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FIELD EVALUATION OF PROGENIES OF A CANOPY MUTANT OF *HEVEA BRASILIENSIS*

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Canopy and tree architecture are important features determining both the tree-level and stand-level productivity of rubber and susceptibility towards wind damage in plantations. However, genetic base of crown architecture is less studied and is rarely utilized in tree improvement programmes. A natural mutant of *Hevea brasiliensis* showing distinct morphological variation in the crown was reported earlier. In the present study, genetic improvement of the compact canopy morphotypes was attempted through half-sib approach and selected progenies were subjected to field evaluation adopting recommended spacing. Girth and yield of four morphotypes (Compact: 12 cm, 5.5 g $t^{-1}t^{-1}$; intermediate: 81.0 cm, 28.3 g $t^{-1}t^{-1}$; semi compact: 46 cm, 17.2 g $t^{-1}t^{-1}$; normal: 76 cm, 25 g $t^{-1}t^{-1}$ and RRII 105-control: 64.2 cm, 45 g $t^{-1}t^{-1}$) showed significant variability while original natural mutant (compact) showed stunted growth and less yield. The mean canopy spread/width in the 5th year in RRII 105 and the normal type ranged from 4.6 to 5.5 m; whereas, the intermediate type had a canopy spread of 2.2 m only. The intermediate crown type can be considered more promising than the check clone in terms of extent of crown width though rubber yield (28 g $t^{-1}t^{-1}$) is less. Increase in plant density can compensate for lower yield and can also reduce the damage/tree loss in wind prone areas. This type could be subjected to further density cum clone evaluations to arrive at an optimum tree stand for profitable yield. Compact canopy genotypes not only avoid wind damage but also help the planters in getting enough room for optimal utilization of land.

Keywords: Compact canopy, Crown variation, Half-sibs, Mutant

INTRODUCTION

Para rubber tree, *Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell. Arg, is one among the rubber synthesizing species that produce commercially acceptable latex which is one of the important raw materials for thousands of products. Belonging to the family *Euphorbiaceae*, it is cultivated extensively in tropical areas of South East Asia. Trees are fast growing, reaching a height of up to 25 to 40 m, and replanted after tapping for 25-30 years. Breeding, selection and vegetative propagation of this species revolutionized global natural rubber out put. Evolving new cultivars with high yield potential and other favorable quantitative traits through recombination breeding is a priority area (Licy *et al.*, 2003; Priyadarshan and CleÂment-Demange, 2004).

Due to its rare occurrence and complexity, introgression of traits like compact canopy needs several generations. Damage to plantations due to uprooting and

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trunk snap is becoming more and more severe in the recent past due to unpredictable climate variation which creates considerable economic loss. Wind is the most persistent of all natural forces to which any individual tree or forest stand is subjected (Jacobs, 1936). Wind damage can cause reduced performance and low productivity of rubber plantations (Yee *et al.*, 1969). Canopy architecture and branching pattern are two important factors mostly determining the tree level as well as stand-level rubber productivity (McCrady and Jokela, 1996; Cilas *et al.*, 2004) and vulnerability to wind (CleÂment-Demange *et al.*, 1995b). Management of tree stand for long period largely depends on many factors like damage due to stem diseases, wind, incidence of tapping panel dryness (TPD) *etc*. Inherent compact canopy of trees not only avoids wind damage but also helps the planters in getting enough room for optimal utilization of land by deploying suitable intercropping systems. In tree species, despite the perennial nature and lengthy breeding cycle, breeders developed ideotype concepts (Donald, 1968) to correlate stem wood production with crown architecture (Wu, 1998). Natural and artificial selection always tends plants to adopt different forms and function for its adaptability in diverse environments. Genetic base of crown architecture has been less intensively studied and is rarely utilized in tree improvement programmes (Martin *et al*., 2001). A natural mutant of *H. brasiliensis* with distinct morphological variation in phyllotaxy and the crown has been reported (Markose *et al.*, 1982; John *et al.*, 1995), but studies on utilization of crown structural variation in conjunction with rubber yield potential are scanty. The objective of the present study is to understand the growth, yield and crown structural variability in selected half-sib progenies of a natural mutant of *H. brasiliensis.*

MATERIALS AND METHODS

Location and plant material

The study was conducted at the Central Experiment Station of Rubber Research Institute of India at Chethackal in Pathanamthitta district (Latitude 9 ^{o}22′ N, Longitude 76 ^{o}5′ E; Altitude 100 m). The planting materials consisted of four morphotypes (compact, intermediate, semi compact, and normal) selected from a half-sib population of a crown mutant categorized as reported earlier (John *et al.*, 1995). The four morphotypes along with control (RRII 105) were brown budded onto rootstocks. After successful bud grafting, stumps were planted in polythene bags of lay flat size 55 cm x 25 cm filled with top soil and raised in a nursery. Six month-old plants were transplanted in the field during July 1994 in replicated blocks adopting randomized block design with plot size of five plants in six replications, and uniform spacing of 4.9 m x 4.9 m. Recommended crop management practices were performed at appropriate time periods throughout the experiment.

Growth, morphology, rubber yield and crown traits

Growth parameters were observed from the field grown plants from the 4th year onwards. Girth (cm), tree height (m) and diameter of the canopy (m) were measured at the age of five years. On maturity of morphotypes (10 year after planting), S/2 d3 6d/7 system of tapping was followed. Dry rubber yield was recorded from each experimental tree in gram per tree per tapping (g $t^{-1}t^{-1}$) by coagulating the latex in collection cups. Mean dry rubber content was recorded by taking one sample per month (12 samples per year). Crown morphology at the age of 15 years was described as per the method proposed by Ford (1985). Extent of uprooting due to wind damage was also assessed.

Statistical analysis

The effects on variables were determined using analysis of variance, all comparisons were based on plot means.

RESULTS AND DISCUSSION

H. brasiliensis is a fast growing tropical tree attaining a height up to 10 meters with in 5 years after planting in normal spacing mainly due to rapid meristematic activity and vegetative growth. To understand the performance of clones on growth, crown variability and rubber yield, four half-sib recombinants were evaluated along with the control (RRII 105). In the first five years of growth (Table 1), normal type registered a height of 7.9 m followed by intermediate type (6.6 m), whereas semi compact type (4.2 m) and compact type (4.1m) imparted less height when compared to the control (RRII 105, 7.6 m). Compact type exhibited comparatively less vigour represented by height in the 5th year after planting indicating its close relationship with original mutant mother tree than the semi compact and intermediate canopy types. Proportionate variation in girth (15.9 cm) was noticed for the compact type while the normal type attained highest girth (33.9 cm). Number of branches of these variants ranged from 16.4 to 26.8, while the intermediate type produced the least number (16.4) of branches in the 5th year of growth. Presence of distinguishable variability in the genotypic level indicates scope for early selection for compact crown types. The trend continued and mean values of girth, tree height and canopy diameter (Fig. 1) showed clear distinction between the types even in the later years.

Canopy width is one of the factors which determines the planting density and total production of trees. The mean canopy spread/width of the normal type and RRII 105 was 4.6 and 5.5 m, respectively whereas the intermediate type has a canopy spread of only 2.2 m in the 5th year. The variability in canopy width (1.2 m to 5.5 m) and height (1.8 m to 5.1 m) in the early phase of growth further indicates presence of substantial variability in the genotypes and scope of selection for compact crown types.

Table 1. **Growth characteristics of morphotypes (5th year after planting)**

Morphotype	Juvenile characters$^{@}$				
	Height (m)	Girth (cm)	No. of branches	Canopy width (m)	Canopy height (m)*
Compact	4.1	15.9	22.0	1.2	1.8
Intermediate	6.6	35.7	16.4	2.2	3.9
Semi compact	4.2	21.4	24.3	2.8	2.0
Normal	7.9	33.9	26.8	5.5	5.1
RRII 105(control)	7.6	32.3	18.8	4.6	4.6

$^{@}$ Juvenile characters observed from randomly selected plants (values are means, n=12-22) in the 5th year after planting; *measured from the first branching to top.

Growth curve of morphotypes from 4th to 18th year after planting is plotted in Figure 2. Among the four crown types assessed for growth, intermediate type registered comparatively high vigour over the years with a mean girth of 81.0 cm followed by normal type (75.7 cm), whereas, both semi compact type (45.6 cm) and the control clone RRII 105 recorded girth of 64.2 cm in the 18th year after field planting. Of the four crown types studied in the juvenile phase, the intermediate one tended to grow faster and attained tappable girth (51.2 cm) in the seventh year indicating scope for improvement of other characters through breeding by using this as one of the parents.

Globose crown is the most frequently occurring canopy type among the different clones of *H. brasiliensis* which showed strong apical dominance preventing the growth of buds on the current year's shoots allowing an active growth of buds produced in previous years. In the present study, four different categories were formed based on the tree canopy diameter with two extremes, compact crown. Compact type characterised by short stature, strong apical control, restricting the growth of shoots produced in previous years. No demarcation of whorls of leaves and bottle brush like appearance (Fig. 1a). Mixed combination of normal and compact, type with near normal vigour in growth, less dense canopy, cylindrical trunk, not prominent leaf scars, high branching and stout branches are the prominent featurs of intermediate type (Fig. 1b). Semi compact

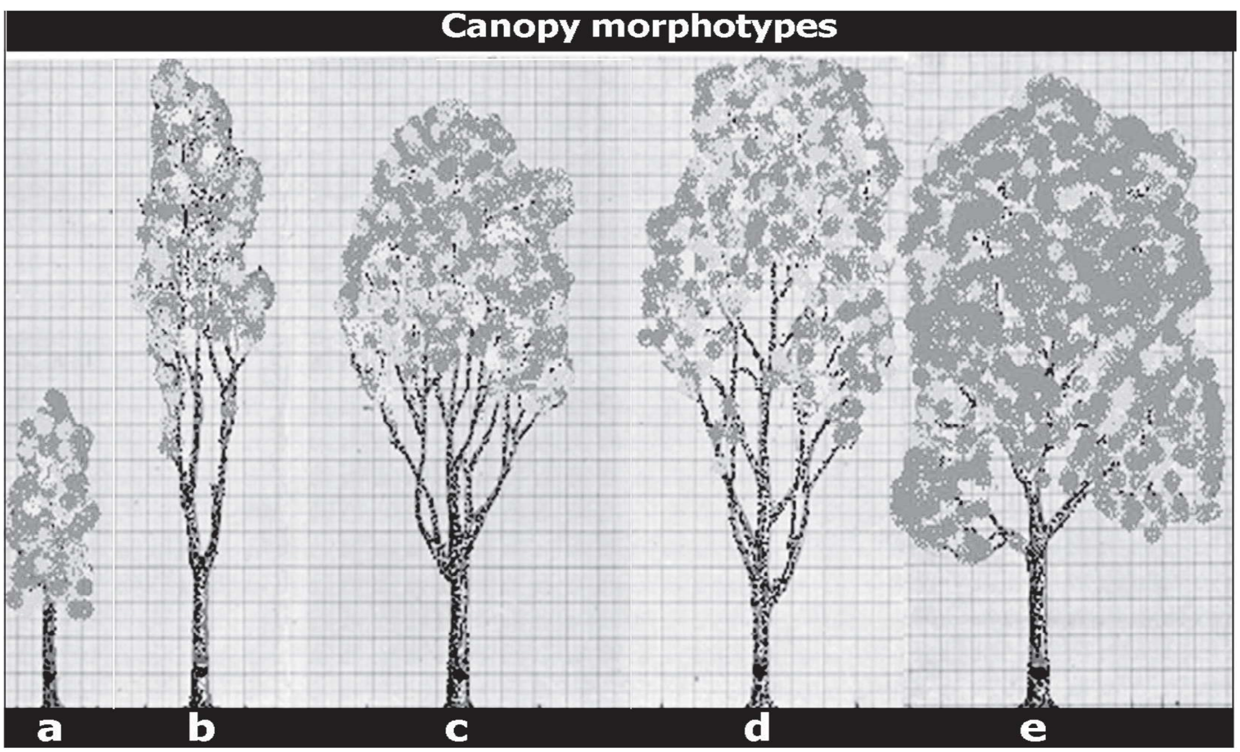

Fig. 1. Canopy variability in morphotypes at mature phase
Canopy width ranges from (a) 1.5-3.5m compact; (b) 2-4m intermediate; (c) 4.0-6.0m semi compact; (d) 5-7 m normal and (e) 7-9 m RRII 105- control at the age of 15 years after planting in spacing 4.9 x 4.9 m (figures drawn to scale based on the mean values).

crown type showed mixed combination of crown with well differentiated leaf storeys, irregular branching with medium growth, (Fig. 1c). Normal type showed less dense canopy, decurrent globose crown. Cylindrical main trunk leaf scars not prominent, low branching habit with profuse sub branches, (Fig. 1d). While the control dense canopy, decurrent globose crown mostly restricted to the top, foliage dark green, leaf lets long and glossy. Vigour before and after tapping is average, (Fig. 1e). Previous studies on crown classifications in *Hevea* are rare; however, Ford (1985) clearly classified different crown types of trees in to two main categories based on the periodicity of growth of buds, such as decurrent crowns and excurrent crowns. Crown development in a tree is a critical factor of tree instability which is naturally compensated by specific reactions like formation of reaction wood zones and extra thickening at the bottom of the trunk (Spatz *et al.*, 1999). No tree loss was observed due to wind in the compact, semi compact and intermediate categories while five per cent tree loss each was registered in the normal type and control (RRII 105) until 18th year of observation. Wind susceptibility studies in *Hevea* clones are rather scanty (Niklas, 2000). Cilas *et al.* (2004) suggests that wind damage could be linked to shape of the trees rather than to the physical properties of the wood. Studies based on the simulation approach to wind damage in rubber trees (Fourcaud *et al.*, 1998) are also suggestive of difference in branching determining crown shape; trees with greater trunk-crown imbalance are more susceptible to wind damage. Hence the compact types in the present study (semi compact and intermediate) may be useful genetic stocks in resisting wind damage and candidates for high density planting.

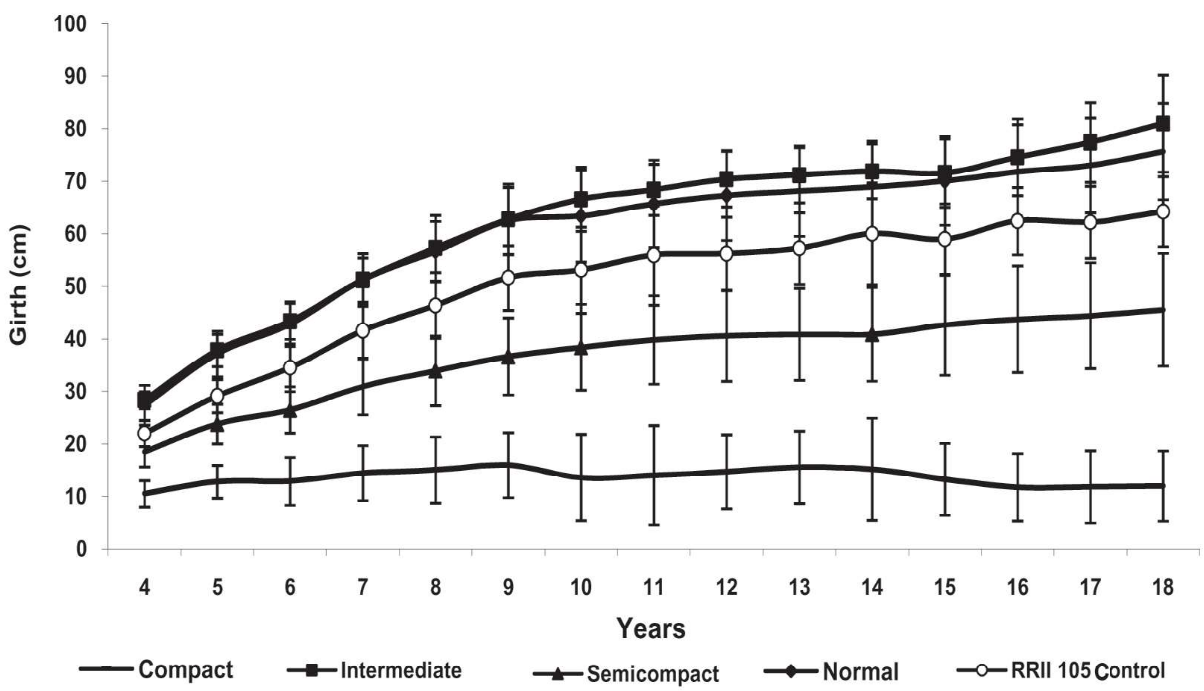

Fig. 2. Growth curve of morphotypes in immature and mature phase

Table 2. **Rubber yield of canopy morphotypes over different years**

Morphotype	Dry rubber yield (g $t^{-1}t^{-1}$) in different years								
	2004 10th year	2005 11th year	2006 12th year	2007 13th year	2008 14th year	2009 15th year	2010 16th year	2011 17th year	Pooled mean
Compact	0	5.8	5	5	9.5	8	5	10.6	5.5
Intermediate	22.6	25.3	24.3	23.3	31.9	36.4	33.7	29.1	28.3
Semi compact	16.2	12.7	17.4	15	13.8	18	27.1	17.3	17.2
Normal	20.2	24	19.9	20.1	31.2	29.1	30	25.7	25
RRII 105 (control)	29.7	43.4	38.4	35.6	49.1	47.9	65	46.6	44.5
CV	31.5	36.6	31.6	38.4	36.6	31.5	19	42.5	33.4
SE	3.2	4.5	3.6	4.2	5.4	4.8	3.4	6.7	4.5
CD (P=0.05)	6.7	9.4	7.6	8.7	11.3	10	7.1	14.1	9.4

Trunk growth is considered as one of the important selection parameters, which is indispensable in realizing the fitness for a particular environmental condition (Chandrasekhar *et al.*, 1998; Hunt *et al.*, 2002). Mean growth values from the morphotypes indicate that the intermediate type and semi compact type could be considered as possible germplasm resource for further recombination with suitable parents to develop suitable canopy types in rubber.

Rubber yield of four morphotypes is shown in the Table 2. ANOVA revealed significant variability (CV 33.4%) among morphotypes in terms of dry rubber yield over eight years. Yield per tree was found to be less for all except control (RRII 105). Among the four morphotypes, the intermediate type recorded maximum yield. It could be possible to select intermediate canopy type trees considering the mean yield (28.3 g $t^{-1}t^{-1}$) and canopy diameter of 2.2 m. Increase in plant density could compensate for lower yield and could also reduce the damage/tree loss in wind prone areas. This morphotype could be subjected to further density cum clone trials to arrive at an optimum tree stand for profitable yield.

Rubber yield improvement in any base material requires continuous breeding and selection cycles (Licy *et al*., 1997). Rubber production from semi compact type and compact type was not satisfactory as it could not meet the commercial target. Apart from the clonal performance, total rubber production from a unit area is always dependant on various factors like management practices wherein spacing and canopy spread is very important. Genetic analysis of crown characteristics in trees is relatively scanty. But there are reports of estimates of broad sense heritability in *Populus*, pine and eucalyptus (Lambeth *et al.,* 1994). It could be possible to use molecular biological tools like compact crown specific RAPD markers (Venkatachalam *et al.,* 2004) and characterization of genes responsible for this trait or developing molecular markers to screen the progeny population. *H. brasiliensis* is known to be a natural cross breeder, producing seeds at a low rate compared to other tree species. The semi compact and intermediate morphotypes could be further improved by utilizing them as parents in the breeding orchards. Subsequent evaluation of its half-sibs could probably lead to effective selection of high yielding compact crown progenies.

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