Natural Rubber : Agromanagement and Crop Processing
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Chapter 3

The Para rubber tree

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1. INTRODUCTION

Hevea brasiliensis, the Para rubber tree, provides 99 per cent of the global natural rubber. Rubber is a constituent of latex, a milky substance produced in the laticiferous tissues. Latex is present in almost all parts of the plant, but the laticifers exploited commercially are those in the bark, and are also known as latex vessels. These latex vessels are developed by the activity of vascular cambium. The rate of cambial activity shows seasonal variation (Rao, 1975; Premakumari *et al.*, 1981). The least rate of cambial growth is from May to July with an increasing trend from August under the climatic conditions of South India (Premakumari, 1992). The highest growth is during November to January.

2. MORPHOLOGY

The plant is a sturdy perennial tree which attains a height of about 30 m. The tree has a straight trunk with light grey bark. Branches are usually developed to form an open leafy crown. The branching habit and crown shape vary among clones.

2.1 Leaf

The leaves are arranged in groups or storeys. From each storey, a cluster of spirally-arranged, trifoliate, glabrous leaves (Plate 4. a) is produced. Morphologically distinct stages of leaf development are described (RRIM, 1971; Premakumari *et al.*, 1989) as bud break stage (bud emerged and just grown to a length of nearly 2 cm), leaflet stage (leaves of the terminal flush still expanding and copper brown to red in colour), pendant stage (leaves almost completely expanded and green but still limp), hardened stage (leaves fully expanded but just hardened with erect lamina) and fully hardened (lamina more stiff and darkened). The petioles are long, usually about 15 cm, with extrafloral nectaries present in the region of insertion of the leaflets (Plate 4. b). The shape, size and number of nectariferous glands vary among clones. Variations in the orientation of petioles and petiolules among clones have been observed. Proximal and distal pulvini of the petiole are characteristics of *Hevea* leaf, the size and orientation of which show clonal differences. The leaflets also show slight variations in shape, margin and relative position. They are short-stalked, elliptic or obovate, with a green or dark green colour above and a paler glaucous beneath. The venation is pinnate type. Variations in leaf morphology are useful parameters for clone identification (Mercykutty *et al.*, 1991).

2.2 Flower

Rubber is a deciduous tree that winters from December to February in South India. Wintering may be either complete or partial depending upon the clone, age of the plants, seasonal factors, location, *etc.* (George *et al.*, 1967). Refoliation and flowering follow wintering. Occasional off-season flowering is observed during September and October. Flowers are short-stalked and fragrant. Both male and female flowers are seen on the same inflorescence (Plate 4. c) which is a pyramid-shaped panicle. The sex ratio shows wide differences among clones. A flower has one whorl of bell-shaped perianth with five yellow lobes. Male flowers are smaller in size but more in number than the female flowers. There are 10 stamens arranged on a slender staminal column in two whorls of five each. Female flowers are seen at the tip of the panicle and its branchlets. They are bigger in size and have green disc below the perianth and ovary. Gynoecium is tricarpellary and syncarpous with an ovule in each locule. Stigma is short-styled and three-lobed.

Pollination in *H. brasiliensis* is by insects. Sticky pollen and stigmatic surfaces indicate the typical entomophilous nature of the flower. When the inflorescence was enclosed in insect proof bags no fruit set was observed (Jayarathnam, 1965). Ceratopogonid midges of the *Forcipomyia* spp. were found to be the major and effective pollinators. Many other species of insects also visit the flowers.

2.3 Fruit and seed

After fertilization, the ovary develops into a three-lobed dehiscent capsule, regma, (Plate 4. d) with three large mottled seeds. Fruit set is generally very low. Fruits ripen five to six months after fertilization. The dry fruit dehisces with a loud noise, breaking the pericarp into six pieces, and seeds are thrown to a distance of about 15 m.

The seed consists of a fairly thick testa enclosing a soft kernel. Seeds of seedling trees and clones show variations in weight, size, shape and seed-coat markings. The weight of seeds may vary from 4 to 6 g. The seed-coat shows mottled or blotched patterns of brown and grey shades. As the seed-coat is formed by the mother tree, generally the pattern of all seeds follow the maternal characteristics regardless of the male parent. The mottlings of seed-coat and the micropyle form infallible characteristics in clone identification (Polhamus, 1962; Saraswathyamma *et al.*, 1981; Mercykutty *et al.*, 1991). Each seed has a dorsal and ventral side. There may be frontal and lateral depressions (Plate 4. e). The prominence of the ridge may vary. Seed-coat may be smooth, rough or shiny. The mature seed has a fully developed embryo and an oily endosperm. The endosperm is massive and fills the seed completely. Nearly 37 per cent by weight of the seed is shell and the rest, kernel. Dried kernel has nearly 47 per cent oil content.

3. CYTOLOGY

There are no genetic or chromosomal barriers among the 10 species of *Hevea*. Hence, all of them can be incorporated in the experimental crosses. The chromosome counts made by various workers showed variations as 2n = 16, 34 and 36 (Heusser, 1919; Bangham, 1931; Paddock, 1943; Perry, 1943; Ong, 1976), but detailed cytological investigations (Ramaer, 1935; Saraswathyamma *et al.*, 1984) have confirmed that the chromosome complement of *Hevea* in the somatic cell is 2n = 2x = 36 (Plate 5. a). Metaphase chromosomes of somatic cells of *H. brasiliensis* differ from one another in size and shape. The chromosomes are small and vary in length and the total chromosome length of the species is 89.7 µm. Meiotic division is regular (Plate 5. b) and pollen fertility in *H. brasiliensis* is over 80 per cent (Saraswathyamma, 1990).

Karyomorphological analysis of four clones of *Hevea brasiliensis, viz.* RRIM 600, GT 1, PB 235 and PB 314 was also carried out (Sankariammal and Saraswathyamma, 1995). There was gross similarity in the karyotype. However, on critical analysis, significant differences in chromosome morphology with reference to centromeric position and total chromosome length were observed.

Spontaneous male sterile clones have been observed and meiotic abnormalities reported in *H. brasiliensis* and among the hybrids of *H. spruceana* and *H. brasiliensis* (Ramaer, 1935). Three male sterile clones were reported in *H. brasiliensis, viz.* GT 1, Ch 2 and RRII 35 (Saraswathyamma *et al.*, 1988; Saraswathyamma, 1990). RRII 17 is a completely sterile clone (both male and female flowers) and sterility is due to desynapsis abnormalities in the chromosome pairing (Saraswathyamma *et al.*, 1990a). Male sterility could be induced by irradiation (Saraswathyamma *et al.*, 1990b) and by treatment with a chemical (ethyl methane sulphonate). Transfusion of chromatin material from one cell to another through cytoplasmic connections (cytomixis) was noted in the radiation induced mutant (Saraswathyamma and Panikkar, 1988). A triploid plant (2n = 3x = 54) in *H. brasiliensis* (Nazeer and Saraswathyamma, 1987), another one in *H. guianensis* and a haploid (2n = 18) in *H. pauciflora* have been reported (Baldwin, 1947). Induced tetraploids of RRII 105, RRII 116, PB 5/51, PR 107 and Tjir 1 having a chromosome complement of 2n = 4x = 72 were developed in *H. brasiliensis* by the application of colchicine, an alkaloid. Wide variation was noted in the meiotic behaviour of the tetraploids of RRII 105 (Saraswathyamma, 1990) and RRII 116 (Sankariammal and Saraswathyamma, 1997). An artificial triploid (2n = 3x = 54) was synthesized by crossing diploid (normal rubber plant) with tetraploid (Saraswathyamma *et al.*, 1984). A wide range of meiotic abnormalities was noted in the triploid, tetraploid, radiation induced mutant and RRII 17 (Saraswathyamma, 1997). These newly evolved materials can enrich the genetic reservoir of *Hevea*.

4. ANATOMY

4.1 Bark

Earlier studies on *Hevea* anatomy were limited to bark structure and laticifer characters (Bobilioff, 1923; Gomez, 1981, 1982; Premakumari *et al.*, 1985b). All the tissue outside the cambium is collectively termed bark. Mature bark has an inner zone which is soft, an intermediate zone which is hard and an outermost protective region consisting of layers of cork cells. The soft zone of the bark is known as soft bast and the hard zone hard bast. Stone cells are abundant in the hard bast region. They occur in groups, appear as dark patches and provide mechanical strength and rigidity to the bark. The hard bast also contains sieve tubes and latex vessels which are discontinuous and non-functional. The soft bast contains most of the functional elements of the bark and consists of latex vessels, sieve tubes, phloem rays and axial parenchyma.

The trunk of seedling trees tapers and the thickness of bark decreases upwards. Moreover, the number of latex vessel rows is more towards the base and decreases towards the level of the first branches. Budded trees, in contrast, have an almost cylindrical trunk and hence bark thickness and number of latex vessel rows are more or less uniform at different levels of the trunk. Latex vessels in the stem and branches show the same structure. Their number, however, is comparatively less in the branches. The bark of a budded tree, in general, is thinner than that of a seedling tree. The distribution of latex vessels is wider in thicker bark and closer in thinner bark (Premakumari *et al.*, 1990). Hence for vigorous clones with thin bark, deep tapping is recommended in order to cut open more number of latex vessel rows, to obtain an economic yield. In the reverse condition, increasing the depth of tapping does not lead to increase in yield. When the distribution pattern of latex vessel rows in virgin and renewed bark is considered, the proportion of vessel rows in the first millimetre from the cambium is higher for renewed bark. Hence, deep tapping to cut open sufficient number of latex vessels would be beneficial when renewed bark is exploited (Premakumari, 1992).

Latex vessels of *Hevea* are articulated and anastomosing. They originate from cells produced by the vascular cambium and are arranged in rows. The vessels do not have a straight vertical course within the bark. Generally, they run in anti-clockwise direction, the angle of inclination varying from 2 to 7° (Gomez, 1981) to the axis of the tree, weaving up the phloem in a zig-zag orientation (Premakumari *et al.*, 1988a). The extent of waviness of the latex vessel depends on the size and distribution of phloem rays which are also clonal characters (Premakumari *et al.*, 1993a). Latex vessels within the same ring are tangentially interconnected. There is practically no connection between latex vessel rows. In transverse sections of the bark they are in discrete concentric rings which are straight tubes in radial longitudinal view. In tangential longitudinal sections, the whole structure looks like an expanded mesh work (Plate 5. c). Latex vessel characters such as number of rows, density of vessels per row, diameter of latex vessels and intensity of anastomosing are significant clonal characters (Premakumari *et al.*, 1985b). The cross-sectional area of latex vessels per unit length of tapping cut (laticifer area index) in a tree and the orientation of laticifers together contribute significantly to the annual mean and summer drop of yield of *Hevea* clones (Premakumari *et al.*, 1993a,b).

On tapping, a thin layer of bark consisting of the hard bast and major part of the soft bast is removed. A thin layer of the innermost region of soft bast along with the vascular cambium, known as residual bark, is left intact. Bark renewal takes place and the renewed bark is also exploited later. The immediate effect of tapping is shrinkage of the outermost cells on the wounded surface of bark which undergoes necrosis. The cells below these enlarge and divide in irregular planes and subsequently become oriented parallel to the severed surface (Panikkar, 1974). From the new meristematic layer, a wound phellogen is differentiated which produces wound periderm. Cork cells of the wound periderm are reddish owing to the presence of anthocyanin. The phloem tissue, including latex vessels, is regenerated by the activity of vascular cambium. Thus the residual bark, wound periderm and the tissue produced by the vascular cambium together constitute the renewed bark. The rate of bark regeneration is a clonal character which depends on the thickness of residual bark, period of regeneration and climatic factors.

4.2 Leaf

Leaf epidermis is unilayered. Leaf stomata are confined to the lower epidermis and epicuticular waxes are prominently formed, making the lower surface more rough and glaucous (Plate 5. d). Stomata also occur on the veins, petioles and on other plant parts such as fruit walls and young stem (Premakumari *et al.*, 1979; Premakumari and Panikkar, 1984). The stomata on such organs are larger and more exposed and are suitable sites of disease infection (Premakumari *et al.*, 1989). Density of petiolar stomata is a reliable criterion for selection of clones tolerant/susceptible to *Phytophthora* leaf fall disease (Premakumari *et al.*, 1988b). Powdery mildew disease occurs on young leaves, before the pendant stage, which is attributed to the difference in rate of epicuticular wax formation at the different phenological stages of leaves (Premakumari *et al.*, 1992).

4.3 Wood

Hevea wood is diffuse-porous and straight grained. It is homogenous with no heartwood and sapwood differentiation. Tyloses are present in older vessels. Tension wood is of common occurrence (Panikkar, 1974; Reghu *et al.*, 1989) the proportion of which varies with the different levels of the trunk. Wood parenchyma is apotracheal and banded in distribution. Starch content is also abundant.

Intraxylary phloem occurs at the pericentral region of the wood (Plate 5. e) in association with the protoxylem (Premakumari *et al.*, 1985a). Clones vary significantly for the quantity of intraxylary phloem (Premakumari, 1992) and occurrence of high quantity of internal phloem was found to be beneficial (Premakumari and Panikkar, 1988) to reduce girth retardation on tapping.

5. GROWTH SPECIALITIES

In *Hevea*, cell fusion by cell wall dissolution is a common feature. The development of laticifers is by the dissolution of cell walls of the laticifer derivatives. Stomatal guard cells are formed by cell fusion, a special phenomenon observed in this species (Premakumari, 1992).

Fasciation, a growth phenomenon of forming flattened stem with clustured cell division, is sometimes observed in the budwood nursery, when shoot regeneration takes place (Thomas, 1993). This can also be attributed to the fusion tendency of cell walls in this species.

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