427

RUBBER PLANTING MATERIALS : A REVIEW

1. CLASSIFICATION AND CHOICE OF PLANTING MATERIALS

C. K. Saraswathy Amma, Joseph G. Marattukalam
and A.O.N. Panikkar

Introduction

Hevea brasiliensis (Willd. ex A. Juss) Muell. Arg, the Para rubber tree belonging to the family Euphorbiaceae, produces 99% of the natural rubber in the world. Natural rubber is one of the most versatile vegetable products. The material has manifold uses. More than 35,000 articles are manufactured from this material and there is hardly any segment of life which does not make use of rubber based products. This has resulted in the tremendous increase in the demand for this product. Rubber plantations have profound influence on the economic and social life of the people of several countries. Over thirty million people in the world are dependent on Natural Rubber for their livelihood. World natural rubber production during 1986 was reported to be 4,430,000 tonnes and the consumptino was 4,385,000 tonnes. The total area under rubber cultivation all over the world is about 7,717,000 ha. The main rubber growing countries are Indonesia (2,674,023 ha. 1985) Malaysia (1,944,227 ha. 1985) Thailand (1,620,160 ha. (1984) China (4,53,000 ha. 1982) India (3,62,000 ha, 1985) and Sri Lanka (2,05,508 ha, 1985). The rubber tree is also grown in Nigeria, Liberia, Vietnam, Zaire, Burma, Phillipines, Ivory Coast, Cambodia, Brazil, Bangladesh, Mexico, Cameroon United Republic, etc.

Hevea brasiliensis is a perennial tree having an economic life span of over thirty years. Because of this unusually long life span selection of planting material should be done with utmost care. If by carelessness or ignorance a poor or undesirable material is planted, the resulting disadvantages will have to be born by the grower over this long period. For the selection of appropriate planting materials a thorough knowledge about the different planting materials is imperative.

Seeds and clones

The rubber tree is propagated both generatively and vegetatively. Generative reproduction is carried out through seeds while vegetative propagation is by cloning. The progeny produced through generative methods always show wide variations and there is no genetic uniformity among the trees raised from seeds. Seeds obtained from seedling trees are called ordinary seeds. Ordinary seeds collected indiscriminately are termed ordinary unselected seeds whereas those collected only from selected trees are named ordinary selected seeds. Clonal seeds are those collected from clonal (budgrafted) populations. Such seeds if collected from monoclonal areas are called monoclonal seeds. Polyclonal seeds are clonal seeds collected from polyclonal areas. When both the parents are known, the term legitimate seed is used and if both the parents are not known they are called illegitimate seeds. In case only one parent is known, the seed is called illegitimate seed of that particular parent.

A group of plants produced by vegetative propagation from a single tree, directly or indirectly, is termed a clone. All the individual trees of a clone possess identical genetic constitution, which is responsible for the uniformity existing among them. Based on the origin, clones are broadly classified into three categories, namely primary, secondary and tertiary. Clones developed from mother trees of unknown parentage are called primary clones. These mother trees are selected from existing seedling populations on the basis of their desirable characteristics. They are then multiplied vegetatively to give rise to the primary clones. Many popular clones like Tjir 1, GT, 1, Gl 1, PR 107, PB 86, PB 28|59 and LCB 1320 belong to this category. Secondary clones are developed from hybrid trees which are the resultant of controlled pollination among two primary clones. These trees are then multiplied vegetatively to raise the respective clonal populations as in the case of primary clones. Most of the modern clones like RRII 105 (Tjir 1 x Gl 1), RRIM 600 (Tjir 1 x PB 86), RRII 208 (Mil 3|2 x AVROS 255) and PB 5|51 (PB 56 x PB 24) belong to this category. Tertiary clones are also produced by controlled pollination of two clones, but they differ from the secondary clones in that at least one of the parents is a secondary clone. Sometimes both the parents may be secondary clones. An example for the former is RRIM 719 resultant of a cross between PB 86 a primary clone and RRIM 623, a secondary clone (PB 49 x Pil B 84). Clone RRIM 708, developed by crossing two secondary clones RRIM 501 (Pil A 44 x Lun N) and RRIM 623 (PB 49 x Pil B 84), is an example for the latter. Many of the latest clones such as RRIM 703, 707, 712, PB 260 also are tertiary clones.

Clones as a planting material has got many advantages. The most important among them is the uniformity exhibited by different individuals, which is due to their uniform genotypic constitution. All the individual trees of a clone under identical conditions show very little variation with regard to their different characters such as growth, vigour, bark thickness, yield, latex properties, wintering, refoliation and tolerance to diseases. This enables the planter to carry out cultural operations in a more uniform, easy and economic manner. For example due to uniform growth vigour number of trees that have to be thinned out is always less in the case of clones. Hence only the required number need be planted in a unit area than seedlings. This results in reduction in the cost of planting and maintenance. Due to uniformity in the properties of latex, it could

The authors are with Rubber Research Institute India, Kottayam 686 009.

be readily used for specific purposes demanding uniformity of properties. Modern high yielding clones have more productaion potential compared to seedling populations. Since there are quite a number of clones with specific characteristics, selection of materials for specific requirement is also possible in the case of clones.

Planting material recommendations

The Rubber Board issues planting material recommendation for the country every year, based on the information available on the performance of the different materials. Materials under category I are proven ones and can be planted on a large scale without any restriction. It is however desirable to use as many materials as possible while undertaking large scale planting. In the case of large estates, it is preferable to reserve 20% of the area for material under the other categories. Currently RRII 105, RRIM 600 and GT 1 are included under category I. Category II consists of old clones which still show good performance in certain localities and promising new clones which are yet to be fully tested. Therefore 20% of area of large estates can be reserved for planting these materials. Buddings of clones PR 107, PB 5|51, Tjir 1, Gl 1, PB 86, PB 5|139, PB 6|9, PB 28|59, RRIM 605, RRIM 623, RRIM 628, 701, 703, RRII 118 and approved polyclonal seeds are included under this category. Clones recommended for experimental planting are included under category III. These clones are released for experimental planting based on the encouraging performance in the small scale trial in India or on the basis of their performance in other countries. There is restriction in planting these materials. Only large growers are allowed to plant this material, as experimental planting, to a maximum of 10% of the area. Buddings of clones RRII 1, 2, 4, 5, 6, 43, 44, 116, 203, 206, 208, 300, 308, RRIM 704, 705, 706, 707, PB 206, 213, 215, 217, 230, 235, 240, 242, 252, RRIC 7, 36, 45, 52, 100, 102, 104, 105, CH 153, Harbel 1 and Wagga 6278 are included in this category. In addition to these, any other promising materials specially approved by the Chairman, Rubber Board on merits under request in individual cases, are also included in this category.

Clone identification

There are morphological variations among different clones. For the identification of clones, certain distinguishing characteristics are helpful. Shape and size of seeds and the pattern of mottlings on them show variations. Seeds of RRIM 600, RRII 208, Mil 3|2, RRII 118 and PB 5|51 are small compared to those of RRIM 623, LCB 1320, PB 86, Tjir 1, Gl 1 and RRII 105. Seeds of RRII 118 have more prominent mottlings. Ridges and frontal depressions are very prominent in certain clones like PR 107. The growth form and appearance of young buddings are characteristic of some other clones. The spindly growth of RRIM 600 can be easily distinguished. In mature trees, shape of the trunk in most of the clones is cylindrical, but there are crooked stems as in PB 6|9 and leaning stems as in Tjir 16. Texture of the bark surface is another feature. Branching habit, growth pattern and the angle of union between stem and branch also vary in different clones. Regular spread of light horizontal branches arranged from the main trunk is characteristic of PB 5|51. In clones like Tjir 1 and RRIM 605 a few heavy branches start from the same point. The shape of crown is also another identifying characteristic. Tre crown of GT 1 is globular or slightly conical and that if RRIM 600 is fan shaped. PB 5|51 shows characteristic conical crown with light and sparse foliage. Colour, texture, shape, position of the leaflets with respect to each other, etc also show clonal variations. Leaves of RRII 105 and GT 1 are dark, green and glossy, those of Gl 1 glossy and bluish green while the leaves of AVROS 255 and RRII 208 are glossy and pale green. Leaf lamina shows wavy margin in clones like PR 107, War 4 and PB 186. Colour of latex can also be considered as a clue to identity of clones. Latex of RRIM 600, PB 86 and RRII 208 is white while that of Tjir 1 shows a pale yellow tinge. Coagulam of certain clones, like that of RRII 203, has tendency for discolouration (blackening).

Choice of planting materials

The profitability of a rubber plantation is closely correlated to the planting materials used. Therefore utmost importance should be given for selecting the planting materials. The performance of planting materials. depends on their genetic constitution and the interaction of environmental factors in the given locality. The performance of planting materials vary widely in different localities. Hence it is necessary that the choice of planting material for any locality has to be done most carefully.

The desirable attributes of a clone are high initial yield, high average yield throughout the economic life span, good vigour and other glowth habits, good response to low intensity tapping, tolerance to common drought, cold and other stress conditions. The environmental factors that influence the performance of a planting material are soil type and terrain, high incidence of diseases, pattern of rainfall, severity of wind forces, severity and duration of drought and temperature. Due consideration of the characteristics of the planting materials as well as the environmental constraints is therefore imperative in the choice of planting materials.

Environmax planting

Realising the influence of environment on the performance of planting materials the Rubber Research Institute of Malaysia has been recommending Environmax planting since 1977. The Environmax concept in choice of clones was developed to maximise the productivity of an area subject to the constraints present. This was done with a view to avoiding predictable adverse interactions between secondary clonal effects and the inhibitory environmental factors. Under this system the rubber growing areas are to be divided into environs which display the factors that act as constraints in the selection of clones. Specific clones are then recommended for each environ. Depending upon the additional informations obtained about clonal characteristics as well as environmental factors, the recommendation of clones are to be revised periodically.

For ranking clones there must be sufficient information regarding clonal characteristics and environmental factors. In other words, information on the performance of different planting materials in varying environmental conditions is a basic requirement for the adoption of this practice. Depending on the available details regarding the agroclimatic condition and soil profile the traditional rubber growing areas in India can broadly be classified into five regions.

1. Kanyakumari region:
   More or less distributed rainfall, laterite and red soils, available magnesium content high, *oidium* incidence high.

2. Central region (Trivandrum, Quilon, Kottayam, Idikki, Ernakulum and part of Trichur district):
   Moderate to high rainfall, laterite soil, soil nutrient status poor in general, incidence of *Phytophthora* and pink diseases high.

3. Calicut and Cannanore region:
   South west monsoon strong, followed by severe drought, laterite and lateritic soils, with pockets of red soils, available magnesium high, incidence of *Phytophthora* and pink diseases high.

4. *Palghat, Malappuram and part of Trichur region*:
   Low rainfall, moderate to severe drought, subjected to strong wind, soils in general fertile, incidence of *Phytophthora* and pink diseases high.

5. Karnataka region:
   South west monsoon strong, plolonged drought, soils poor in available nutrients, incidence of *Phytophthora* and *Oidium* diseases likely to be high.

However, minor environmental variations do occur within each region. Also a particular environ may be found in different regions.

The non-traditional rubber growing areas comprise mainly of the Andaman and Nicobar Islands and the north eastern region. The climatic conditions in the Andaman-Nicobar region are better suited to rubber as there is no pronounced wet and dry seasons. However, there is wide variation in soil conditions. There is strong wind also in the area.

The North Eastern region comprises of Tripura, Meghalaya, Assam, Mizoram etc. The south-west monsoon is high and the north-east monsoon is not very prevalent. The drought period is fairly long. The terrain is generally hilly. Winter season is pronounced and prolonged, with very low temperature. Soil is generally sandly to loamy, deep and deficient in major nutrients in Tripura, while it is loamy to clayey and more fertile in Assam and Meghalaya. Incidence of diseases is comparatively very low in this region.

Clones suited for different regions could be chosen on the basis of their genetic potentialities and response to environmental conditions. Depending upon the available information the following categorisation can be made.

Area		*Clones suggested*
1. Severe *Phyphthora*	:	GT 1, PB 5|51 RRIM 623, 628, 701, RRII 105
2. High incidence of *Phytophthora* and Pink	:	GT 1, PB 5|51, PB 235, PB 260
3. Subjected to severe wind	:	GT 1, PB 5|51, PR 107, Gl 1, PB 217, Haikan 1.
4. Exposed to severe wind and pink	:	GT 1, PR 107, PB 5|51, PB 235, PB 260
5. High incidence of *Oidium*	:	GT 1, PR 107, RRIM 600, RRIM 703, RRII 105, PB 255, 260
6. Exposed to severe wind, pink and *Oidium*	:	GT 1, PR 107, PB 260
7. Strong wind, low rainfall moderate to high drought	:	Gl 1, RRII 118, RRIM 600
8. Subjected to severe cold	.	SCAT 93-114
9. Undefined areas	:	GT 1, PB 5|51, 28|59, PB 217, 235, 255, 260 PR 107, RRIM 600, RRII 105, 118.

The clones suggested for a particular locality only indicate that their performance in the concerned tract will be better than that of other clones currently available. The ideal condition would be the choice of specific clones possessing characters best suited to each locality.

References

Anonymous 1953. Seed gardens for estates. Plrs' Bull. Rubb. Res. Inst. Malaya No. 4: 14-21.

Anonymous 1975. Environmax planting recommendation 1975-76. Plrs' Bull. Rubb. Res. Inst. Malaysia. No. 137: 27-50.

Anonymous 1977. Environmax planting recommendation 1977-78. Plrs' Bull. Rubb. Res. Inst. Malaysia, No. 153: 163-182.

Anonymous 1986. Quarterly Natural Rubber Statistical bulletin. Volume 11 No. 1, P. 41-48.

Anonymous 1987. Rubber Statistical bulletin Vol. 41, No. 8, P. 6, 7, 44.

Anonymous 1987. Rubber Grower's Companion 1987. The Rubber Board, Kottayam.

Anonymous 1987. Rubber planting materials approved for 1987. The Rubber Board, Kottayam.

Dijkman, M.J. 1951. *Hevea. Thirty years of research in the Far East*. University of Miami Press, Florida.

Edgar, A.T. 1958. *Manual of rubber planting*. The incorporated society of planters Kuala Lumpur.

Polhamus, L.G. 1962. *Rubber* Leonard Hill (Books) Ltd. London.

Radhakrishna Pillai, P.U. 1980. Handbook of natural rubber production in India. The Rubber Research Institute of India, Kottayam.

RUBBER PLANTING MATERIALS : A REVIEW

2. BREEDING AND TREE IMPROVEMENT

by

C. K. Saraswathy Amma, Joseph G. Marattukalam and A. O. N. Panikkar

Before the begnning of the twentieth century, plant breeding was considered as an art rather than a science. Plant breeding efforts in **Havea** had a beginning in the first quarter of the present century. During the initial stages of the rubber plantation industry only unselected seedlings, the productivity of which was as low as 200-300 kg. per hectare per year, were available for raising plantations. Since then due to the sustained efforts of breeders towards the improvement of the crop, tremendous progress could be made in increasing the productivity. The initial attempt involved identification of high yielding mother trees and use of seeds collected from them to raise plantations, which increased the production potential to around 500 kg. In 1916-17 Van Heltan and coworkers in Indonesia, perfected a method of budgrafting rubber which gave an impetus to the efforts of breeders. The basis for **Hevea** improvement, making use of generative and vegetative methods in a complementary manner, was laid by Whitby in Malaysia, Cramer in Indonesia and Wright in Sri Lanka during the second decade of this century, Even though breeding and selection of this century,. Even though breeding and selection of new clones is a very long, laborious and expensive process due to the very long life span of the crop, steady progress was made by the breeders in this line. As a result, primary clones which could yield about 1000 kg, polyclonal seeds yielding approximately 1500 kg. and secondary clones having still higher yields of 2000-2500 kg|ha|year were evolved. Thus over a short period the productivity could be increased almost ten fold. Production and productivity indices of rubber are the highest among the plantation crops in this country.

The ultimate aim of breeding and tree improvement is to evolve an ideal tree, combining all the desirable attributes into a single one. But the breeding of the ideal or perfect 'wonder tree' which will yield fabulously and possess all the desirable secondary attributes is indeed an extremely difficult task. The concept of an ideal plant type in **Hevea** is a clone having high initial yield with steadily increasing trend, good vigour, straight and cylindrical stem, rapid girth increment, sooth and thick bark, high rate of bark renewal, relatively small wide angled branches and narrow and short crown with healthy foliage. It should be resistant to wind damage and all common diseases and should be adaptable to adverse agroclimatic conditions. It should also respond well to low frequency tapping and stimulation. The technological properties of rubber may also require to be treated as additional objectives. The breeder will have to develop clones suited to differen sectors of the industry. Clones that perform well under high density are suitable for small holders. The clones which will perform well under low density are more suited for estate conditions.

Several methods are being adopted for developing improved clones. The most important among them is cross pollination or hybridisation between desirable clones. The method universally followed in **Hevea** breeding involves choice of the parents, hybridisation, selection of superior seedlings and their vegetative multiplication, evaluation, selection of superior clones and testing of the clones for adaptation under different agroclimatic conditions. The method which has been popular with most rubber breeders is to make a few paired crosses and then repeat the crosses that had produced superior types. This process is called Generation wise Assortative Mating (GAM), 'assortative' because the best is crossed with the best in each cycle. Currently, the choice of parents is becoming more complex because of the multiple trait objective in the breeding programme.

Hybridisation

The method of artificial crossing followed in **Hevea** is popularly known as hand pollination. The first hand pollinations were made in Sumatra (Indonesia) by Heusser in 1920.

---

* The authors are with the Rubber Research Institute of India, Kottayam 686 009.

Top : A view of Rubber Estate. Bottom : Hybrid Seeds of Hevea produced by hand pollination.

A thorough knowledge of the structure of flowers and the mode of pollination is essential for doing hand pollination properly. **Heva brasiliensis** is monoecious with diclinous flowers arranged in paniciles. The pistillate flowers are found at the terminal ends of the panicle and its major branches. When fully developed they may be recognized by the green torus disc as well as the relative large size. Female flower has one whorl of bell shaped perianth five yellow lobes. Gynoecium is tricarpellary, syncarpus, with single ovule in each locule. Stigma is three lobed. The male flowers are yellow and smaller in size having the perianth lobes. They possess ten stamens. The anthers are sessile and are arranged in two whorls five each, on a central staminal column. Each anther contains two pollen sacs which splits longitudinally. Pollen grains are tricolpate, smooth and sticky.

Technique of hand pollination

Emasculation is the first step in hybridisation. As the flowers in **Hevea** are unisexual, this is a simple process of clipping off the male flowers. Only the mature, unopened and healthy female flowers are chosen for hybridisation. All the female flowers which have already opened as well as the immature ones are also removed. The staminal column separated from the male flower is placed on the stigmatic surface of the female flower, by gently opening the perianth lobes and allowed to rest there. To avoid the entry of any external pollen, the female flower is sealed after pollination with a small plug of cotton which is kept in position with a drop of latex. A label showing informations of the female and male parents with date of pollination is then tied to the base of the panicle. The period between pollination and full maturity of fruit is about five months. In rubber the rate of fruitset is low and is usually on 2-5% for hand pollination. The mature fruit is enclosed in a net bag so that the fruit on dehiscence will leave the seeds within. The seeds after collection from the bags are put to germination and the germinated seeds are raised in the nursery.

Juvenile selection of superior seedlings

Selection of the seedlings in the nursery stage to rogue the undesirable elements is the next step. Although seedling vigour has been used by some breeders, it has not been found correlated with yield of the clones made from them.

A method which has been found to be reasonably good is nursery test tapping. In this method the seedlings are test tapped. When they are about two years old. The method of tapping is a modification of the Hammekar Morris Man 'testatex' system. The highest yielding seedlings are selected and cloned.

Selection of superior clones

The clones developed from the selected seedlings are tested in a small scale trial or preliminary proof trial. It is desirable that such trials are of simple lattice design with two replications, each plot having six to eight trees and a control clone which is a widely planted commercial clone.

During the period of immaturity of the trial annual girth measurements are made from the second year onwards. Other secondary characters like resistance to diseases wind damage and branching habit are also recorded. When mature the trees are opened for tapping and yield recording begins. Yield is recorded by coagulating the latex from each tree in the cup once in a month. The coagulated latex is dried well and then the weight of dry rubber is determined. After one year's recording mean yield is calculated as grammes per tree per tapping. Once the trial has been tapped for three to five years the promising clones are selected on the basis of yield and secondary characters such as vigour, crown shape, branching, thickness of virgin bark and renewed bark, incidence of diseases and wind damage. Observations are continued even after making the first selection.

The selected clones are subjected to large scale clone trials or further proof trials, preferably under different agroclimatic conditions along with a few standard clones of known performance which are used as controls. The method of recording characters during immaturity period is same as that adopted in the small scale trial. The yield recording is done only in the sample area in the centre of each plot. In addition to recording sample yield by cup coagulation bulk yield (latex and the scrap) from the whole trial is also collected separately on each tapping day so that at the end of the tapping year the total quantity of rubber obtained from the trial will be known. The bulk yield is apportioned to the different clones in the trial based on the sample yield using this formula —

$$\frac{\text{Wt. of cup samples of the clone}}{\text{Total weight of cup samples}} \times \frac{\text{Total crop of exp. area}}{\text{Hectarage of clone}}$$

The yield is expressed as kilogram per hectare per year.

In the light of the information obtained from such trials as well as the commercial performance of the experimental materials the promising clones are recommended to the industry. The time span for evaluating cultivars from hand pollination upto commercial recommendation by the conventional methods is about thirty years. With the aim of shortening this long testing period the Rubber Research Institute of Malaysia introduced promotion plot clone trial in the early seventies. In this new approach the very best yielding seedlings from the nursery are cloned and tested directly in promotion plot clone trial which simulate large scale clone trial thus bypassing small scale clone trials resulting in a reduction of about ten years in the testing time. The whole procedure outlined above is briefly summarised in the chart, below.

PERIOD OF TESTING FOR CLONES

Year		
	Seedling planted in the nursery ↓	
1	Measurement of vigour ↓	
2	Test tapping, Latex vessel count and DRC estimation ↓	
3	Best seedling cloned and planted in small scale clone trials ↓	→
4		Promotion plots trial. Best 6-10 clones from proven crosses are multiplied further and planted in one acre blocks or 2 x 50 tree plot in different sites ↓
13	Best clones selected for large scale testing ↓	
15		Recommended for moderate scale testing ↓
21		Recommended for large scale planting
24	Recommended for moderate scale planting ↓	
30	Recommended for large scale planting	

Other methods

The second important method employed for evolving improved clones is ortet selection (mother tree selection or estate selection or plus tree selection). Elite trees possessing desirable attributes are selected from existing seedling population. From each selected seedling a new clone is established by vegetative multiplication. They are then evaluated at various steps in field experimentation as in the case of clones produced by hand pollination.

In addition to the above two methods certain special techniques like mutation and polyploidy are also employed for breeding. An important aim of mutation and polyploidy breeding is to induce and enrich the genetic variability in **Hevea.** The main advantage that could be derived from mutation breeding is that it is possible to change one or a few characters in a cultivar, without altering the other characteristics of the genotype. During the last decade attempts have been made to induce genetic variation in **Hevea** through mutation and polyploidy using chemical and physical means.

There are two types of mutations — chemical mutation and physical mutation. Chemical mutations are effected by using mutagenic chemicals like EMS (Ethyl Methane Sulphonate) and MMS (Methyl Methane Sulphonate) and Physical mutation is by application of X rays, gamma rays and ultra violet rays.

The alkaloid colchicine, extracted from **Colchicum autumnale,** is commonly used for the induction of polyploidy. Application of aquous solution of colchicine at a concentration of 0.75 to 0.80 per cent could induce polyploidy in meristematic shoot tissues. The application of the chemical is done by cotton swab method daily for 10-15 days, continuously. Due to chimeric nature, isolation of polyploid tissue is very difficult and is achieved step by step by continuous vegetative multiplication over several generations. Very rarely mutation also appears spontaneously in nature.

Selective hybridisation between superior clones, vegetative multiplication and testing of most promising selections have so far produced planting materials with a production potential around 3000 kg|ha| annum. On theoretical consideration the yield summit of the crop is estimated to be between 7500-10000 kg. dry rubber per ha per year. Thus there is considerable gap between existing and achievable production potentials. Identification, collection, conservation and incorporation of the diversity of genotypes available in the centre of origin of the genus in the breeding programmes are essential for future crop improvement. For evolving an ideal plant type of **Hevea,** suitable for varying agroclimatic conditions, a broad based breeding programme involving divergent genotypes and appropriate selection procedures are very essential.

Nomenclature of clones

In 1941 the Rubber Research Institutions decided to establish a code of uniform nomenclature for rubber planting materials. Clones are usually named after the institutions which developed them. In the case of primary clones they are generally known by the plantations from which they are selected. The following points were agreed upon by the organizations involved.

(1) Use the first syllable or use the first two letters if consonants.

(2) Do not abbreviate less known clones.

(3) All the numbers are written in arabic characters.

(4) Between the clone name and clone number a space is left.

(5) The number is written without spaces.

(6) Use longer abbreviation, should ambiguity occur.

(7) Write the abbreviated name as a unit.

Standardised abbreviations of a few clones are given below :—

AVROS	—	Algemene Vereniging planters Oostknst Sumatra
AVT	—	AV Thomas
Bal	—	Balombissie
BD	—	Bodgong Datar
BR	—	Bogorredjo
BS	—	Beau Sejour
Ch	—	Chemara
CHM	—	CH Mears
CI	—	Corey Island
Ct (Cult)	—	Cultuurtuin
Dev	—	Devon
DH	—	Dunlop Hill side estate
Djas	—	Djasinga
F	—	Ford
FMS	—	Federation of Malayan States
Gl	—	Glenshiel
GT	—	Gondang Tapen
Hen	—	Heneratgoda
Hil	—	Hilcroft
IAN	—	Institute Agronomico du Nort_
IRCI	—	Institute des Recherches Surle Cauotchouc en Indochine
Kaj	—	Kajang
KD	—	Kali Djeroek
Kw	—	Kaliwining
Lamp	—	Lampongiana
LCB	—	s'Lands Caoutchouc Bedrijven
Li	—	Limburg
LMOD	—	Land b. Mij. "Oud Djember"
Lun	—	Lunderston
MAP	—	Malayan American Plantations
Mil	—	Millakande
Nab	—	Nabutenne
Pat	—	Pataroeman
PB	—	Prang Besar

Pil	—	Pilmoor
Plt	—	Planter strots
PR	—	Profestation voor rubber
RRIC	—	Rubber Research Institute of Sri Lanka (Ceylon)
RRII	—	Ruber Research Institute of India
RRIM	—	Ruber Research Institute of Malaysia
RSY	—	Ranny Shaliacary Yendayar
Rub	—	Rubana
Sid (SR)	—	Sidoredjo
Sreko	—	Sungu Reko
Tjio (TMS)	—	Tjiomas
Tjir (Tj)	—	Tjirandi
TK	—	Tandjoeng Kemala
TR	—	Terres Rouges
TT	—	Tebing Tinggi
Wagga	—	Wagga
War	—	Waringiana
WR	—	Wangoenredja

International registration and clone exchange

International authorities are functioning for various crops to register new cultivars bred or developed. The complete record of the cultivars will be maintanied by a central agency and which will be made available for research purposes and crop improvement programmes. The necessity for having a similar body for **Hevea** was felt at a meeting of the breeders and selectionists in 1968. The 'International Registration Authority for **Hevea** cultivars was formed with its headquarters at the Rubber Research Institute of Malaysia in 1968.

When a new clone is evolved by an Institute or organisation the type specimens are deposited with this Authority along with its name, origin, morphological description, performance etc and the Authority keeps all the records. Only clones registered with this Authority could usually be exchanged between the member institutes.

References :

Anonymous, 1957. Planting recommendation. **Plrs' Bull. Rubb. Res. Inst. Malaya.**

Dijkman, M. J. 1951. **Hevea : thirty years of research in the Far East.** University of Miami Press Florida.

Edgar, A. T. 1958. **Manual of rubber planting.** The incorporated society of planters, Kuala Lumpur.

Khoo, S. K., Sultan M.O. and Ong S. H. 1981. Promotion plot clone trials (First series). First report **Plrs' bull. Rubb. Res. Inst. Malaysia** No. 168.

Paardekooper, E. C. 1965. **Planting Manual No. 11. Rubb. Res. Inst. Malaya.**

Polhamus, L. G. 1962. **Rubber.** Leonard Hill (Books Ltd., London.

Radhakrishna Pillai, P. N. 1980. **Handbook of natural rubber production in India.** The Rubber Research Institute of India Kottayam.

Simmonds, N. W. 1985. The strategy of Rubber Breeding International Rubber Conference, Kuala Lumpur.

Subramaniam, S. 1980. Development in **Hevea** breeding research and their future. Paper presented at the National Rubber Symposium, Brazil, 23-29 June.

Swaminathan, M. S. 1975. Recent trends in plant breeding. **Plrs' Bull. Rubb. Res. Inst. Malaya.** No. 141 : 136-144.

RUBBER PLANTING MATERIALS : A REVIEW

3. CROP IMPROVEMENT IN INDIA

by

C. K. Saraswathy Amma, Joseph G. Marattukalam
and A. O. N. Panikkar*

Though commercial cultivation of the Para Rubber tree started in India around 1902, the progress of the plantation industry was rather slow till 1947. The Rubber Board and its Research Department — the Rubber Research Institute of India — were established in 1947 and 1955 respectively. By the efforts of the Board and the Institute, the industry started developing fast. The production during 1986-87 has touched 219,520 tonnes compared to 21,774 tonnes in 1954-55 and the average productivity has gone up from 326 kg. to 926 kg. per hectare per annum.

The Rubber Research Institute of India is housed in a hillock, 8 kms east of Kottayam town in Kerala, where it also has a small Experiment Station. In addition to the Experiment Station at the headquarters, the Institute has a Central Experiment Station (CES) at Chethackal, near Ranni, 50 kms away, which was started in 1966 over an area of 250 ha. Most of the field experiments are being conducted at this Station. The RRII has recently established a Research Complex for North-Eastern Region with headquarters at Guwahati. The Complex has Regional Research Stations in Tripura, Assam, Meghalaya and Mizoram.

The Regional Research Station in Tripura, established in 1979, is situated at Taranagar about 22 kms away from Agartala. The extent of the station is 77 ha. The station in Assam, extending over an area of 50 ha. was started in 1985 in Surutari about 25 kms away from Guwahati. In Meghalaya there are two Regional Research Stations, one at Ganolegre and the other at Darachigre. Both are about 13 kms away from Tura and were etablished in 1985. Extent of the first station is 16 ha while that of the other is 50 ha. The station in Mizoram also was established in 1985 over an area of 100 ha at Tuichuan, 16 kms away from Kolasib.

In addition to the North-Eastern Research Complex the Institute also has a Regional Research Station in Maharashtra. This station is located at Dapchari, about 150 kms from Bombay and was commenced in 1981, over an area of 50 ha. A Regional Research Station is also under establishment at Annapurna Village, in Orissa.

The Regional Research Stations are carrying out location specific investigations for developing suitable agro-management techniques for the cultivation of rubber in the regions concerned. Apart from the Regional Stations there is also a Hevea Breeding Station under the RRII consisting of two sub-stations, one in Tamil Nadu and the other in Karnataka. The sub station in Tamil Nadu is located at Paraliar, about 35 kms. away from Nagercoil. The one in Karnataka is located at Nettana, about 100 kms. away from Mangalore. Both the substations were started in 1987.

Breeding work in rubber was commenced in India in 1954. All the important methods of breeding such as hybridization, ortet selection, mutation and polyploidy are adopted by the Institute. Hybridization is carried out by hand pollination, the method of which had been described elsewhere. So far about 1,03,000 hand pollinations were attempted and from the progenies a total of more than 1800 clones have been evolved.

The first step in the evolution of a clone, after the hand pollination is collection of the seeds and raising the seedlings in the nursery. Juvenile selection of high yielders is attempted by adopting microtapping or test tapping at the age of two years and ascertaining the nursery vigour and other secondary attributes so that the undesirable and weak seedlings can be discarded at this stage. The basal buds of the selected seedlings are then grafted and the clones thus prepared are planted in the field for small scale experimentation. The girth as well as other secondary characters are recorded during the experimental period. After opening the monthly yield is also assessed during the initial years of tapping for three to five years. The promising clones are selected for further testing in statistically laid out large scale trials as well as under block trials in commercial condition in different regions. Clones which come out promising in all these three stages of experimentation are declared proven clones and released for unrestricted planting. Field evalutation for selection, make use of the long duration technique, lasting for a period of above 30 years. Attempts are being made to make use of a short duration one covering a span of about 20 years.

The second method employed for evolving improved clones is ortet selection. Trees of seedling origin are thorcughly screened and from each selec-

* The authors are with the Rubber Research Institute of India, Kottayam 686 009.

ted seedling tree a new clone is evolved by vegetative method. In India about 150 clones have been evolved so far through this method. These clones are also subjected to detailed experimentation as in the case of clones produced by hybridisation.

Techniques involving mutation and polyploidisation are also followed by the Institute. Mutations are induced by chemicals like EMS (Ethylmethane sulphonate), MMS (Methyl methane sulphonate), NMU (Nitroso methyl urea) and NMNG (N. Methyl N. Nitroguandine). Gamma rays and X rays are also used for inducing mutations. Induction of polyploidy is attempted by the application of colchicine. The chromosome constitution of **Hevea brasiliensis** is 2n = 36. True polyploids having a chromosome complement of 2n = 72 (tetraploid) and 2n = 54 (triploid) have also been evolved by the Institute. A spontaneous triploid (2n = 54) has been identified in **Hevea brasiliensis** for the first time by this Institute. In the polyploids, the degree of expression varied with different clonal materials. A genetic mutant having close internodes and smaller leaves has also been identified and the potentiality of this mutant is being exploited.

Selective hybridization between superior clones, vegetative multiplication and testing of most promising selections have so far produced planting materials with a production potential of about 3000 kg|ha|annum. Considering a theoretical summit between 7500-10000 kg. dry rubber per ha per year, there is considerable scope for enhancing the production potential. Since **Hevea** germplasm available in the East is limited all efforts should be made to broaden the genetic base. Identification, collection and conservation of the diversity of genotypes available in the centre of origin of the genus and their incorporation in breeding programmes assumes paramount importance in this context. The Institute is actively co-operating with the International Rubber Research and Development Board in the programme of germplasm conservation. A broad based breeding programme involving divergent genotypes and appropriate selection of offspring based on definite parameters could help evolve appropriate plant types of **Hevea** suitable for varying agro-climatic conditions.

A brief description of the important characteristics of a few outstanding clones developed by the RRII is given below :

RRII 105

This is the most promising one, among the clones evolved by the Rubber Research Institute of India. It is sturdy with average vigour and good branching habit. The tree is tall with sraight trunk. Canopy is dense with dark green and glossy leaves characteristic of the male parent Gl 1. Vigour at opening

A tree of the high yielding clone RRII 105

bark and renewed bark are of above average thickness. Bark contains high number of latex vessels. The initial yield and yield during subsequent years are high. Mean yield from the small scale trial during the 15 years of tapping is 78.8 g|tree|tap. Estimated yield in large scale trial during ten years of tapping is 2425 kg ha|year. Encouraging yield trend is reported from commercial plantings showing an average yield of 1560|kg|ha|year over first six years of tapping. The clone has fair degree of tolerance to abnormal leaf fall disease under normal prophylactic measures. It is susceptible to pink but fairly tolerant to yield depression during drought. Since brown bast tendency is reported in certain areas 1|2S d|3 system of tapping is preferable.

RRII 116

It is a vigorous clone. The tree is straight with balanced branches. Canopy is mostly restricted to the top. Vigour at opening is above average. Thickness of virgin bark is below average and number of latext vessel rings average. The mean estimated yield in a large scale trial for 10 years of tapping is 2470 kg|ha|year.

RRII 118

This is a very vigorous clone. Trees of this clone have tall and straight trunk with prominent heavy branches. Secondary branches are long and slightly drooping in young stage. Several branches arise almost at the same level. Canopy is dense and well balanced. High vigour at opening. Above average initial yield with rising yield trend. The average yield in commercial estates for five years of tapping is 1145 kg|ha|year.

RRII 203

This is another high yielding and vigorous clone. Stem is straight and tall, rather robust. Canopy is will distributed and balanced. It shows high vigour at opening. The thickness of virgin bark and renewed bark is above average. In the large scale trial and and estate trial this clone shows good vigour. The mean yield from the small scale trial during 15 years of tapping was 85 g|tree|tap. In the large scale trial the average estimated yield for five years is 2080 and in the block wise planting the average annual yield is 1140 kg|ha|yr for five years of tapping. The coagulam has a tendency for black discoloration.

RRII 208

Trees of this promising high yielding clone have good branching habit, having straight trunk with light secondaries. Canopy is light. The clone is susceptible to **Phytophthora** causing shoot rot on young plants. The average yield from small scale trial during 15 years of tapping was 87 g|tree|tap. The mean estmated yield from the large scale trial during five years of tapping was 2100 kg|ha|yr and that from block wise planting during six years of tapping was 1226 kg|ha|yr.

RRII 300

RRII 300 is also a high yielding clone evolved by the Institute. Stem is slightly crooked in young trees. The trees are low branching and branch union is strong. Canopy is open, well distributed and medium. The average yield from small scale trial during 11 years of tapping was 97 g|tree|tap. The performance of this clone in the large scale and estate trials is being investigated.

RRII 308

The trees of RRII 308 are vigorous. The branches are medium to heavy. Canopy is heavy, distributed and broom shaped. The average yield from small scale trial during 11 years of tapping was 71 g|tree|tap.

RRII 5

This is a primary clone selected from Malankara Estate. It is very vigorous and shows rising yield trend. In the small scale trial the mean yield for 10 years of tapping is 89.06 g|tree|tap.

RRII 33

This is also a primary clone selected from Kadamankulam Estate. Even though the yield of this clone is poor, it shows resistance to abnormal leaf fall disease. Trees have very stout stem with light secondary branches. Crown is well balanced and the leaf is dark green and large. The clone is used for crown budding on high yielding clones having susceptible crowns.

Origin of a few RRII clones

A. Primary clones

Clone	Estate from which selected
RRII 1	RRII Experiment Station
RRII 2	RRII Experiment Station
RRII 3	Kollamkulam Estate
RRII 5	Malankara Estate
RRII 6	Malankara Estate
RRII 33	Kadamankulam Estate
RRII 44	Pulingappally Estate
RRII 45	Thodupuzha

B. Secondary clones

Clone	Parentage
RRII 101	Tjir 1 x AVROS 255
RRII 102	Tjir 1 x Gl 1
RRII 103	Tjir 1 x Gl 1
RRII 104	Tjir 1 x Gl 1
RRII 105	Tjir 1 x Gl 1
RRII 106	Tjir 1 x Mil 3|2
RRII 107	Tjir 1 x Mil 3|2
RRII 108	Tjir 1 x Mil 3|2
RRII 109	Tjir 1 x Mil 3|2
RRII 110	Tjir 1 x Hil 28
RRII 111	Tjir 1 x Hil 28
RRII 112	Mil 3|2 x Hil 28
RRII 113	Mil 3|2 x Hil 28
RRII 114	Mil 3|2 x Hil 28
RRII 115	Mil 3|2 x Hil 28
RRII 116	Mil 3|2 x Hil 28
RRII 117	Mil 3|2 x Hil 28
RRII 118	Mil 3|2 x Hil 28
RRII 119	Mil 3|2 x Hil 28
RRII 120	Mil 3|2 x Gl 1
RRII 121	Mil 3|2 x PB 5|60
RRII 122	Mil 3|2 x PB 5|60
RRII 201	Tjir 1 x PB 25
RRII 202	PB 86 x Mil 3|2
RRII 203	PB 86 x Mil 3|2
RRII 204	FB 86 x Mil 3|2
RRII 205	PB 86 x BD 10
RRII 206	Mil 3|2 x AVROS 255
RRII 207	Mil 3|2 x AVROS 255
RRII 208	Mil 3|2 x AVROS 255
RRII 300	Tjir 1 x PR 107
RRII 301	Tjirl x Mil 3|2
RRII 302	Tjir 1 x PB 6|9
RRII 303	Tjir 1 x PB 6|9

RRII 304	Tjir 1 x PB 6|9
RRII 305	Tjir 1 x PB 6|9
RRII 306	Tjir 1 x PB 6|9
RRII 307	PB 86 x CHM 3
RRII 308	Gl 1 x PB 6|50
RRII 309	LCB 1320 x PB 86
RRII 310	LCB 1320 x Gl 1

Four of the outstanding clones, namely RRII 105, RRII 118, RRII 203 and RRII 208 have been registered with the International Registration Authority for Hevea Cultivars.

With a view to making available good clones to the rubber growers of our country, the Institute regularly introduce, from other countries, clones which are found to be promising in the countries concerned. So far 114 clones have been introduced from countries such as Malaysia, Indonesia, China, Sri Lanka and Thailand. To find out their adaptability to the agroclimatic conditions prevalent in block wise trials in different regions. Those which were found suitable have been recommended for planting. Among these clones a total of 46 nos. are approved by the Rubber Board under different categories, two under category I, thirteen under category II, and thirty one under category III for planting in India. Vast majority of the clones at present recommended for planting in the country are exotic in origin. In exchange for the clones obtained from other countries RRII clones are being supplied to them.

Collection and conservation of germplasm is an essential prerequisite for plant breeding. Most of the introduced clones as well as all Indian clones of any significance are being maintained in gene banks, both as budwood plants and trees. With a view to widening the genetic base of the crop wild germplasm collected from Brazil are also being introduced to our cnuntry.

Polyclonal seed gardens

In India polyclonal seeds are also recommended under category II as planting materials. They are produced in certain specially designed plantations called polyclonal seed gardens. In these gardens only clones from which seeds are intended to be collected are planted. The number of clones usually varies from three to six. The clones selected for this purpose should possess, apart from the usual desirable characters like high yield, disease resistance and vigour certain other additional attributes also. They should produce good seedling families, yield plenty of seeds and flower simultaneously so that there are adequate chances for cross pollination among them. RRIM 600, RRIM 605, RRIM 623, RRIM 628, PB 5|51, PB 28|59, GT 1, Tjir 1, PR 107, LCB 1320 and some modern clones are planted in polyclonal seed gardens in the country. The different clones included in plo振clonal gardens are planted interspersed to provide maximum chance for cross pollination among them. For this purpose specific designs are to be followed while laying out polyclonal seed gardens.

Anonymous, 1965, Seedgardens for estates **Plrs' bull. R**ubb. **Res. Inst. Malaya,** No. 81.

Anonymous, 1972-79. Report of activities. Rubber Board, India.

Anonymous, 1987. Unpublished data Agricultural Economics Division, RRII.

Anonymous, 1988. The rubber growers companion.

Dijkman M. J., 1951, **Hevea.** Thirty years of research in the Far East, University of Miami Press, Florida.

Edgar A. T., 1958. **Manual of rubber planting.** The Incorporated Society of Planters, Kuala Lumpur. 11

Jostph G. Marattukalam, Saraswathyamma C. K. and George P. J. 1980. Crop improvement of **Hevea** through ortet selection in India. **Int. Rubb. Conf., India Abs.**

Joseph G. Marattukalam, Panikkar A.O.N. and Saraswathyamma C. K., 1986. Early performaice of a few **Hevea** clones in large scale trial presented at Placrosym 7.

Markose, V. C., Saraswathyamma, C. K., Sulochanamma S. and Nair, V. K. B. 1974. Mutation and polyploidy breeding in Hevea brasiliensis. IRRDB Scientific Symposium, Cochin, India.

Markose, V. C., and Panikkar, A.O.N., 1984. Breeding strategies for **Hevea** improvement. Compte — Rendu du Colloqut Exploitation — Physiologie tt Ame'lioration de l' Hevea. 9-12, July, France.

Nair, V. K. B. and Panikkar, A.O N. 1966. Progress of Investigations on the improvement of rubber Hevea brasiliensis. Muell. Arg. Planting Materials in India. **Rubb. Bd. Bull.,** 8.

Nair, V. K. B. and George, P. J., 1968. The Indian clones. RRII 100 series **Rubb. Bd. Bull,** 10.

Nair. V. K. B., George, P. J. and Saraswathyamma, C. K.. Breeding improved **Hevea** clones in India. **Proc. Int. Rubb. Conf., Kuala Lumpur 2.**

Premakumari, D., George, P. J., Panikkar, A.O.N., Bhaskaran Nair, V. K. and Sulochanamaa, S., 1982. Performance of RRII 300 series. Clones in the small scale trial. **Proc. of the fifth annual symposium on Plantation crops.**

Radhakrishna Pillai, P. N., 1980. **Hand book of natural rubber production in India.** The Rubber Research Institute of India, Kottayam.

Saraswathyamma, C. K.. George, P. J., Nair, V. K. B., and Panikkar, A.O.N., 1980. RRII clones 200 series. Int. Rubb. Conf., India, Abs.

Saraswathyamma, C. K., George, P..J., and Panikkar, A.O.N., 1987. Performance of a few RRII clones in the estate trials, **Paper presented at Planters' conf.,** Kottayam.

RUBBER PLANTING MATERIALS : A REVIEW

4. CROP IMPROVEMENT IN MALAYSIA

by

C. K. Saraswathy Amma, Joseph G. Marattukalam

and

A. O. N. Panikkar

Malaysia is the premier rubber producing country in the world, enjoying about one fourth of the area under rubber cultivation. The extent of the area under this crop in Malaysia is two million hectares, the production of rubber being about 1.5 million tonnes, which accounts for one third of the world production. The average productivity, which is above 1000 kg|ha is the highest among the various rubber producing countries.

Rubber was introduced to Malaysia through Singapore in 1877. Commercial cultivation started in 1895, and ever since, the country has been making rapid strides in rubber plantation industry culminating in its present pre-eminent position.

Crop improvement work in Malaysia commenced in 1928 is being done by two research institutes; the Rubber Research Institute of Malaysia and the Prang Besar Research Station. Rubber Research Institute of Malaysia is more important among the two. This Institute, started in 1925, is at present the leading Rubber Research Institute in the world. It is situated at Kuala Lumpur and has two experiment stations, one at Sungei Buloh established in 1928 over an area of more than 1255 ha and the other at Kota Tinggi established in 1972 with an area of 1170 ha. The Institute has done tremendous research for the improvement of the crop. Clones developed by this Institute are named RRIM clones. Five series of clones namely, 500, 600, 700, 800 and 900 have been already released by this Institute. Some of them, like RRIM 600 are vary outstanding and popular in several countries including India. Clones evolved by the Prang Besar Research Station are known as PB clones. Some of the important clones developed in Malaysia are described below.

RRIM 600

It is very promising and the most popular among the clones evolved by the RRIM. Trees of this clone are tall with straight stem. Branches which are moderate to fairly heavy are upright and many in number. They arise at right angles resulting in weak forks. Crown is somewhat narrow and broom shaped. The sparse foliage comprises of small yellowish leaves. Young plants show characteristic spindly growth with late branching resulting in a tendency to lean. Even though the vigour upto the time of tapping is below average girth increment on tapping is very good. While thickness of virgin bark is below average, it is very good in the case of renewed bark which often bulges out above the tapping cut. Though the clone is tolerant to **Oidium**, brown bast and wind damage it is highly susceptible to diseases caused by **Phytophthora.** It is one of the highest yielding clones available now, with high initial yield and rising yield trend. Mean yield of this clone in Malaysia over a period of 15 years was 2199 kg|ha|yr. In India the average productivity in commercial plantations is found to be to the tune of 1317 kg|ha|yr. over 10 years. Latex is not suited for centrifuging. Recommended in category I in India.

RRIM 623

Trees of this clone are tall with straight stem and tall, heavy, acute angled branches forming weak fork junctions and showing a characteristic bending at high levels. Crown is rather narrow and confined to the top. The foliage is dense and the leaves are fairly large and dull green in colour. Vigour during immaturity is very high though after commencement of tapping it is not as high. Both virgin bark and renewed bark are thin. Tolerance to **Oidium** and Brown bast is average. It is susceptible to **Phytophthora** diseases, pink disease and wind damage. Yield is very high initially, with rising trend. But yield during wintering is very poor. In Malaysia mean yield over 15 years of tapping was 1622 kg|ha|yr compared to 1089 kg|ha|yr in India over 10 years in commercial plantings.

RRIM 628

This is another high yielding clone evolved by the RRIM. It has straight and slightly leaning stem, which some time shows bending during immaturity. Branches are many, moderately heavy and growing upwards. Vigour before tapping though average is very poor after opening. Virgin bark is of average thickness while renewed bark is thinner. Tolerance to **Phytophthora** diseases and wind is average; to **Oidium** and brown bast poor. Incidence of pink is high. Yield is very high in the beginning

The authors are with the Rubber Research Institute of India, Kottayam-686 009.

with a steady yield trend. Yield during wintering is very low. Mean yield|ha|yr during first 15 years of tapping in Malaysia is recorded as 1863 kg. In our country over a period of 8 years, commercial plantations yielded an average of 1029 kg|ha|yr.

RRIM 701

Stem of the tree is straight. Branches are few in number, acute angled and heavy. Canopy, which is broom or oval shaped, is high and heavy. Thicknes of virgin and renewed bark is above average. It is a very vigorously growing clone with average girth increment after opening. Yield, though average initially is very high later on. In Malaysia mean yield over 13 years is 1775 kg|ha|yr. In India, in commercial estates during seven years of tapping the clone yielded at the rate of 996 kg|ha|yr. The clone though tolerant to **Phytophthora** is highly susceptible to pink and **Oidium.** Incidence of brown bast and wind damage is average. Yield during wintering is very poor.

RRIM 703

Stem of the tree is upright and slightly kinked. Usualsy shows late branching. Branches are few and heavy with narrow angles. Crown is narrow and open with a somewhat oval shape. Vigour before tapping is average and after tapping is below average. Virgin and renewed bark are very thick. Very high yielding throughout. In Malaysia mean annual yield per ha was 1726 kg. over 13 years. In our country from a trial planting the estimated mean yield over five years has been 2115 kg|ha|yr. Yield drop during wintering is pronounced in this clone. Very highly susceptible to brown bast, but tolerant to **Oidium.** Resistance to pink disease and wind damage is poor. Shows average tolerance to **Phytophthora** diseases.

RRIM 712

Stem of the tree is slightly bending, kinked and crooked with prominent buds and showing bleeding. Branching is clustered and regular with moderately spreading branches. Canopy oval, wide and open. Vigour is below average both before and after tapping. Virgin bark is very thin and bark renewal poor. Yield is as high as 2137 kg|ha|yr over 11 years in Malaysia. Yield during wintering is average. Even though high yielding, susceptibility to brown bast is low. Highly resistant to wind damage. Tolerance to pink, **Phytophthora** diseases and **Oidium** is average.

PB 86

A primary clone developed by Prang Besar. Trees are poor in vigour. Canopy is light and open with yellowish green foliage. Seed prduction is prolific. Tolerant to powdery mildew and wind but highly susceptible to **Phytophthora** diseases. Yield from commercial plantings in Malaysia, over a perid of 15 years was 1360 kg|ha|yr. In India commercial yield was recorded at the level of 1129 kg|ha|yr over ten years.

PB 5|51

Stem is straight with light horizontal branches Average vigour before tapping and less vigour subsequently. Leaves are small and yiellowish green forming a light sparse canopy. Crown is high and conical. Thickness of virgin bark is average and that of renewed bark poor. Highly resistant to wind. Shows average tolerance to **Phytophthora** and pink. Susceptible to brown bast and highly susceptible to **Oidium.** Yield from commercial plantations in Malaysia over a period of 15 years was 1514 kg|ha|yr. In India Commercial production had been 1261 kg|ha|yr over 10 years.

PB 28|59

A high yielding primary clone. Growth habit of the plant is not very desirable due to the fluted and crooked nature of the trunk which shows a leaning tendency. Branching is low and branches are moderate to heavy. Though young plants show average vigour, girth increment after tapping is very poor. Virgin bark is thin. But bark renewal is good. In Malaysia trial plantings yielded at the rate of 2275 kg|ha|yr over a period of 12 years. Commercial yield in India over 10 years is found to be 1389 kg|ha|yr. Wintering depression and incidence of brown bast are high. Resistance to wind is average, whereas to other diseases like pink, **Phytophthora** and **Oidium** it is below average.

PB 217

Trees have straight trunk with usually light branches and one or two moderate to heavy branches. Crown is fairly heavy. Vigour of immature plants is average, but trees under tapping exhibi good girth increase. Virgin bark is very thin and bark renewal is moderate. Initial yield though not very high subsequent yield is very high. Mean yield over 13 years in trials in Malaysia was 1778 kg|ha|yr. In our country commercial yield during 5 years was 1014 kg|ha|yr. Yield during wintering also is very high. The clone shows good resistance to brown bast and wind and below average, tolerance to pink and **Oidium.** Very high susceptibility to **Phytophthora** is reported from Malaysia. But in our country it is reported to show slight tolerance to this disease in some estates.

PB 235

Growth habit is good owing to very high vigour during immaturity. Straight stem, with branching habit resembling that of PB 5|51, dense foliage and moderate and fairly high crown. The trunk is slightly fluted. Vigour after opening is only average. Thickness of virgin bark is average and renewed bark below average. The clone is fairly tolerant to **Phytophthora,** pink and wind damage. To **Oidium** it exhibits high susceptibility. It is high yielding throughout, with an average annual experimental yield of 2349 kg|ha|yr during 12 years in Malaysia. In India commercial yield from a few estates was found to be 1086 kg|ha|yr over five years. Yield during wintering was also high. Incidence of brown bast is above average and hence low intensity of tapping is preferable.

PB 255

The clone resembles PB 5|51 in its growth habits during the first ten years. Later heavier and upright branches alone are present. Density of foliage is average. Vigour during immature phase is high and after tapping average. Virgin and renewed bark are very thick and above average respectively. Tolerance to pink and **Phytophthora** is below average and that to **Oidium** is average. The clone is resistant to wind damage. Yield is very high both initially and subsequently. Production from experimental plantings in Malaysia over 10 years is reported to be 2265 kg|ha|yr. Yield during wintering is only average. Incidence of brown bast is high.

PB 260

Growth habit is generally similar to that of PB 5|51 with prominent leader and light, spreading, self shedding branches. Occasionally the trees show late branching habit. Foliage is thick and dense. Canopy is balanced and rather high. Early vigour is high but subsequently only average. Bark is comparatively thin. Yield is very high throughout. In Malaysia from clone trials an yield of 2168 kg|ha|yr was obtained during the first ten years of tapping. Not affected much by wintering depression. Susceptible to brown bast to a higher degree. Tolerance to pink and Oidium is high and that to **Phytophthora** and wind average.

PB 310

Trees have straight trunk with light to moderate branches. Crown is conical with a fairly dense foliage which refoliates early. The clone is of average vigour when young, but after tapping shows high girth increase. Virgin bark thin but renewed bark satisfactory. Mean yield from experimental plantings over three years in Malaysia was around 1020 kg|ha|yr. Yield shows rising trend. Yield depression during refoliation is low. Number of trees affected by brown bast was found to be average. Susceptibility to **Oidium** was low. Incidence of damage by wind was found negligible.

The Malaysian clones and their parentage are given below.

Clone	**Parentage**
RRIM 501	Pil A 44 x Lun N
RRIM 513	Pil B 16 x Pil A 44
RRIM 519	Pil A 44 x Pii B 16
RRIM 526	Pil B 84 x Pil D 65
RRIM 527	Pil B 50 x Pil B 84
RRIM 600	Tjir 1 x PB 86
RRIM 601	Tjir 1 x Gl 1
RRIM 602	Tjir 1 x Gl 1
RRIM 603	PB 86 x Pil B 84
RRIM 604	Tjir 1 x PB 49
RRIM 605	Tjir 1 x PB 49
RRIM 606	Tjir 1 x PB 49
RRIM 607	Tjir 1 x PB 49
RRIM 608	AVROS 33 x Tjir 1
RRIM 609	AVROS 157 x BD 5
RRIM 610	RRIM 504 x Tjir 1
RRIM 611	RRIM 504 x Tjir 1
RRIM 612	AVROS 157 x PB 49
RRIM 613	Tjir 1 x RRIM 509
RRIM 614	Tjir 1 x RRIM 509
RRIM 615	RRIM 511 x Tjir 1
RRIM 616	Tjir 1 x RRIM 507
RRIM 617	BR 2x RRIM 500
RRIM 618	Lun N x RRIM 501
RRIM 619	RRIM 501 x Tjir 1
RRIM 620	RRIM 501 x RRIM 511
RRIM 621	RRIM 504 x Tjir 1
RRIM 622	Tjir 1 x Pil B 84
RRIM 623	PB 49 x Pil B 84
RRIM 624	Tjir 1 x RRIM 529
RRIM 625	Tjir - x RRIM 526
RRIM 626	Tjir 1 x RRIM 500
RRIM 627	Tjir - x RRIM 526
RRIM 628	Tjir 1 x RRIM 527
RRIM 629	Tjir 1 x RRIM 529
RRIM 630	Tjir 1 x RRIM 527
RRIM 700	44|553 x RRIM 501
RRIM 701	44|553 x RRIM 501
RRIM 702	44|553 x RRIM 501
RRIM 703	RRIM 600 x RRIM 500
RRIM 704	RRIM 600 x RRIM 500
RRIM 705	RRIM 632 x RRIM 500
RRIM 706	RRIM 632 x RRIM 500
RRIM 707	RRIM 632 x RRIM 501
RRIM 708	RRIM 632 x RRIM 501
RRIM 709	RRIM 605 x RRIM 71
RRIM 710	RRIM 605 x RRIM 71
RRIM 711	RRIM 605 x RRIM 71
RRIM 712	RRIM 605 x RRIM 71
RRIM 713	RRIM 605 x RRIM 71
RRIM 714	RRIM 605 x PB 49
RRIM 715	War 4 x PB 49
RRIM 716	PB 49 x RRIM 603
RRIM 717	PB 49 x RRIM 603
RRIM 718	War 4 x RRIM 616
RRIM 719	PB 86 x RRIM 623
RRIM 720	PB 5|60 x RRIM 501
RRIM 721	PB 5|60 x RRIM 603
RRIM 722	RRIM 600 x TK 4
RRIM 723	RRIM 600 x Tjir 1
RRIM 724	RRIM 605 x RRIM 618
RRIM 725	F x 25 illegitimate
RRIM 726	PB 49 x PR 107
RRIM 727	GT 1 x RRIM 612
RRIM 728	GT 1 x RRIM 623

RRIM 729	RRIM 623 x F x 25
RRIM 730	LCB 1320 x RRIM 623
RRIM 731	PB 49 x PR 107
RRIM 732	PB 5|60 x RRIM 501
RRIM 733	PB 5|60 x RRIM 501
RRIM 734	PR 107 x RRIM 612
RRIM 735	PR 107 x RRIM 612
RRIM 801	RRIM 628 x RRIM 612
RRIM 802	RRIM 501 x RRIM 623
RRIM 803	RRIM 501 x RRIM 623
RRIM 804	RRIM 501 x 44|553
RRIM 901	PB 5|51 x RRIM 600
RRIM 905	PB 5|51 x RRIM 600
PB 86	Primary clone
PB 5|37	PB 56 x PB 24
PP 5|51	PB 56 x PB 24
PPB 5|63	PB 56 x PB 24
PB 28|59	Primary clone
PB 28|83	Primary clone
PB 32|36	PB 49 x PB 186
PB T|157	Primary clone
PB T|495	Primary clone
PB 186	Primary clone
PB 206	Primary clone
PB 213	PP 56 x PB 86
PB 217	PP 5|51 x PB 6|9
PB 233	PB S|15 x PB 5|63
PB 235	PB 5|51 x PB S|78
PB 242	PB 5|51 x PB 32|36
PB 243	PB 5|51 x PB S|78
PB 252	PB 86 x PB 32
PB 253	RRIM 501 near legitimate
PB 254	PB 5|51 x PB S|78
PB 255	PB 5|51 x PB 32|36
PB 260	PB 5|51 x PB 49
PB 262	PB 28|59 x PB 32|36
PB 274	PB 28|59 x PB 32|36
PB 280	PBIG seedling
PB 281	PB 86 x PB 32|36
PB 290	PB 49 x PB 202
PB 294	PB 5|51 x PB 28|83
PB 310	PB 5|51 x RRIM 600
PB 311	RRIM 600 x PB 235
PB 330	PB 5|51 x PB 32|36
Ch 2	Primary clone
Ch 4	Primary clone
Ch 8	Primary clone
Ch 26	BR 2 x BR 2
Ch 29	BR 2 x BR 2
Ch 30	BR 2 x BR 2
Ch 31	BR 2 x BR 2
Ch 32	BR 2 x BR 2
Ch 148	Tjir 1 x Ch 5
Ch 153	Tjir 1 x Ch 5
CHM 3	Primary clone
Gl 1	Primary clone
Lun N	Primary clone
Pil A 44	Primary clone
Pil B 16	Primery clone
Pil B 84	Primary clone

References :

Anonymous 1971. Planting recommendations 1971-72. **Plrs' bull. Rubb. Res. Inst. Malaya.** No. 112.

Anonymous 1976. Performance of clones in Commercial practice. Plrs'. bull. Rubb. Res. Inst. Malaysia. No. 144.

Anonymous 1977. RRIM 700 series colone trials. **Plrs' bull. Rubb. Res. Inst. Malaysia.** No. 151.

Ang, B. B. and Sheapherd, R. 1979. Promising New Prang Besar Rubber Clones. **Proc. RRIM Plrs'. Conf. 1979.**

Anonymous 1980. RRIM Planting Recommendations, 1980-82. **Plrs' bull. Rubb. Res. Inst. Malaysia.** No 162.

Ang Boon Beng, 1982. Prang Besar Rubber Cultivars. Harrisons Malaysian Plantations Berhad. Recommended Prang Besar Rubber Cultivars 1982.

Anonymous 1983. RRIM Planting Recommendations. 1983-85. **Plrs' bull. Rubb. Res. Inst. Malaysia.** No. 175.

Anonymous 1987. The rubber growers companion.

Anonymous 1987. Rubber Statistical Bulletin. Volume 41 No. 8. I.R.S.G.

Dijkman, M. J., 1951. **Hevea** Thirty years of research in the Far East. University of Miami Press. Florida.

Drabble, J. H., 1973. **Rubber in Malaya** 1876-1922. Oxford University Press.

Edgar, A. T., 1958. **Manual of rubber planting.** The incorporated society of planters, Kuala Lumpur.

Khoo, S. K., Sultan, M. O., and Ong, S. H. 1981. RRIM 800 series clone trials. **Plrs' bull. Rubb. Res. Inst.** Malaysia, No. 168.

Lim Sow Ching, Malaysian Natural Rubber Production trend upto 2000. .Presented in IRSG 96th group meeting. International Rubber Forum.

Ong, S. H., and Khoo, S. K. 1981. RRIM 700 series clone trials. **Plrs' bull. Rubb. Res. Inst. Malaysia.** No. 168. 168.

Ong. S. H., Sultan, M. D., Khoo. S. K., and Tan, H. 1981. Performance of clones in RRIM 800 seriies and promotion plot clone trials. Paper presented at the **Plrs' Conf. Rubb. Res. Inst. Malaysia, Kuala Lumpur.**

Radhakrishnna Pillai. P. N., 1980. **Hand book of natural rubber production in India.** The Rubber Research Institute of India. Kottayam.

Sultan, M. O., 1980. RRIM 700 series clone trials. **Plrs. bull. Rubb. Res. Inst. Malaysia.** No. 162.

1840 ~~436~~

RUBBER PLANTING MATERIAL : A REVIEW

5. CROP IMPROVEMENT IN OTHER COUNTRIES

by

C. K. Saraswathy Amma, Joseph G. Marattukalam
and A. O. N. Panikkar*

Brazil

Brazil is the Centre of origin of the genus **Hevea.** It was the main producer of natural rubber, meeting 98 per cent of the world requirement until 1876 the production having been mainly from wild rubber trees. Many attempts to plant rubber in Brazil failed due to the lack of suitable infrastructure, appropriate technological inputs and worst of all, the SALB disease caused by **Microcyclus ulei.** In 1967 the Brazilian Rubber Authority "SUDHEVEA" was created to co-ordinate and supervise the implementation of the Economic Policy of Rubber in Brazil with the support of National Rubber Control. The Government launched the first programme of Rubber Production PROBOR I in 1972, followed by PROBOR II in 1977 and PROBOR III in 1983 for intensified rubber cultivation. The national production of natural rubber in Brazil as a result, incr ased to 30,000 tonnes in 1981 and to 32,800 tonnes in 1982. The production during 1986 was 41,000 tonnes. A series of **Hevea benthamiana** selections, Fx clones and IAN clones, which are reported to show disease tolerance, were also developed by Brazil.

The clone IAN 45-873 is a vigourous and high yielding one. This clone is reported to give 1680 kg/ha/yr during the first four years of tapping in a clone trial in Sri Lanka. In Malaysia this clone gave an average of 1490 kg/ha/yr during the first five years of tapping. Girth increment on tapping as well as girth at opening is above average. It shows average resistance to **Oidium** and below average resistance to pink. IAN 45-710 and IAN 45-717 are also giving an average yield of above 1400 kg/ha/yr during four years of tapping.

China

The rubber growing region in China lies between 18° and 24°N which is outside the traditional rubber growing belt. The pronounced defoliation spell during wintering owing to very low winter temperature affects the tree and active growth phase is restricted to seven to nine months. This is the main obstacle faced by the rubber plantation industry. Typhoon is another major constraint affecting rubber cultivation.

The natural rubber industry in China has developed greatly since its liberation. From 1952 onwards the rubber planting area has expanded steadily resulting in an enormous increase in total dry rubber production. China occupies the fourth place among the world's rubber growing countries in terms of area under rubber and ranks fifth in terms of production Natural rubber production during 1986 was 210,000 tonnes.

The peculiar climatic conditions in the country have necessitated the selection and breeding of cold and wind resistant clones. Variation in endurance to cold waves of different types and intensities is a clonal characteristic. Some selections show better tolerance to advective type cold damage and some to radiative type. To cite an example the China-bred clone SCATC (South China Academy & Tropical Crops) 93-114 appears so far to be the most resistant to advective type of cold damage. Another clone, Wuxing 1, seems to be more endurant to radiative type, but not so tolerant to advective type as SCATC 93-114.

The planting density in the wind prone areas in China has been increased from 375 trees to 630 trees per hectare. With proper close spacing more trees are maintained per unit area with a view to minimising wind damage.

Wind fast clones like Haiken 1 and PR 107 are reported to have an yield potential of 1050-1500 kg/ha/yr in the 3rd year of tapping. For clone RRIM 600 yield level of 1800-2250 kg/ha/yr is reported to be expected in areas without pronounced wind and cold damage. The per unit area yield of this clone is only comparable to that of clone PR 107 in wind and cold prone areas due to its susceptibility to these two factors. The moderately cold endurant clone GT 1 is reported to give an yield of 1050-1200 kg/ha/yr in China's south sub-tropical monsoon region. The most important clones developed by China are Haiken 1 noted for its wind fastness and SCATC 93-114 notworthy for its high yield, which is 750-900 kg/ha/yr in regions where the climatic conditions are inhospitable for rubber.

Indonesia

The Rubber Conference held at Jakarta in 1914 marked a milestone for rubber selection in Indonesia. Indonesia initiated commercial planting of Hevea in 1918. The clones released initially were Ct 3, Ct 9 and Ct 88. The Balai Penelitian Perkebunan Medan (BPPM) began breeding of **Hevea brasiliensis** as early as in 1920. They are the pioneers in the selection of **Hevea** planting materials, nursery testing of seedlings and development of budding techniques.

---

* The authors are with the Rubber Research Institute of India, Kottayam-686 009.

Prior to world war II. **Hevea** breeding was done by Government and Private Experiment Stations. These stations were located in different provinces. After the war most of the estates were owned by the Government. Three Research Institutes for Estate Crops (Medan, Bogor and Sungi Putih) are financed by the Central Government and in addition there are two developmental Rubber Research Centres which are financed by the estates. The Research Institutes serve the estates as well as small holders while the Research Centres, being financed by the estates, serve only the estates. BPP Medan and the Rubber Research Centre, Tanjung Morawa, solve the problem for the Provinces of West Sumatra, Jambi and other Northern sumatra region. BPP, Bogor, and the Rubber Research Centre, Getas, serve the rest of the country. All research activities on rubber are amalgamated by the Central Rubber Research Institute with the main office at Sungi Putih, North Sumatra. Indonesia developed a series of PR, AVROS, BPM, LCB, PPN and RR clones. Natural Rubber production during 1985 was 1,226,000 tonnes and the total area under rubber cultivation during 1985 had been 2,674,023 hectares.

GT 1 : The most popular clone evolved by Indonesia is GT 1. It is a high yielding clone with desirable secondary attributes. The trees have upright stem which is slightly kinked and sometimes fluted. Branching habit is variable. Crown is narrow and open with globular shape. Foliage is dense, dark green and glossy with small leaves. Vigour at opening is average. Girth increment on tapping is also average. Thickness of virgin bark is average while that of renewed bark is below average. The clone shows good tolerance to pink disease and brown bast; average to above average tolerance to wind damage and average to below average tolerance to **Phytophthora** diseases. Tolerance to powdery mildew shows variation from average to below average in different centres. The response to high intensity tapping is good. Due to the high yield and good secondary characters this clone is more suited to small growers. Yield obtained from commercial plantations in Malaysia during the first 15 years of tapping was 1723 kg/ha/yr. In India it has given 1359 kg/ha/yr during the first 10 years of tapping. Latex is white and suited for concentration.

PR 255 : It is high yielding clone with good secondary characters. Yield obtained from commercial plantations in Malaysia during 15 years of tapping was 2017 kg/ha/yr. It shows above average resistance to pink disease and **Phytophthora.** Resistance to **Oidium** is below average to poor. This clone exhibits good vigour at opening and average girth increment on tapping. Virgin and renewed bark shows above average thickness. It is reported recently that a race of **Colletotrichum** is especially agressive towards this clone.

PR 261 : It is also a high yielding clone giving an average annual yield of 1971 kg/ha/yr during 5 years of tapping from commercial plantations in Malaysia. The clone shows good response to stimulation. It exhibits good resistance to wind damage and average resistance to pink disease and average to below average resistance to **Oidium.** Thickness of virgin bark is average and that of renewed bark is above average. Girth increment on tapping is average.

BPM 24 : Report from the multilateral exchange clone trials in Malaysia has shown that the highest yielding clone is BPM 24 giving an average yield of 1563 kg/ha/yr over the first three years of tapping. It is resistant to **Phytophthora** and also shows above average vigour.

Sri Lanka

The rubber tree was introduced into South East Asia through Sri Lanka (Ceylon) in 1876. The Rubber Research Institute of Sri Lanka is the oldest Research Centre for rubber in the world having started its activities in 1909. Breeding of **Hevea** was commenced in 1939. The Institute is situated at Agalawatta, Darton Field. The development of rubber plantation in Sri Lanka was not so fast as in Malaysia. In 1890, Ceylon had only about 125 ha under rubber but a steady increase in area was recorded by 1910. Sri Lanka first started export of natural rubber in 1885. Natural rubber production for the year 1986 was 138,000 tonnes and the area under rubber 205,508 ha during 1985.

A series of high yielding and vigorous clones have been evolved by the Rubber Research Institute of Sri Lanka.

Nab 17 : It is reported to be vigorous and high yielding. In Sri Lanka the mean yield for five years of tapping from the clone is estimated to be about 2800 kg/ha/yr. In Malaysia from the clone trials the mean yield over eight years of tapping is 1650 kg/ha/yr. The clone shows average vigour at opening and good girth increment on tapping. The thickness of virgin bark is poor. It shows above average resistance to pink and below average resistance to **Oidium.** It is susceptible to brown bast.

Wagga 6278 : It is a fairly high yielding clone. The mean yield in the small scale trial for first eight years of tapping is reported to be 1940 kg/ha/yr. The clone is sensitive to soil conditions and not suited for very steep areas.

RRIC 36 : This clone has rising yield trend and shows fairly good bark renewal. The girth increment on tapping is above average to good. This clone is reported to give an average yield of 1770 kg/ha/yr for six years of tapping in the clone trials. In Malaysia the average yield of this clone is reported to be

1332 kg/ha/yr for six years of tapping. It is susceptible to bark rot and is not suited for areas having heavy rain. In India in a trial planting this clone gave an estimated mean yield of 1339 kg/ha/yr over the first three years of tapping.

RRIC 52: It is a very vigorous clone. Mean yield for six years of tapping in the clone trial is about 1430 kg/ha/yr. The trees of this clone are tall and develop a heavy canopy. It is reported to normally reach tappable girth one year earlier than most clones. It is tolerant to both **Phytophthora** and **Oidium.** In India the estimated mean yield for the first three years of tapping is 992 kg/ha/yr from a trial:

RRIC 100: This clone had shown a high degree of adaptability to tapping at reduced frequencies. It is also a high yielding clone. Mean yield for five years of tapping in the clone trial is reported to be 1570 kg/ha/yr. In the multilateral exchange clone trials in Malaysia the yield for three years of tapping is 1350 kg/ha/yr. This clone gave an estimated mean yield of 1740 kg/ha/yr for first three years of tapping in an experimental planting in India.

RRIC 102: This is also a vigorous clone. The mean yield for eight years of tapping in the clone trial is 1820 kg/ha/yr. In the multilateral exchange clone trials in Malaysia yield for three years of tapping is 1150 kg/ha/yr. The clone shows satisfactory bark renewal. It is less susceptible to **Phytophthora**. From a trial planting in India this clone gave an estimated mean yield of 1578 kg/ha/yr over three years of tapping.

RRIC 104: This is a high yielding clone. It is reported to be less susceptible to bark rot and vigorously growing in drier areas. In the small scale trials at Sri Lanka this clone is reported to give an estimated mean yield of 2715 kg/ha/yr over 16 years of tapping. In India, in a large scale trial planting this clone showed an estimated mean yield of 1490 kg/ha/yr over three years of tapping.

The names of clones, along with their origin, developed in different countries, are given below.

1. BRAZIL

Clone	Parentage
F 4542	Hevea benthamiana
Fx 349	F 4542 x Tjir 1
Fx 505	F 4542 x AVROS 363
Fx 516	F 4542 x AVROS 363
Fx 567	F 4542 x AVROS 363
Fx 590	F 4542 x AVROS 363
Fx 614	F 4542 x Tjir 1
Fx 645	F 4542 x Tjir 1
Fx 1042	F 1425 x PB 186
Fx 2261	F 1619 x AVROS 183
Fx 2818	F 4542 x AVROS 363
Fx 3432	F 4542 x PB 86
Fx 3899	F 4542 x AVROS 363
Fx 4098	PB 86 x B 74
Fx 637	F 4542 x Tjir 1
Fx 3810	F 4542 x AVROS 363
Fx 3925	F 4542 x AVROS 363
Fx 4065	F 4542 x PB 86
Fx 4073	F 4542 x PB 86
Fx 4068	F 4542 x PB 86
Fx 43-443	PB 86 x Fx 2251
Fx 43-448	PB 86 x Fx 2251
Fx 43-651	Fx 213 x AVROS 183
Fx 43-655	Fx 213 x AVROS 183
IAN 45-710	PB 86 x F 409
IAN 45-713	PB 86 x F 409
IAN 45-717	PB 86 x F 4542
IAN 45-873	PB 86 x F 1717
IAN 2361	PB 86 x Fx 4371
IAN 2363	PB 86 x Fx 4371
IAN 2489	Fx 4068 x Tjir 1
IAN 2491	Fx 4068 x Tjir 1
IAN 2570	Fx 4068 x Tjir 1
IAN 2667	Fx 4068 x PB 86
IAN 2668	Fx 4068 x PB 86
IAN 2744	Fx 4068 x Tjir 1
IAN 2750	Fx 4068 x Tjir 1
IAN 2829	Fx 516 x PB 86
IAN 2833	Fx 516 x PB 86
IAN 2878	Fx 516 x PB 86
IAN 2897	Fx 516 x PB 86
IAN 2899	Fx 2831 x PB 86
IAN 2879	Fx 2831 x PB 86
IAN 2900	Fx 516 x PB 86
IAN 2920	Fx 516 x PB 86
IAN 2921	Fx 516 x PB 86
IAN 2954	Fx 4073 x PB 86
IAN 2958	Fx 4073 x PB 86
IAN 2960	Fx 4073 x PB 86
IAN 2965	Fx 4073 x PB 86
IAN 2664	Fx 4068 x PB 86
IAN 3434	Fx 4371 x PB 86
IAN 3457	Tjir 1 x Fx 652
IAN 3460	Tjir 1 x Fx 652
IAN 3646	Fx 516 x Tjir 1
IAN 3702	Fx 516 x Tjir 1
IAN 3787	Fx 516 x Tjir 1
IAN 3793	Fx 4371 x PB 86
IAN 3795	Fx 516 x Tjir 1
IAN 3803	Fx 567 x PB 86
IAN 3819	Fx 617 x Tjir 1
IAN 3827	Fx 516 x AVROS 363
IAN 3828	Fx 516 x AVROS 363
IAN 3892	Fx 617 x Tjir 1
IAN 3893	Fx 617 x Tjir 1
IAN 6163	Fx 43-443 x Tjir 1
IAN 6165	Fx 43-448 x Tjir 1
IAN 6497	IAN 2828 x PB 86
IAN 6584	Fx 43-651 x PB 86
IAN 6640	Fx 43-655 x PB 86

2. INDONESIA

AVROS 255	Primary clone
AVROS 427	AVROS 214 x AVROS 256
AVROS 529	AVROS 279 x AVROS 281
AVROS 1191	AVROS 256 x AVROS 317
AVROS 1279	AVROS 256 x AVROS 374

AVROS 1518	AVROS 214 x AVROS 256
AVROS 1734	AVRAS 214 x AVROS 374
AVROS 1328	AVROS 214 x AVROS 317
AVROS 1350	AVROS 256 x AVROS 185
AVROS 2012	AVROS 152 x AVRAS 161
AVROS 2037	AVROS 256 x AVROS 252
GT 1	Primary clone
LCB 1320	Primary clone
PR 107	Primary clone
PR 228	BR 2 x PR 107
PR 248	BD 5 x PR 107
PR 251	Pil A 44 x PR 107
PR 253	Pil A 44 x PR 107
PR 255	Tjir 1 x PR 107
PR 258	BR 2 x Tjir 16
PR 259	Tjir 1 x BR 2
PR 261	Tjir 1 x PR 107
WR 101	Primary clone
BPM 1	AVROS 163 x AVROS 308
BPM 3	Tjir 1 x AVROS 152
BPM 22	TT 5 x AVROS 1734
BPM 24	GT 1 x AVROS 1734
BPM 26	GT 1 x AVROS 1191
PR 302	Tjir 1 x PR 107
PR 305	Tjir 1 x BD 2
PR 306	Tjir 1 x PR 107
PR 307	Tjir 1 x PR 107
PR 309	Tjir 1 x PR 107

3. **SRI LANKA**

Clone	**Parentage**
RRIC 7	Primary clone
RRIC 9	RRIC 8 x Mil 3/2
RRIC 13	RRIC 8 x Mil 3/2
RRIC 14	RRIC 8 x Wag 6278
RRIC 16	RRIC 8 x Mil 3/2
RRIC 17	RRIC 8 x Mil 3/2
RRIC 24	RRIC 8 x Mil 3/2
RRIC 28	RRIC 8 x Hil 28
RRIC 31	RRIC 8 x Tjir 1
RRIC 32	RRIC 8 x H 24
PRIC 33	RRIC 8 x Dal 5315
RRIC 35	PB 86 x Tjir 1
RRIC 36	PB 86 x PR 107
RRIC 37	RRIC 8 x Diy 1
RRIC 38	PB 86 x PR 107
RRIC 39	RRIC 8 x Tjir 1
RRIC 40	RRIC 8 x Hil 28
RRIC 41	RRIC 8 x Tjir 1
RRIC 42	RRIC 8 x Tjir 1
RRIC 45	RRIC 8 x Tjir 1
RRIC 47	Diy 1 x Mil 3/2
RRIC 48	TKD 113 x RRIC 48
RRIC 51	RRIC 8 x Mil 3/2
RRIC 50	Tjir 1 x PB 86
RRIC 52	Primary clone
RRIC 54	PB 86 x Wag 6278
RRIC 55	PB 86 x Wag 6278
RRIC 59	RRIC 8 x Hil 28
RRIC 60	RRIC 8 x Hil 28
RRIC 61	PB 86 x RRIC 8
RRIC 62	PB 86 x RRIC 8
RRIC 64	PB 5/139 x TKD 113
RRIC 65	PB 5/139 x TKD 113
RRIC 66	PB 5/139 x TKD 113
RRIC 74	PB 86 x PR 107
RRIC 75	RRIC 8 x Tjir 16
RRIC 76	TKD 113 x RRIC 8
RRIC 77	PB 86 x Wag 6278
RRIC 79	PB 86 x M 162
RRIC 86	Primary clone
RRIC 87	Primary clone
RRIC 88	Primary clone
RRIC 89	Primary clone
Nab 15	Primary clone
Nab 17	Primary clone
Nab 20	Primary clone
Mil 3/2	Primary clone
Hil 28	Primary clone
Wag 6278	Primary clone
RRIC 100	RRIC 52 x PB 83
RRIC 101	Ch 26 x RRIC 7
RRIC 102	RRIC 52 x RRIC 7
RRIC 103	RRIC 52 x PB 86
RRIC 104	RRIC 52 x Tjir 1
RRIC 105	RRIC 52 x Tjir 1
RRIC 106	PB 5/139 x RRIC 52
RRIC 107	RRIC 52 x PB 86
RRIC 108	RRIC 36 x Ch 26
RRIC 109	Ch 26 x RRIC 36
RRIC 110	LCB 1312 x RRIC 7
RRIC 111	RRIC 52 x PB 5/139
RRIC 112	RRIC 41 x Ch 26
RRIC 113	RRIC 52 x RRIC 36
RRIC 114	RRIC 45 x FX 4098
RRIC 115	RRIC 45 x FX 4098
RRIC 116	RRIC 88 x Fx 4098
RRIC 117	RRIC 45 x IAN 45-873
RRIC 118	RRIC 52 x RRIC 52
RRIC 119	IAN 343 x RRIC 52
RRIC 120	RRIC 36 x Fx 516
RRIC 121	PB 28/59 x IAN 45-873
RRIC 122	LCB 1320 x RRIC 52
RRIC 123	IAN 45-710 x Ch 26
RRIC 124	Ch 26 x RRIC 111
RRIC 125	RRIC 102 x RRIC 89
RRIC 126	RRIC 103 x Ch 26
RRIC 127	Ch 26 x 1458
RRIC 128	RRIC 101 x Ch 26
RRIC 129	Ch 26 x RRIC 100
RRIC 130	IAN 45-710 x RRIC 52
RRIC 131	PB 86 x F 1633

4. **LIBERIA**

Harbel 1	Primary Clone

5. **THAILAND**

KRS 21	PB 86 x KRS 13
KRS 23	Primary clone
KRS 25	Primary clone
KRS 26	Frimary clone
KRS 29	Primary clone
KRS 41	PB 86 x G1 1
KRS 48	PB 86 x LCB 1320
KRS 57	PB 86 x LCB 1320

KRS 88	PB 86 x Ch 31
KRS 110	PB 86 x LCB 1320
KRS 116	PB 86 x LCB 1320
KRS 122	PB 86 x LCB 1320
KRS 127	PB 86 x LCB 1320
KRS 128	PB 5/63 x KRS 13
KRS 130	PB 5/63 x KRS 13
KRS 131	PB 5/63 x KRS 13
KRS 156	PB 5/63 x PR 107
KRS 160	PB 5/63 x PR 107
KRS 163	PB 6/63 x RRIM 501

6. **CAMBODIA**

KHA 1	Pil A 44 x AVROS 152
KHA 7	Djas 1 x Tjir 1
KHA 10	S. Reko 9 x Tjir 1
KHA 11	Tjir 1 x BD 10

7. **CHINA**

HSI	Primary clone
W 193	PB 5/51 x PR 107
RY 88-13	RRIC 600 x Pil B 84
HK 2	PB 86 x PR 107
TP 95	PB 86 x PR 107
SCATC 88-13	RRIM 600 x Pil B 84
SCATC 93-114	TR 31-45 x HK 3-11

8. **VIETNAM**

TR 3702	AVROS 163 x War 4
IRCI 7	BD 10 BD 5
IRCI 13	Pil B 84 x Pil A 44
IRCI 22	AVROS 163 x Waring 4
IRCI 23	BD 2 x AVROS 50
IRCI 30	AVROS 163 x BD 2

References :

Anonymous, 1972. Annual Review. Rubb. Res. Inst. Sri Lanka.

Anonymous, 1974. Annual Review. Rubb. Res. Inst. Sri Lanka.

Anonymous, 1975. Annual Review. Rubb. Res. Inst. Sri Lanka.

Anonymous, 1976. Annual Review. Rubb. Res. Inst. Sri Lanka.

Anonymous, 1978. Annual Review. Rubb. Res. Inst. Sri Lanka.

Anonymous, 1979. Annual Review. Rubb. Res. Inst. Sri Lanka.

Anonymous, 1983. Annual Review. Rubb. Res. Inst. Sri Lanka.

Anonymous, 1985. Annual Review. Rubb. Res. Inst. Sri Lanka.

Raptiste, E.D.C. 1960. Breeding for high yield and disease resistance in Heveu **Proc. of Nat. Rubb. Res. Conf. Kuala Lumpur.**

Chandrasekharan, L. B., 1971. Developments in Hevea planting materials in Ceylon. **Q. JC. Rubb. Res. Inst. Ceylon 48.**

Chandrasekharan, 1972. Recommended planting Materials., **Rubb. Res. Inst. Sri Lanka.**

Dijkman, M. J., 1951. **Hevea.** Thirty years of research in the Far East. University of Miami Press, Florida.

De Silva C. A., 1960. The performance of RRIC clones under Ceylon conditions. **Proc. of the Nat. Res. Conf. Kuala Lumpur.**

Edgar. A. T., 1958. **Manual of rubber planting.** The incorporated Society of Planters, Kuala Lumpur.

Fernando. D.M., 1967. Problems of achieving agricultural production potential in Rubber. **Rubb. Res. Inst. Ceylon.**

Fernando. D.M., 1977. Some aspects of **Hevea breeding** and selection. **Jl. Rubb. Res. Inst. Sri Lanka 54.**

Jayewickreme, M.M. 1984. 75 years of Research and what of the future. **Proc. Int. Rubb. Conf. Colombo. Sri Lanka.** Vol. 1.

Jose Cezario Menezes de Barros, Antonio Maria, Gomes de castro, Josias Miranda and Celso salatino schenkel, 1983, Development anl present status of Rubber cultivation in Brazil. **Proc. Rubb. Res. Inst. Malaysia,** Plrs' Conf. **Kuala Lumpur.**

Huang Zondao and Sheng Xueguim 1983. Rubber cultivation in **China. Proc. Rubb. Res. Inst. Malaysia Plrs' Conf. Kuala Lumpur.**

Langlois, S., 1969. Results of Vegetative selection in Cambodia. **J. Rubb. Res. Inst. Malaya 21** (1).

Napitupulu, L. A. 1973. Relation between growth habit and yield in **Hevea** cultivars in North Sumatra. **Q. Jl. Rubb. Res. Inst. Sri Lanka.**

Napitupulu, L.A. and Harris, A.S. 1981. Preliminary evaluation of the 1974 International Exchange Rubber clones. **Bull. BPP Medan 12** (1).

Radhakrishna Pillai, P. N., 1980. **Hand book of natural rubber production** in India. The Rubber Research Institute of India, Kottayam.

growth; composition and biological utilization of foods in rats. Annual Nutritional Alimentation 24(4):297-300.

30. MORRIS, H.J.; WOOD, E.R. 1956. Influence of moisture content on keeping quality of dry beans. Food and Technology 10:225-229.

31. NATIONAL RESEARCH COUNCIL. 1963. Evaluation of protein quality. Report of an international conference. Washington, D.C., National Academy of Science. National Research Council. Publication 1100. p. 23-27.

32. PRICE, M.L.; VAN SCOYOC, S.; BUTTLER, L.G. 1978. A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. Journal of Agricultural and Food Chemistry 26(5):1 214-1 218.

33. RUTGER, I.N. 1971. Variation in protein content and its relation to other characters in beans (*Phaseolus vulgaris* L.) In Report of the Tenth Dry Bean Research Conference. Washington, D.C., Agr. Ress. Serv. Dept. of Agriculture. p. 59-69.

34. SWAIN, T. 1966. Comparative Phytochemistry. N.Y., USA., Academic Press. p. 360.

35. TANDON, O.B.; BRESSANI, R.; SCRIMSHAW, N.S.; LEBEAU, F. 1957. Nutrient value of beans: Nutrients in Central American beans. Journal of Agricultural and Food Chemistry 5(2):137-142.

36. WILLIAMS, P.C.; KUZINA, F.D.; HLYNKA, I. 1970. A rapid calorimetric procedure for estimating the amylose content of starches and flours. Cereal Chemistry 47(4):411-420.

Anthesis and Pollen Germination in *Hevea brasiliensis* Muell. Arg.[1]

C.K. Saraswathyamma, A.O.N. Panikkar**

ABSTRACT

Anthesis, pollen germination and tube growth of RRII 33, a clone of *Hevea brasiliensis*, were investigated. Anthesis of male flowers takes place between 1:30 and 1:45 pm and that of female flowers between 3:15 and 4:00 pm. Pollen stainability was 94.7% and pollen size ranged from 35 µm to 45 µm. Pollen grains recorded high germination and tube growth in the medium comprising 20% sucrose with 100 ppm each of calcium, boron, magnesium and potassium.

COMPENDIO

Se estudió la antesis, la germinación del polen y el crecimiento del tubo germinativo del clon RRII 33 de *Hevea brasiliensis*. La antesis de las flores masculinas se lleva a cabo entre las 13:30 y 13:45 horas, mientras que las flores femeninas lo hacen entre las 15:15 y las 16:00 horas. La tinción del polen fue de 94.7% y el tamaño varió de 35 µm a 45 µm. La germinación del polen y el crecimiento del tubo germinativo fueron altas en medio conteniendo 20% de sacarosa con 100 ppm de cada uno de los elementos calcio, boro, magnesio y potasio.

INTRODUCTION

Mature trees of *Hevea brasiliensis* undergo wintering, refoliation and flowering during the period December-February. In some trees there is occasionally off-seasonal flowering during September-October. A knowledge of anthesis and germination potential of pollen grains is an essential pre-requisite in breeding programmes. However, work on this aspect is only fragmentary. Dijkman (2) gave a general account of floral biology and generative selection in *Hevea*. Germination of pollen grains and anthesis of a few clones of *Hevea* were also reported (4, 6, 7, 8). In the present investigation an attempt is made to study the anthesis, germination of pollen grains and effect of calcium, boron, magnesium and potassium on pollen germination and tube growth with respect to one clone of this species.

MATERIALS AND METHODS

The clone used for the study was RRII 33, an ortet selection of *Hevea brasiliensis* Muell. Arg, made by the Rubber Research Institute of India. The clone has been found to be a modest seeder. Five trees of the clone were selected, and from each tree five branches were selected at random for regular observation of

1 Received for publication 27 March 1986.
The authors thank Dr. M.R. Sethuraj, Director, Rubber Research Institute of India and Shri. P.N. Radhakrishna Pillai, Joint Director of Research, for their critical comments on the manuscript. Thanks also go to Shri. G. Subbarayalu, Statistician, for the analysis of the data.

* Division of Botany, Rubber Research Institute of India Kottayam 686009, Kerala, India.

anthesis. Male flowers just prior to anthesis were collected for pollen studies. Pollen grains were dusted in 1:1 acetocarmine-glycerol mixture and stainability was assessed after one hour. Pollen morphology was studied by acetolysis (3). Measurements of 50 pollen grains were taken for the observations. Germination was studied by dusting pollen to a drop of the medium on a glass slide and the slides were inserted in a Petri dish containing two glass rods. The Petri dishes were lined with moist filter paper. Different concentrations of sucrose (10, 15, 20 and 25%) were employed for a preliminary assessment of pollen germination. Based on the observations, a 20% sucrose medium was chosen for further study, with the following treatments:

1. 20% sucrose with 100 ppm of Ca.
2. 20% sucrose with 100 ppm of B.
3. 20% sucrose with 100 ppm each of B and Ca.
4. 20% sucrose with 100 ppm of Mg.
5. 20% sucrose with 100 ppm of K.
6. 20% sucrose with 100 ppm each of Ca, B, Mg, and K.

Each treatment consisted of a minimum of five replicates and the average values were calculated. The data were subjected to statistical analysis. The growth of the pollen tube could be studied only with treatments one, two, three and six as the percentage of germination was very poor in treatment four and five. Fifty germinated pollen grains were chosen randomly to ascertain the tube length, which was measured after 3 h.

RESULTS

The clone RRII 33 is a complete wintering type whose refoliation starts after wintering by the middle of January. Anthesis of the male flower takes place between 1:15 pm and 1:45 pm. The anthesis of the female flower takes place between 3:15 pm and 4:00 pm. The stainability of pollen grains in acetocarmine-glycerol mixture was 94.7%. The pollen grains are 3-zonicolporate. They showed a size ranging from 35-45 μm. Among the four treatments of different concentrations of sucrose alone, the medium containing 20% recorded the maximum pollen germination (35%), whereas the medium containing 25% sucrose showed 15% germination, and 15% sucrose produced 10% germination. There was no pollen germination in the 10% sucrose solution. Based on this, Ca, B, Mg, and K alone and in combinations were incorporated into a 20% sucrose basal medium. The results are summarized in Table 1. There is significant variation in the germination percentage between the treatments. The highest percentage of pollen germination (86.44%) was recorded in the

Table 1. Germinación of pollen grains.

Treatment No.	Medium	Percentage pollen germination. Mean
1.	20% sucrose with 100 ppm of Ca.	39.95 / (41.26)
2.	20 % sucrose with 100 ppm each of B + Ca	60.33 / (75.28)
3.	20% sucrose with 100 ppm of B.	63.06 / (79.28)
4.	20% sucrose with 100 ppm of Mg.	13.98 / (5.8
5.	20% sucrose with 100 ppm of K.	11.71 / (4.38)
6.	20% sucrose with 100 ppm each of Ca, B, Mg and K	68.41 / (86.44)

S.E. = 1.41 C.D. = 4.12

Note: 1. S.E. and C.D. are for angles obtained using arc sine transformation.
2. The figures within brackets indicate respective germination percentage.

medium containing 100 pm each of Ca, B, Mg and K in addition to 20% sucrose. This was followed, in order, by 20% sucrose with 100 ppm boron alone (79.28%) and 20% sucrose with 100 ppm each of boron and calcium (75.28%).

Observations on the growth of the pollen tube, measured in terms of tube length after three hours of treatment, are given in Table 2. Among the five treatments, highest tube growth (294 μm) was recorded in the treatment containing 100 ppm each of Ca, B, Mg and K in addition to sucrose. The medium with 100 ppm Ca alone, in addition to sucrose, recorded the lowest tube growth (138 μm), while the other two treatments were in between.

DISCUSSION

Among the different concentrations of sucrose solution tried, 20% solution was found to be the optimum for pollen grain germination. The germination of pollen grains as well as the growth of pollen tubes were high in the medium comprising 20% sucrose with 100 ppm of Ca, B, Mg and K. In the presence of boron, the germination was accelerated, whereas the tube growth was greater in the presence of Ca and B compared to B alone. Media with K and Mg showed only low percentages of germination. But traces of these chemicals along with B and Ca in the medium appeared to enhance germination and tube growth. Some chemicals stimulating pollen germination as well as tube growth, e.g. boron, calcium and magnesium, were first noted in the stigmatic fluid in which the pollen naturally germinates (11). Importance of Ca and B for germination and tube growth had been investigated by Vasil (12) and Johri and Vasil (5). The role of calcium ions in pollen tube growth was reported by Brewbaker and Kwack (1). Ground nut pollen showed high germination and tube growth in a basal medium comprising Ca, Mg, K and B (10).

Pollen grains are considered to constitute one of the central units in the biological cycle of plants. Information pertaining to pollen viability is essential to attempt a generative improvement programme in any crop. Ramaer (9) indicated that *Hevea* pollen will not germinate in aqueous sucrose or glucose, but Majumder (6) had shown a fairly high percentage of germination in the same medium. Majumder (6) and Samaranayake *et al.* (8) showed that the percentage of sucrose solution required for germination was 15%. Markose and Bhaskaran Nair (7) reported that a 20% sucrose solution gave better germination. In the present investigation, it was observed that very good germination and tube growth was obtained in a 20% sucrose solution. However, it appears probable that the optimum requirement of sucrose concentration in the medium may vary depending on the genotype. This has also been indicated by Markose and Bhaskaran Nair (7). The pollen collected late in the season as well as that from flowers infected by *Cidium* gave poor germination and also showed short tube length compared to those from healthy flowers. Though the clone studied is a modest seeder, the present studies indicate that pollen sterility is not the cause.

Table 2. Pollen tube growth.

Treatment No.	Medium	Mean tube length (μm)
1.	*20% sucrose with 100 ppm of Ca.*	138.20 ± [illegible]
2.	20% sucrose with 100 ppm of B.	208.60 ± 9.01
3.	20% sucrose with 100 ppm each of B and Ca.	234.30 ± 8.14
4.	20% sucrose with 100 ppm each of Ca, B, Mg and K	294.17 ± 12.56

Literature cited

1. BREWBAKER, J.L.; KWACK, B.H. 1968. The essential role of calcium ions in pollen germination and pollen tube growth. American Journal of Botany 50:859-865.

2. DIJKMAN, M.J. 1951. *Hevea*: Thirty years of research in the Far East. University of Miami Press. p. 178-180.

3. ERDTMAN, G. 1952. Pollen Morphology and Plant Taxonomy: Angiosperms. Waltham, Mass. USA.

4. GEORGE, P.J.; PANIKKAR, A.O.N.; NAIR, V.K.B. 1966. Observation on the floral biology and fruit set in *Hevea brasiliensis* Muell. Arg. Rubber Board Bulletin 9:18-27.

5. JOHRI, B.M.; VASIL, I.K. 1962. Physiology of pollen. Botanical Review 27:325.

6. MAJUMDER, S.K. 1964. Studies on the germination of pollen of *Hevea brasiliensis* in vivo and an artificial media. Journal of the Rubber Research Institute of Malaysia 18:185-193.

7. MARKOSE, V.C.; BHASKARAN NAIR, V.K. 1970. Studies on the pollen of *Hevea.* Rubber Board Bulletin 11:24-28.

8. SAMARANAYAKE, P.; RUPATUNGA, [illegible] FERNANDO, D.M.; JAYASEKERA, N.E.M. [illegible] *In vitro* germination of pollen and pollen [illegible] growth of *Hevea brasiliensis* in the presence of calcium and boron. Journal of the Rubber Research Institute of Sri Lanka 56:29-33.

9. RAMAER, H. 1932. Germination of *Hevea* pollen. Arch. Rubber Cult. 16:328.

10. MALIK, C.P. 1978. Physiology of Sexual Reproduction in Flowering Plants. New Delhi, India., Kalyani Publishers. p. 31-38.

11. STANLEY, R.G.; LINSKENS, H.F. 1974. Pollen-biology Biochemistry and Management. Berlin, Springer-Verlag. p. 67-70.

12. VASIL, I.K. 1960. Studies on pollen germination of certain cucurbitaceae. American Journal of Botany 47:239-247.