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Early growth and yield performance of *Hevea* germplasm in a drought prone region of central-eastern India

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Abstract

Thirty wild *Hevea* germplasm accessions from three provenances *viz.* Acre, Rondonia and Mato Grosso of Brazil along with six cultivated clones, were evaluated for their early growth and yield performance under the drought prone conditions in Bastar region of central-eastern India. Highly significant clonal variability was observed for yield, bark thickness, number of latex vessel rows and growth characters such as girth, girth increment, crotch height. The girth of the plants ranged from 19.50 cm (AC 623) to 64.70 cm (RRII 118); girth increment from 2.87 cm (AC 623) to 9.80 cm (RRII 208); crotch height ranged from 130 cm (AC 5463) to 570 cm (AC 680); bark thickness from 3 mm (MT 2229, RO 5430, RO 2635, RO 5348, RO 5553, AC 680) to 7.50 mm (RO 2629, RO 5408, RRII 208); number of latex vessel rows from 3 (RO 5554) to 18 (RO 5363) and yield from 0.04 g (RO 5445) to 43.33 g (RRII 118). Among the 36 genotypes, RRII 208 recorded the highest girth followed by RO 2635, RO 5430, RRII 118, RO 5554 and MT 196. Highest yield was recorded in RRII 118 followed by RRII 208, GI 1 and RO 5363. These results are in conformity with the performance in other non traditional rubber growing areas in India. Components of variance, heritability in broad sense and correlations among six quantitative characters were estimated. The genotypes were ranked for overall performance based on rank sum values, which ranged from 47 to 177 with a general mean of 110.67. Top 25% of potential genotypes showing early growth vigour and higher yield could be identified for use in future crop improvement

Key words: *Hevea brasiliensis*, wild germplasm, genetic variation, performance index.

Introduction

Hevea brasiliensis is a popularly cultivated species for its natural rubber, commercially more valuable raw material for enormous number of rubber products in the world. It has been evolved from within a very small gene pool, popularly known as the 'Wickham' gene pool, since it was collected from a limited area of native Amazon region, Brazil (Schutles, 1977). Due to human interventions, genetic resources of *Hevea* are fast depleting in the primary center of origin. The intensive directional selection over the years for yield alone has further narrowed the genetic base (Wycherley, 1969), and has further resulted in a slow down in genetic advances in recent breeding phases (Tan, 1981; Seguin *et al.*, 1995). The urgency of *Hevea* conservation was felt by the natural rubber industry, thus the International Rubber Research and Development Board (IRRDB) has organized an expedition in the primary centre of origin of the crop, the Amazon basin, covering wide agro-climatic areas in the states, Acre (AC), Mato Grosso (MT) and Rondonia (RO) in Brazil, for collection and conservation of variability in the wild *Hevea* germplasm. This resulted in collection of over 60,000 seeds and budwood from 194 exceptionally good trees (Ong *et al.*, 1983). These accessions were distributed to IRRDB member countries, and those received in India, are being conserved in conservation cum source bush nurseries.

There is a wide gap between production and consumption of natural rubber world wide. In India, the situation is more acute with non-availability of land in traditionally cultivated region (8^0 to 12^0 N) in South India. To bridge this gap, steps were taken to explore the possibilities of extending *Hevea* cultivation to less congenial non-traditional areas. This necessitated evaluation of wild accessions for selection of potential drought tolerant clones. This is the first report on the assessment of the growth and yield performance of *Hevea* germplasm under the drought prone conditions in Bastar region of central-eastern India. The present study was undertaken to ascertain the extent of genetic variability in the population and identify desirable genotypes for use.

Materials and Methods

The study was conducted at the Regional Research Station at Sukma (19°5'N, 82° 02'E, 202 m MSL) in the Bastar region of central-eastern India. The trial was located on plain land with uniform stand and soil status. The main soil types in Sukma are red and yellow soils (Khanna and Motiramani, 1972). The soil is acidic in nature (pH 5.3) and low in organic content (0.53%). Available P, K and Mg are 0.20, 4.25 and 4.62 mg per 100 g soil, respectively. The soil exhibited considerable shrinkage and cracking on drying. The region received a total annual rainfall of 1530.70 mm during 1996 to 2000. The maximum rainfall was received during four months (June-September) with only 65 rainy days and more than seven months of dry period. In summer months, ambient temperature during day time crossed 38°C.

A field trial was laid out in 1996, to screen the *Hevea* germplasm for tolerance to drought. A total of 30 wild accessions from Acre (9), Mato Grosso (5) and Rondonia (16) provenances along with six popular clones *viz*., RRII 105, RRII 118, RRII 208, PB 260, GT 1, Gl 1 were included in the trial. The experiment was laid out in a simple lattice design with two replications. The spacing adopted was 4.9 m x 4.9 m with 10 plants per plot. The recommended cultural practices of Rubber Board were followed.

The variability in growth characters *viz*., girth (cm) of the stem at a height of 150 cm above the bud union, girth increment (cm), crotch height (cm), bark thickness (mm), number of latex vessel rows and yield (g/t/t) during peak yielding season and summer season were recorded. The tapping system followed was ½S d/2. The data were subjected to statistical analysis. The correlations between various growth and yield parameters were computed following the methods of Panse and Sukhatme (1978). The genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and broad sense heritability (H^2) were calculated according to Zoble and Talbert (1984). Performance of all these genotypes were assessed by rank sum method.

Results and Discussion

The Bastar region of central-eastern India experiences a warm dry sub-humid climate. During the study period, this region received a mean annual rainfall of 1530 mm with only 65 rainy days, almost confined to June September, with July recording the highest rainfall. In general, during March to June, the mean maximum temperature was higher than 38°C. In this region, soil moisture deficit and high summer temperature are the major environmental constraints.

The range and mean values of six characters in comparison with the control clone is presented in Table 1. All the genotypes exhibited significantly high variation for the characters studied. Girth of the plants ranged from 19.50 cm (AC 623) to 64.70 cm (RRII 118) and girth increment from 2.87 cm (AC 623) to 9.80 cm (RRII 208). Highest girth was recorded in the clone RRII 208 followed by RO 2635, RO 5430, RRII 118 and RO 5554. Girth increment was the highest in RRII 208 (9.80 cm), followed by MT 196 (6.94 cm), RO 5430 (6.16 cm) and RO 2635 (6.09 cm). Genotypes with early growth vigour are high useful for reducing immaturity period. Superiority of RRII 208 in drought area of North Konkan and Dapchari regions was also reported by Nazeer *et al.* (1992) and Chandrashekar *et al.* (1994). Reju *et al.* (2001) also

Table 1. Variability for growth and yield related characters in the population

Character	Minimum	Maximum	Mean	RRII 105	CV
Girth (cm)	19.50 (AC 623)	64.70 (RRII 118)	43.53	41.31	8.93
Girth increment (cm)	2.87 (AC 623)	9.80 (RRII 208)	6.43	7.59	11.85
Crotch height (cm)	130 (AC 5463)	570 (AC 680)	285.85	260.20	8.73
Bark thickness (mm)	3.00 (MT 2229, RO 5430, RO 2635, RO5348, RO5553, AC 680)	7.50 (RO 2629, RO 5408, RRII 208)	5.08	6.25	10.49
No of latex vessel rows	3.00 (RO 5554)	18.00 (RO 5363)	8.77	11.40	15.42
Yield (g/t/t)	0.04 (RO 5445)	43.33 (RRII 118)	4.31	19.57	50.62

Note: Figures in parenthesis denote the name of accession/clone reported superiority of the clone RRII 208 and RRII 118 in the West Garo Hills of Meghalaya at Tura.

The crotch height ranged from 130 cm (AC 5463) to 570 cm (AC 680). The highest mean crotch height was noted in RO 5430 followed by AC 680, MT 44, RO 2629, MT 196 and RO 5408. The general mean for crotch height (285.85 cm) of the wild germplasm was higher than that of Wickham clone RRII 105 (260.20 cm). These genotypes with high crotch height coupled with good girth have high timber potential. The tendency of wild *Hevea* germplasm to branch at a higher level than the Wickham clones was also reported by Azwar *et al.* (1995) and Rao *et al.* (1999). Chapuset *et al.* (1995) also reported variation in branching behavior among the wild germplasm.

The range of bark thickness varied from 3 mm (MT 2229, RO 5430, RO 2635, RO 5348, RO 5553, AC 680) to 7.50 mm (RO 2629, RO 5408, RRII 208). RRII 208 (6.25 mm), RRII 105 (6.25 mm), RO 2890 (5.80 mm), RO 5408 (5.74 mm) and RO 2629 (5.56 mm) showed the highest bark thickness, while more number of latex vessel rows (LVR) were found in RRII 208 (13.30), RRII 105 (11.40), MT 2229 (11.20), MT 2594 (10.10) and RO 2629 (10) with a range of 3 (RO 5554) to 18 (RO 5363). Similar wide variation in bark thickness was also reported by Azwar *et al.* (1995). The yield per tree per tap ranged from 0.04 g (RO 5445) to 43.33 g (RRII 118) with a general mean of 4.31 g. RRII 118 (26.55 g) was the highest yielder followed by RRII 208 (20.19 g), GI 1 (11.96 g), RO 5363 (10.84 g), GT 1 (10.50 g), PB 260 (8.66 g), RO 5329 (8.40 g), AC 1950 (5.09 g) and RO 5430 (4.39 g), whereas the control clone RRII 105 recorded 8.40 g. Annamma *et al.* (1989), Mercy *et al.* (1995), Rao *et al.* (1999) and Abraham *et al.* (2002) have also reported wide variability in the wild germplasm with respect to certain growth and yield traits in traditional rubber growing regions in India.

Performance of top 10 genotypes for growth characters in terms of girth, mean annual girth increment, crotch height, mean yields over peak and summer season and yield related traits are shown in Table 2. When the mean values of wild accessions were compared with the popular clone RRII 105, the general mean values of the wild germplasm for all the characters except girth and crotch height were found to be lower than that of the popular clone. Though the wild accessions in general showed lower general mean values than the control clone, the mean values of the wild accessions was high particularly in RO 5430 for girth and crotch height, MT 196 for girth increment. The wide variation observed in the wild germplasm were in accordance with the general expectations that wild and primitive forms from the centre of origin exhibit more variability (Varghese, 1992).

High mean yield over two seasons was observed in some genotypes : RRII 118 (27.85 g) being the highest yielder followed by RRII 208 (26.04 g), RO 5363 (15.82 g), GT 1 (15.01 g), RRII 105 (13.99 g), PB 260 (13.34 g), GI 1 (13.28 g), RO 5430 (8.12 g) and RO 5329 (7.59 g). These genotypes showed high adaptability and superiority for yield traits such as high number of latex vessel rows. Yield superiority of RRII 208 in drought prone areas of North Konkan region was also reported by Nazeer *et al.* (1992) and Chandrashekar *et al.* (1994). Superiority of the clone RRII 208 and RRII 118 was reported by Reju *et al.* (2001) in the West Garo Hills of

Table 2. Mean performance of top ten genotypes for growth, yield and related characters

Accession/ clone	Girth (cm) after 8th year of planting	Annual girth increment (cm) over 4 years	Crotch height (cm)	Bark thickness (mm)	Latex vessel rows	Mean yield of two seasons (g/t/t)
RRII 118	49.66	5.10	299.86	5.25	7.28	27.86
RRII 208	53.72	9.80	284.44	6.75	13.25	26.04
RO 5363	46.05	4.88	297.75	5.29	9.46	15.82
GT 1	46.11	4.63	305.48	5.50	9.50	15.01
RRII 105	41.31	3.57	260.21	6.25	11.40	13.99
PB 260	46.83	5.01	289.63	5.02	9.83	13.35
GI 1	40.73	4.84	275.13	5.55	8.62	13.29
RO 5430	50.99	6.16	350.21	5.15	8.87	8.12
RO 5329	42.20	5.54	281.11	5.13	9.50	7.60
MT 196	49.06	6.94	315.31	4.85	8.10	6.74
C.D.(0.05)	7.78	1.53	54.91	1.07	2.73	6.28

Meghalaya at Tura. Yield related trait like bark thickness was more in the genotype RRII 208 followed by RRII 105, RO 2890, RO 5408 and RO 2629. High number of latex vessel rows was found in RRII 208, RRII 105, RO 2229, RO 2594 and RO 2629.

Components of variation in the population were estimated through the genotypic and phenotypic coefficients of variation, and heritability in the broad sense (Table 3). A high phenotypic coefficient of variation (PCV) was observed for yield (138.49), girth increment (20.13) and number of latex vessel rows (19.94), whereas it was lowest for crotch height (10.80) and girth (12.89). The highest estimate of genotypic coefficient of variation (GCV) was for yield (128.93) followed by girth increment (16.27) and LVR (12.63). For all the characters studied, the PCV was higher than the GCV. High magnitude of genetic variability was evidenced by medium to high estimates of PCV and GCV for majority of the characters. Similarly, moderate estimates of coefficients of variation for certain growth and yield characters in wild *Hevea* germplasm was reported by Rao *et al.* (1999) and Abraham *et al.* (2002).

Table 3. Phenotypic and genotypic coefficients of variation and heritability for six quantitative characters

Characters	PCV	GCV	Heritability (H^2)
Girth	12.89	9.29	0.52
Girth increment	20.13	16.27	0.65
Crotch height	10.80	6.36	0.35
Bark thickness	13.11	7.87	0.36
Latex vessel rows	19.94	12.63	0.40
Yield	138.49	128.93	0.87

Heritability in the broadsense (H^2) was found to be medium to high for the growth and yield characters (Table 3). Higher H^2 estimate was recorded for yield (0.87) and girth increment (0.65) with medium heritability for girth (0.52), LVR (0.40), bark thickness (0.36) and crotch height (0.35). Rao *et al.* (1999) and Abraham *et al.* (2002) have reported moderate to high H^2 in the wild germplasm with respect to certain growth parameters like girth, branching height and bark thickness. In the present study, moderate to high heritability for most of the characters suggests that the characters are under moderate genetic control.

Simple correlation coefficients between pairs of different characters is presented in Table 4. Bark thickness was highly correlated with the number of latex vessel rows (0.613). Girth was significantly correlated with the girth increment (0.513). The yield was significantly correlated with bark thickness (0.441) and moderately with girth (0,299) and LVR (0.299). No significant correlations however, could be detected between yield and crotch height and girth increment. However, high correlation between bark thickness and girth has been reported in wild *Hevea* germplasm by Madhavan *et al.* (1996) and Rao and Reghu (2000). Zeng *et al.* (2005) also reported significantly high correlations between the yield and bark thickness bark thickness and LVR in wild germplasm.

Table 4. Correlation coefficients among six quantitative characters

Characters	Crotch height	Girth	Girth increment	Bark thickness	Latex vessel rows
Yield	0.096	0.299	-0.136	0.441**	0.299
Crotch height	0.412**	-0.288	0.042	-0.038	
Girth			0.513**	0.269	0.314
Girth increment				0.040	0.078
Bark thickness					0.613**

** Significant at P<0.01

Performance index

In order to identify genotypes with maximum number of desirable attributes, the performance of each of the six characters was pooled using rank sum method. The ranking of each genotype based on parametric relationship of growth and yield are shown in Table 5.

The rank sum value ranged from 47 – 177 with the general mean of 110.67. The highest rank sum value was recorded in the genotype RRII 208 (177) followed by RO 5430 (165), RRII 105 (161), GT 1 (159), MT 44 (153) RO 2629 (152), RO 5408 (143), AC 619 (135), RO 5363 (135), RRII 118 (134) and RO 5329 (132). These genotypes showed relatively high yield and vigorous growth. The wild accessions RO 2822 and AC 62? recorded the lowest rank sum value (47). Balasimha *et al.* (1988) and Mercy (2001) also reported similar ranking in Cocoa and wild *Hevea* accessions, respectively, while evaluating genotypes for drought tolerance. Overall performance of each genotype was assessed by summing up the rank values obtained for each of character studied Top 25 per cent of the potential genotypes identified as best performers were RRII 208, RO 5430, RRII 105, GT 1, MT 44, RO 2629, RO 5408, AC 619, RO 5363 and RRII 118.

Table 5. Ranking based on growth and yield parameters

Accession/ clone	Rank sum	Rank
RRII 208	177	1
RO 5430	165	2
RRII 105	161	3
GT 1	159	4
MT 44	153	5
RO 2629	152	6
RO 5408	143	7
AC 619	135	8
RO 5363	135	8
RRII 118	134	10
RO 5329	132	11
MT 196	131	12
RO 2890	128	13
PB 260	128	13
MT 2229	124	15
RO 5557	121	16
MT 2594	115	17
AC 5463	112	18
RO 5554	112	18
MT 2217	110	20
AC 607	107	21
RO 5369	106	22
RO 3172	104	23
RO 2635	101	24
GI 1	100	25
AC 685	99	26
RO 6139	84	27
RO 5348	80	28
AC 680	76	29
AC 1950	73	30
RO 5445	67	31
RO 5553	63	32
AC 763	55	33
AC 707	48	34
AC 623	47	35
RO 2822	47	35

General mean = 110.67

Various morphological, anatomical, biochemical and physiological characters of the rubber tree are ultimately manifested in the volume of latex obtained by tapping and the quantum of rubber it contains. A vigorous habit in the early growth phase of the plant reduces the immaturity period. In general, yield and vigour in *Hevea brasiliensis* are hardly separable (Simmonds, 1989). The present study resulted in the identification of vigorous accessions/clones with wide variability for growth and yield traits. Certain genotypes showed superiority and adaptability for growth and yield characters in the drought prone region.

Conclusion

Wide variability was observed for various growth and yield contributing traits. RRII 208, RO 2635, RO 5430, RRII 118, RO 5554 were identified as vigorous genotypes which will be useful for reducing the immaturity period. The high yielders identified from this drought prone area include RRII 118, RRII 208, RO 5363, GT 1 and RRII 105. These selections could be utilized directly, and/or incorporated in breeding programmes for evolving rubber clones suitable for drought prone locations.

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