GROWTH OF SEVERAL RUBBER CLONES FOR TIMBER PRODUCTION

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Keywords: *Hevea brasiliensis,* planting density, clonal material, clonal seedling, interaction

LOKMAL, N., MOHD ZAKI, A., FARAH FAZWA, M. A., SUHAIMI, W. C., AZMY, Y., ZAKARIA, I., TAN, H., KHOO, S. K. & WAN-AKIL, T. A. 2008. Pertumbuhan beberapa klon pokok getah untuk penghasilan balak. Kajian ini bertujuan menilai pertumbuhan beberapa klon pokok getah yang dipilih untuk pengurusan ladang hutan bagi penghasilan balak. Klon pada mulanya dibangunkan di bawah sistem pertanian intensif bagi penghasilan lateks. Kami memerhati pertumbuhan ladang getah berusia tujuh tahun di Hutan Simpan Bukit Hari dan Hutan Simpan Sungai Buloh, Selangor. Di kedua-dua tapak, klon PB 235 menunjukkan ketinggian dan diameter yang terbesar. Semua klon menunjukkan pertumbuhan yang lebih baik apabila ditanam pada ketumpatan rendah (600 pokok/ha) berbanding ketumpatan tinggi (900 pokok/ha). Analisis tapak individu dan analisis tergabung menunjukkan kesan klon yang signifikan. Interaksi antara klon dan tapak adalah sangat signifikan namun semua klon menunjukkan kedudukan yang sama di kedua-dua tapak. Interaksi klon dan ketumpatan adalah tidak signifikan dan pekali ubahan bahan klon adalah lebih rendah daripada anak benih klon.

INTRODUCTION

The rubber tree *Hevea brasiliensis* is well known for its latex production, and now, for its timber. Rubberwood is an evenly light coloured hardwood and is mainly used for furniture making. With good acceptance worldwide, Malaysia's export for rubberwood sawn-timber has increased steadily over the years, reaching RM1.2 billion in 2004 (Anonymous 2006).

Despite the tremendous potential for export, the industry faces shortage of raw material due to low volume harvested, logistic problems and poor recovery rate at the mills (Ser 1990). The Rubber Research Institute of Malaysia (RRIM) has produced several hundred rubber clones for latex production. Several of these clones have shown vigorous stem growth. A proper selection and testing of these high timber yielder clones could result in viable establishment of forest plantations of rubber trees.

Here, we discuss the performance of selected rubber clones carried out at the Forest Research Institute Malaysia (FRIM). The rubber trees were planted under forest plantation for the production of rubberwood.

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MATERIALS AND METHODS

In April 1986 a project on planting of *H. brasiliensis* under forest plantation management was initiated at FRIM with the collaboration of RRIM. Two types of planting materials were used, namely, clonals and illegitimate seedlings. Illegitimate seedlings used in this study were seedlings that grew from seeds collected from monoclonal plot. The rubber clones tested were RRIM 921, RRIM 922, PB 235, PB 260 and illegitimate seedling, RRIM 623. The selection of clones was based on growth vigour, resistance to disease and windbreak from various trials at RRIM (Mercykutty *et al.* 1995).

Two trial sites were established at the Bukit Lagong Forest Reserve and Sungai Buloh Forest Reserve in Selangor. At both sites a four-ha plot was established in 1986 using a randomized complete block with factorial design. The experiment was replicated with four and five blocks in Bukit Hari and Sungai Buloh respectively. A single-tree plot layout was adopted at Sungai Buloh Forest Reserve to study the effects of polyclonal planting. Two planting distances were used at both sites, 2 × 5.5 m (900 trees/ha) and 3 × 5.5 m (600 trees/ha). Plot size varied between 30–40 trees depending on availability of planting stocks.

Trial sites were clear-felled without any burning and levelling of sites. Debris were cut into one-meter lengths and stacked up in between the planting line. No cover crops were introduced into the sites. Planting materials from the clones were prepared by using polybags and planted in the field three months after budding. The RRIM 623 seedlings, taken from the ground nursery at six months old, were planted as bare-root stumps of 0.5 m lengths. Heptachlor (100 g) and Christmas Island Rock Phosphate (100 g) were added in each planting hole during planting. Besides annual weeding (line clearing) no other tending operations were carried out. No tapping of rubber trees was done during the period of observation until now. However, growth data presented in this paper were for seven-year-old stands.

Statistical analysis

A general linear model was performed using individual tree data for every site.

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + \theta_k + \beta\theta_{(jk)} + \varepsilon_{ijkl}$$

where

Y_{ijkl} = observation of individual tree of clone j, in block i with spacing k
μ = population mean
α_i = fixed effect of the block i
β_j = effect of the clone j (random)
θ_k = effect of the spacing k (random)
$\beta\theta_{(jk)}$ = effect of the interaction between clone i and spacing k (treated as random effect)
ε_{ijkl} = random error associated with all effects.

In addition to this, a combined analysis was also performed using a mixed model as follows:

$$Y_{ijklm} = \mu + \alpha(\eta)_{ij} + \eta_j + \beta_k + \eta\beta_{(jk)} + \theta_l + \beta\theta_{(kl)} + \varepsilon_{ijklm}$$

where

Y_{ijklm} = observation of individual tree of clone replicated in block i within site j with spacing l
μ = population mean
$\alpha(\eta)_{ij}$ = effect of block i within site j
η_j = effect of site j (random)
β_k = effect of clone k
$\eta\beta_{(jk)}$ = effect of interaction between site j with clone k (random)
θ_l = effect of spacing l (random)
$\beta\theta_{(kl)}$ = effect of interaction between clone k and spacing l
ε_{ijklm} = random error associated with all effects.

An appropriate error term was used to perform the F-test of variates in both models as suggested in SAS (1989). Multiple range comparison was also conducted.

RESULTS AND DISCUSSIONS

Individual site analysis

Analysis at each site revealed significant difference between clones and spacing but interaction between clone and spacing for height and diameter at both sites was not significant (Tables 1 and 2). Clone PB 235 was always the best followed by RRIM 922 (Tables 3 and 4). All clones were better in growth compared with clonal seedling RRIM 623. A multiple range test for height in Bukit Hari showed that at 2 × 5.5 m spacing, all clones except RRIM 623 were not significantly different. In the same spacing at Sungai Buloh height of clone PB 235 was highly significant compared with the rest of the clones.

At Bukit Hari, PB 235, RRIM 922 and PB 260 clones at 2 × 5.5 m showed similar but better diameter at breast height (dbh) growth compared with RRIM 623 and RRIM 921. At spacing 3 × 5.5 m, clones PB 235 and RRIM 922 had better dbh growth than the rest. In Sungai Buloh, PB 235 had the greatest dbh at both spacings followed by RRIM 922 and PB 260. RRIM 623 again had the lowest dbh growth.

Combined analysis

Combined analysis for total height and diameter growth indicated that clones, sites and spacings have significant effects on growth performance (Table 5). Clone PB 235 displayed greater total height and diameter growth compared with the rest of the clones (Table 6). As in the individual site, all clones performed better than clonal seedlings of RRIM 623. Similar trend was reported by Westgarth and Buttery (1965) who studied growth of estate rubber trees. Interaction between clones and spacing was not significant but clones and site interaction was significant (Table 5). However, all clones maintained similar ranking (Table 4). Although the interaction between clone and site was significant, it did not implicate serious problem. Interaction at the clonal level in *H. brasiliensis* is not a new phenomenon. The extent of interaction between rubber clones and environment was reported by Tan (1995), Aidi-Daslin *et al.* (1986), Onokpise *et al.* (1986) and Rajeswary *et al.* (1991).

Mortality of trees in our study was minimal (results not shown). In fact densities used in this study were too high compared with normal practices in the estate. No serious outbreak of pest and disease was recorded over this period. The incidence of wind damage was observed to be low although clone PB 235 is generally known to be susceptible (Cilas *et al.* 2004).

Table 1 Analysis of variance for height and diameter at Bukit Hari

Source of variation	Degree of freedom	Mean square	
		Height (m)	Dbh (cm)
Bl	3	21.1^{ns}	267.1****
Cl	4	403.8**	288.3**
Sp	1	583.4****	1108.7****
Cl × Sp	4	11.0^{ns}	9.4^{ns}
Residual	1580	11.2	19.2

Note: **, ***, **** = significant at p ≥ 0.01, 0.001 and 0.0001 respectively; ns = not significant at p ≤ 0.05; Bl = block; Cl = clone; Sp = spacing

Table 2 Analysis of variance for height and diameter at Sungai Buloh

Source of variation	Degree of freedom	Mean square	
		Height (m)	Dbh (cm)
Bl	4	38.1****	24.7^{ns}
Cl	4	533.1***	1298.3***
Sp	1	418.2***	1963.5***
Cl × Sp	4	6.2^{ns}	15.7^{ns}
Residual	1587	4.5	11.4

Note: **, ***, **** = significant at p ≥ 0.01, 0.001 and 0.0001 respectively; ns = not significant at p ≤ 0.05; Bl = block; Cl = clone; Sp = spacing

Table 3 Growth of all clones at two spacings in Bukit Hari and Sungai Buloh

Clone	Bukit Hari				Sungai Buloh			
	2 × 5.5 m		3 × 5.5 m		2 × 5.5 m		3 × 5.5 m	
	Height (m)	Dbh (cm)	Height (m)	Dbh (cm)	Height (m)	Dbh (cm)	Height (m)	Dbh (cm)
RRIM 623 (s)	12.1^{b}	11.7^{c}	13.1^{c}	13.9^{c}	12.1^{c}	11.4^{d}	13.5^{c}	14.2^{d}
RRIM 921	14.0^{a}	13.2^{b}	14.9^{b}	14.3^{b}	14.6^{b}	14.0^{c}	15.4^{b}	16.1^{c}
RRIM 922	14.6^{a}	14.4^{a}	16.3^{a}	16.0^{a}	14.7^{b}	15.6^{b}	15.8^{b}	17.4^{b}
PB 235	14.7^{a}	14.6^{a}	16.4^{a}	15.9^{a}	16.0^{a}	17.4^{a}	16.7^{a}	19.3^{a}
PB 260	14.4^{a}	13.7^{b}	15.9^{a}	14.7^{b}	14.7^{b}	14.3^{c}	15.9^{b}	17.0^{b}

Means followed by the same letter within the same column are not significantly different at $p \leq 0.05$; (s) = clonal seedling.

Table 4 Growth of all clones at Bukit Hari and Sungai Buloh

Clone	Bukit Hari		Sungai Buloh	
	Height (m)	Dbh (cm)	Height (m)	Dbh (cm)
RRIM 623 (s)	12.3^{c}	12.2^{c}	12.6^{c}	12.5^{d}
RRIM 921	14.4^{b}	13.8^{b}	14.9^{b}	14.8^{c}
RRIM 922	15.4^{a}	15.2^{a}	15.2^{a}	16.4^{b}
PB 235	15.6^{a}	15.3^{a}	16.3^{a}	18.1^{a}
PB 260	15.1^{a}	14.2^{b}	15.2^{a}	15.4^{c}

Means followed by the same letters within the same column are not significantly different at $p \leq 0.05$; (s) = clonal seedling.

Table 5 Combined analysis of variance for height and diameter

Source of variation	Degree of freedom	Mean square	
		Height (m)	Dbh (cm)
Si	1	75.4^{ns}	1542.5^{*}
Bl (Si)	7	30.6^{***}	149.2^{****}
Cl	4	927.1^{*}	1334.3^{*}
Cl × Si	4	27.6^{**}	224.7^{****}
Sp	1	971.3^{****}	3055.8^{****}
Cl × Sp	4	6.5^{ns}	16.2^{ns}
Residual	3172	7.9	15.3

Note: **, ***, **** = significant at $p \geq 0.01$, 0.001 and 0.0001 respectively; ns = not significant at $p \leq 0.05$. Bl = block; Cl = clone; Sp = spacing

The clones are generally much more uniform in terms of growth while seedling populations are expected to contain a certain portion of runts (Table 5). This uniform growth makes clonal materials more preferable for commercial planting since logs produced are expected to be uniform, with greater height and diameter. On the other hand, seedling populations by virtue of their wider genetic base would be less prone to epidemic fungal disease outbreak. The danger of such epidemics in susceptible clonal stands even under estate management is well acknowledged.

Direct comparison between the performance of rubber clone under forest plantation and

Table 6 Height and diameter growth of all clones

Clone	Dbh (cm)	Coefficient of variation	Height (m)	Coefficient of variation
RRIM 623 (s)	12.4[c]	40.4	12.5[c]	28.3
RRIM 921	14.3[b]	23.8	14.7[b]	16.5
RRIM 922	15.8[a]	24.0	15.3[a]	17.8
PB 235	16.8[a]	25.1	16.0[a]	16.9
PB 260	14.8[b]	27.1	15.1[a]	19.2

Means followed by the same letters within the same column are not significantly different at $p \leq 0.05$.
(s) = clonal seedling.

under estate management is still not available. However, in general, the growth is expected to be better in the latter. This is due to the fact that rubber trees under estate management are managed intensively in terms of site preparation, introduction of cover crops, intensive fertilizer application and weeding schedule. Most importantly all estates are located in areas which have good soil that further enhances the growth of trees, while in forest plantation, the soil is normally poor in nutrient and not suitable for agricultural activities. However, growth can be higher if planting materials were derived from seed orchard or via clonal materials as shown in this study.

CONCLUSIONS

Rubber trees, grown under forest plantation conditions with minimum maintenance such as weeding and manuring plus pest and disease rounds, seem to be rather competitive. This was reflected in this study by the high growth of height and diameter of trees which allowed them to dominate over surrounding vegetations. Culling of poor seedlings should be carried out which in turn would raise the mean of the seedling population.

Seedling populations by virtue of their wider genetic base would be less prone to epidemic fungal disease outbreak. In view of this, it was felt that the use of polyclonal may be a better solution to buffer up the clone from natural disasters.

With regard to planting materials, more experiments should be carried out to test other clones as well as seedlings derived from seed orchards. Testing potential clones produced by RRIM is vital since all clones are selected and developed under totally different management system. Experiments should be focused on determining if the best clones produced under estate management will remain the best under forest plantation.

The presence of interaction between clones and sites give some indication about lack of stability of the clones tested over different locations. In this trial, the interaction is not a serious problem. However, planting of additional clones should be carried out with extra care since clones might perform and behave differently in different locations especially in extreme environment such as long dry season, poor soil and strong wind. Results over several locations will help in deciding effective allocation of clones to appropriate sites, hence maximizing their best potential growth.

Although clonal seedlings of RRIM 623 performed poorly, they could still be considered with high selection intensity as early as at nursery stage up to field. Culling of poor seedlings and thinning of poor trees in the plantation should be carried out to raise the growth mean of the seedling population in the plantation. It is very important to ensure that only the best trees are allowed to grow in order to obtain good growth. Seedlings are also cheaper than clonal materials and easier to handle in bulk.

All these factors as well as the availability of research and good market for rubber wood at the local and international levels make *H. brasiliensis* a potential forest plantation species in Malaysia. It is also useful to set up species trials of other *Hevea* spp. such as *H. benthamiana, H. camargoana, H. guianensis, H. nitida, H. pauciflora* and *H.spruceana,* including their hybrids. They are good genetic resources for future breeding programme of rubber forest plantation.

In view of the current shortage of rubberwood it has been demonstrated that rubber can grow rather well under forest plantations and merits to be thoroughly considered as one of the exotic species that could be planted in the forest plantation programme.

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