Provenance Variation in Growth Characteristics of Wild *Hevea* Genotypes in Bastar Region of Central-eastern India

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A study to evaluate thirty wild genotypes of three provenances Acre, Matto Grosso and Rondonia along with six Wickham clones, was conducted for the screening of their existing nature and extent of variation under the drought prone conditions in Bastar region of central-eastern India. The region received rain for about four months (June-September) with only sixty-five rainy days and had more than seven months of dry period. In summer months ambient temperature during daytime crossed 38^0C. The observation on variability in growth were recorded for girth, plant height, canopy height, canopy breadth, number of branches, branching height, branching angle and bark thickness at fourth year after field planting. Correlation, components of variance and heritability in broad sense were worked out. Wide inter and intra provenance variability was observed for all the characters studied. In general, Matto Grosso provenance showed comparatively high adaptability and superiority for all characters except branching height and branching angle ; while in general Acre exhibited lowest growth performance. Several genotypes could be identified as superior to Wickham clones for certain important characters like bark thickness, plant height, canopy height and branching height. The existing wide variability would ultimately help to identify certain potential genotypes for future breeding and crop improvement programmes.

Key Words: *Hevea,* Provenance, Wild germplasm, Variability, Heritability

Introduction

The source of origin of almost all the present cultivated rubber *(Hevea brasiliensis)* has been evolved within the 'Wickham' genetic group, which represents a very small gene pool, since it was collected from a limited area (Schutles, 1977). 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 breeding phases (Tan, 1981; Seguin *et al*., 1995).

Considering the gravity of the situation, the International Rubber Research and Development Board (IRRDB), organized an expedition in vast region of the primary centre of origin of the crop, the Amazon basin, covering wide agro-climatic areas in the states, Acre, Matto Grosso and Rondonia in Brazil, for collection and conservation of the high variability. This resulted in collection of over 60,000 seeds and bud wood from 194 exceptionally good trees (Ong *et al*., 1983). These genotypes were distributed to IRRDB member countries, and those received in India, were being conserved in conservation nurseries.

In India with non-availability of land in traditionally cultivated region (8^0 to 12^0 N), and to bridge the widening gap between production and consumption, steps were taken to explore the possibilities of extending *Hevea* cultivation to less congenial areas. This necessitated evaluation of wild genotypes capable of withstanding stress conditions, for their further utilization in selection of stress/drought tolerant clones.

Earlier, no study has been made to assess the performance of wild *Hevea* germplasm under the drought prone conditions in Bastar region of central-eastern India. The present first ever study of its kind in this region was undertaken to identify the nature and extent of variability in wild population, which would ultimately help to identify genotypes for breeding programmes.

Materials and Methods

The study was conducted at the Regional Research Station at Sukma (19^o5'N, 82^o02'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 gm soil, respectively. The soil exhibited considerable shrinkage and cracking on drying.

A field trial was laid out in 1996, to screen the wild *Hevea* germplasm. In total thirty wild genotypes of Acre,

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Matto Grosso and Rondonia provenances and six Wickham clones as controls were included in the trial (Table 1). 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 ten plants per plot. During drought period (March to May) the plants were given uniform life saving irrigation at fortnightly intervals, at the rate of 15 litres per plant during the first year (1996-97) and 30 liters during the further years of study period (1998-2000). The recommended cultural practices (Rubber Board, 1990) were followed.

Table 1. Genotypes planted in the field trial

Rondonia	Matto Grosso	Acre	Wickham clones
RO 2822, RO 2635	MT 44	AC 685	RRII 105
RO 2629, RO 3172	MT 196	AC 707	RRII 118
RO 2890, RO 5557	MT 2594	AC 607	RRII 208
RO 5369, RO 5348	MT 2217	AC 623	PB 260
RO 5463, RO 5408	MT 2229	AC 619	GT 1
RO 5553, RO 5554		AC 763	GL 1
RO 6135, RO 5329		AC 68	
RO 5363, RO 5430		AC 1950	
RO 5445			

The variability in growth, as girth of the stem at the height of 150 cm above the ground level, and observations on variations in other morphological characters, plant height, canopy height, canopy breadth, number of branches, branching height, branching angle and bark thickness were recorded during the fourth year after field planting for ten trees per genotypes.

The correlations between various growth parameters were computed following the methods of Panse and Sukhatme (1978). The genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV) and broad sense heritability (h^2) were calculated according to Zoble and Talbert (1984).

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 to September, with July recording the highest rainfall. In general, during March to June, the mean maximum temperature was higher than 38^0C (Table 2). In this region, soil moisture deficit and high summer temperature are the major environmental constraints.

The genotypes exhibited wide variation for the characters studied. The range of variation and mean values in wild *Hevea* germplasm are given in Table 3. In fourth year after field planting, the girth of the plants ranged from 16.98 cm (AC 707) to 27.3 cm (MT 2594), plant height from 474.65 cm (AC 685) to 802.30 cm (MT 196) and bark thickness from 1.85 mm (AC 685) to 3.21 mm (RO 2890). Similar wide variation in bark thickness was also reported among the three provenances by Azwar *et al*. (1995). Varghese (1992), Abraham *et al*. (1992, 2002), and Mercy *et al*. (1995) have also reported wide variability in wild germplasm in respect to certain growth morphological characters.

The wide variability was also recorded for other secondary characters, canopy height, canopy breadth and first branching height. The number of branches and

Table 2. Average temperature and rainfall during the experimental period (1996-2000)

Month	Temperature (^{0}C)		Rainfall	No. of
	Max.	Min.	(mm)	Rainy days
January	29.2	10.7	5.4	1
February	32.0	13.8	3.0	1
March	36.6	17.8	11.4	1
April	38.6	25.6	42.3	3
May	38.4	24.9	42.4	3
June	34.0	23.9	273.6	7
July	29.3	23.3	444.5	17
August	29.5	22.5	351.6	15
September	30.9	22.2	222.0	12
October	30.9	20.6	92.9	3
November	30.2	15.6	35.6	1
December	27.9	9.5	6.0	1
Total	–	–	1530.7	65
Mean	32.3	19.2	–	–

Table 3. Variability in growth characters of 4-year-old-trees

Characters	Wild genotypes			Wickham clones		
	Minimum	Maximum	General mean	Minimum	Maximum	General mean
Girth (cm)	16.98 (AC 707)	27.30 (MT 2594)	23.34	21.36 (GL 1)	29.26 (RRII 118)	26.77
Plant height (cm)	474.65 (AC 685)	802.30 (MT 196)	674.15	587.09 (RRII 105)	782.10 (RRII 118)	704.06
Canopy height (cm)	198.32 (AC 707)	494.00 (RO 3172)	356.17	292.50 (GL 1)	457.50 (RRII 118)	392.51
Canopy breadth (cm)	273.20 (AC 707)	467.50 (RO 5557)	403.41	380.00 (RRII 105)	512.00 (RRII 118)	440.86
Branching height (cm)	256.50 (AC 1950)	404.00 (RO 5430)	311.67	273.40 (RRII 105)	338.00 (GT 1)	302.11
No. of branches	7.66 (AC 707)	34.10 (RO 5553)	21.52	14.30 (RRII 105)	37.40 (GT 1)	24.95
Branching angle (^{0})	49.11 (AC 1950)	61.14 (AC 623)	55.51	55.26 (RRII 105)	61.51 (RRII 118)	58.17
Bark thickness (mm)	1.85 (AC 685)	3.21 (RO 2890)	2.43	2.91 (PB 260)	3.10 (RRII 208)	2.99

branching angle also widely varied. The branching height ranged from 256.50 cm (AC 1950) to highest as 404.00 cm (RO 5430) (Table 3), with a general mean value of 311.67 cm, which was higher than those of Wickham clones. The tendency of wild *Hevea* germplasm to branch at a higher than that of 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. Branching height related to early or late branching. Number of branches and canopy size have got considerable influence on the rate of growth, as stem and branching characters attributed to differences in dimensions of form of tree crown (Jankiewicz and Stecki, 1976), and has a direct effect on the spatial distribution of photosynthetic surface by forming the plant skeleton.

When the mean values of wild genotypes were compared with the Wickham clones, the general mean values of the wild germplasm for all the characters except the branching height were found to lower than those of Wickham clones. Though the wild genotypes in general showed lower general mean values than that of Wickham clones, the mean values of the wild genotypes particularly MT 196 for plant height, RO 3172 for canopy height, RO 5430 for branching height and RO 2830 for bark thickness, were found to show superiority over Wickham clones. 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 (Annamma *et al*. 1989).

A provenance wise comparison of the performance of wild genotypes is depicted in Table 4. The genotypes from Matto Grosso were found to be comparatively vigorous with highest provenance mean for girth, height, branching height, canopy breadth, and also exhibited the almost highest mean values for canopy height and bark thickness. The general performance of Matto Grosso provenance was superior is in agreement with the general observations made by Chevallier (1988), Clement-Demange *et al*. (1990), Abraham *et al*. (1992), Mercy *et al*. (1995) and Rao *et al*. (1999). Though, the Matto Grosso provenance revealed the vigorous nature with higher mean values, the Rondonia and Acre provenances exhibited comparatively higher variability. Acre showed higher heterogenity for the characters studied except for girth, branching height and bark thickness. In general, Rondonia provenance appeared to be intermediate in the mean values between Acre and Matto Grosso provenances. Chevallier (1988), Nicolas *et al*. (1988) and Rao *et al*. (1999) have reported similar results of intermediate position of the Rondonian genotypes.

Simple correlation coefficients between pairs of different characters are presented in Table 5. The girth is significantly correlated with plant height (0.840), branching height (0.557), canopy height (0.691), canopy breadth (0.792) and bark thickness (0.651). Plant height is also significantly correlated with the character except branching angle. Similarly, canopy height was positively correlated with canopy breadth. No significant correlation, however, could be detected between branching angle and any other trait. Significant high correlation between bark thickness and girth has been reported in wild *Hevea* genotypes by Madhavan *et al.* (1996) and Rao and Reghu (2000). Significant positive correlation of plant height with canopy height, indicates that the total height of the plant is influenced by the growth of the canopy (Nazeer *et al*., 1992).

Components of variation in the population were estimated through the genotypic and phenotypic coefficients of variation, and heritability in the broad

Table 4. Provenance-wise comparison of 4-year-old trees

Characters	Provenance						Wickham clones	
	Acre		Matto Grosso		Rondonia			
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Girth (cm)	20.32	16.98 – 23.40	25.71	24.19 – 27.34	24.00	19.50 – 27.25	26.77	21.36 – 29.26
Plant height (cm)	591.68	474.65 – 717.54	723.97	635.00 – 802.30	706.80	592.60 – 749.58	704.06	587.09 – 782.10
Canopy height (cm)	288.60	198.32 –377.00	389.48	276.20 –429.70	390.43	318.70 – 494.00	392.51	292.50 – 457.50
Canopy breadth (cm)	355.86	273.20 – 441.50	428.36	344.90 – 455.20	426.01	373.20 – 467.50	440.86	380.00 – 512.00
Branching height (cm)	299.50	256.50 – 359.10	326.40	295.80 –356.30	309.13	255.40 –404.00	302.11	273.40 – 338.00
No. of branches	20.70	7.66 – 29.60	23.26	18.80 – 28.60	20.60	13.30 – 34.10	24.95	14.30 – 37.40
Branching angle (^{0})	56.44	49.11 – 61.14	55.47	55.44 – 56.52	54.64	52.78 – 60.72	58.17	55.26 – 61.51
Bark thickness (mm)	2.21	1.85 – 3.04	2.51	2.00 – 3.09	2.57	2.01 – 3.21	2.99	2.91 – 3.10

Table 5. Correlation coefficients among growth characters of wild genotypes

Characters	Characters						
	Plant height	Branching height	No. of branches	Canopy height	Canopy breadth	Branching angle	Bark thickness
Girth	0.840**	0.557**	0.110	0.691**	– 0.792**	– 0.269	0.651**
Plant height		0.538**	0.652**	0.902**	0.876**	– 0.314	0.550**
Branching height			– 0.103	0.134	0.314	– 0.087	0.257
No. of branches				0.131	0.257	– 0.356	0.252
Canopy height					0.873**	– 0.319	0.496
Canopy breadth						–0.239	0.618**
Branching angle							– 0.110

* Significant at P<0.05
** Significant at P<0.01

sense (Table 6). A high phenotypic coefficient of variation (PCV) was observed for number of branches (40.83), canopy height (27.77) and bark thickness (23.43), whereas it was lowest for branching angle (5.83). The highest estimate of genotypic coefficient of variation (GCV) was for number of branches (24.36) followed by canopy height and bark thickness. For all the characters studied, the PCV was higher than the GCV ; and the existence of high magnitude of genetic variability was evidenced by medium to high estimates of PCV and GCV for majority of the characters. Earlier, almost similar moderate estimates of coefficients of variation was reported by Abraham *et al*. (1992, 2002) and Rao *et al*. (1999) for certain morphological growth characters in wild *Hevea* germplasm.

Heritability in the broad sense (h^2) was found to be medium to high for the morphological characters. Higher h^2 estimates were recorded for plant height (0.58), girth (0.53) and bark thickness (0.46). 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 height, girth, branching height and bark thickness. In the present study moderate to high heritability for most of the characters suggests the predominance of additive gene action in the inheritance of these traits and hence indicates the possible good response of these characters to selection.

Table 6. Phenotypic and genotypic coefficients of variation and heritability in growth characters of wild germplasm

Characters	PCV	GCV	Heritability (H^2)
Girth	16.28	11.89	0.53
Plant height	15.42	11.82	0.58
Canopy height	27.77	18.58	0.45
Canopy breadth	20.00	11.59	0.34
Branching height	19.68	9.40	0.23
No. of branches	40.83	24.36	0.36
Branch angle	5.83	5.19	0.79
Bark thickness	23.43	15.94	0.46

The present study showed a general superiority of Matto Grosso provenance for growth characters and adaptability. The wide variability observed for the growth characters, therefore can be utilized for broadening the genetic base, for further use in breeding and improvement of cultivated rubber.

Acknowledgement

The authors are grateful to the Director, Rubber Research Institute of India for providing necessary facilities. The suggestions from Dr. Y. Annamma Varghese, former Joint Director (Crop Improvement) is also acknowledged.

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