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The selection for high rubberwood yielding genotypes in 1995 *Hevea* germplasm, Rantau Panjang Forest Reserve

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Abstract
Rubberwood has become a major source of raw material for furniture manufacturing and wood-based product industries in Malaysia. The increasing demand for rubberwood has triggered Rubber Research Institute of Malaysia (RRIM) search for the high rubberwood yielding genotypes available in Malaysia. However, there are not many genotypes planted in commercial rubber plantations and smallholdings in Malaysia that can produce high wood volume to meet the demand of furniture and wood-base industries. There are also no *Hevea* wild relatives available in Malaysia to produce rubberwood except the one and only species *Hevea brasiliensis*. Moreover, the destruction of wild genetic resources of rubber trees (*Hevea* spp.) in Amazon basin due to mass conversion of native habitat to urban has resulted in irreplaceable loss of much wild genetic resources such as the genotypes that can produce high rubberwood volume. Therefore, an attempt by RRIM in 1995 to put *Hevea* wild relatives from Amazon basin into conserving genetic resources in Malaysia and making them available for crop improvement especially to produce high rubberwood genotypes. Genotypes and wild relatives that are seen as vigorous and generated high rubberwood yield can be exploited as promising planting material in the RRIM's breeding programmes. This study was intended to identify the most promising rubberwood yielding genotypes and *Hevea* wild relatives that conserved in 1995 *Hevea* germplasm, Rantau Panjang Forest Reserve, Batu Arang, Selangor, Malaysia.
Keywords: selections, *Hevea* spp., germplasm, genotypes

1.0 Introduction

There is a continuing and widespread destruction of the wild genetic resources in Amazon basin due to the conversion of the vast native flora and fauna habitat into farming and urban activities (Shukla *et al*., 1990; The Amazon, URL: http://rainforests.mongabay.com/amazon/deforestation_calculations.html). Rubber tree (*Hevea* spp.) and its wild relatives are the plant species that are facing the deforestation problem in Amazon. Meanwhile, the demand for rubberwood is increasing rapidly in Malaysia and become the important raw material for wood-based industries such as furniture and carpentry (Mohd.Nasaruddin, 2003; Mohd. Johari, 2005; MRB 2009; Shigematsu *et al*., 2010). Rubberwood has its natural milky cream in colour with fine wood texture is pleasant as the environmentally friendly material of furniture production, wood panel products and decorative use (Rathasingam *et al*., 2011; Yi *et al*., 2011). The establishment of the *Hevea* germplasm in Malaysia is inevitable as an attempt to overcome the lesser genetic resources available for high rubberwood yielding genotypes with the deforestation continuing in Amazon basin.

2.0 Materials and Methods

2.1 1995 *Hevea* germplasm

Baulkwill (1989) and Schultes (1990) have coined that there are 10 *Hevea* wild relatives distributed at different geographical regions in the Amazon basin. In 1995, a mission to Amazon basin searched for *Hevea* wild relatives and species and bought back to Malaysia was initiated by Rubber Research Institute of Malaysia (RRIM), and supported by Forest Research Institute Malaysia (FRIM) and Forestry Department Peninsular Malaysia (FDPM). The expedition was aimed to collect the seeds of wild relatives and transported them back to Malaysia as conservation and germplasm materials. The expedition has covered at least 13 different locations in Amazon basin mainly in Brazil *viz.* Acre, Atalia de Norte, Belem, Borba, Benjamin Constant, CPAA Manaus, Iranduba, Manaus, Manicore, Sao Gabriel, Sao Paulo de Olivencia, Tapajos and Tabatinga. Seeds from eight different wild relatives were found and collected including *H.brasiliensis, H.benthamiana, H.camargoana, H.guianensis, H.nitida, H.pauciflora, H.rigidifolia* and *H.spruceana.* These seeds were transported to RRIM for disinfectant, quarantine treatments and germination at the treated seed beds. Later, seeds that successfully germinated into seedlings plants were transplanted to 1995 *Hevea* germplasm, Rantau Panjang Forest Reserve, Batu Arang, Selangor (Ong *et al*., 2007).

2.2 Genotype selection

The selection was carried out mainly on the measurement of wood volume at tenth-year after planting. A total of 15,113 genotypes were measured according to the girth growth (60 and 150 cm from ground level), bole height and estimated wood volume similar to the method applied in RRIM's planting recoomendations (RRIM, 1995; MRB, 1998; MRB, 2003). Two different measurements for girth growth from ground level are required to allow the calculation of estimated truncated wood volume using the formula $3.142/12\ [(D1+D2)^2 - D1D2]\ L$, where D1 is the diameter at 60 cm from ground level (m); D2 is the diameter at 150 cm from ground level (m); L is the bole height (m). The measurement of bole height was taken from the ground level where the first crotch larger than five cm in diameter. The data collected was statistical analysed for comparison between the genotypes where Duncan's Multiple Comparison was applied to differentiate among the means. The final selection for high rubberwood yielding genotypes at 1995 *Hevea* germplasm is based on the highest 150 truncated wood volume among the measured genotypes.

3.0 Results and discussion

3.1 Girth growth at 60 cm from ground level

The girth growth at 60 cm from ground level is summarized in Table 1. The mean girth for *Hevea* wild relatives were ranged from the highest 80.6 cm (*H.nitida*) to the lowest 51.7 cm (*H.benthamiana*). The result revealed that *H.nitida* obtained the highest mean girth performance whenever measured the girth at 60 cm from the ground level. The other species that with fairly vigorous mean girth were *H.camargoana* (75.7 cm) and *H.brasiliensis* (74.6 cm). Although *H.camargoana* and *H.nitida* showed the vigorous girth growth, the measurement was based on 36 and 58 trees respectively, compared to more than seven thousands trees that were measured in *H.brasiliensis*. This might indicate the low germination and transplanting rates in *H.camargoana* and *H.nitida* eventhough they have vigorous girth growth at 60 cm from ground level.

3.2 Girth growth at 150 cm from ground level

In Table 2, *H.nitida* has been projected as the highest mean girth over the years with 62.0 cm followed by *H.camargoana* at 58.0 cm. The lowest mean girth were from *H.guianensis* and *H.rigidifolia*. This result showed that the girth growth at 150 cm from ground level of *H.nitida* was the most vigorous compared to other wild relatives that conserved at the same agro-climatic condition. However, there was an individual tree that achieved the highest girth growth from *H.brasilensis* (133.4 cm). This result suggested that there was some potential high girth growth genotypes in *H.brasiliensis* along with *H.nitida* and *H.camargoana*.

3.3 Bole height

Bole height from ground level has revealed that *H.brasiliensis* was the highest with mean height at 503.1 cm (Table 3). Wild relatives that with high bole height were from *H.spruceana* and *H.nitida*, mean bole height at 405.8 cm and 382.9 respectively. The bole height measurement was crucial to determine the estimation of truncated wood volume, with the girth growth data taken at 60 and 150 cm from ground level. High bole height is one of the preferable character in the selection for promising rubberwood genotypes due to the higher wood volume will come from those trees with higher bole height.

3.4 Wood volume

A total of 15,113 wild relatives have been measured to estimate the truncated wood volume using the data taken from the girth growth and bole height. In Table 4, the means of truncated wood volume between *Hevea* wild relatives ranged from the lowest at 0.05 to the highest at 0.19 m^3. Higher truncated wood volume could be seen on wild relatives such as *H.brasiliensis*, *H.spruceana* and *H.nitida*. The lowest mean wood volume was from *H.benthamiana* at 0.05 m^3.

3.5 Selection for the highest wood volume among the top 150 genotypes

A total of 15,113 *Hevea* genotypes were examined and sorted according to the truncated wood volume at tenth-year after planting at the 1995 *Hevea* germplasm. In table 5, there are 150 genotypes with their means in different measurements have been identified as the highest rubberwood yielding genotypes and given temporary identification codes (codes starting from BA/GX1 to BA/GX 150). There were 138 genotypes mainly from *H.brasiliensis* and 12 genotypes from other wild relatives such as *H.spruceana* (10), *H.benthamiana* (1) and *H.nitida* (1). Meanwhile, *H.camargoana, H.guianensis, H.pauciflora,* and *H.rigidifolia* were not considered as good rubberwood genotypes as some of them contained unfavourable characteristics such as crooked bole, cracked and uneven wood surfaces.

4. Conclusion

The selected 150 genotypes in this study have exhibited high girth performance and truncated wood volume compare to other genotypes that have been measured in 1995 *Hevea* germplasm. This study has indicate the selection for the high rubberwood yielding genotypes must take into the consideration of the strong influences of girth growth and bole height that eventually lead to high truncated wood volume. Multiplication of these potential genotypes as elite clone for rubberwodd production have been carried out and tested as a new source of

genetic materials in RRIM. The next thing to be considered is to test the wood quality of the selected genotypes such as moisture content, density and hardness to meet the requirement of the rubberwood market. This matter is crucial to ensure rubberwood to be branded as good in both quantity and quality besides seen as environmentally friendly wood material in local and international markets. In short, the expedition to collect *Hevea* wild relatives in 1995 was a worthwhile scientific activity to safeguard the most valuable genetic resources and for the future crop improvement of *Hevea* species.

Table 1 . Girth (cm) comparison of different *Hevea* wild relatives at 60 cm from ground level.

Species	n	Mean	Max	Min
H.brasiliensis	7205	74.6 ab	163.8	10.0
H.benthamiana	5986	51.7 d	143.0	10.1
H.camargoana	36	75.7 ab	100.6	17.1
H.guainensis	862	60.3 c	140.8	15.8
H.nitida	58	80.6 a	110.3	33.0
H.pauciflora	166	70.1 b	136.3	27.5
H.rigidifolia	31	63.2 c	90.2	18.5
H.spruceana	769	70.3 b	142.8	14.5

Means with the same letter are not significant difference by DMRT, p=0.05

Table 2. Girth (cm) comparison of different Hevea wild relatives at 150 cm from ground level.

Species	n	Mean	Max	Min
H.brasiliensis	7205	54.2 bc	133.4	7.0
H.benthamiana	5986	36.0 f	110.5	7.0
H.camargoana	36	58.0 ab	75.5	13.2
H.guainensis	862	44.7 e	95.8	11.1
H.nitida	58	62.0 a	88.7	25.0
H.pauciflora	166	52.9 c	109.0	22.0
H.rigidifolia	31	47.9 de	72.0	14.0
H.spruceana	769	50.7 cd	113.0	7.7

Means with the same letter are not significant difference by DMRT, p=0.05

Table 3. The comparison of bole height (cm) between *Hevea* wild relatives.

Species	n	Mean	Max	Min
H.brasiliensis	7205	503.1 a	1555.0	40.1
H.benthamiana	5986	253.0 d	850.0	14.1
H.camargoana	36	336.9 c	660.5	163.5
H.guainensis	862	270.8 d	778.0	107.0
H.nitida	58	382.9 b	905.0	146.5
H.pauciflora	166	299.0 cd	846.0	141.0
H.rigidifolia	31	287.7 d	529.0	154.0
H.spruceana	769	405.8 b	1305.0	80.0

Means with the same letter are not significant difference by DMRT, p=0.05

Table 4. The comparison of truncated wood volume (m^3) between *Hevea* wild relatives at tenth-year after planting.

Species	n	Mean	Max	Min
H.brasiliensis	7205	0.19 a	1.45	0.00
H.benthamiana	5986	0.05 e	0.57	0.00
H.camargoana	36	0.13 b	0.32	0.00
H.guainensis	862	0.07 de	0.50	0.00
H.nitida	58	0.17 a	0.63	0.02
H.pauciflora	166	0.11 bc	0.48	0.01
H.rigidifolia	31	0.08 cd	0.19	0.01
H.spruceana	769	0.14 a	0.89	0.00

Means with the same letter are not significant difference by DMRT, p=0.05

Table 5. Summary of the means from the 150 highest truncated wood volume genotypes.

Parameters	Mean	Max	Min
Girth 60 cm (cm)	113.4	163.8	84.2
Girth 150 cm (cm)	85.3	133.4	60.1
Bark Thickness (mm)	6.9	11.0	4.0
Bole Height (cm)	859.2	1555.0	347.5
Truncated Wood Volume (m^3)	0.66	1.45	0.54

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