Growth and yield performance of half-sib progenies of para rubber (*Hevea brasiliensis*) generated through poly-cross breeding in a polyclonal seed garden

C. Narayanan C* and K. K. Mydin

Rubber Research Institute of India, Kottayam 686009, India
*cnarayanan@rubberboard.org.in

ABSTRACT: *As a part of polycross breeding, half-sibs were collected from nine clones in a polyclonal seed garden in Karnataka (India) and evaluated in mature trial. More trees of polyclonal seedling origin (71%) attained tappable girth compared to check clone, RRII 105 (11 %). Families of PB 217 followed by RRII 203 showed high CV for girth indicating wide variability and scope for selection. Family of Ch 26 attained maximum mean girth (71.5 cm) compared to other families and check clone (51.3 cm). Family PB 28-83 showed a minimum girth of 62.1 cm and low CV. Check clone showed lowest girth of 51.3 cm. Families RRII 105, AVT 73 followed by PB 28-83 showed high CV for yield indicating scope for selection. Family Ch 26 followed by PB 242 and RRII 203 showed maximum yield of more than 38 $gt^{-1}t^{-1}$. CH 26 produced a polycross progeny with highest yield of 72.9 $gt^{-1}t^{-1}$. Family PB 28-83 showed minimum yield (26.6 $gt^{-1}t^{-1}$). Progenies of Ch 26 indicated high potential for selection for growth as shown by high proportion of superior performers. Families PB 217, AVT 73, PB 215 and RRII 203 also offered scope for selection for growth. Family Ch 26 produced higher proportion of superior yielders. Based on rank sum method, progenies of clone Ch 26 was ranked as top performer followed by RRII 203 and PB 217. The above study showed high rate of recovery of superior genotypes could be achieved through poly-cross breeding.*

Key words: *Hevea brasiliensis,* Co-efficient of variation, grams per tree per tap.

Introduction

The Para rubber tree *Hevea brasiliensis* (Willd. ex A. Juss.) Müll. Arg. (family, Euphorbiaceae; diploid, 2n=36), is a forest species native to the tropical rain forests of Central and South America, domesticated outside its natural range of distribution only in recent times (Narayanan and Mydin 2011). The tree, which is monoecious, entomophilic, and predominantly out-crossing (>60%), produces latex (essentially cytoplasmic fluid) in its specialized laticifer cells located in bark tissue. The latex is a major source of natural rubber in the entire plant kingdom attributed with only hypothetical roles in the host tree's life-cycle. Latex is manually extracted through systematic incision ('tapping') of bark tissue and forms significant raw material with manifold uses including those for medical, automotive and strategic purposes. Almost all of the cultivated clones of *Hevea* were derived either through selection or breeding among the few selected seedlings (or their progenies) reportedly collected in 1876 from a site in Boim, near the Tapajos river in Brazil (Allen 1984; Baulkwill 1989; Schultes 1977; Wycherley 1968).

Crop improvement in *Hevea*, primarily aimed at breeding clones with potential to produce more dry rubber, has been achieved predominantly through introduction, ortet (plus tree) selection, or hybridization, ultimately followed by clonal selection (Mydin and Saraswathyamma 2005). The conventional method of cyclical 'generation-wise assortative mating' (GAM), where superior genotypes of one generation form parents for subsequent breeding programs has been the prime breeding strategy in *Hevea* (Simmonds 1989). While hybridization has been major method for forming recombinants with selected traits, the size of initial selection population has been limited due to various inherent as well as management limitations. Owing to its high-outcrossing behaviour, the species has capability of producing large number of natural hybrids. This predominantly out-breeding trait led to establishment of polyclonal seed gardens for production of genetically improved genotypes, or poly-cross progenies, through natural hybridization between superior clones (Simmonds 1989). Thus, the polyclonal gardens assisted in rapid crop improvement in *Hevea* through poly-cross breeding. This paper discusses the performance of a population of polycross progenies derived from nine clones in a polyclonal seed garden in the Karnataka State of India. The possibility of recovering several potentially superior clones from the above population is also highlighted.

Materials and methods

The experimental population of polycross progenies (half-sibs) was collected from a polyclonal seed garden established at the *Hevea* Breeding Sub-Station (Nettana, Dakshina Kannada Dt., Karnataka). Half-sibs were separately collected from nine clones (RRII 105, CH 26, AVT 73, PB 215, PB 217, PB 28/83, PB 242, PB 252 and PB 5/51) and planted in a trial in 2005 at the Central Experimental Station of Rubber Research Institute of India (Pathanamthitta Dt., Kerala). For comparative evaluation, clone RRII 105 was planted as check clone. Details of the half-sibs and their parental clones are given in Table 1. The trees were planted at a spacing of 4.9 x 4.9 m following CRD with each progeny constituting a single tree plot. In 2012 (seven years after planting), the trees were evaluated for their tappability and those trees which attained tappable girth (polycross progenies, ≥ 50 cm girth at 90 cm height; clonal population, ≥ 50 cm girth at 150 cm height) were tapped following standard tapping system (S/2 d3 6d/7). Growth performance of the polycross progenies and check clone was compared in terms of girth (at 90 cm for seedlings and 150 cm height for check clone) during the third year of tapping. Dry rubber yield (gram per tree per tap; $gt^{-1}t^{-1}$) was recorded in all the tress following cupcoagulation method based on annual mean of monthly recordings (Mydin and Saraswathyamma 2005). The data was subjected to '*t*' test analysis for finding significance and variability among the families, which for the basis for selection, was assessed based on coefficient of variation (CV). Proportion of family-wise best performers (per cent recovery of superior clones) was computed based on number of progenies exhibiting better growth and yield than the population mean. Rank sum method was followed to identify top families for growth and yield performance.

Table 1: Details of half-sibs

Parent clone	Parentage (Country of origin)	Hal-sib family size
PB 242	PB 5/51 x PB 32/36 (Malaysia)	21
RRII 203	PB 86 x Mil 3/2 (India)	22
PB 217	PB 5/51 x PB 6/9 (Malaysia)	21
Ch 26	Primary clone (Malaysia)	22
RRII 105	Tjir 1 x Gl 1 (India)	18
AVT 73	Estate selection (India)	15
PB 5/51	PB 56 x PB 24 (Malaysia)	22
PB 215	Primary clone (Malaysia)	23
PB 28/83	Primary clone (Malaysia)	14

Results and Discussion

The half-sib population exhibited high level of variability for growth and yield performance as supported by '*t*' test. Regarding growth performance in terms of girth attained by trees seven years after planting (Table 2), more trees of polyclonal seedling origin (71%) attained tappable girth when compared to check clone, RRII 105 (11%). Polyclonal seedlings are known to possess comparatively more vigorous growth trait compared to clonal populations which is also in agreement with present observation. Family of clone Ch 26 attained maximum mean girth (71.5 cm) compared to other families as well as check clone RRII 105 (51.3 cm). Families of clones PB 217 followed by RRII 203 comparatively higher *CV* indicating wide variability and scope for selection. Family of clone PB 28-83 showed a minimum girth of 62.1 cm and low level of *CV*. Check clone showed lowest girth of 51.3 cm reflected in its low tappability percentage in the initial years. Based on performance of individual polycross progenies, a progeny of clone RRII 203 showed highest girth (97 cm) followed by a progeny of Ch 26 (96 cm). It is may be noted that RRII 203 is a clone with high girth developed by RRII through hybridization and selection. Lower level of CV in this family also indicated uniform growth among the progenies.

Table 2: Variability for girth (cm) and family-wise recovery of superior performers in half-sib families

Family	Mean girth (range)	Co-efficient of variation (C.V. %)	Family-wise superior selections (%)
PB 242	62.7 (31.0-80.0)	18.2	38.1
RRII 203	67.3 (42.0-97.0)	19.1	50.0
PB 217	67.7 (39.0-85.0)	20.0	61.9
Ch 26	71.5 (48.0-96.0)	18.1	72.7
RRII 105	61.4 (39.5-83.0)	18.7	33.3
AVT 73	68.7 (52.5-83.0)	14.2	60.0
PB 5-51	67.6 (43.0-88.0)	18.9	54.6
PB 215	65.9 (52.0-83.0)	14.4	43.5
PB 28-83	62.1 (47.0-78.0)	13.0	21.4
RRII 105 (Check)	51.3 (24.0-73.0)	16.3	
Population mean	66.3		

*Based on half-sib population performance

Polycross progenies exhibited superior yield performance compared to check clone (Table 3). Families of RRII 105, AVT 73 followed by PB 28-83 showed high CV for yield indicating scope for selection for this trait. Among the half-sibs, family of clone Ch 26 followed by PB 242 and RRII 203 showed maximum yield performance of more than 38$gt^{-1}t^{-1}$. CH 26 also produced a polycross progeny with highest yield of 72.9 $gt^{-1}t^{-1}$. Half-sibs of family PB 28-83 showed minimum yield (26.6 $gt^{-1}t^{-1}$).

Polycross progenies generally exhibit very high variability for growth and yield traits due to their inherent heterozygosity caused by high outcrossing rate as shown in many studies using polycross progenies (Chandrasekhar et al. 2002; Deepthy et al. 2014; Mydin et al. 1996; 2002, 2010; Mydin 2014). The data on growth and yield from the present study also supported the above observation. The present study showed scope for selection of appreciable proportions of superior performers in terms of growth and yield. Regarding growth vigour, polycross progenies belonging to family Ch 26 indicated high potential for selection against this trait as shown by high proportion of superior performers (Table 2). Families of clones PB 217, AVT 73, PB 215 and RRII 203 also offered scope for selection as reflected by more than 50 % superior performers. With reference to yield, progenies of family Ch 26 carried higher proportion of superior yielders based on family mean yield as well as general mean yield (Table 3). Based on rank sum method, polycross progenies of clone Ch 26 was ranked as top performer followed by RRII 203 and PB 217 (Table 4).

Table 3: Variability for dry rubber yield ($gt^{-1}t^{-1}$) and family-wise recovery of superior performers in half-sib families

Family	Mean yield (range)	*CV* (%)	Family-wisesuperior selections (%)	
			Based on family mean	Based on general mean
PB 242	39.2 (16.1-69.6)	37.3	42.86	57.1
RRII 203	38.4 (19.1-57.6)	31.3	40.91	63.6
PB 217	35.6 (16.6-58.6)	34.7	42.86	47.6
Ch 26	39.6 (11.9-72.9)	38.9	50.00	59.1
RRII 105	28.7 (8.6-56.2)	46.6	33.33	38.9
AVT 73	34.9 (10.6-70.8)	46.4	33.33	46.7
PB 5-51	35.0 (14.4-49.3)	29.2	40.91	59.1
PB 215	37.7 (6.8-70.5)	42.9	34.78	47.8
PB 28-83	26.6 (12.9-49.1)	45.2	21.43	35.7
RRII 105 (Check)	29.9 (9.0-55.8)	32.5		
Population mean	35.6 (6.8-72.9)	39.2		
General mean	33.1			

Table 4: Ranking of clones

Clone	Rank*
Ch 26	1
RRII 203	2
PB 217	2
PB 242	4
AVT 73	4
PB 5-51	6
PB 215	6
RRII 105	8
PB 28-83	8

*Based on rank sum method using mean girth and yield

In an earlier study based on nursery evaluation using nine separate sets of half-sib progenies collected from the parental clones in the above polyclonal seed garden, an attempt was made to assess the drought tolerance potential of the half-sib families based on test-tap yield during summer (Mercy and Mydin 2012). The above study showed a high proportion of seedlings with high summer yield which indicated scope for selection for drought tolerance. Since drought tolerance is a complex trait dependent upon environmental factors, more long-term observation in drought prone sites is required to derive such conclusion from the present mature tree population. However, the present study as well as the pervious study based on nursery evaluation indicated good scope for selection of many good performers from the polycross progenies of the above nine parental clones.

The present study is only indicative and requires further long-term monitoring of yield in the experimental clones in different tapping panels to confirm the superior yield potential of the top performers. Nevertheless, recovery of a high proportion of superior performers in terms of growth and yield in the initial years of tapping based on mature tree data, is highly encouraging, offering good scope for selection.

Acknowledgements

The authors wish to thank Director, Rubber Research Institute of India, Kottayam, for providing all facilities and support during the study. The authors also thank the Statistician, Rubber Research Institute of India, Kottayam, for help in statistical analysis.

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