Chapter 1

Introduction

Euphorbiaceae is one of the most diverse and largest dicot family with about 326 genera and over 8935 species (Govaerts, *et al.*, 2000). This family is having a significant position among the other taxa as many of its members possess the most important plant product 'latex'. The occurrence of latex has been reported in various plants belonging to dicots, monocots and even pteridophytes (Bras, 1957; Metcalfe, 1967; Romberger, *et al.*, 1995). The milky latex of *H. brasiliensis* (para rubber) is the sole source of Natural Rubber (NR) which almost satisfies the needs of Rubber Industry. World NR output has reached up to 8.4 million tons in 2004 (Malaysian Rubber Review, 2005).

Hevea brasiliensis, a perennial tree species belonging to the family Euphorbiaceae, is the major contributor of NR. Even though laticiferous species account for several thousands, only about 2000 species contain rubber hydrocarbon in their latex. Among these, 500 species have been experimented as the source of NR (Bonner and Galston, 1947). Latex vessels or laticiferous tissues are specialized cells or tissues in which latex is synthesized and stored. Economically, the rubber content in the latex is an important criterion which differentiate many species, as source of NR. In this regard, *H. brasiliensis* stands top as it possesses very high NR content compared to other rubber yielding plants (Raghavendra, 1991).

1.1 The genus *Hevea*

The primary centre of origin of the genus *Hevea* is the Amazon basin of South America and the surrounding regions of Manas, Mato Gross and Acre. Natural habitat of different species of *Hevea* are also found in Brazil, Bolivia, Colombia, Ecuador, French Guiana, Guyana, Peru, Surinam and Venezuela (Wycherley, 1992).

Under the genus *Hevea*, 10 species have been recognized so far *viz. H.guianensis, H. brasiliensis, H pauciflora, H. spruceana, H.rigidifolia, H. benthamiana, H .nitida, H. microphylla, H. camporum* and *H.camargoana* in the order of first descriptions of the concepts (Schultes, 1970; 1977; 1987; Wycherley, 1992; Annamma and Abraham, 2005).

1.2 Structural organization of bark and distribution of laticifers in *Hevea*

Bobilioff (1923) and Gomez (1982) have described different cell types and organization of *Hevea* bark. During the course of secondary growth, cambial derivatives divide the wood elements and phloem elements towards the inside and outside, respectively. The whole phloem tissue formed exterior to the cambium is termed as bark.

Anatomically *Hevea* bark consists of two distint zones, the inner soft bark and the outer hard bark (Bryce and Campbell, 1917). Laticifers are differentiated from the fusiform initials of the cambium, in the form of concentric rings, alternating with other phloic elements such as sieve tubes, companion cells, phloem fibres, axial parenchyma and ray parenchyma. Due to the continued activity of the vascular cambium new laticifers are differentiated and the older ones are pushed outwards. Outer zone of bark is hard due to the occurrence of copious amount of sclerified stone cells.

In cross section of bark, latex vessels appear as more or less circular in shape and remain almost parallel to the cambium. In radial longitudinal plane, latex vessels look like tubular structure in different rows. The rows are arranged as straight tubes running in between other phloic tissues. Eventhough rare connections have been reported in between latex vessel rows (Arisz, 1918; 1919), most of the other researchers reported the absence of such radial connections between laticifer rows (Arens, 1911; Meunier, 1912; Kaimal, 1951). In tangential longitudinal sections, laticifers resembled anastomosing network of tubes, weaving round the phloic rays.

1.3 Alignment of phloic elements in the bark

Petch (1911) made the first observation about the orientation of wood elements, when bark was stripped off. Out of 25 trees observed, wood elements were oriented vertically in seven trees and towards the right in 18 trees. Later, De Jong (1916) studied the angle of inclination of latex vessels in 93 trees and reported an average angle of inclination of 3.7° to the right from the vertical.

An authentic investigation to determine the angle of wood elements in *H. brasiliensis,* was that of Gomez and Chen (1967). Of the 28 clones studied, all of them showed an average rightward inclination of laticifers ranging from 2.1° to 7.1°. Out of this, three clones *viz.* RRIM 600, BD 5 and RRIM 618 had groups of trees with leftward inclination of latex vessels within the range of 3.22° to 3.84°. They also noticed the inclination of laticifers in seedling trees with a rightward inclination of 4.2° to 5.1°.

1.4 Tapping

Tapping is the process of controlled wounding of the bark for latex extraction. The evolution and development of modern tapping system resulted in the economic exploitation of the rubber crop (Ridley, 1897; Abraham and Tayler, 1967). It has been demonstrated that rubber trees can be regularly exploited by periodic excision of shavings of bark along a tapping cut made on the tree trunk in a spiral fashion. The present system of tapping was formulated based on various experiments conducted on the anatomy and physiology of *Hevea* (De Jong 1916; Bobilioff, 1923; Mass, 1925). Tapping process is carried out by using tapping knives (Wright, 1912). Generally, tapping is performed on rubber tree by means of half spiral cut from upper left to lower right at a specific angle of 25° for seedlings and 30° for budded trees (Vijayakumar *et al.*, 2000). To avoid confusion and difficulty regarding the notations while dealing with different tapping systems, International Rubber Research and Development Board (IRRDB) has formulated a tapping notation for *Hevea* which was later revised by Lukman (1983).

1.5 Slope of tapping cut and tissue alignment

During the early evolution of modern tapping system, one of the most intriguing question was that whether the slope of the spiral cut should be to the left or to the right. Petch (1911) recommended left hand cut for more yield than right hand cut based on the finding of rightward inclination of wood elements in *Hevea*.

De Jong (1916) calculated the extra yield of left hand slope over the right, for various angles of cut, with a deviation of 3.5° of the latex vessels to the right. These theoretical results proved to be important while, comparing with the practical results on seedling trees (Mass, 1925) and budded trees (Rubber Research Institute of Malaya, 1940). Similar studies conducted by Dijkman (1951) also proved the extra yield on tapping in relation to the inclination of latex vessels.

Gomez and Chen (1967) also thoroughly discussed the advantages and disadvantages of steepening the slope of cut in buddings from the recommended 30° for buddings to 45° considering the latex vessel inclination at 3-4° towards the right and observed an yield increase upto 2-3% whereas the length of tapping cut has been increased by 22%. Similar result was also observed in seedling trees. Thus steepening of the tapping cut resulted in higher bark consumption which is considered as a serious disadvantage. In this context Gomez and Chen (1967) opined that a thorough knowledge of the inclination of latex vessels in *Hevea* should be essential before adopting the system of tapping. The survey of literature revealed that detailed investigation in this line has not been conducted so far.

1.6 Relevance of the present study

In the above circumstances, understanding the actual alignment, orientation and angle of inclination of laticifers and other phloic elements in the bark of rubber tree, pertaining to the exploitation of this perennial crop for latex yield is of utmost significance. This would enable to categorize different clones which are having specific pattern of inclination and orientation of laticifers. Similarly studies on the interrelationship with various bark characters as well as factors influencing the orientation of latex vessel in the bark tissue also helps to derive appropriate clonal specific exploitation systems.

In this context a detailed investigation on the structure of bark of *Hevea brasiliensis* with special reference to alignment of phloic elements and clonal variability has been carried out in ten clones of *Hevea brasiliensis* in the mature phase. Attempt was also made to understand the inclination pattern of laticifers in the juvenile growth phase of *H. brasiliensis*. The present investigation was carried out with the following objectives:

1. Structure of bark of *Hevea*
2. Variation of different structural characters within clones and between clones
3. The alignment and angle of inclination of laticiferous tissue and phloic elements
4. Angle of inclination of laticifers in seedling and budded trees at the juvenile stage
5. Structural factors affecting inclination of latex vessels in the bark
6. Association and interrelationship of various structural characters of bark
7. Histochemical status of different reserve metabolites in the bark