) PLANCH. (*Ulmaceae*). Samples measuring 60 × 20 mm were stripped off from the main stem. Simultaneously small pieces of young branches (measuring 10 mm diameter) were also collected. The samples were cut into small pieces and fixed in FAA and later preserved in 70% alcohol. 12–20 μm thick sections in transverse, tangential and radial planes were cut using a Jung wood microtome and a Reichert sliding microtome. The sections were stained with tannic acid – ferric chloride combination (CHEADLE *et al.* 1953) and toluidine blue (O' BRIEN *et al.* 1964). Measurements of the cambial initials and xylem fibers were made with the help of a projection disc mounted on a Carl Zeiss Research Microscope with planapochromatic objectives.

RESULTS

Structure

Vascular cambium in *Holoptelea* is storied comprising vertically elongated fusiform initials and cuboidal clusters of small ray initials (Fig. 1A).

Fusiform initials are arranged in more or less definite horizontal rows or storeys (Fig. 1A). Occasionally, at some sites of cambium, fusiform initials undergo deviation from storied arrangement and acquire an abnormal pattern of arrangement (Fig. 1B). The length of fusiform initials show marked changes during periodicity of cambium (see RAO and DAVE 1985b). Similarly the nuclei of the uninucleate fusiform initials also undergo changes in dimensions during seasonal activity of cambium (unpublished data).

Periclinal divisions: The occurrence of periclinal divisions in the cambial zone starts in March-April and involves the formation of a vertical cell plate in tangential plane. The cell plate begins to form between the two nuclei and it spreads towards the cell ends (Fig. 1C at arrow).

Anticlinal divisions: The fusiform initials divide anticlinally by the formation of new cell wall in the radial longitudinal plane which intersects the vertical ends of the dividing cell (Fig. 1D at arrows). This results in the two daughter initials lying side by side after division and the absence of any subsequent elongation of these initials permits the development of the characteristic storied pattern. The daughter initials enlarge tangentially which necessitates the radial expansion of the cambial cylinder. Most of the anticlinal divisions occur in the cells that are in contact with ray initials.

Cell wall intrusive growth: The radial walls of fusiform initials during dormant period are thicker with beaded appearance (Fig. 1E) and become thinner during active period. The growth of fusiform cambial cells involves an intrusion of some cells among the others. Being storied, fusiform initials do not show much elongation by intrusive growth. But sometimes one or two cells of one storey may intrude into the adjoining storey (Fig. 1E arrows). Occasionally forking of the ends also occurs (Fig. 1D arrowhead). But intrusion of fusiform initials into ray initials is not noticed in *Holoptelea*.

Loss of initials: Loss of fusiform initials occurs mostly during the active period of cambium. Normally the failing initials do not enlarge and gradually disappear from the cambial zone. Loss and multiplication of cells occur simultaneously in the adjacent radial files of the cambial zone.

Dimensional Changes

Mean length: The fusiform initials slightly change in their length during periodicity of cambium. It ranges from 238 to 304 µm. The mean length is comparatively less in June and August when compared to the cell length in the remaining months.

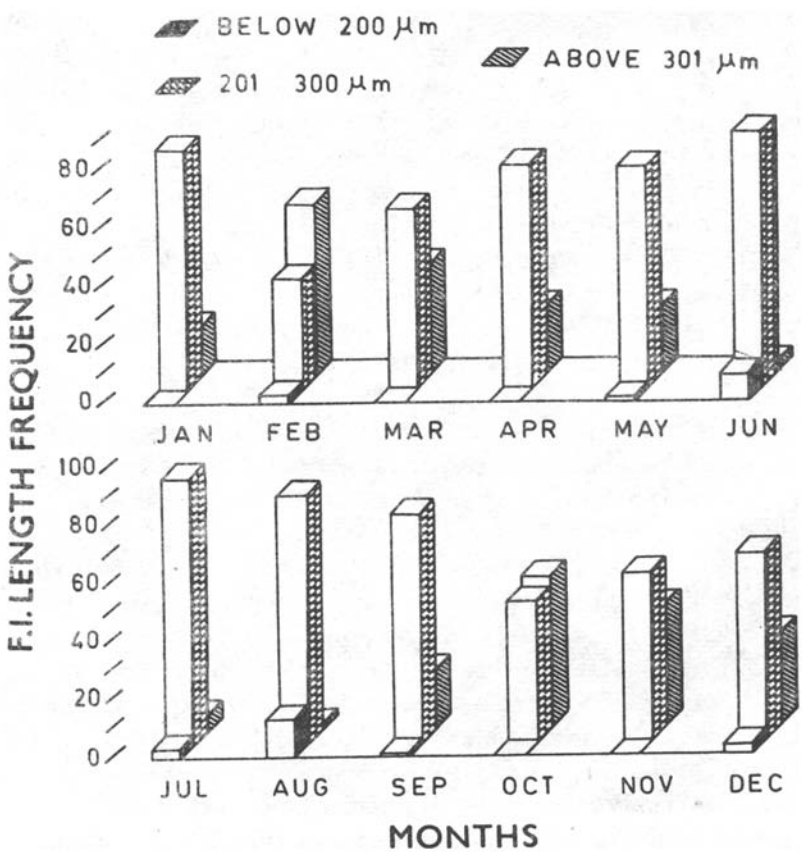

Fig. 2. Histograms showing seasonal variations in the frequency of length classes of fusiform initials.

Length frequency: The length of fusiform initials is divided into three classes and the number of cells representing each class is noted. The variations in the frequency of different length classes are presented in Fig. 2. Class one representing the cells of below 222 μm in length has a very low frequency (10–13%) in all the months and in some months no cell falls under this class. This class has a slightly high frequency in June and August, when the mean cell length is lower. Class two represents the cells of a length ranging from 201 to 300 μm. The frequency of cells in this class is high and dominating the other two classes in all the months except in February (33%) and October (48%). Class three represents the cells of above 301 μm in length. The frequency of cells in this class is high in February (59%) and October (52%) and the changes are paralleled by the changes in mean length.

Mean width: The tangential width of fusiform initials also changes during periodicity of cambium. Maximum nad minimum cell widths are noted in December (25 μm) when cambial activity ceases and in May (18.3 μm) when the cambium is active. The decrease and increase in tangential width correspond to the increase and decrease in mean length of fusiform initials.

Length variation in relation to xylem fibre length: The mean length of fusiform initials and xylem fibres are closely related throughout the year. The variations in the length of fibres involve the same sequence shown by fusiform initials from January to December. However, the mean length of fibres is greater than the mean length of fusiform initials. Fibres are 4.1 to 5.0 and 3.8 to 4.5 times longer than fusiform initials during dormant and active periods of cambium, respectively.

DISCUSSION

Periclinal (tangential) divisions in the cambial zone lead to an increment in the amount of secondary vascular tissue. Periclinal divisions were observed and described for the first time by Bailey (1919). The dividing nucleus is located at the centre of the cell. Towards the end of mitosis, a cell plate – the first step in tangential wall development – forms between the two daughter nuclei.

The circumference of cambium increases by anticlinal divisions, cell elongation and formation of ray initials from fusiform initials. In the structurally less specialized arborescent dicotyledons with relatively long fusiform initials, almost all anticlinal divisions are oblique and the daughter cells elongate considerably producing a non-storied cambium (Bailey 1923). Bailey also suggested that in some highly specialized arborescent dicotyledons with short fusiform initials the anticlinal divisions are radially oriented and the daughter cells expand laterally, but do not elongate to any considerable extent. In *Holoptelea*, anticlinal divisions are radial and rarely oblique.

During dormant period of cambium the radial walls of fusiform initials in *Holoptelea* are thick with conspicuous beaded nature as observed in *Tectona* and

Gmelina by RAO and DAVE (1985a). The daughter cells formed after oblique division undergo rapid elongation and the elongating end walls penetrate the intracellular spaces of adjacent cells and glide over them. However, this apical elongation in fusiform initials by intrusive growth occurs to a minimum extent only in *Holoptelea* when compared to those in certain angiosperm trees (RAO and DAVE 1985A).

The storied type of cambium develops as a result of predominant radial longitudinal divisions in fusiform initials followed by lateral rather then intrusive growth. Transition from non-storied to storied cambium has been noted by CHALK (1937) and EAMES and MACDANIELS (1947). In *Holoptelea* the storied cambium at times shows an intermediate condition as observed in *Fraxinus excelsior* (KRAWCZYSYN 1977). This kind of an intermediate arrangement of cells between storied and non-storied is probably due to the intrusive growth of the fusiform initials as reported in storied cambium by HEJNOWICZ and ZAGORSKA-MAREK (1974) and ZAGORSKA-MAREK (1975).

The amount of loss of fusiform initials from the cambium depends on the frequency of anticlinal divisions and rate of elongation of initials together with the rate of increase in circumference of the cambium (PHILIPSON *et al.* 1971). The loss of fusiform initials in *Holoptelea* during the active period of cambium is probably due to the over-production of cells which exceed the cambial zone requirement.

Changes in the length of fusiform initials are just one aspect of the profound modifications which take place in the cambial zone during the life of plants (CATESSON 1974). In *Holoptelea* the fusiform initials show slight variations in their dimensions and volume. The mean length and width of fusiform initials during seasonal periodicity of cambium ranges from 238–304 μm and 18–25 μm, respectively. The frequency distribution of different length classes indicates that higher mean length corresponds with the greater frequency of the higher class and a shorter length corresponds with the less frequency of the lower class.

Sequence of divisions and changes in size of the cambial initials can be obtained by studying the secondary xylem, since divisions are more frequent on the xylem side. Only a few results are published on the size relationship between cambial cells and their derivative elements (PHILIPSON *et al.* 1971, MAHAMOODUZZAFAR and IQBAL 1986). ANAND *et al.* (1978) and SHARMA *et al.* (1979) studied the size variations of cambial initials and their derivatives in the xylem and phloem of *Dalbergia sissoo* and *Polyalthia longifolia*, respectively. The periodic changes in the length of fusiform initials are reflected in the variation in length in the resulting xylem cells (ESAU 1977). From the present study of the size variation of fusiform initials and xylem fibers in relation to season, it is evident that in *Holoptelea* a definite correlation exists throughout the year, as the cambial cells leave a record of their activities in their derivatives. CHATTAWAY (1936) has observed that the fibers in dicotyledonous wood are 1.1 to 9.5 times longer than the cambial initials. AJMAL *et al.* (1985) also noted that in *Eucalyptus* species while the fibre length increases 1.75 to 2.75

times, their width on the other hand, remains more or less equal to that of the mother initials. In *Holoptelea* the xylem fibres are 3.8 to 5.0 times longer than fusiform initials and hence fall under the range recorder by CHATTAWAY (1936).

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Fig. 1 at the end of the issue

BOOK REVIEW

DUNBAR, B. S.: TWO-DIMENSIONAL ELECTROPHORESIS AND IMMUNOLOGICAL TECHNIQUES. – Plenum Press, New York – London 1988. 371 pp., 127 figs. US $ 59.50.

The book is divided into two methodically connected parts dealing with two-dimensional electrophoresis and immunological techniques.

The first part summarizes the principles of electrophoretic methods starting with the introduction into the basic theories of the electrophoresis (movement of molecules in electrical field, choise of buffers for electrophoresis, basic types of electrophoresis), and the basic principles of polyacrylamide gel electrophoresis with the accent on the role of catalysts (initiators) in acrylamide polymerization, acrylamide pore size and SDS-acrylamide gel electrophoresis.

The following parts of the book concern the practical application to and strategies for using polyacrylamide gel electrophoresis in the fields of purification of proteins and peptide mapping.

Special chapters deal with the sample preparation for electrophoresis and protein detection in polyacrylamide gel electrophoresis, including the isotopic labelling of protein for electrophoresis analysis.

An important part of this book is devoted to strategies for using the polyacrylamide gel electrophoresis in the preparation and characterization of antibodies. This is a very useful review of the isolation of monoclonal and polyclonal antibodies immunization procedures and of methods for immunoglobulins purification and detection.

The readers will find here plenty of photographic material which can help to a full understanding of the topic studied.

The book is a useful laboratory manual and can be recommended to all research workers who begin to use some of these techniques in their research program.

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