Performance of certain new hybrid clones of *Hevea brasiliensis* in preliminary yield trails

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ABSTRACT: *The performance of 21 hybrid clones of rubber, Hevea brasiliensis evolved from 1986 hand pollination programme, was evaluated in two small-scale trials over a period of 18 years after planting. RRII 105 was the check clone in both trials. RRIM 600 was included as a second check clone in Trial 2. Annual growth during immature and mature phase of tapping, dry rubber yield over a period of 10 years and secondary attributes including bark structural traits, incidence of diseases and bole volume were recorded. In trial 1, mean yield of clones ranged from 17.7 to 79.6 gram tree^{-1}tap^{-1}. The clone 86/772 recorded the highest dry rubber yield in the BO-1panel (78.6 gramtree $^{-1}$ tap $^{-1}$) as well as over 10 years of tapping (79.6gram tree $^{-1}$ tap $^{-1}$) which was significantly superior to the yield of RRII 105 (40.8 and 50gram tree^{-1}tap^{-1} respectively). Clone 86/380 was the second best performer with 56 gram tree^{-1}tap^{-1}. Girth at opening ranged from 37.7 (86/789) to 62cm (86/772). In trial 2, Clone 86/575 recorded significantly superior yield to RRII 105 and comparable yield with RRIM 600. The range in yield was 23.2 (86/894) to 64 gram tree^{-1}tap^{-1}(86/575) and girth at opening ranged from 37.8 (86/916) to 58.7cm (86/575). Bark structural traits showed significant clonal variation in both the trials. Clones 86/772 and 86/756 registered superior clear bole volume of 0.2m^3 as against 0.1m^3 for RRII 105. Based on overall performance, four clones viz. 86/772, and 86/575 with high yield and 86/380 and 86/ 756 with moderate yield combining desirable secondary attributes could be identified as clones in the pipeline for the final phase of evaluation.*

Key words: *Hevea brasiliensis, rubber yield, clones.*

Introduction

Genetic improvement in the para rubber tree *Hevea brasiliensis* (Willd. ex A. Juss.) Müll. Arg. is mainly through hybridization and clonal selection. Parent clones for hybridization are selected so as to combine high yield with desirable secondary characters like high vigour, smooth and thick bark, high number of latex vessel rows, good bark renewal, high growth rate and tolerance to diseases and environmental stresses (Varghese and Mydin 2000). Indigenous development of the high yielding hybrid clone RRII 105 (Nair and George 1969) largely contributed to the success story of rubber in the country in terms of production and productivity. The adoption of recent hybrids of RRII 400 series clones (Licy et al. 2003) is on the increase. Several newer clones in the pipeline are under various stages of evaluation (Mydin 2014). Conventionally, the development and release of a clone, starting from nursery selection passes through 3 stages of field evaluation i.e. the small scale (SST), large scale (LST) and onfarm trials (OFTs). The present study reports the long term growth and yield performance of a set of 21 clones

derived from crosses involving 14 parental clones in two small scale trials with the objective of estimating the extent of genetic variability for yield and major yield components and to identify clones showing high yield and desirable secondary attributes in comparison with popular check clones.

Materials and Methods

A total of 1394 seedlings belonging to 56 cross combinations were obtained in the 1986 hybridisation programme. Based on test tap yield in the nursery, 189 and 131 selections were cloned and evaluated in SSTs 1989 and 1990 respectively. The final set of 21 clones was laid out in two SSTs in 1992 at the Central Experiment Station of RRII at Chethackal, Ranni in Central Kerala. These clones were derived from crosses involving four indigenous clones *viz*. RRII 105, RRII 118 and RRII 203 and RRII 208 and 11exotic clones *viz*. PR 107, IAN 45-873, PB 5/51, PB 86, PB 217, PB 242, PB 235, RRIM 612, RRIM 600, Tjir 1 and Gl 1. Details of clones and their parentage are given in Table 1.

A randomized block design with three replications and plot size of four (trial 1) and three trees (trial 2) was adopted for planting with a spacing of 4.9 x 4.9m. The trees were opened for tapping during the eighth year. Tapping system followed was S/2 d3 6d/7. Yield recording was done by cup coagulation and data over 10 years was collected. Girth of the trees was recorded annually from the third year onwards and used to determine the girth increment rate during pre-tapping and tapping phases. Bark samples were collected at the time of opening (virgin bark) and from the renewed panel, at 150 cm height. Bark thickness and number of latex vessel rows was determined under a bright field microscope. Number of trees showing incidence of powdery mildew and pink disease was noted. Clonal variability for all the traits was statistically analysed. Clear bole volume of the high yielding clones was determined at 22 years following Chathurvedi and Khanna (1982). In order to assess the overall performance of clones, a performance index was worked out based on eight characters following Mydin et al. (1996).

Table 1: Hybrid clones and their parentage

Clone	Trial 1 Parentage	Clone	Trial 2
86/337	RRII 105 x PR 107		Parentage
86/356	IAN 45-873 x RRII 105	86/264	RRIM 600 x PB 235
86/380	RRII 105 x PB 5/51	86/575	RRIM 600 x PB 235
86/424	RRII 105 x RRII 118	86/592	RRII 105 x PB 242
86/450	RRII 105 x PB 217	86/618	RRIM 600 x IAN 45-873
86/459	RRIM 600 x Gl1	86/756	IAN 45-873 x RRIM 600
86/583	RRII 203 x RRII 105	86/368	RRII 105 x PB 5/51

86/761	RRII 105 x PB 86	86/894	PB 5/51 x RRII 203
86/764	RRII 105 x PB 86	86/916	RRII 105 x RRII 208
86/772	RRII 105 x IAN 45-873	RRIM 600	Tjir 1 x PB 86
6/779	PB 5/51 x RRIM 612	RRII 105	Tjir 1 x Gl1
86/789	PB 242 x RRII 105		
86/948	PB 242 x RRIM 600		
RRII 105	Tjir 1 x Gl1		
	Country of origin of parents		
RRII	Rubber Research Institute of India		
IAN	Institute Agronomico du Norte, Brazil		
PR	Profestation voorRubber, Indonesia		
PB	Prang Besar, Malaysia		
RRIM	Rubber Research Institute of Malaysia		
Tjir1	Tjirandji, Indonesia		
Gl 1	Glenshiel, Malaysia		

Results

Yield of clones

The performance of 21 hybrid clones in respect of yield is presented in Table 2. Highly significant clonal variation was observed in panel wise yield as well as over 10 years of tapping. In trial 1, mean yield over six years in the BO- 1 panel revealed three clones viz., 86/772, 86/380 and 86/424 to be significantly superior to the check clone. The hybrid clone 86/772 was the highest yielder with 78.6 gram tree^{-1}tap^{-1}. The control clone recorded 40.8 gram tree^{-1}tap^{-1}. In the BO-2 panel 86/772 and 86/380 showed a rising trend with 80.9 gram tree^{-1}tap^{-1} and 67.5 gram tree^{-1}tap^{-1} respectively whereas 86/424 showed a declining trend. RRII 105 also recorded a rising trend with 64 gram tree^{-1}tap^{-1}. Mean yield over 10 years of tapping ranged from 29.5 (86/789) to 79.6 gram tree^{-1}tap^{-1} (86/772). The yield of 86/772 was significantly superior to that of RRII 105 which recorded 50.4 gram tree^{-1}tap^{-1}. 86/380 was the second best clone with 56 gram tree^{-1}tap^{-1}. The average yield of clones in trial 2 was less than that in trial 1. In the BO-1 panel, among the check clones RRIM 600 was the top yielder with 51.5 gram tree^{-1}tap^{-1} compared to 35 gram tree^{-1}tap^{-1} for RRII 105. The yield of the best clone 86/575 was better than RRIM 600 with 55.3 gram tree^{-1}tap^{-1} and significantly superior to that of RRII 105.86/756 was the second best with 41.2 gram tree^{-1}tap^{-1}. These two clones showed a rising yield trend in the BO-2 panel also with 76.2 and 56.5 gram tree^{-1}tap^{-1} respectively. Over 10 years of tapping, mean yield of the top ranking clone 86/575 (64 gram tree^{-1}tap^{-1}) was comparable to that of RRIM 600 (62 gram tree^{-1}tap^{-1}) and significantly superior to that of RRII 105 (40 gram tree^{-1}tap^{-1}). The hybrid clone 86/756 recorded 47 gram tree^{-1}tap^{-1}.

Table 2: Dry rubber yield of clones in different panels

Clone	Trial 1 Mean yield (gramtree $^{-1}$ tap $^{-1}$)			Clone	Trail 2 Mean yield (gramtree $^{-1}$ tap $^{-1}$)		
	BO -1 (over 6 years)	BO-2 (over 4 years)	Over 10 years		BO -1 (over 6 years)	BO-2 (over 4 years)	Over 10 years
86/337	15.5	21.0	17.7	86/264	20.9	29.6	24.4
86/356	30.5	59.2	42.0	86/575	55.3	76.2	63.7
86/380	48.0	67.5	55.9	86/592	27.5	37.3	31.4
86/424	47.3	42.8	48.7	86/618	33.2	34.5	33.7
86/450	36.4	54.4	43.6	86/756	41.2	56.5	47.3
86/459	28.7	32.6	30.3	86/368	28.8	54.2	38.9
86/583	29.2	31.3	30.1	86/894	20.5	26.5	23.2
86/761	29.0	44.0	35.0	86/916	18.5	36.9	25.3
86/764	31.2	32.7	31.8	RRIM 600	51.5	77	62
86/772	78.6	80.9	79.6	RRII 105	35	45	40
86/779	32.1	35.5	33.5	**CD**	17.6	28	21
86/789	33.4	21.8	29.5	*** (P <0.05)**			
86/948	33.2	60.3	44.0				
RRII 105	40.9	64.4	50.4				
CD*	13.9	18.8	13.4				

Growth parameters

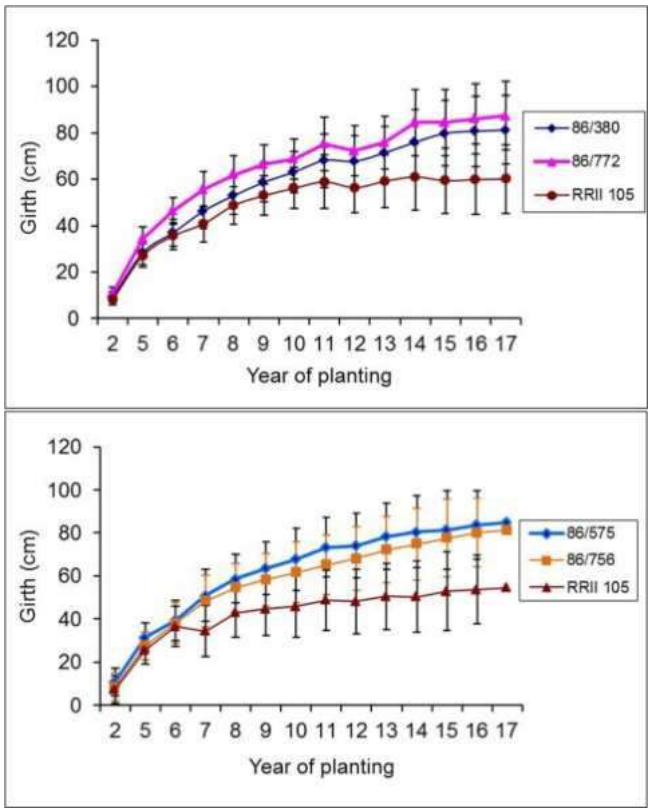
The growth performance of clones from both trials is presented in Table 3. In trial1, mean girth of the clones ranged from 37.7 (86/789) to 62 (86/772) cm. Girth at opening of 86/772 was significantly superior to that of RRII 105. The clones showed varied girth incrementrate in the pre tapping and tapping phases. At immaturity, maximum girth increment rate was exhibited by 86/772 (8.5 cm per year) followed by 86/948 (7.9 cm per year). Clone 86/948 also recorded the highest girth increment rate on tapping (4.4 cm per year). Girth increment rate under tapping of all the clones except 86/459 and 86/583 was better than the control. In trial 2, mean growth performance of clones was relatively poor compared to trial 1. The highest girth at opening was recorded by 86/575 (58.7 cm). The check clone RRIM 600 exhibited better growth (54 cm) than RRII 105. Clones 86/756 and 86/368 showed comparable girth with RRIM 600. During the immature phase, clones 86/575, 86/756 and 86/368 recorded a girth increment rate of more than 7 cm per year. The check clones recorded 7mm (RRIM 600) and 6 mm (RRII 105) increment per year. The girth increment rate on tapping also showed similar trend and the above clones

recorded 3mm girth increment rate on par with RRIM 600. Girth increment rate of RRII 105 on tapping was 1.3 mm. Growth curve plotted for the high yielding clones 86/772 and 86/380 in trial 1 and 86/575 and 86/756 in trial 2 showed consistently superior growth to RRII 105 during the entire study period (Fig. 1).

Table 3: Growth characters of clones

Trial 1				Trial 2			
Clone	Girth at opening (cm)	Girth increment rate/yr (cm)		Clone	Girth at opening (cm)	Girth increment rate/ yr (cm)	
		At immaturity	On tapping			At immaturity	On tapping
86/337	42.0	5.6	2.0	86/264	47.1	6.3	1.3
86/356	43.2	6.0	4.0	86/575	58.7	7.9	3
86/380	52.9	7.2	3.1	86/592	47.0	6.2	1.5
86/424	53.2	7.1	2.0	86/618	46.8	6.3	2.3
86/450	53.3	7.0	1.9	86/756	54.5	7.6	3
86/459	43.5	5.8	1.3	86/368	55.8	7.8	3.0
86/583	50.5	7.1	1.3	86/894	39.8	5.2	1.9
86/761	46.8	6.8	2.4	86/916	37.8	4.9	2.7
86/764	45.5	6.1	1.6	RRIM 600	54	6.9	3.1
86/772	62	8.5	2.8	RRII 105	48	5.9	1.2
86/779	51.7	7.3	2.5	**CD**	11.3	1.8	-
86/789	37.7	5.5	2.3				
86/948	57.1	7.9	4.3				
RRII 105	48.7	6.7	1.2				
CD	8.6	1.3	1.3				

Figure 1: Growth trend of selected high yielding clones**.** Vertical bars indicate CD values.



Bark characters

Bark thickness (BT) and number of latex vessel rows (LVR) in the clones are given in Table 4. Significant clonal variation was observed for both the traits in both the trials. In trial 1, the virgin bark thickness, ranged from 5-7 mm and LVR of the clones ranged from 5.7 to 12.6. Three clones recorded significantly superior LVR in the virgin bark than the check clone. Renewed bark thickness varied from 6.3 to 9.7mm and number of latex vessel rows in the renewed bark ranged from 18 to 31. The bark anatomical features of the top yielding clones 86/772 and 86/380 was comparable to RRII 105 which recorded high values for these traits. In trial 2, in the virgin bark, clones 86/575 and 86/756 showed the highest bark thickness above 6mm. Maximum LVR was observed in 86/618 (12). Renewed BT ranged from 6.1mm to 8.4mm and LVR in the renewed bark from 8.6 to 29.3. Among the controls, BT and LVR of RRII 105 were better than RRIM 600 in the virgin bark and vice versa in the renewed bark. The top yielding clones 86/575 and 86/756 showed more number of LVR in the renewed bark than the controls.

Table 4: Structural features of clones

Clone	Trial 1				Clone	Trail 2			
	Virgin bark		Renewed bark			Virgin bark		Renewed bark	
	BT†(mm)	LVR #	BT (mm)	LVR		BT (mm)	LVR	BT (mm)	LVR
86/337	4.9	6.8	6.9	18.4	86/264	5.8	6.7	6.1	16.0
86/356	6.0	5.7	9.1	18.6	86/575	6.0	7.1	8.5	29.3
86/380	6.1	8.2	8.1	28.4	86/592	5.3	6.7	6.4	17.0
86/424	5.3	8.4	7.7	23.6	86/618	5.7	12	6.5	20.8
86/450	5.8	12.6	6.3	21.9	86/756	6.3	6	7	23
86/459	5.5	9.9	6.3	23.5	86/368	4.8	4.6	6.7	16.1
86/583	6.3	7.5	7.5	20.5	86/894	5.7	6.6	6.8	16.9
86/761	4.8	7.3	8.0	22.8	86/916	5.6	7.7	4.8	8.6
					RRIM		6.8		
86/764	5.9	10.8	7.4	24.1	600	5.3		8.1	22.6
					RRII	6.1	8.8		
86/772	6.2	6.8	9.7	30.4	105			6.5	20
86/779	6.9	9.2	7.6	26.6	**CD**	0.7	1.8	1.8	9.3
					†bark thickness # number of latex				
86/789	-	-	7.4	26	vessel rows				
86/948	5.8	10.6	8.8	29.9					
RRII 105	6.0	6.9	8.4	30.9					
CD	0.6	2.1	1.8	6.5					

With respect to disease incidence, 86/772 and 86/756 showed the lowest incidence compared to the other clones. These two clones also registered superior clear bole volume of 0.2m^3 as against 0.1m^3 for RRII 105. The bole volume of the other two clones was comparable to that of RRII 105. The performance index of clones in trial 1 ranged from 23 to 83 (Table 5). The two high yielding selections 86/772 and 86/380 were in the 2nd and 4th position respectively, whereas RRII 105 occupied the 8th position. In trial 2, the index values were low, and ranged from 40 to 54. The clones 86/756 and 86/575 topped the ranking, against 4th and 5th position for the controls.

Discussion

Highly significant clonal variation for dry rubber yield, growth and girth increment rate, thickness of virgin and renewed bark and number of latex vessel rows in virgin and renewed bark was observed in the present study. Significant clonal variations for the above mentioned traits have been reported earlier (Licy et al.

2003). The variability for secondary traits could be exploited for component level selection of clones apart from identifying promising clones for rubber yield.

Growth is a major criterion in deciding the yielding capacity of a clone by way of length of the tapping panel. According to Simmonds (1989), yield and vigour in this crop are hardly separable. Girth increment rate in the initial years determine the tappability of the trees and early tappability combined with precocious yield could be ideal. Maintaining the girth increment rate over long years of exploitation is needed to sustain high yield levels (Mydin et al. 2007). On opening the trees for tapping, growth rate tends to decline due to partitioning of photosynthates (Templeton 1969). In the present study, the clones with high rubber yield combined high growth vigour in the immature as well as mature phase which implies the capacity of these clones to come to tapping phase early and also maintain the growth rate under tapping stress.

The laticifer system in *Hevea* is not only the region of storage of latex which is released during tapping but also the site of the final stages of rubber biosynthesis and hence the structure and orientation of laticifers has a direct bearing on the productivity of rubber (Gomez 1982). Bark thickness is a clonal character showing association with number of latex vessel rows and influencing the latex yield of different clones (Premakumari et al. 1985). In general, high correlation of girth with yield and bark thickness has been noticed in high yielding clones during early selection (Lavorintic et al. 1990). Results from the present study are in conformity with these findings.

Two high yielding hybrid clones viz., 86/772, 86/575, with significantly superior yield and two moderate yielders 86/380 and 86/ 756 with comparable yield to RRII 105 were identified from the study. Among the check clones, the growth and yield performance of RRII 105 was better in trial 1 whereas RRIM 600 performed better than RRII 105 in trial 2. This could be presumably due to the slope aspect, since trial 2 was laid out on top of the slope were soil depth was relatively low. In such areas RRIM 600 is a better performer than RRII 105. The parents of 21 hybrid clones tested were of diverse origin. The clone 86/772 (RRII 105 x IAN 45-873) emerged as the most promising high yielder combining high growth vigour, timber yield and better tolerance to diseases. Tolerance to various biotic and abiotic stresses is of great significance in assessing the performance of different clones. Disease assessment from small scale trials with a small plot size is however not conclusive. Nevertheless it gives an indication of the clonal response. IAN 45-873 is reported to be tolerant to *Oidium* (John et al. 2000; Varghese and Abraham 2007) and the clones with least incidence of disease had IAN 45-873 as one of the parents. 86/380 (RRII 105 x PB 5/51) combined high girth increment under tapping with a rising yield trend in the BO-2 panel. The clones 86/575 and 86/756 had RRIM 600 as one of its

parents. Both the clones showed vigorous growth coupled with good bark regeneration after tapping in a not so congenial terrain.

Among the ancillary products from rubber plantations rubber wood is the major by product in enhancing the net farm income (Viswanathan et al. 2002). Vigorous and fast growing trees not only attain early tappability but timber output will also be high (Meenakumari et al. 2013). Clones 86/772 and 86/756 indicated suitability as latex –timber clones by way of high clear bole volume. The performance index worked out for trials 1 and 2, indicate clearly the conditions under which both the trials were conducted. The index values in trial 1 were higher than that of trial 2. However the selections 86/772, 86/380, 86/575 and 86/756 adjudged for superior performance in both the trials showed a very high index confirming their overall superiority and potential to combine high yield with desirable secondary traits.

Table 5: Performance index (PI) of clones

Trial 1		Trial 2	
Clone	**PI**	**Clone**	**PI**
86/779	82.8	86/756	54.1
86/772	81.7	86/575	52.3
86/948	81.3	86/368	51.7
86/380	78.5	RRII 105	51.1
86/356	75.1	RRIM 600	50.8
86/583	74.5	86/592	49.6
86/450	74.0	86/618	45.8
RRII 105	72.9	86/264	45.2
86/764	72.2	86/916	44.4
86/424	69.8	86/894	40.6
86/761	65.3		
86/337	61.7		
86/789	23.5		
86/779	82.8		

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