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EVALUATION OF POLYCROSS SEEDLINGS OF PREPOTENT *HEVEA* CLONES POTENTIAL FOR YIELD IMPROVEMENT AND DROUGHT TOLERANCE

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A seedling nursery evaluation of nine sets of half-sib seedlings was conducted at Rubber Research Institute of India. The family-wise performance of the progenies was assessed by considering their juvenile yield on test tapping during peak and summer seasons along with seedling girth. An attempt was also made to study their drought tolerance potential by conducting a pot culture study in the second phase along with one set of seedlings of assorted origin. Growth parameters like plant height, girth and number of leaves were recorded at regular intervals during summer and non-summer periods. Visual scoring leaf yellowing was done in pot culture. From nursery evaluation, 126 potential seedlings out of 397 (31.7 %) could be identified with high summer yield. In pot culture study, the highest number of seedlings with green leaves was in the family of PB 28/83. The performance of the family of assorted seeds was inferior to polycross progenies throughout the period. The progenies of clones PB 28/83 and PB 215 were identified as ideal populations for selection and further detailed studies.

Key words: Drought tolerance, Girth, *Hevea brasiliensis*, Juvenile yield, Polycross seeds

INTRODUCTION

Breeding in *Hevea* aims at evolving clones for specific objectives and environments. The efforts for rapid genetic improvement are often hindered due to the perennial nature of the crop where procedures are often lengthy and laborious (Tan, 1987; Simmonds, 1989; Varghese and Mydin, 2000) and hence early evaluation techniques must be practised in seedling and clonal nursery screening for shortening the breeding cycle in *Hevea.* Seedling morphology is very important in the improvement of perennial crops and seedling vigour gives an indication of the vigour of clones after budding. Good immature vigour is one of the most important attributes associated with yield potential in rubber and is one of the early selection criteria in *Hevea* breeding programmes. Being an outcrossing perennial tree, *Hevea brasiliensis* offers abundant scope for producing natural polycross seeds, which are recommended for planting in marginal lands as the heterogeneity of the seeds becomes advantageous in imparting stability of performance under adverse conditions.

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Earlier studies (Tan, 1998) have established that nursery yield alone could be adopted as the early selection criterion and additional parameters could only marginally enhance the selection efficiency. In addition to this, if the seedling progenies are derived from prepotent *Hevea* clones, that will be an added advantage towards yield improvement as the parent has the capacity to impress characteristics on its offsprings. Prepotent parent clones by way of their high general continuing ability (GCA) are best used as components in polyclonal seed gardens for producing good quality polycross seeds. The open pollinated progeny of such clones also comprises superior base population for selection and cloning of the best individuals. A seedling nursery evaluation of nine sets of half-sib seedlings derived from a polyclonal seed garden of nine pre-potent *Hevea* clones was conducted at Rubber Research Institute of India. The family-wise performance of the progenies was assessed by considering their juvenile yield on test tapping during peak and summer seasons along with seedling girth.

MATERIALS AND METHODS

The polyclonal seed garden which is the source of the seeds was planted in 1995 at *Hevea* Breeding Sub Station, Nettana, South Karnataka, a region which experiences severe summer stress with low soil moisture and high temperature. The nine component clones of this garden were PB 242, RRII 203, PB 217, Ch 26, RRII 105, AVT 73, PB 5/51, PB 215 and PB 28/83.

In 2003, healthy seeds were collected from each of the nine clones by harvesting mature fruits from each clone separately. The seeds were brought to RRII, Kottayam, Kerala, South India (9^0 32′N, 76^0 36′E, altitude 73 m MSL). Healthy sprouted seeds were planted in the seedling nursery as family block, at a spacing of 30 cm. x 30 cm. A total of 359 polycross seedlings were test tapped by the modified Hammaker-Morris-Mann method under S/2 d/3 system during the peak yielding period in the fourth year of planting (September- October, 2007) using modified Michie-Golledge tapping knife and test tapping was repeated in the following two summer periods (March- April of 2008 and 2009). Girth of the plants was recorded at a height of 30 cm from ground level during 2009 to assess the plant vigour.

As the parent clones were exposed to severe summer stress in Nettana, Karnataka during February – May, when flower and fruit development occurs, certain extent of drought tolerance could be expected in the surviving fruits and the resultant progeny. Hence the drought tolerance potential of these seedlings was studied by conducting a pot culture study in the second phase using 10 seedlings from each of the nine clones in the same polyclonal seed garden at HBSS, Nettana and one set of 10 assorted seedlings. The sprouted seeds were directly sown in large cement pots of 60 cm height and 30 cm diameter. The objective of the study was to compare the drought tolerance potential of the progeny of pre-potent clones with those raised from assorted seeds at the age of two years. During the summer months water stress was induced by withholding irrigation. Growth parameters like plant height, girth at 10 cm from the ground level and number of leaves (green and yellow leaves separately) were recorded at regular intervals including summer and non-summer periods (February, March and October, 2008). Visual scoring on leaf yellowing was done during summer period (January- February, 2009) and the percentage of yellow leaves in a plant was calculated. The data on dry rubber yield (g), plant height (m), girth (cm) and number of green and yellow leaves were subjected to statistical analysis. The mean, standard deviation (SD) and coefficient of variation (CV) were worked out according to Panse and Sukhatme (1961).

RESULTS AND DISCUSSION

Family-wise performance with respect to test tap yield and percentage recovery of seedlings above the overall mean of summer yield is shown in Table 1. The number of seedling progenies evaluated in the nine clones ranged from 19 – 67. The mean peak season yield of the nine progenies in general was 6.54 g/10 tappings, whereas it was 7.61 g/10 tappings during the summer season. The progeny of clones RRII 203 and PB 217 showed a reduction in yield during summer season (after 16 months) compared to peak season yield. In all the nine clones there was very high coefficient of variation both for peak and summer season yield indicating the presence of high variability within the family. The individual seedling variation in dry rubber yield is attributed to the differences in genotypic potential (Tan and Subramaniam, 1976; Saraswathyamma and Panikkar, 1989). Summer season test tap yield was the highest in the family of the clone PB 28/83 (10.2 g/10 tappings) followed by that of PB 215 (9.5 g) whereas in the family of clone RRII 105, it was 7.3g The highest summer test tap yield combined with very high CV (96%) in the progeny of clone PB 28/83 indicates scope for selection of the best individual within the family, which can be cloned and evaluated further for drought tolerance. The progeny of clones PB 5/51 and PB 215 also showed high summer test tap yield combined with very high CV indicating the variability available within the family for selection. The progeny of clone PB 242 showed high summer test tap yield (8.3 g/10

Table 1. **Family-wise performance on test tap yield and percentage of seedlings with promising summer yield**

Progeny of clone	No. of seedlings evaluated	Mean yield (g/10 tap) (peak season)	Range in peak season yield	CV (%) (peak season)	Mean yield (g/10 tap) (summer season)	Range in summer yield	CV (%) (Summer Season)	% of superior seedlings (summer)
PB 242	48	7.0	2.83- 14.73	49	8.3	0.06-26.27	87	42
RRII 203	67	5.4	2.01-16.84	63	5.0	0-44.9	162	21
PB 217	22	6.9	2.92-17.54	57	6.0	0-22.12	103	26
Ch 26	45	6.2	2.91-23.54	69	6.9	0-34.28	106	33
RRII 105	28	6.1	3.23-17.57	54	7.3	0.21-26.24	95	32
AVT 73	50	5.2	2.49-22.86	67	6.1	0-34.88	147	18
PB 5/51	19	7.1	2.98-14.69	59	9.2	0-35.65	108	42
PB 215	29	7.8	0-28.17	75	9.5	0-37.67	93	45
PB 28/83	50	7.2	0-23.83	64	10.2	0-35.51	96	42
G. Mean		6.54			7.61			

Table 2. **Mean girth and test tap yield/unit length of cut**

Progeny of clone	Meangirth (cm)	Range in girth (cm)	CV %	Yield/cm girth (g)	Range in yield/cm(g)	CV %
PB 242	15.44	8.0-34.0	36	0.449	0-1.56	74
RRII 203	14.13	8.0-27.0	34	0.329	0-4.49	191
PB 217	17.35	9.0-22.0	45	0.346	0-1.55	105
Ch 26	15.09	8.0-28.0	35	0.529	0-1.43	91
RRII 105	15.18	9.0-24.0	31	0.393	0-1.13	77
AVT 73	14.96	8.0-35.0	39	0.257	0-2.57	133
PB 5/51	17.70	10.0-27.0	34	0.401	0-1.32	90
PB 215	17.63	8.0-30.0	31	0.457	0-1.51	80
PB 28/83	16.04	9.0-27.0	31	0.545	0-1.68	72
G Mean	15.95			0.412		

tappings) with comparatively low CV (86.8%) among the nine clones indicating that the progenies are superior and uniform, developed from the pre-potent parent clone. Progeny of clone RRII 203 had the lowest summer test tap yield (5.0 g/10 tappings) combined with highest CV (162.3%) showing that the progenies are inferior with respect to drought tolerance. Mydin *et al.* (1990; 1996) have used both family and population means of characters like growth, test tap yield and performance index for preliminary selection of progenies. The highest percentage recovery of superior seedlings based on population mean of summer period test tap yield was from the family of clone PB 215 (44.8%) followed by PB 5/51(42.1%), PB 28/ 83 (42%) and PB 242 (41.7%). Altogether, 115 potential seedlings out of 359 (32%) could be identified having high summer test tap

Table 3. **Growth performance of polycross and assorted seedlings**

Clone	Ht (cm) (Feb.-08)	Ht (cm) (March-08)	Girth (mm) (Feb.-08)	Girth(mm) (Mar-08)
RRII 203	82.53 ^{ab}	85.41 ^{ab}	24.57 ^{ab}	22.16 ^{ab}
PB 217	54 ^{b}	53 ^{c}	19.89 ^{ab}	15.7 ^{b}
PB 215	73.75 ^{ab}	75.25 ^{abc}	23.55 ^{ab}	19.63 ^{ab}
PB 5/51	75.8 ^{ab}	76.6 ^{abc}	22.61 ^{ab}	18.21 ^{ab}
PB 28/83	57.3 ^{b}	60.63 ^{bc}	17.58 ^{b}	16.49 ^{b}
PB 242	73.69 ^{ab}	74.15 ^{abc}	23.18 ^{ab}	19.32 ^{ab}
RRII 105	63.17 ^{ab}	71.7 ^{abc}	20.93 ^{ab}	19.15 ^{ab}
AVT 73	88.42 ^{a}	91.92 ^{a}	27.21 ^{a}	25.64
Ch 26	66.25 ^{ab}	70.25 ^{abc}	22.77 ^{ab}	18.57 ^{ab}
Assorted	61.75 ^{ab}	65.42 ^{abc}	18.84 ^{b}	15.96 ^{b}
G Mean	69.67	72.43	22.11	19.08

Any two means having common alphabets are not significantly different yield showing potential for cloning and further evaluation at drought prone regions. Efficiency of clonal selection largely depends on the genetic variability and broad sense heritability of traits. In *Hevea*, dry rubber yield and early maturity are considered as important agronomic traits. Broad sense heritability can be used to predict the gain in a clonally propagated species like rubber. Studies (Simmonds, 1989; Mydin, 1992; Licy *et al.*, 1993 a and b) show that rubber yield is highly heritable and is a useful parameter for improving the efficiency of selection (Mydin and Mecykutty, 2007).

Vigour in terms of seedling girth is an important juvenile trait as far as reduction in immaturity period is concerned. Seedlings with high vigour reach early tappability (Simmonds, 1989). A positive correlation of girth of seedlings in the nursery with girth at matuirity has been reported by Mydin *et al.* (2004). The mean girth was highest in the family of clone PB 5/51 (17.7 cm) followed by PB 215 (17.63 cm) and PB 217 (17.35 cm), whereas it was 15.19 cm in the family of RRII 105 indicating the general vigour of PB clones (Table 2). The seedlings with good girth in each family indicate the possible heterotic vigour of the progenies. When summer test tap yield per unit length of tapping cut was compared among the families, it was highest in the family of PB 28/83 and lowest in the family of AVT 73 followed by RRII 203. In these cases also, progeny of clone PB 28/83 showed the highest summer yield per unit cut combined with lowest CV among the nine families indicating the uniformity within the family and merit of progeny derived from a pre-potent parent. The very low yield per unit length of cut combined with highest CV for this character in the progeny of clone RRII 203 reconfirms the inferiority of this family contrary to the report by Mydin *et al* (2002) indicating prepotency of the parent clone RRII 203. From the nursery evaluation of progeny of nine clones, it was concluded that the progeny of clones PB 28/83 and PB 215 were the potential ones for cloning and evaluation for drought tolerance attributes.

Table 4. **Leaf yellowing in polycross and assorted seedlings**

Clone	No. of green leaves/plant		No. of yellow leaves/plant		% yellow leaves/plant	
	(Feb.-09)	(Mar-09)	(Feb.-09)	(Mar-09)	(Feb-09)	(Mar-09)
RRII 203	13.59	10.41	1.24	1.06	7.78	8.8
PB 217	11	8.67	0.67	-	6.77	-
PB 215	11.5	6.5	1	0.25	5.56	12.5
PB 5/51	12.8	9	1.2	1.4	9.2	13
PB 28/83	11	10.88	0.7	0.25	6	1.88
PB 242	10.38	8.85	2.31	0.92	16.95	13.97
RRII 105	9.75	10.4	0.75	1.2	8.02	12.16
AVT 73	13.67	13.33	1.75	1.75	12.23	9.63
Ch 26	12.58	10.25	0.5	0.67	3.7	6.28
Assorted	10.08	9.17	1.08	1.58	12.25	13.7
G Mean	11.6+4	9.75	1.12	1.01		

Table 5. **Growth of seedlings and grading on leaf yellowing during the second year**

Clone	Height (cm)	Girth(cm)	Grading on yellowing (total no.of plants in parenthesis)
RRII 203	178.64 [b]	5.2 [abc]	(17)-GL-8,YL-2,NL-1,PYL-5,FYL-1
PB 217	92 [c]	3.2 [c]	(3)-NL-3
PB 215	148 [bc]	3.9 [bc]	(4)- NL-1, GL-1,PYL-2
PB 5/51	156.8 [bc]	4.0 [bc]	(5)- YL-2, PYL-1,NL-2
PB 28/83	198 [ab]	4.8 [abc]	(10)- NL-2, GL-6, YL-1, PYL-1
PB 242	201.09 [ab]	5.6 [ab]	(13)-YL-1, NL-3, GL-6, PYL-3
RRII 105	199.66 [ab]	5.3 [abc]	(12)-GL-6, NL-5, PYL-1,
AVT 73	261.41 [a]	6.9 [a]	(12)- PYL-2, GL-7, NL-3,
Ch 26	193.25 [ab]	5.1 [abc]	(12)- PYL-4, GL-7, NL-1
Assorted	143.75 [bc]	3.4 [bc]	(12)- PYL-6, GL-2, NL-4
G Mean	177.3	4.74	

GL- Green leaves; NL- No leaves; PYL- Partially yellow leaves; YL- Yellow leaves
Any two means having common alphabets are not significantly different at P = 0.05

Growth performance of clonal seedlings and seedlings of assorted origin in the pot culture experiment is shown in Table 3. During the first summer season, family of clone AVT 73 showed good growth characters in terms of girth, while the performance of progeny of assorted origin was inferior in which the values for height and girth were lower than the general mean. It was found that the proportion of yellow leaves was less in the clone PB 28/83 while studying the senescence of leaves as a result of soil moisture stress; whereas it was the highest in PB 242 after a month of water stress in the pots (Table 4). Growth performance was assessed during the second year also after the plants experienced one more summer period when assessing of leaf yellowing was done (Table 5). During the second year of growth, the highest mean girth was shown by the family of AVT 73 (6.9 cm) followed by PB 242 (5.6 cm), whereas it was 5.3 cm in the family of RRII 105. On comparison of leaf yellowing, it was observed that the highest number of seedlings with green leaves were in the family of PB 28/83. Throughout the period, the performance of the family of assorted seeds was inferior in all the nine families both in terms of growth and proportion of senescent leaves indicating the merit of the polycross progenies in terms of drought tolerance.

It was concluded from the pot culture experiment that the progeny of clone PB 28/83 are good with less proportion of leaves during first year of moisture stress and with more number of green leaves during second year of stress period. The present study highlights the importance of adopting screening at the nursery stage itself and the potential use of polycross seeds towards the development of high yielding *Hevea* clones possessing drought tolerance. The progenies of clones PB 28/83 and PB 215 can be considered as the ideal populations for selection and further large-scale evaluation.

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