ATTEMPTS TO EVOLVE COMPACT CROWN CLONES OF HEVEA BRASILIENSIS

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ABSTRACT

High yielding compact canopy clones of *Hevea brasiliensis* are beneficial to growers in resisting wind damage, favouring high density planting and deploying suitable intercrops to increase net income from the plantations. Genetic diversity for compact canopy trait in the available gene pool of *Hevea* is meagre except for a natural mutant (NM) selected from the seedling population. Utilization of NM was explored by using it as one of the parent in half-sib progeny selection approach. Four selected genotypes (compact, semi compact, intermediate and normal type) were evaluated in normal spacing (22 x 11 feet) along with the control (RRII 105). Trunk growth (cm), dry rubber yield (g/t/t) and canopy diameter/width (m) were assessed. Each types exhibited wide variability in terms of growth, dry rubber yield and crown compactness up to 17th year after planting. Girth, canopy diameter and yield of four types (Compact: 58.5 cm, 1.2 m and 14.5 g/t/t; Semi Compact: 59.0 cm, 4.0 m and 8.1 g/t/t; Intermediate: 61.0 cm, 2.0 m and 34.8 g/t/t; Normal type: 78.7 cm, 5.5 m and 63.7 g/t/t, RRII 105:63.3 cm, 4.6 m and 57.6 g/t/t) showed considerable variability. Intermediate crown type was found to be promising than its female parent in growth and yield, and modified crown type. This would be selected for further evaluation and confirmation in clonally replicated trials. Selection of clones with medium to high growth and compact canopy could maximize space utilization and better crop management practices such as high density planting and intercropping. The present study could identify potential compact crown types which can be either utilized directly for close spacing trials or could be added to present genetic resources for repeated cross breeding to generate more productive progenies with modified crown architecture.

Key words: *Hevea* breeding, crown variation, mutant, compact canopy

INTRODUCTION

The para rubber tree, *Hevea brasiliensis* (Willd. ex A. Juss.) Muell. Arg., belonging to the family *Euphorbiaceae*, is cultivated extensively in South East Asia. Creation of new genotypes with high yielding potential and other favorable agronomic traits through recombination breeding is a priority area in rubber research. Inheritance of most of the agronomic characters in *Hevea* is quantitative in nature. Therefore introgression of complex traits needs many generations. Canopy and branching pattern of tree are important features often determining both the tree-level and stand-level productivity (McCrady and Jokela 1996; Cilas *et al.*, 2004) and its vulnerability towards wind fastness (CleÂment-Demange *et al.*, 1995b). Retention of tree stands for a long period is affected by many factors but occurrence of tapping

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panel dryness, damage due to uprooting and trunk snapping needs much attention because of considerable economic loss. Development of compact canopy genotypes not only avoids wind damage but also helps the planters in getting enough room for optimal utilization of land by deploying suitable intercropping systems.

Both natural and artificial selection always tends plants to adopt different forms and function for its survival in diverse environments. Genetic variation forms the basis for phenotypic change through selection and further it is important for the breeders to understand whether the trait in question varies with in population. Ideotype breeding concept (Donald, 1968) has been developed for introgression of many desirable traits in many economic plant species. In tree species also, despite the perennial nature and lengthy breeding cycle, breeders developed ideotype concepts especially to correlate stem wood production with crown architecture (Wu, 1998). However genetic base of crown architecture has been much less intensively studied and is rarely utilized in tree improvement programmes (Martin *et al*., 2001). A natural mutant of *H. brasiliensis* showing distinct morphological variation in the crown has been reported by Markose *et al.,* (1982) and John *et al.,* (1995) attempted juvenile characterization of its progenies. However, there were no reports available in literature about utilization of crown structural variation in *Hevea* breeding programmes and rubber yielding potential under field conditions. The objectives of the present study are to quantify growth and crown structural variability in the selected half-sib progenies of a natural mutant under field conditions.

MATERIALS AND METHODS

Location and plant material

The study was performed at the experiment field of Rubber Research Institute of India head quarters at Kottayam, South India (Latitude 9 °32' N, Longitude 76 °36' E; Altitude 73m). The planting materials consisted of four genotypes selected from half-sib population of crown mutant. These four clones along with control (RRII 105) were brown budded onto rootstocks. After successful bud grafting, stumps were planted in polythene bags (55 cm x 25 cm when laid flat) filled with top soil and raised in a nursery. Six month-old plants (12- 32 numbers of each morphotypes) were planted in the field site in separate unreplicated blocks adopting uniform spacing of 22.0 feet x 11.0 feet. Recommended crop management practices were performed throughout the experiment.

Growth, rubber yield and crown traits

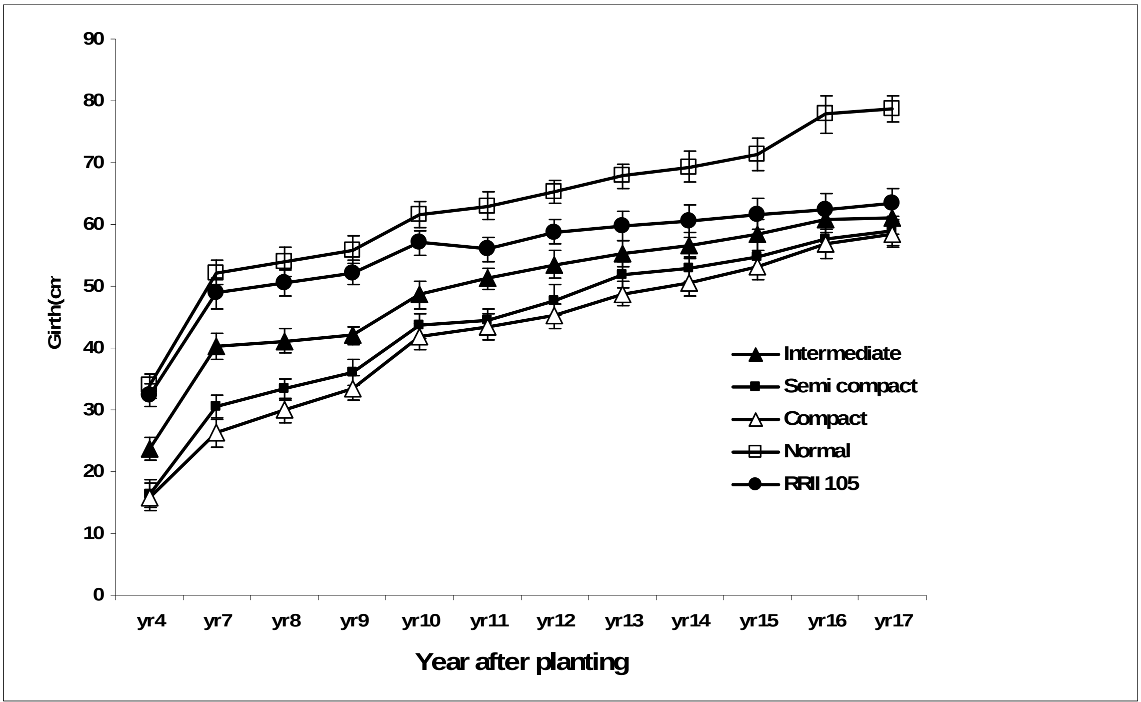
Parameters observed from the field grown plants in the first year after planting were: (a) total height of the plant; (b) girth of the main trunk measured at a height of 1.0 m from the bud union; (c) canopy diameter; (d) number of nodes per meter of stem;(e) number of whorls; and (f) number of leaves per whorl. Fourth year onwards yearly girth measurements (at a height of 1.5 m) were measured. Tree height (m) and diameter of the canopy (m) also measured at the age of four years. Crown classification was made as suggested by Ford (1985) and described in the Table 2. Trees were opened for tapping when the average girth of trees reached 50 cm at 150 cm height from the bud union. The tapping system followed was S/2 d3 6d/7. Dry rubber yield was measured from each experimental tree in grams per tree per tapping (g/t/t) by coagulating the latex in collection cups. Mean dry rubber yield was recorded by taking one sample per month (12 samples per year).

Population mean of the data on dry rubber yield (g), plant height (m), canopy diameter (m), girth (cm), petiole length (cm), number of whorls and number of leaves per whorl were computed comparison.

RESULT AND DISCUSSION

Four recombinants derived from natural crosses along with the control (RRII 105) were field planted in separate blocks to the see the performance of growth, crown shape and yield. Growth pattern is shown in the Figure 1. Among the four crown types assessed for growth, normal type registered noticeable high vigour over years with a girth of 78.7 cm followed by RRII 105 (63.3 cm) in the 17th year after field planting. Whereas both semi compact and intermediate type recorded only medium girth (59.0 cm and 61.0 cm respectively). Compact type attained comparatively less vigour with a girth of 58 cm. Right from the year 4 after planting, the semi compact and intermediate types registered less growth, indicates that it might be due to the altered canopy structure and effect of recombination with unknown male parents. Of the four crown types studied in the juvenile phase, the intermediate tended to grow slower and attained tappable girth only in the year 11.

Figure1 Growth curve of morphotypes in the field



Juvenile characters such as girth, plant height, canopy diameter, number of nodes per unit length of stem, number of whorls and number of leaves per whorl were recorded in the first year after planting. Girth, tree height, canopy diameter and height-diameter ratio were recoded in the year 4 and presented (Table 1). Of these parameters studied initial girth ranged from 3.1 to 5.8cm; plant height (0.9 -1.5 m); canopy diameter (0.2 - 0.8 m); number of nodes per meter of stem (30.0 - 147.0); number of whorls (1.0 - 4.7) and number of leaves per whorl (7.8 - 45.5). Range of these means clearly indicates distinguishable variability present in the genotypes and scope for early selection for compact crown types. When these types completed four years of growth in the field, similar trend was continued and mean values of girth, tree height and canopy diameter showed clear distinction between the types. Compact crown attained comparatively less growth (15.9 cm) and narrow compact canopy (diameter 1.2 m) when compared to the normal type (33.9 cm; 5.5 m); intermediate type (23.7cm and 2.0 m) and control (32.3 cm and 4.6 m). Trunk growth is considered as one of the important selection parameter in rubber and a study on the growth is indispensable in realizing the fitness for a particular environmental condition (Hunts, 1982; Chandrasekhar *et al.*, 1998). Mean values from each type is indicative rather than conclusive, but it is possible that intermediate type and semi compact type could be considered as possible germplasm resource for further recombination and selection.

Table 1 Characterization of four morphotypes

Crown types	One yr. after planting						4th yr. after planting			
	Girth * (cm)	Pl. ht. (m)	Canopy diameter (m)	No. of nodes/m	No. of Whorls	No. of Leaves/ whorls	Girth @ (cm)	Tree ht. (m)	Canopy Dia (m)	Tree ht-canopy dia ratio
Intermediate (n=22)	4.0	1.38	0.6	57.0	2.0	10.0	23.7	6.6	2.0	3.3
Semi compact (n=32)	3.3	0.95	0.56	85.0	1.5	19.0	16.4	8.8	4.0	2.2
Compact (n=13)	3.1	0.75	0.29	147.0	1.0	45.5	15.9	5.1	1.2	4.2
Normal (n=20)	5.8	1.34	0.85	38.0	4.0	8.0	33.9	7.9	5.5	1.4
RRII 105 (n=12)	5.5	1.50	0.80	30.0	4.7	7.8	32.3	7.6	4.6	1.6

* 1.0m from the bud union; @1.5 m from the bud union

Normal round crown is 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 years shoots allowing the active growth of buds produced in previous years, 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. Four different categories were formed based on the tree height-canopy diameter ratio (Table 2) with two extremes (normal type crown and compact crown type) and two medium (semi compact crown and intermediate crown type). Previous studies of crown classifications in *Hevea* are rare, available reports demonstrates crown development is a factor in tree instability which is naturally compensated by specific reactions and formation of reaction wood zones and extra thickening a the bottom of the trunk (Spatz *et al.*, 1999 and Niklas, 2000). Clonal susceptibility studies in *Hevea* is relatively less, however 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 that determine 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.

Table 2 Categorization of crown types

Tree height-crown diameter ratio#	Crown classification@	Description
0.5 – 2.0	Normal	Decurrent globose crown present in the most of the cultivated clones. Strong apical dominance, preventing the growth of buds on the current year's shoots, weak apical control, allowing the active growth of buds produced in previous years.
2.1- 3.0	Semi compact	Mixed combination of crown but leaf stories can be differentiated.
3.1 – 3.5	Intermediate	Mixed combination of normal and compact type with near normal vigour in growth.
3.5 and above	Compact	Excurrent crown present weak apical dominance of buds on the current year's shoots. Strong apical control, restricting the growth of shoots produced in previous years. Showed characters similar to the mutant female parent, no demarcation of whorls of leaves bottle brush like appearance.

derived from the mean values of height and diameter of plants, 4th year after planting in normal spacing, @ Ford (1985).

Clone wise dry rubber yield determined and presented in the Table 3. Yield per tree found to be less for all except normal type. Of the five genotypes tested semi compact and compact type registered a yield of 8.1 and 14.5 g/t/t respectively, while intermediate type recorded mean yield of 34.8 g/t/t when compared to the control (57.6 g/t/t). In addition to the medium yield, it could be possible to select intermediate canopy type trees considering the canopy diameter (2.0 m) and desirable height-canopy diameter ratio (3.3). Based on this preliminary study, it could be possible to lay out replicated space cum yield trials for optimum stand and estimating tapping task. 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.

Table 3 Dry rubber yield of morphotypes

Crown types	**Mean yield(g/t/t) at different age**							
	yr 10	**yr 11**	**yr 12**	**yr 13**	**yr 14**	**yr15**	**yr16**	**Pooled mean (yr10-yr16)**
Intermediate	20.5	38.6	39.3	40.0	36.7	26.5	42.1	34.8
Semi compact	--	--	--	--	--	8.7	7.6	8.1
Compact	--	--	--	--	--	9.6	19.5	14.5
Normal	45.7	65.4	64.5	63.7	48.1	70.6	87.9	63.7
RRII 105 (control)	57.1	60.0	61.3	62.6	58.0	45.2	59.4	57.6

Apart from the clonal performance, total rubber production from a unit area is always dependant on various factors like management practices adopted 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. *Hevea brasiliensis* is known to be a natural cross breeder, producing seeds at a low rate compared to other tree crops. However, semi compact and intermediate type could be further improved by using it in the breeding orchards and subsequent evaluation of its half-sibs would probably lead to effective selection of high yielding compact crown progenies.

CONCLUSIONS

Utilization of compact crown mutant was explored by using it as one of the parent in half-sib progeny selection approach. From the four selected genotypes evaluated in the present study, two compact crown types (semi compact and intermediate) were promising, even though it imparted marginal rubber production. However, these crown variant genetic stocks can be further utilized in breeding programmes i.e., in the breeding orchards and subsequent evaluation of its half-sibs. This would probably lead to effective selection of high yielding compact crown progenies. It is also possible that, these selected lines are good candidates for developing suitable cropping systems and studies on wind susceptibility.

ACKNOWLEDGEMENTS

We thank Dr. James Jacob, Director, Rubber Research Institute of India for the continuous encouragement and support. The authors acknowledge the efforts made by Dr. C. K. Saraswathyamma, former Joint Director (Crop Improvement), RRII who initially laid out this experiment.

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