Natural Rubber : Agromanagement and Crop Processing
Editors : P. J. George and C. Kuruvilla Jacob

Chapter 2

Rubber yielding plants

P. J. George and A. O. N. Panikkar

1. INTRODUCTION

Natural rubber (NR) is one of the cell constituents of several plant species. Most of the rubber producing plants have latex, but in a few, tiny rubber particles are scattered in the tissues. Majority of the rubber bearing plants belong to a few plant families like Euphorbiaceae, Moraceae, Apocyanaceae and Asteraceae, but the presence of latex is not an indication of any taxonomic relationship (Metcalfe, 1966). However, all laticiferous plants do not contain rubber. Of the several thousand laticiferous species in the plant kingdom only about 2000 contain rubber in their latex. Among those, 500 have been tried as sources of NR (Bonner and Galston, 1947). Latex is synthesized by and contained in specialized cells or tissues which permeate bark, leaves and other parts of the plants.

Rubber content may vary widely in different species which limits their consideration as sources of NR (Raghavendra, 1991). In species which are not laticiferous, rubber extraction has to be done by mechanical and chemical means. In laticiferous plants where

the rubber content in latex is comparatively high, latex is obtained by specific wounding techniques and the rubber recovered by relatively simple methods. In many species, rubber content is too little to consider it as a source of rubber.

Hevea brasiliensis is the most important source of NR and the other rubber bearing plants are of minor importance. Among the alternative sources of NR, less important species of the genus *Hevea, Manihot glaziovii, Parthenium argentatum, Castilla elastica, Ficus elastica, Cryptostegia* spp., *Taraxacum kok-saghyz* and *Funtumia elastica* only merit mention.

2. THE GENUS *HEVEA*

The genus *Hevea*, belonging to the family Euphorbiaceae, grows wild in the Amazon basin and in the surrounding regions of Manaus, Mato Grosso and Acre. Although the different species of *Hevea* prefer varying habitats, all are found in Brazil. *Hevea* is also found growing naturally in Bolivia, Colombia, Ecuador, French Guiana, Guyana, Peru, Surinam and Venezuela (Wycherley, 1977). Based on taxonomic description, ten species *H. benthamiana, H. brasiliensis, H. camargoana, H. camporum, H. guianensis, H. microphylla, H. nitida, H. pauciflora, H. rigidifolia* and *H. spruceana* have been recognized in the genus (Schultes, 1970; 1977; 1987; Wycherley, 1992).

There is considerable variation in growth pattern, both within and between species, ranging from the very tall trees of *H. brasiliensis* (growing to a height of 40 m) to the shrubby habit of *H. nitida* var. *toxicodendroides* and *H. camporum*, which are usually little more than 2 m in height. Xeromorphic traits such as lignotubers have been reported in plants growing under savannah conditions. The 'short shoot' or 'spur' pattern of growth, in which internodes are highly compressed and marked by scale leaves has been observed in many of the species and is regarded as the typical growth pattern of the genus (Wycherley, 1992). The juvenile period (till flowering) for most species is not known though in *H. brasiliensis* and a few others it is normally five years. *H. camargoana* is extremely precocious and flowers within one year of planting the seed.

The genus *Hevea* has trifoliate leaves which droop backwards with the laminae pressed against each other at emergence. Subsequently, the leaves assume various positions from reclinate in most species, to erect as in *H. guianensis*. Leaflets are obovate to elliptical in shape. Varying degrees of pubescence on the abaxial surface of the leaves are seen in different species. Nectaries are present at the junction of the three petiolules.

All species of *Hevea* are monoecious and bear unisexual flowers in the same inflorescence. Racemose panicles arise in the axils of scale leaves and a few of the lower normal leaves. The male flowers are much more numerous than the female, which are bigger and found terminating the main branches of the panicle. The flowers are typically pentamerous with a bell-shaped, five-lobed perianth. Flowers in most cases are yellow in colour. The pistillate flowers do not have a pronounced torus except in the case of *H. microphylla*. The central axis in the male flowers is occupied by the staminal column and by the pistil in the female flowers. A disc is found at the base of the central axis which may be strongly or weakly developed depending on the species. There are normally 10 sessile anthers arranged in two whorls on the central staminal column in most of the species. In some species, the number varies from three to nine and the arrangement may

be in one or two irregular whorls. The gynoecium is tricarpellary syncarpous. The ovary is superior, trilocular with axile placentation and one ovule in each locule. Stigma is three lobed and usually sessile.

The fruit in all species is a trilocular regma, each locule containing one seed. The seeds vary in size depending on the species and are mottled. Seed viability in all species is short.

2.1 *Hevea benthamiana* Muell. Arg.

H. benthamiana grows well in areas prone to flooding. The trees are medium sized, 20 to 24 m in height (Plate 2. a). The trunk is usually swollen at the base. Leaflets are papyraceous, lanceolate and horizontal and have a soft reddish or brown pubescence beneath. Flowers are yellow and seeds are small, ovoid and greyish with rich brown mottling. It hybridizes rather freely with other species of *Hevea*. Latex is white and the rubber is of good quality.

2.2 *Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell. Arg.

H. brasiliensis, the well-known species of the genus, is widely distributed over a fair range of habitats and covers over two-thirds of the geographical area of distribution of *Hevea* in its centre of origin. Of all the species of the genus, *H. brasiliensis* is the only one grown commercially as the source of NR. This industrial crop species supplies more than 99 per cent of the world's NR.

2.3 *Hevea camargoana* Pires

This is the most recently reported species and is restricted to the Marajo Island in the Amazon delta. The trees are small to medium in size and grow in transition savannahs and woodlands near swamps and streams. Leaves are glabrous with pale green undersides. It is extremely precocious and flowers within one year of planting. Flowers are whitish with rose-red colouration at the base and have only one whorl of three to five anthers. Seeds are small.

2.4 *Hevea camporum* Ducke

H. camporum is endemic to far South Amazon tributaries. The trees are small, usually attain a height less than 2 m and grow in dry savannahs. Flowers are yellow. The seeds are the smallest in the genus and are grey in colour with blackish spots. Latex is white but its properties are unknown.

2.5 *Hevea guianensis* Aubl.

The *H. guianensis* complex comprises of typical *H. guianensis*, a widespread and variable variety *H. guianensis* var. *lutea* and a localized somewhat enigmatic form *H. guianensis* var. *marginata*. *H. guianensis* grows in well-drained areas, from sea level up to 760 m. It is tall, attaining a height of 24 to 27 m with a cylindrical trunk. Branches are formed at a high level and the crown is compact. Leaflets are membraneous to subcoriaceous, usually obovate, and short acuminate. The leaflets when mature are borne erect and this character is peculiar to this species. *Hevea guianensis* and *H. guianensis* var. *lutea* have five anthers, arranged in one regular whorl in the former but in one irregular or two

regular whorls in the latter. Seeds are angular in shape. *H. guianensis* produces a cream yellow latex which is of an inferior quality. Of the other varieties, *H. guianensis* var. *lutea*, is also tall while *H. guianensis* var. *marginata*, is much smaller in size.

2.6 *Hevea microphylla* Ule

Trees are slender, reaching a height of about 21 m with a whip-like trunk slightly swollen at the base and sparse crown. It grows along deeply flooded river banks. Leaflets are reclinate and papyraceous. *H. microphylla* has the largest female flowers in the genus, with a distinctive, greatly swollen torus. Bark is reddish and brittle. The fruit of *H. microphylla* is yellow with green stripes and a bright red tip. The triangular coriaceous (not woody) capsule and the pyramidal shape are characteristic of the species. Unlike other species, the capsule opens slowly and the seeds are not ejected violently. Latex is white and watery with very little rubber.

2.7 *Hevea nitida* Mart. ex Muell. Arg.

This is a small to medium-sized tree, usually growing in quartzitic or sandy areas. It has a cylindrical trunk with characteristic red brown bark. Leaflets are strongly reclinate and markedly folded upwards from the midrib. Both surfaces are bright glossy green. Flowers are pale yellow or whitish yellow. The fruits have reddish tips and the seeds are angular in shape. Latex is pure white in colour with high resin and low rubber content and has anticoagulant properties. *H. nitida* var. *toxicodendroides* is a shrub about 2 m tall and has smaller seeds than *H. nitida*.

2.8 *Hevea pauciflora* (Spr. ex Benth.) Muell. Arg.

H. pauciflora is a stout tree growing to a height of about 27 m, with a cylindrical trunk and brittle, dark brown bark. It prefers well-drained rocky hill slopes. Leaflets are usually reclinate, papyraceous and lanceolate and have blunt tips with a subterminal gland beneath. Fruits have reddish tips and seeds are comparatively large in size. It produces a white or dull, sticky latex, rich in resins and containing a weak and hardly elastic rubber. *H. pauciflora* is a rare tree of the Rio Negro, though the variety *coriacea* is widely distributed. The flowers of *H. pauciflora* var. *coriacea* have a reddish colour at the base, and its seeds are markedly smaller.

2.9 *Hevea rigidifolia* (Spr. ex Benth.) Muell. Arg.

This is a rare species in the genus endemic to the uppermost Rio Negro. The tree, which grows to a height of 12 to 18 m, has a slender cylindrical trunk and a small crown. Leaflets are glabrous, glossy, rigid, very thick and leathery. Flowers are large. Usually only six anthers, in two irregular whorls, are present. Fruit tips are red in colour. The white latex, which contains resins, does not yield good quality rubber.

2.10 *Hevea spruceana* (Benth.) Muell. Arg.

H. spruceana usually grows on river banks prone to flooding. The tree is medium sized with a swollen trunk and a comparatively dense crown of membraneous leaves with whitish pubescence on the underside. Flowers are large, red or brownish purple in colour and excessively pungent. Fruits open slowly. The seeds, which are the largest in the genus, are ventrally compressed, long and angular. Latex is white and watery.

3. OTHER RUBBER BEARING SPECIES

Prior to the identification of the genus *Hevea* as the most economic source of NR, plants belonging to a wide spectrum of families (Table 1) had been exploited for natural rubber (George, 1994). Among these, extractable quantities of rubber could be obtained from *Manihot glaziovii, Parthenium argentatum, Castilla elastica, Ficus elastica, Cryptostegia grandiflora, Taraxacum kok-saghyz* and *Funtumia elastica.*

Table 1. Rubber bearing species other than *Hevea*

Family	Botanical name	Country/Region	Habit	Common name
Euphorbiaceae	*Manihot glaziovii*	North East Brazil	Tree	Ceara (Manicoba) rubber
	M. dichotoma			
	Sapium thompsonii	Colombia	Tree	
	Euphorbia intisy	Madagascar	Tree	
	E. resinifera	Morocco	Cactoid	
Moraceae	*Castilla elastica*	Central America	Tree	Castilla (Panama) rubber
	C. ulei	High regions of Amazon	Tree	
	Ficus elastica	India, Burma	Tree	Assam rubber
Apocynaceae	*Funtumia elastica*	African coast	Tree	Lagos silk rubber
	Landolphia heudelotii	African coast, Sudan	Climbing vine	
	L. owariensis	West Africa	Climbing vine	Red Congo rubber
	L. madagascariensis	Madagascar	Climbing vine	
	Clitandra sp.	Tropical Africa	Climbing vine	Black Congo (Root) rubber
Asteraceae	*Parthenium argentatum*	North Mexico	Shrub	Guayule (Mexican) rubber
	Scorzonera tau-saghyz	Russia	Shrub	Russian dandelion rubber
	Taraxacum kok-saghyz	Crimea	Shrub	Russian dandelion rubber
Asclepiadaceae	*Cryptostegia grandiflora*	Madagascar	Vine	Madagascar (Palay) rubber
	Hancornia speciosa	Brazil (Bahia Mato Grosso)		Mangabeira rubber
	Calotropis procera	Venezuela	Shrub	
	Urceola elastica	North West Bengal	Tree	White Assam rubber

Adapted from Le Bras, 1957

3.1 *Manihot glaziovii* Muell. Arg.

Manihot glaziovii, the Ceara (Manicoba) rubber was a source of NR exploited in its native land, Brazil, for a long period even before the plant was botanically identified (Seelingman *et al.*, 1910). Ceara rubber was introduced into India in 1877 (RBGK, 1907). The tree is tall (10–15 m) dichotomously branched (Plate 2. b), with palmately-lobed (usually 3–5 lobes), glabrous, light green leaves (Plate 2. c). The flowers are unisexual with male flowers clustered at the top of the panicle. The fruit is a three-lobed globular capsule with small planoconvex seeds having a tough, brilliant and mottled integument. The tree can be propagated through seeds and vegetative cuttings.

M. glaziovii grows well in dry rocky areas. The tree attains a girth of 50 cm in about four years. The bark has an easily peelable leathery rhytidome which helps in moisture retention in the bark. Beneath the rhytidome the bark is smooth, soft and white to green in colour, rich in chlorophyll and with horizontal lenticels (George and Reghu, 1994). The latex vessels are articulated and are situated away from the cambium

(George, 1994). The bark is sufficiently thick for tapping. Due to the spontaneous coagulating nature of latex, the slope of the tapping cut should be steeper than that for *Hevea* to ensure easy flow.

The latex is white and thick. A dry rubber content of about 25 per cent has been noted in some trees. The latex diluted with equal quantity of water and kept overnight, coagulates perfectly, without adding any coagulating agent. The potential yield is estimated as 500 kg per ha (George, 1993) which could further be improved if crop improvement is attempted.

The seeds of *M. glaziovii* contain 40.88 per cent oil. This oil was once used in Brazil as fuel for motor vehicles (Serier, 1988). The wood is little exploited, but may be useful after appropriate treatments. As the leaves contain 25 to 30 per cent protein, it can be used as cattle feed after removing the hydrocyanic acid content (CSIR, 1962). *M. glaziovii* is also useful as an off-season source of nectar and pollen for bee forage in *Hevea*-based apiaries (Nehru *et al.*, 1989). Being a xerothermic plant, it is suitable as a life support species in marginal lands.

3. 2 *Parthenium argentatum* Gray.

This species, known as guayule (pronounced wy-oo-lee) or Mexican rubber, is a desert shrub native to the Chihuahuan desert of Texas and Mexico, where rainfall is low and erratic. Guayule provided about 10 per cent of the world's NR in the first half of the twentieth century. Now this plant is again receiving considerable attention as a source of NR in countries like Mexico and USA where cultivation of *Hevea* is not possible. Guayule grows best in well-drained soils with an annual rainfall of 230 to 400 mm and can withstand a temperature range of –18 to 49°C.

P. argentatum, a member of the sunflower family (Asteraceae), is a bushy shrub, attaining a height of about 60 cm (Plate 2. d). The plant develops a deep tap root with extensive lateral roots that spread up to 3 m. The stem is branched and the leaves are alternate, narrow and wax-coated. It is grey-green in colour with a characteristic silvery sheen which gives the species its name. Flowers are arranged in capitate inflorescences borne on long stalks. The plant is a prolific seeder. Guayule is seed-propagated. Vegetative propagation through grafts and cuttings is also possible. Rubber is contained in single, thin-walled cells in most parts of the plant except leaves. Such cells are concentrated more in the cortical region and medullary rays. The rubber particles are suspended in the cell sap. Two-thirds of the rubber is contained in the stem and branches, and the roots contain the rest.

Rubber content in *P. argentatum* is highly variable and the species shows wide genetic variability. In varietal trials, 8.9 per cent rubber content has been reported (Estilai and Ray, 1991). The plant produces little or no rubber when the growth is luxuriant (NAS, 1977). Rubber synthesis is triggered by environmental stress like cool weather and reduced moisture availability. Yield increase up to two to six times could be achieved by spraying bioregulators (NAS, 1977). The potential yield of improved varieties is estimated to be 600 to 900 kg per ha (Estilai and Ray, 1991). Guayule produces high molecular weight rubber comparable to that from *Hevea*. As tapping is not possible, the entire plant with the root

system is harvested. Alternatively, the stand is lopped at a height of 5 cm above the ground level to allow coppice. Rubber is extracted by mechano-chemical means. The first step is dipping in hot water of about 75°C for approximately 10 min to coagulate the rubber in the cells so that deterioration during processing is decreased and separation simplified. This process also removes soil and leaves, thus reducing the bulk of the matter to be handled subsequently and improves the quality of the final product. It is then hammer-milled and pulped with addition of caustic soda. Rubber and resin agglomerate into a spongy substance, known as guayule worms. The worms and the bagasse are separated in large slurry tanks. The worms are rinsed in water to remove caustic soda and warmed in water containing a little surfactant. The worms contain about 17 to 25 per cent resin which is removed by acetone extraction. The residual acetone is removed by steam sparging and the rubber, which still contains about two per cent resin and small quantities of debris, is dried in hot air. Further purification is done by solvent methods to give a product of uniform quality. Guayule cultivation demands high input for mechanized operations and its productivity is low. The rubber is inferior to *Hevea* rubber in several respects (NAS, 1977). However, guayule has become useful in development of hypo-allergenic latex for the manufacture of hypo-allergenic latex products for medical use (Cornish and Siler, 1996).

3.3 *Castilla elastica* Cerv.

Belonging to the family Moraceae, *Castilla elastica* was once used as a source of NR known as Castilla or Panama rubber (Polhamus, 1962). The tree is distributed in Mexico, Bolivia and Brazil. It is large, attaining a height of 20 m or more with a stout trunk (Plate 3. a). Leaves are large and simple and the crown is dense. The tree is monoecious and both male and female flowers occur in the same cluster. The ovary has only one ovule and the fruit is a drupe. The tap root is rather short with several very long lateral roots spreading horizontally close to the surface. Propagation is through seeds but vegetative propagation by cuttings is also possible. Bark is relatively smooth, but difficult to tap. The latex vessels are elongated single cells and are found in the bark of roots, trunk and branches. They also occur in leaves, fruits and pith. The trees are tapped when eight to ten years of age with a very sharp machete or knife, making deep cuts up to the wood. Latex flows for a very long period (Schery, 1954). Bark renewal is slow and the regenerated bark forms thick callus tissues and is more difficult to tap. The latex is relatively stable and its regeneration is slow. *C. elastica* and *C. ulei* were known since 1794 and were sources of NR till 1850. The natives used to coagulate latex with plant juices, alum and by boiling or exposure to air (Hill, 1952).

3.4 *Ficus elastica* Roxb.

This plant, known as Assam or Rambong rubber tree, was one of the earliest sources of NR in tropical Asia. The tree, belonging to the family Moraceae, is a native of Asia and was originally described from Assam. It is very large and spreading, tree with numerous, huge buttress roots (Plate 3. b,c). *F. elastica* is usually propagated by cuttings and the tree requires 12 to 15 years to reach tapping age. It grows well under hot climatic conditions with heavy rainfall. Stem and buttresses are tapped. Latex is produced in long latex tubes. Bark is fibrous and tapping is difficult. Latex is very stable and rubber is of inferior quality.

3.5 *Cryptostegia grandiflora* R.Br.

C. grandiflora and *C. madagascariensis*, known as rubber vine or Palay rubber, are ornamental woody climbers belonging to the family Asclepiadaceae. Though native to Madagascar, the species are now found in the tropics and subtropics. *C. grandiflora* (Plate 3. d) is commonly found in India. It is adapted to wide variations in soil and climate and grows well from arid desert to humid tropics. The climber puts forth long, whip-like branches. Leaves are entire, glossy and opposite. Flowers are large, showy, bell-shaped and purplish. Leaves of *C. madagascariensis* are thicker, smaller and more glossy. Flowers are smaller with deep purple colour. Hybrids of these species are also recognized. Propagation is easy and is through seeds. Vegetative propagation through cuttings is also successful. Latex vessels are of the non-articulated, branched type and they occur in bark, pith and leaves. The common method of exploitation is tip bleeding. The tender shoots are tied together, and the tips are chopped. The exuding latex, which coagulates and dries on the cut ends, is collected.

3.6 *Taraxacum kok-saghyz* Rodin

The Russian dandelion, *Taraxacum kok-saghyz*, of the family Asteraceae is the source of dandelion rubber discovered in Russia in 1931. It is a perennial herb adapted to severe winter and drought. Natural stands are seen at elevations of 1800 to 1900 m above sea level. The tap root is long and often twisted. In cultivation, it branches and all the main branches grow vertically. The leaves are arranged in rosettes and show variation in size and shape. The branched laticifers are of the articulated type and are chiefly concentrated in the phloem region of the root. The plant is propagated by seeds. The roots are harvested, cleaned and the rubber is extracted by mechano- chemical methods. *T. megalorhizon*, another species commonly known as krim-saghyz, is also a minor source of natural rubber and has greater adaptability.

3.7 *Funtumia elastica* Stapf

Funtumia elastica of the family Apocynaceae is the source of Lagos silk rubber. The tree which is tall and slender, is found in Tropical Africa. It prefers a well-drained soil. Bark is thin and tapping is by double herringbone system. Latex is stable, but coagulates spontaneously on exposure to air and its regeneration is relatively very slow. Propagation is by seeds.

REFERENCES

Bonner, J. M. and Galston, A.W. (1947). The physiology and biochemistry of rubber formation in plants. *Botanical Review*, 13 : 543-596.

Cornish, K. and Siler, D.J. (1996). Hypoallergenic guayule latex provides the only immediate natural rubber solution to life threatening *Hevea* latex allergy. *Proceedings of the Third International Conference on Industrial Crops and Products*, USDA-ARS, USA, pp. 262-266.

CSIR (1962). Wealth of India : Raw materials. Council of Scientific and Industrial Research, New Delhi, 6 : 297-298.

Estilai, A. and Ray, T. (1991). Genetics, cytogenetics and breeding of guayule. In : *Guayule Natural Rubber: A Technical Publication with Emphasis on Recent Findings* (Eds. J.W. Whitworth and E.E. Whiteread). USDA, University of Arizona, Arizona, pp. 47-91.

George, P. J. (1993). Ceara rubber (*Manihot glaziovii* Muell. Arg.) : A drought resistant tree for semi-arid and marginal lands. *Rubber Board Bulletin*, **27**(1) : 25-28.

George, P. J. (1994). *Studies on Manihot glaziovii Muell. Arg. with special reference to its potentiality as an alternative source of natural rubber.* Ph.D. Thesis, Mahatma Gandhi University, Kottayam, India. 214 p.

George, P. J. and Reghu, C. P. (1994). Collecting Ceara rubber (*M. glaziovii* Muell. Arg.) germplasm. *Indian Journal of Plant Genetic Resources*, **7**(2) : 151-155.

Hill, A. F. (1952). Economic botany. Ed. 2. Tata McGraw-Hill Publishing Co. Ltd., New Delhi, p. 140.

Le Bras, J. (1957). Rubber : Fundamentals of its science and technology. Chemical Publishing Co. Inc., New York, p. 47.

Metcalfe, C. R. (1966). Distribution of latex in the plant kingdom. In : *Notes from the Jordell Laboratory*. Royal Botanical Gardens, Kew, p. 3.

NAS (1977). Guayule : An alternative source of natural rubber. National Academy of Science, Washington D.C., 80 p.

Nehru, C. R., Thankamony, S., Jayarathnam, K. and Joseph, P. M. L. (1989). Nectar and pollen plants for extending the flow period in rubber-growing areas in India. *Bee World*, 70(3) : 118-119.

Polhamus, L. G. (1962). Rubber: Botany, production and utilization. Leonard Hill (Books) Ltd., London, 450 p.

Raghavendra, A. S. (1991). Latex exudation from rubber tree, *Hevea brasiliensis*. In : *Physiology of Trees* (Ed. A.S. Raghavendra). John Wiley and Sons. Inc., New York, pp. 403-417.

RBGK (1907). Distribution of rubber plants from Kew. *Bulletin of Miscellaneous Information*, Royal Botanic Gardens, Kew, 3 : 103-105.

Schery, R. (1954). Plants for man. Alow and Unwin, London.

Schultes, R.E. (1970). The history of taxonomic studies in *Hevea*. *The Botanical Review*, 36(3) : 197-276.

Schultes, R.E. (1977). Wild *Hevea* : An untapped source of germplasm. *Journal of the Rubber Research Institute of Sri Lanka*,. 54 : 227-257.

Schultes, R.E. (1987). Studies in the genus *Hevea:* 8. Notes on infraspecific variants of *Hevea brasiliensis* (Euphorbiaceae). *Economic Botany*, 41(2) : 125-147.

Seelingman, T., Torrihon, L. and Faleonnet, H. (1910). India rubber and gutta percha. Scott Greenwood and Son, London, 408 p.

Serier, J.B. (1988). Le Manicoba : Histoire, biologie, culture, interest economic. *Revue Generale des Caoutchouc et Plastiques*, 677 : 117-122.

Wycherley, P.R. (1977). The genus *Hevea*. *Workshop on International Collaboration in Hevea Breeding and the Collection and Establishment of Material from the Neotropics*, 1977, Kuala Lumpur, Malaysia, 12 p.

Wycherley, P.R. (1992). The genus *Hevea* : Botanical aspects. In: *Natural Rubber : Biology, Cultivation and Technology* (Eds. M.R. Sethuraj and N. M. Mathew). Elsevier, Amsterdam, pp. 50-66.