Research Article

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Evaluation of Brazilian wild *Hevea* germplasm in India for cold tolerance: Variability and character associations in juvenile growth phase

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Abstract

Natural rubber (*Hevea brasiliensis*), cultivation has been extended to non-traditional regions due to limited scope of further expansion in traditional rubber growing areas in India. These areas are often confronted with various abiotic stresses especially temperature extremes. A set of 18 wild accessions, two popular clones along with two control clones RRIM 600 and Haiken 1, were evaluated in the juvenile growth phase at the Regional Experiment Station of the Rubber Research Institute of India, Nagrakata, West Bengal, a sub-Himalayan cold prone region of India. The genotypes exhibited highly significant clonal differences ($P<0.01$) for all the eight quantitative traits. During the pre-winter period, the number of leaves per plant ranged from 14.2 (AC 3074) to 47.6 (MT 2229). In the post winter period maximum leaves per plant was recorded in MT 900 (29.27) comparable to the control clone Haiken 1 (28.20), while the accession AC 3293 recorded very high loss in leaves. An increase in number of whorls per plant during winter period was noted in MT 1020 as compared to Haiken 1 (0.80). Increment of plant height during winter ranged from 6.53 cm (AC 3293) to 45.01 cm (MT 1020) as compared to the control clone Haiken 1 (40.73 cm). Girth ranged from 5.36 cm (AC 3293) to 11.53 cm (MT 915) while the control clone Haiken 1 recorded a girth of 10.50 cm. Girth was significantly correlated with the other growth traits. Based on rank sum values, the accessions were ranked for overall performance and the top 20 per cent of the potential accessions showing early growth vigour were identified. These can be used for the development of cold tolerant clones.

Keywords: Cold tolerance, correlations, *Hevea brasiliensis*, rank sum, wild accessions

Introduction

The para rubber tree (*Hevea brasiliensis* Muell. Arg.), is a strategic industrial crop cultivated mainly in the Southeast Asian countries. In order to protect the fast depleting genetic resources and also to broaden the narrow genetic base of cultivated rubber in this region (Schultes, 1977), a huge collection of wild *Hevea* germplasm was made at its center of origin in the Amazon rainforests of Brazil, by the International Rubber Research and Development Board during 1981 (Ong *et al*., 1983). The expedition area comprised three states in Brazil *viz*., Acre (AC), Rondonia (RO) and Mato Grosso (MT) and the germplasm was distributed to member countries including India. Around 4548 accessions are being conserved in source bush nurseries in India, and are under different stages of evaluation for identification of desirable genes.

Rubber cultivation has been expanded to non-traditional regions in India, due to limited scope of further expansion in traditional area. These areas are often confronted with various biotic and abiotic stresses especially drought and temperature extremes. Cold stress in particular, is a serious threat for growth and development of plants and to the sustainability of crop yields. Various phenotypic symptoms in response to cold stress include poor germination of seeds, stunted growth *etc*. Indeed,

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cold stress can lead to major crop losses. It was reported that long durations of low temperatures affects the productivity and normal growth of *Hevea* plant (Alam *et al*., 2005). The present study was undertaken in a cold prone region to evaluate the performance of accessions in the juvenile growth phase, to ascertain the extent of variability in the population and the character associations.

Materials and methods

The study was conducted at the Regional Experiment Station of the Rubber Research Institute of India, Nagrakata, West Bengal, sub-Himalayan region of India, where, during peak winter period, the minimum winter temperature falls below 17 °C. A set of 18 wild accessions, two popular clones along with two control clones RRIM 600 and Haiken 1, were planted in a field trial in randomized block design during 2000, with three replications. The spacing adopted was 4.9 x 4.9 m with five plants per plot and the recommended cultural practices of Rubber Board were followed. Among the 18 wild accessions, five were from Acre, four from Mato Grosso and nine from Rondonia (Table 1).

Table 1. Provenance wise distribution of accessions

Provenance	Accessions/Clones	Sub total
Acre	AC 3074, AC 3075, AC 3293, AC 3514, AC 3810	5
Mato Grosso	MT 1020, MT 2229, MT 915, MT 900	4
Rondonia	RO 2901, RO 2886, RO 2638, RO 2908, RO 2727, RO 2948, RO 3043, RO 3169, RO 3197	9
Modern clones	RRII 203, PB 235, RRIM 600, Haiken 1	4
	Total	**22**

Data on number of leaves, whorls per plant and plant height were recorded pre winter and post winter. Height increment (cm) and girth of the plant (cm) at 15 cm height was recorded in the first year. Plant height (cm) was measured from the bud union to the tip of the tree. The average increment (cm) in plant height over winter season and increase or decrease in no. of leaves and no of whorls per plant during winter season in the juvenile phase was calculated using the pre and post winter growth data. The data were subjected to analysis of variance for randomized block design. Correlation coefficients were estimated following the method of Panse and Sukhatme (1989). Overall performance of all these genotypes was assessed by rank sum method (Kang, 1988) using all the traits.

Results and discussion

The genotypes exhibited highly significant clonal differences for all the eight quantitative traits studied. The range and population mean values in comparison with the control clone for each of the eight traits in the early growth phase are presented in Table 2.

During the pre-winter period, number of leaves per plant ranged from 14.2 (AC 3074) to 47.6 (MT 2229). Cold stress has been reported to inhibit growth of *Hevea* plants (Alam *et al*., 2005; Jacob *et al*., 1999; Sethuraj *et al*., 1991). In the post-winter period, maximum leaves per plant was recorded in MT 900 (29.27) as compared to the control clone Haiken 1 (28.20), while the accession AC 3293 recorded the maximum loss in leaves. Increase in number of whorls per plant during winter period was noted in MT 1020 (2) as compared to the control Haiken 1 (0.80). Increment of plant height during

Table 2. Mean and range of variability for various growth characters in wild *Hevea* germplasm

Character	Wild accessions		General mean	Control		CD (0.01)
	Minimum	Maximum		RRIM 600	Haiken 1	
No of leaves plant^{-1} - pre winter	14.20 (AC 3074)	47.60 (MT 2229)	31.21	26.33	35.73	8.14
No of Leaves plant^{-1} - post winter	0.00 (AC 3293)	29.27 (MT 900)	21.71	22.02	28.20	6.64
No of whorls plant^{-1} - pre winter	2.78 (RO 2948)	4.87 (RO 2908)	3.87	3.40	4.33	0.60
No of whorls plant^{-1} - post winter	3.47 (AC 3074)	5.87 (RO 2886)	4.78	4.07	5.13	0.99
Plant height- pre winter (cm)	78.08 (RO 2901)	196.13 (MT 900)	134.02	87.40	139.13	28.62
Plant height- post winter (cm)	87.48 (AC 3074)	210.73 (MT 900)	154.79	112.78	164.48	34.34
Plant height- increment (cm)	6.53 (AC 3293)	45.01 (MT 1020)	20.78	25.38	40.73	21.21
Girth of plant (cm)	5.36 (AC 3293)	11.53 (MT 915)	8.78	8.40	10.50	2.28

Note: Figures in parenthesis denotes the name of accession

winter ranged from 6.53 cm (AC 3293) to 45.01 cm (MT 1020) as compared to that of the control clone Haiken 1 (40.73 cm). Girth of a plant indicates its vigorous habit in the early growth phase. Girth of the trees at the juvenile phase ranged from 5.36 cm (AC 3293) to 11.53 cm (MT 915) while the control clone Haiken 1 recorded a girth of 10.50 cm. Varghese *et al*., (1989), Mercy *et al.,* (1995), Rao *et al.,* (1999), Abraham *et al*., (2002), Krishan *et al*., (2010), Rao and Varghese (2011) have also reported wide variation in the wild germplasm with respect to certain growth traits in traditional and non-traditional rubber growing regions in India.

Correlation estimates between girth and other morphological traits are useful in selection of desirable plant type in designing an effective breeding programme. Growth is a complex phenomenon encompassing the interactions between many morphological traits. Therefore, selection should be based on these traits and their correlation with girth. Correlations worked out between the eight quantitative traits revealed that girth was significantly correlated with other morphological traits (Table 3). Girth was significantly positively correlated with the plant height of pre-winter (0.561) and post-winter (0.623), number of leaves of pre-winter (0.509) and post-winter (0.593) and number of whorls per plant in the pre winter (0.709) and post winter (0.677) period. Plant height has significant correlation with no of leaves and no of whorls per plant in the pre and post winter period. Rao and Reghu (2000), Rao and Varghese (2011) also reported positive correlation between girth and plant height in wild *Hevea* germplasm in traditional rubber growing area in Kerala. Krishan *et al*. (2011) reported significantly positive correlation between girth, plant height, number of whorls and number of leaves while studying in a set of wild *Hevea* germplasm in a drought prone region of India.

The accessions were ranked using seven parameters-annual girth and pre and post winter growth traits, for overall performance. Rank sum values ranged from 12 to 144 with a general mean of 80.09 (Table 4). Vigorous accessions such as MT 900, RO 2908, RO 2886, RO 3197, MT 2229, MT 915, AC 3810, RO 3169 and MT 1020 could be identified. Balasimha *et al.* (1988), Mercy *et al*. (1995), Rao *et al.* (2006 and 2011), Rao and Varghese (2011) also reported similar ranking in cocoa and wild *Hevea* accessions

Table 4. Ranking of wild accessions and clones based on growth parameters

Accession	Rank sum	Rank
MT 900	144	1
PB 235	127	2
RO 2908	124	3
RO 2886	119	4
Haiken 1	117	5
RO 3197	111	6
MT 2229	109	7
MT 915	108	8
RRII 203	95	9
AC 3810	93	10
RO 3169	83	11
MT 1020	78	12
RO 3043	77	13
AC 3514	76	14
RO 2727	71	15
RRIM 600	49	16
RO 2638	48	17
RO 2901	41	18
AC 3075	36	19
RO 2948	26	20
AC 3293	18	21
AC 3074	12	22
General mean	80.09	

Table 3. Correlation coefficients among quantitative characters

Character	Plant height- pre winter	Plant height- post winter	Height- increment	No of leaves per plant- prewinter	No of leaves per plant- postwinter	No of whorls per plant- prewinter	No of whorls per plant- postwinter
Girth 1yr	0.561**	0.623**	0.237	0.509 *	0.593 **	0.709 **	0.677**
Plant height- pre winter		0.935**	-0.072	0.839 **	0.409 *	0.670 **	0.632**
Plant height- post winter			0.287	0.871 **	0.628 **	0.745 **	0.806**
Height-increment				0.182	0.629 **	0.284	0.557**
No of leaves per plant- prewinter					0.625 **	0.723 **	0.683**
No of leaves per plant- postwinter					0.567 **	0.769 **	
No of whorls per plant- prewinter						0.846 **	

*, **significant at P = 0.05 & 0.01 levels, respectively

Table 5. Superior accessions for each character

Character	Nos	Superior accessions	RRIM 600
No. of leaves plant^{-1} - pre winter	10	RO 2886, AC 3514, AC 3810, MT 2229, RO 2908, MT 915, RO 3169, RO 3197, MT 900	26.33
No. of leaves plant^{-1} - post winter	6	RO 2886, MT 1020, MT 2229, RO 3043, RO 3197, MT 900	22.02
No. of whorls plant^{-1} - pre winter	14	AC 3075, RO 2886, AC 3514, AC 3810, RO 2638, (MT 1020), MT 2229, RO 2908, MT 915, RO 2727, RO 3043, RO 3169, RO 3197, MT 900	3.40
No. of whorls plant^{-1} - post winter	15	RO 2901, RO 2886, AC 3514, AC 3810, RO 2638, MT 1020, MT 2229, RO 2908, MT 915, RO 2727, RO 2948, RO 3043, RO 3169, RO 3197, MT 900	4.07
Plant height- pre winter	16	AC 3075, RO 2886, AC 3293, AC 3514, AC 3810, RO 2638, MT 1020, MT 2229, RO 2908, MT 915, RO 2727, RO 2948, RO 3043, RO 3169, RO 3197	87.40
Plant height- post winter	15	AC 3075, RO 2886, AC 3514, AC 3810, RO 2638, MT 1020, MT 2229, RO 2908, MT 915, RO 2727, RO 2948, RO 3043, RO 3169, RO 3197	112.78
Plant height- increment	6	RO 2901, RO 2886, MT 1020, RO 2908, RO 3043, RO 3197	25.38
Girth of plant	11	AC 3810, RO 2638, MT 1020, MT 2229, RO 2908, MT 915, RO 2727, RO 3169, RO 3197, MT 900, RO 3043	8.40

respectively while evaluating the germplasm. Table 5 gives the list of accessions identified as potentially superior for various growth traits.

The present study confirmed the presence of wide variability in the germplasm for various growth traits. Vigorous accessions such as MT 900, RO 2908 and MT 1020 were identified which showed good growth during the juvenile phase in cold prone sub-Himalayan region of India. These accessions will be useful in future crop improvement programmes after assessment of their mature performance. These selections have the potential for developing as cold tolerant clones for these regions and also in broadening the genetic base of present-day cultivated rubber.

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