UNIVERSITI PUTRA MALAYSIA

JUVENILE AND MATURE PERFORMANCES OF HANDPOLLINATED RUBBER PROGENIES AND THE IMPLICATION IN HEVEA BREEDING

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JUVENILE AND MATURE PERFORMANCES OF HAND-POLLINATED RUBBER PROGENIES AND THE IMPLICATION IN *HEVEA* BREEDING

By

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LIST OF ABBREVIATIONS

AC, MT, RO	Acre, Matto Grosso and Rondonia: Districts in Brazil where the Hevea materials were collected
Am	Amazon material, *Hevea* germplasm from Amazon
ANOVA	Analysis of variance
FX	Ford cross
GCA	General Combining Ability
GT	Gondang Tapen Estate, East Central Java
IAN	Instituto Agronomico do Norte
IRRDB	International Rubber Research and Development Board
IRCA	Institut de Recherches sur le Caoutchouc au Afrique
LSCT	Large Scale Clone Trial
PB	Prang Besar Station
PBIG/GG	Prang Besar Isolated Seed Garden/ Gough Garden
PR	Proefstation voor Rubber
PSA	Potato Sucrose Aga
SCA	Specific Combining Ability
RRIC	Rubber Research Institute of Ceylon
RRIM	Rubber Research Institute of Malaysia
RRIV	Rubber Research Institute of Vietnam
SSCT	Small Scale Clone Trial
W	Wickham, *Hevea* material from Wickham's collection

Abstract of Thesis Presented to the Senate of Universiti Putra Malaysia in Fulfillment of the Requirements for the Degree of Master of Agricultural Science

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Faculty: Agriculture

The RRIM's 1988 Hand-Pollination Programme was conducted using two different sources of materials, e.i. Wickham and Amazon. The progenies obtained from the Hand-Pollination Programme were used to establish a Seedling Evaluation Trial at RRIM Experiment Station, Sungai Buloh. Test tapping was carried out at three and half years after planting. The trial was opened for normal tapping at seven years old. The performances of progenies using data both at immature and mature stages were studied.

Generally, progenies from W x Am crosses were inferior to that of W x W crosses in latex yield. However, there was a W x Am family (PB 5/51 x 64/151) and produced high yield in normal tapping that was comparable to the best of W x W families. High correlation (r = 0.972) was found between the

two test tapping yield characters (mean yield over three cycles and five cycles of tapping). The correlation between normal tapping yield and the two test tapping yields were significant but lower (r = 0.660 and 0.715, respectively). The family ranking order based on yield of normal tapping in comparison with that on yield of test tapping was not very much different except for few cases. There were families that produced better yield at normal tapping than in test tapping and *vice versa*. Selection for top 10% yield of test tapping can get only about half of expected individuals in the same proportion selected on yield at normal tapping.

For growth vigour, many W x Am families were more vigorous than the W x W families. Family ranking order based on girth after test tapping and at opening appeared to be similar. The correlation between the two girth measurements was highly significant (r = 0.951). The common individuals in top 10% ranking on the two girth measurements were higher than that of yield performances, from 77.07% for top 10% to 78.03% for top 20%, respectively.

Generally, W x Am families had better girth increment under normal tapping than W x W families. However, the family RRIM 600 x RRIM 929 (W x W) was among the best in this character.

As for secondary characters, most W x W families had better virgin bark thickness than that of W x Am families. PB 5/51 was the best parent for

tree form. Progenies derived from W x Am had light infection to *Oidium* leaf disease, especially the progenies from family RRIM 600 x 44/745 were free from the disease. For latex colour, all families were satisfactory in this character.

GCA estimates for both yield and vigour support earlier findings that immature performances can be used for early identification of potential parents. Strong correlation was found between GCA values estimated on yield of normal tapping and that of the yield characters of test tapping. For girth measurements, particularly high correlation was found between GCA values estimated on girth after test tapping and that of girth at opening.

In the *Corynespora* screening experiment, the clone PB 5/51 was found as the best parent: almost all progenies with PB 5/51 as female parent showed resistance against *Corynespora*, even when PB 5/51 was crossed with the highly susceptible male parents. On the other hand, RRIM 600 must be avoided in *Hevea* breeding for *Corynespora* resistance because all progenies derived from the clone as the female parent were infected with the disease.

Abstrak Tesis yang Dikemukakan Kepada Senat Universiti Putra Malaysia
Sebagai Memenuhi Syarat Keperluan Untuk Ijazah Master Sains Pertanian

PRESTASI JUVENIL DAN MATANG PROGENI-PROGENI GETAH PEDEBUNGAAN TANGAN DAN IMPLIKASI DALAM BIAKBAKA *HEVEA*

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Program Pendebungaan Tangan RRIM 1988 dijalankan dengan menggunakan dua sumber bahan genetik yang berlainan, Wickham dan Amazon. Progeni-progeni yang diperolehi daripada program pendebungaan tangan ini digunakan untuk Percubaan Penilaian Anakbenih di Stesen Percubaan RRIM, Sg. Buloh. Torehan -ujian dijalankan pada umur tiga setengah tahun selepas penanaman. Manakala torehan biasa dijalankan tujuh tahun selepas penanaman.

Pada amnya, hasil lateks progeni-progeni dari kacukan W x Am adalah lebih rendah berbanding dengan kacukan-kacukan W x W. Walaupun demikian, terdapat famili W x Am iaitu PB 5/51 x 64/151 yang mengeluarkan hasil tinggi pada torehan biasa yang mana setanding dengan famili-famili W x W yang terbaik. Terdapat korelasi yang tinggi (r = 0.972) di antara dua ciri

hasil torehan ujian (min hasil tiga pusingan dan min hasil lima pusingan). Manakala korelasi di antara hasil torehan biasa dengan hasil dua torehan ujian adalah juga bererti tetapi lebih rendah (r = 0.660 dan 0.715). Untuk kedudukan prestasi famili berdasarkan hasil torehan biasa berbanding dengan torehan ujian adalah tidak banyak berbeza kecuali untuk beberapa kes. Terdapat famili-famili yang mengeluarkan hasil lebih baik pada torehan biasa berbanding dengan torehan ujian dan sebaliknya. Pemilihan untuk 10% terbaik ke atas hasil torehan ujian hanya boleh mendapati lebih kurang separuh individu-individu yang dijangka dalam pilihan perkadaran yang sama ke atas hasil torehan biasa.

Untuk kecergasan pertumbuhan, banyak famili W x Am adalah lebih cergas berbanding dengan famili-famili W x W. Kedudukan prestasi famili berdasarkan ke atas ukur lilitan selepas torehan dan pada pembukaan torehan adalah lebih kurang sama. Korelasi di antara pengukuran kedua-dua ukur lilitan adalah tinggi dan bererti (r = 0.951). Individu-individu yang sama dalam kedudukan prestasi 10% terbaik ke atas kedua-dua pengukuran ukur lilitan adalah lebih tinggi berbanding dengan prestasi hasil, daripada 77.07% untuk 10% terbaik sehingga 78.03% untuk 20% terbaik masing-masing.

Pada amnya, famili-famili W x Am mempunyai pertambahan ukur lilitan yang lebih baik pada torehan biasa berbanding dengan famili W x W. Walaubagaimana pun, famili RRIM 600 x RRIM 929 (W x W) adalah di antara yang terbaik untuk ciri ini.

Manakala untuk ciri-ciri sekunder, kebanyakan famili W x W mempunyai ketebalan kulit dara yang lebih baik berbanding dengan famili-famili W x Am. PB 5/51 adalah induk yang terbaik untuk bentuk pokok. Progeni-progeni yang diperolehi daripada W x Am mempunyai jangkitan yang kurang teruk terhadap penyakit daun *Oidium*, terutama progeni-progeni daripada famili RRIM 600 x 44/745 adalah bebas daripada penyakit. Untuk warna lateks, kesemua famili adalah memuaskan dalam ciri ini.

Anggaran GCA untuk hasil dan kecergasan menyokong pendapat-pendapat awal bahawa prestasi juvenil boleh digunakan untuk pengenalpastian awal induk-induk berpotensi. Korelasi yang kuat didapati di antara nilai-nilai anggaran GCA ke atas hasil torehan biasa dengan hasil torehan ujian. Untuk pengukuran ukur lilitan, korelasi yang tinggi didapati di antara nilai-nilai anggaran GCA ke atas ukur lilitan selepas torehan ujian dengan ukur lilitan semasa pembukaan torehan.

Dalam percubaan penapisan *Corynespora*, klon PB 5/51 didapati sebagai induk terbaik, hampir kesemua progeni dengan induk PB 5/51 sebagai induk betina menunjukkan keresistanan terhadap *Corynespora*, walaupun PB 5/51 dikacuk dengan induk jantan yang sangat rentan. Sebaliknya, RRIM 600 mestilah dielakkan dalam biakbaka Hevea untuk keresistanan terhadap *Corynespora* kerana semua porgeni yang dihasilkan daripada klon ini dijangkiti dengan penyakit tersebut.

CHAPTER I

INTRODUCTION

Hevea breeding in South East Asia is one of the most successful breeding programme that has played the key role in the six-fold increase in rubber yield from 500 kg/ha/year (unselected seedlings) to 3000 kg/ha/year (modern clones). However, several problems are known to hamper rapid progress in yield improvement in rubber. Among them are narrow genetic base, long breeding and selection cycle, difficulty in selection for multiple characters, lack of disease resistance, genotype-environment interaction and non-synchronisation of flowering and low fruit-set. (Tan, 1987).

Breeding and selection of clones is one of the most important areas of research at the Rubber Research Institute of Malaysia. Each year, tens of thousands of hand-pollinations were carried out and few thousands of seeds were obtained. In conventional approach, seeds from successful hand-pollination were germinated in polybags. When the seedlings reach three-whorl stage, they were transferred to nursery field with close planting distance and test-tapping will be done at two and half years later.

Based on the results of early test-tapping and second characters, the better performing seedlings were selected and cloned for further testing in Small Scale Clone Trial, Larger Scale Clone Trial, Promotion Plot and Block Planting. Elite clones will be recommended for commercial planting.

In another RRIM breeding approach, seedlings from 1988 Hand-Pollination programme were planted directly to the field using commercial planting distance. Test tapping was done three years later and normal tapping was done at mature stage. First round of selection was done based on the early performances, the selected seedlings were cloned and planted in a Small Scale Clone Trial. At mature stage, seedlings from the Hand-Pollination programme were subjected to normal tapping in 1996 and another round of selection to identify promising progenies was carried out on those were not selected in the first selection.

As a continuation of the above programme, this study was conducted to investigate the performances of hybrids from crosses between different genetic resources, to study the relationship between the juvenile and mature performances for possible use of the Seedling Evaluation Trial for selection and to study the combining ability of main characters and resistance to diseases.

CHAPTER II

REVIEW OF LITERATURE

Origin of the Rubber Tree

Latex occurs in some 12,500 species of plants belonging to about 900 genera, however only about 1000 species from seventy-six families and a few hundred genera contain rubber. Of these plants, rubber tree was the most successful for rubber production and one of the reasons for its success being the favourable anatomy of the tree for exploitation of latex (Gomez, 1980).

Beside rubber tree, three other plant species had been found to produce enough rubber to merit domestication. They are *Parthenium argentatum* (guayule) of Central America, *Taraxacum* (kok-saghyz) of Southern Russia and *Solidago* spp. (golden rod) of North and South America with the former being the highest yielder (National Academy of Sciences 1977; cited by Baulkwill, 1989).

The Para rubber (named after Para State, Brazil from where the first natural rubber was produced), *Hevea brasiliensis* (Willd. ex A. de Juss) Mueller-Argoviensis belongs to the genus *Hevea* of the Euphorbiaceae family. The genus *Hevea* comprises 10 species and occurs in the wild in an area which covers the whole of the Amazon basin and extended southwards into the foothills of the Matto Grosso region of Brazil and northwards into the upper part of the Oricono basin, the lower slopes of the Guiana Highlands and parts of the lowlands of the Guianas. This large area covers parts of Brazil, Bolivia, Peru, Colombia, Ecuador, Venezuela, French Guiana, Surinam and Guyana (Webster and Paardekooper, 1989).

According to Webster and Paardekooper (1989), *Hevea brasiliensis* occurs naturally over about half the range of the genus. It mainly occupies the region south of the Amazon, extending to the Arce, Matto Grosso and Parana areas of Brazil and into parts of Bolivia and Peru, but it is also found north of the Amazon to the west of Manaus as far as the extreme south of Colombia. The seeds which formed the foundation of the rubber industry of the East were collected by Wickham in a very small area at the confluence of the rivers Tapajoz and Amazon, near the town of Santarém, and was clearly not a representative sample of the germplasm of the species. Indeed it has been suggested that it might have included seeds from inter-specific hybrids, but it has now been clearly established that it was genetically pure *H. brasiliensis*.

H. brasiliensis and the other *Hevea* species are diploid with chromosome number of 2n = 2x = 36. This is a common somatic chromosome number in the Euphorbiaceae but several genera have the basic n = 7, 8, 9, 10, 11. The 36-chromosome genera were therefore probably old tetraploids based on x = 9 (Ong, 1976; Simmonds, 1989). The karyotype analyses of the seven species of the genus *Hevea* also suggest that the species have diverged from each other concerning chromosome morphology. Judging by the criterion of asymmetry, *H. brasiliensis* appears to be the most advanced while *H. guinanensis* was the most primitive. The order of advanceness of the other species is as follows: *H. benthamiana*, *H. rigidifolia* and *H. spruceana*, *H. nitida* and *H. pauciflora* (Ong, 1980).

There are no cytogenetic barriers to interspecific hybridization among species, and interspecific hybrids have been found in nature as well as produced in breeding programmes. There was no evidence of self-incompatibility in rubber tree although they usually set more fruits from cross-pollination than selfing. Male sterility in rubber tree was found in only a few clones namely GT 1, Ch 2 and RRII 35 (Saraswathy and Panikka, 1989 cited by Lai, 1995).

Hevea Germplasm

Genetic Base in the East

In 1876, the first successful transfer of the Wickham seeds from Brazil to South-East Asia was the starting point to the creation of the entire present *Hevea* industry in Asia and Africa. From seventy thousands of Wickham seeds, only 2700 were successfully germinated in Kew. In the first distribution, 1900 seedlings were sent to Sri Lanka and 1876 survived. A total of 50 seedlings were sent to Singapore but none survived and 18 went to Indonesia of which two of them survived (Webster and Paardekooper, 1989; Jones and Allen, 1992).

Sri Lanka was a major source of rubber seeds for domestic use and exported to other South East Asia countries. In India, the first seedlings from Sri Lanka were received in 1878 (Jones and Allen, 1992).The first *Hevea* breeding programmes were started in Ceylon (then Sri Lanka), Netherlands East Indies (Indonesia) and Malaya Federal State using only the Wickham materials.

The following account relates to the distribution of Wickham's introduction in Ceylon as reported by Dr. Trimen, Director of Botanic Garden, Ceylon (Schidrowitz and Dawson, 1952).

1876: Receipt of 38 Wardian cases containing some hundreds of rubber seedlings by Dr. Thwaites (Director of Gardens), Ceylon, from Kew.

1878-1879: Propagated cuttings from the above plants were distributed to Burma, Ceylon and India.

1887: Large quantities of seeds were collected, sown in nurseries and distributed in Ceylon.

1887-1888: Seeds were sent to Penang Singapore, Fiji, Queensland, North Borneo, Jamaica, Java and German East Africa.

1890-1894: Tapping results were reported and samples of rubber were valued by brokers. The early plantations in Ceylon and Malaya were started using seeds obtained from trees derived from the seed obtained by Wickham in 1876. The subsequent extensive developments in Ceylon and particularly in Malaya and later in Netherlands East Indies were mostly derived from the second generation of trees, very large quantities of seed being collected and sold for further planting from the beginning of the present century.

Following is the dates and activities of the introduction of rubber tree into Malaya Peninsular (Schidrowitz and Dawson, 1952).

1877 (June): First plants received alive in Singapore.

1877(Oct.): The first tree was planted by Mr. Murton in Perak (Fed. Malay State).

1882: Seeds were sent from Singapore to Kuala Kangsar (Perak) and also to Sarawak.

1895: Mr. Kindersley started first "practical" estate in Federal Malaya State.

In the same year, after the arrival of Wickham seeds, there was another collection done by Robert Cross who returned from Brazil with about 1000 seedlings but the fate of these seedlings was a mystery. Baulkwill (1989) believed that some small admixture of Cross genetic material in Wickham material cannot be entirely ruled out.

Amazonian *Hevea* Germplasm

After Wickham material, a few introductions, including *H. spruceana* and *H. guianensis*, were made in Indonesia from Brazil and Surinam in 1869, 1898 and between 1913 and 1916 (Dijkman, 1951). In Malaya, during 1951 and 1952, 1614 seedlings of collections of *H. brasiliensis, H. bethamiana, H. guinanensis, H. spruceana* and *H. paucifora* and of hybrids from different provenances in Brazil were imported (Brookson, 1956). Other introductions to Malaysia were 25 South America Leaf Blight (SALB) resistant clones from