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RESEARCH ARTICLE

Early Growth and Yield Performance at Nursery Stage of a Set of Brazilian Wild *Hevea* Germplasm of IRRDB Collection

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A set of 55 wild *Hevea brasilensis* accessions from three provenances of Brazil *viz.,* Acre (AC), Rondonia (RO) and Mato Grosso (MT), along with two popularly cultivated clones RRII 105 and RRIM 600 were evaluated for their early growth and yield performance in the first six years of growth in a nursery in the traditional rubber growing region of Kerala state, India. Relatively high clonal variability was observed for yield, while variation for girth, girth increment, single leaf area, total number of laticifer rows, diameter of latex vessels, bark thickness and crotch height ranged from medium to low. The yield ranged from 0.04 g/t/t (RO 5358) to 11.19 g/t/t (RO 5018), bark thickness from 1 mm (AC 5896) to 5.30 mm (MT 4771), total number of laticifer rows from 3 (MT 5824) to 10.67 (RO 2841) and diameter of latex vessels from 10.69 µm (AC 5487) to 21.66 µm (MT 4762). Girth ranged from 10.75 cm (AC 5896) to 35.60 cm (RO 5432) in the 6^{th} year, while girth increment over three years ranged from 0.50 cm/year (AC 5466) to 5.47 cm/year (RO 5432), crotch height ranged from 1.88 m (RO 5364) to 5.14 m (MT 4690) and single leaf area from 37.51 cm^2 (RO 5318) to 150.40 cm^2 (RO 5365). The accessions were ranked using all the above parameters except single leaf area, for overall performance. Rank sum values ranged from 30 to 340 with a general mean of 194.33. Based on this study, the top 20% of the potential accessions showing early growth vigour and yield were identified which could be of use in broadening the narrow genetic base of currently cultivated genotypes and for future crop improvement programmes.

Key Words: *Hevea brasiliensis,* Performance index, Variation, Wild germplasm

Introduction

Although *Hevea* genus has 11 species, *Hevea brasiliensis* is the popularly cultivated species for its natural rubber production in the world. Currently cultivated popular clones were derived from the Wickham collection comprised of a very small gene pool, since it was collected from a limited area of native Amazon region, Brazil (Schultes, 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 slowdown in genetic advances in recent breeding phases (Tan, 1981; Seguin *et al*., 1995; Simmonds, 1989). Due to human interventions, genetic resources of *Hevea* are fast depleting in the primary center of origin. The need of *Hevea* conservation was felt by the natural rubber industry, thus the International Rubber Research and Development Board (IRRDB) had organized an expedition during 1981 in the primary centre of origin of the *Hevea* crop, the Amazon basin, covering three states, Acre (AC), Mato Grosso (MT) and Rondonia (RO) in Brazil. 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.

As part of evaluation of this germplasm, data on various growth parameters and juvenile yield characters were recorded in the early growth phase. The present study was undertaken to ascertain the extent of genetic variability in the population and identify potential accessions for using in the breeding programmes.

Materials and Methods

The study was conducted at the Central Experiment Station of the Rubber Research Institute of India, Chethackal, Kerala state, India. A nursery was laid out in an augmented block design during 2001, to evaluate the *Hevea* germplasm for various characteristics. A total of fifty five wild *Hevea brasiliensis* accessions from three provenances of Brazil *i.e*., Acre (11), Mato Grosso (33) and Rondonia (11), along with two popular clones *viz*.,

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RRII 105 and RRIM 600 were included in this study**.** The spacing adopted was 1 × 1 m with five plants per plot (Fig. 1). The recommended cultural practices of Rubber Board were followed.

The characters studied include test tap yield (g/t/t) at a height of 30 cm above the bud union, bark thickness (mm), total number of laticifer rows (TLVR), diameter (µm) of latex vessels and growth characters *viz*., girth (cm) of the stem at a height of 30 cm above the bud union from the third to sixth year after planting and average girth increment (cm/year) over three years, calculated using the girth data of 3rd year to 6th year. Crotch height (m) was recorded as the height from the bud union to the first branching level and single leaf area (cm^2) measured using leaf area meter. All the plants were test tapped at the age of 5 years following ½S d/3 (half spiral, once in three days) system of tapping. The data were subjected to analysis of variance for augmented design (Petersen, 1994). Performance of all these genotypes were assessed by rank sum method (Kang, 1988).

Results and Discussion

The range and general mean values of nine characters in comparison with the two control clones is presented in Table 1. Relatively high clonal variability was observed for yield, while variation for girth, girth increment, single leaf area, total number of laticifer rows, diameter of latex vessels, bark thickness and crotch height ranged from medium to low. The yield per tree per tap (g/tree/tap) ranged from 0.04 g/t/t (RO 5358) to 11.19 g/t/t (RO 5018) with a general mean of 1.17 g. Accession RO 5018 was the highest yielder followed by RO 2841 (8.71 g/t/t), RO 5432 (7.86 g/t/t), MT 4762 (2.79 g/t/t), MT 4885 (2.66 g/t/t) and AC 5817 (1.64 g/t/t),

Fig. 1. A view of *Hevea* germplasm nursery at RRII, India

Table 1. Variability for yield, yield components and growth related characters in wild *Hevea* germplasm

Characters	Wild accessions			Control clones		CV (%)
	Minimum	Maximum	General mean	RRII 105	RRIM 600	
Yield (g/t/t)	0.04 (RO 5358)	11.19 (RO 5018)	1.17	2.88	5.82	41.97
Bark thickness (mm)	1.00 (AC 5896)	5.30 (MT4771)	2.76	3.17	3.08	15.14
Total number of laticifer rows	3.00 (MT 5824)	10.67 (RO2841)	6.39	9.74	8.41	21.98
Diameter (µm) of latex vessels	10.69 (AC 5487)	21.66 (MT4762)	16.74	17.19	18.42	25.23
Girth (cm) after 6th year of planting	10.75 (AC5896)	35.60 (RO5432)	20.62	21.56	20.54	20.91
Girth increment (cm/yr) over 3 years	0.50 (AC5466)	5.47 (RO 5432)	2.35	2.47	2.69	22.45
Crotch height (m)	1.88 (RO 5364)	5.14 (MT 4690)	3.04	2.65	2.46	14.09
Single leaf area (cm^2)	37.51(RO5318)	150.40 (RO 5365)	69.34	52.68	56.46	22.93

Note: Figures in parenthesis denotes the name of accession.

where as the control clone RRII 105 and RRIM 600 recorded 2.88 g/t/t and 5.82 g/t/t, respectively. Yield components such as bark thickness ranged from 1 mm (AC 5896) to 5.30 mm (MT 4771), total number of laticifer rows from 3 (MT 5824) to 10.67 (RO 2841), diameter of latex vessels from 10.69 µm (AC 5487) to 21.66 µm (MT 4762). Studies by Reghu *et al*. (2008). Annamma *et al*. (1989), Mercy *et al*. (1995), Rao *et al.* (1999 & 2011) and Abraham *et al*. (2002) have also reported wide variability in the wild *Hevea* germplasm with respect to certain yield and growth traits in traditional rubber growing region in India.

Girth has been identified as one of the most important traits contributing for latex yield in *Hevea* (Ho *et al*., 1973; Narayanan *et al*., 1974; Hamzah and Gomez, 1982). Girth of the plants ranged from 10.75 cm (AC 5896) to 35.60 cm (RO 5432) and girth increment over three years ranged from 0.50 cm/yr (AC 5466) to 5.47 cm/yr (RO 5432). Highest girth was recorded in the clones RO 5432 (35.60 cm), MT 4906 (31.63 cm) and MT 6021 (27.90 cm). Girth increment was the highest in RO 5432 (5.47 cm/yr), followed by RO 2841 (4.25 cm/yr), AC 4677 (3.68 cm/yr) and MT 4707 (3.67 cm/yr). Growth vigour is genetically controlled and there is marked clonal variation with regard to girth increment under tapping and its effect on yield (Ferwerda, 1969). Genotypes with early growth vigour are highly useful for reducing immaturity period.

The crotch height showed a range of 1.88 m (RO 5364) to 5.14 m (MT 4690). MT 4690 registered the highest crotch height followed by RO 5442 (5.05 m) and MT 4772 (4.36 m). Moderate estimates of coefficients of variation for certain growth and yield characters in wild *Hevea* germplasm was reported by Rao *et al*. (1999, 2006 & 2011) and Abraham *et al*. (2002). Wide range of variability was observed for the trait single leaf area which ranged from 37.51 cm^2 (RO 5318) to 150.40 cm^2 (RO 5365) with a general mean of 69.34 cm^2. Accession RO 5365 (150.40 cm^2), AC 5497 (108.20 cm^2) and RO 5350 (96.70 cm^2) recorded higher leaf area.

Even though the general mean values of the hybrid controls were higher than those of the wild accessions for all traits except crotch height and single leaf area, certain individual wild accessions showed high mean values for yield and growth characters particularly in RO 5018, RO 2841 and RO 5432 for yield, MT 4771, RO 5432 and MT 4906 for bark thickness, MT 4762, RO 5432 and MT 6021 for total number of laticifer rows, MT 4762, RO 5432 and MT 6021 for diameter of latex vessels, RO 5432, MT 4906 and MT 6021 for girth, RO 5432, RO 2841 and AC 4677 for girth increment, MT 4690, RO 5442 and MT 4772 for crotch height, AC 2719, RO 5365 and AC 5497 for single leaf area. Accessions superior to the control clone RRII 105 for yield and growth characters are shown in Table 2. These genotypes with high girth and girth increment coupled with higher crotch height and yield gives an early indication of fast growth of these wild germplasm which is useful in reducing the immaturity period. Moreover, those genotypes with high crotch height coupled with good girth also indicate their high timber potential. Chapuset *et al*. (1995) reported variation in branching behavior among the wild germplasm. Branching habit in rubber tree was a clonal character and many clones were found to branch at a higher levels in the plantations of Malaysia (MRB, 2003). 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 2006 and 2011).

Table 2. Accessions superior to the control clone RRII 105 for yield and growth related characters

Characters	No.	Accessions	RRII 105	RRIM 600	CD (5%)
Yield (g/t/t)	3	RO 5018, RO 2841, RO 5432	2.88	5.82	3.79
Bark thickness (mm)	18	(Top fifteen only) MT4771, RO5432, MT4906, MT6051, MT4839, RO2841, RO5002, MT4762, MT6020, MT6021, MT5095, AC4677, MT5117, MT4707, RO5018.	3.17	3.08	0.98
Total number of laticifer rows	3	RO 2841, MT 6020, MT 4762	9.74	8.41	NS
Diameter (μm) of latex vessels	29	(Top fifteen only) MT4762, RO5432, MT6021, RO2841, MT4757, AC5896, AC6134, MT5940, MT4885, AC5688, MT4771, MT5117, MT4796, MT5924, MT5993.	17.19	18.42	NS
Girth (cm) after 6th year of planting	25	(Top fifteen only) RO5432, MT4906, MT6021, AC5688, MT6051, RO2841, MT4839, RO5002, MT4707, AC4677, MT5095, AC4816, MT4785, AC5497, MT5122.	21.56	20.54	9.14
Girth increment (cm/yr)	25	(Top fifteen only) RO5432, RO2841, AC4677, MT4707, MT6021, MT5924, MT4771, MT4906, RO5002, AC5688, AC4816, MT6048, MT4762, MT5940, AC5497.	2.47	2.69	1.20
Crotch height (m)	34	(Top fifteen only) MT4690, RO5442, MT4772, MT6051, MT5122, MT5095, RO5413, AC4677, MT4694, AC5904, MT5086, MT4771, MT4757, MT6007, AC5487.	2.65	2.46	0.75
Single leaf area (cm^2)	43	(Top fifteen only) RO5365, AC5497, RO5350, AC5904, MT5993, MT5152, MT4694, RO5002, AC5487, MT4772, RO5358, MT5951, MT4796, MT5117, MT5095.	52.68	56.46	26.00

NS- not significant.

In order to identify genotypes with maximum number of desirable attributes, the performance of each of the eight characters was pooled using rank sum method. The ranking of each genotype based on parametric relationship of yield and yield components- bark thickness, total number of laticifer rows, diameter of latex vessels and growth characters such as girth, girth increment and crotch height are shown in Table 3.

The rank sum values ranged from 30 to 340 with a general mean of 194.33. High rank was recorded in the genotype RO 5432 (340) followed by RO 2841(322), MT 4906 (320), MT 6021 (310), AC 5688 (306) and MT 4762 (291). These genotypes showed relatively high yield and vigorous growth. The wild accessions MT 5824 (77), RO 5365 (74) and AC 5466 (30) recorded the lowest rank sum value. Balasimha *et al*. (1988), Mercy (2001) and Rao *et al*. (2006) also reported similar ranking in cocoa and wild *Hevea* accessions, respectively while evaluating the genotypes. Top 20 per cent of the potential genotypes identified as best performers are RO 5432 (340), RO 2841 (322), MT 4906 (320), MT 6021 (310), AC 5688 (306), MT 4762 (291), MT 4771 (278), AC 4677 (275), RO 5018 (274), MT 6051 (272), RO 5002 (271), MT 4757 (269) and MT 5095 (264).

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 with wide variability for growth and yield

Table 3. Top ranking of wild accessions based on yield and growth parameters

Accession	Rank sum	Rank
RO 5432	340	1
RO 2841	322	2
MT 4906	320	3
MT 6021	310	4
AC 5688	306	5
MT 4762	291	6
MT 4771	278	7
AC 4677	275	8
RO 5018	274	9
MT 6051	272	10
RO 5002	271	11
MT 4757	269	12
MT 5095	264	13
MT 4707	253	14
AC 4816	251	15
MT 4885	251	15
MT 4839	239	17
MT 6048	237	18

General mean = 194.33

traits. Certain genotypes showed superiority for growth and yield characters which indicated its early vigour and yield.

Wide variability was observed for various growth and yield contributing traits. RO 5018, RO 2841, RO 5432, MT 4762, MT 4885, AC 5817, AC 5688, AC 4816, AC 6134, MT 4906, MT 4771, AC 4677, MT 6051, RO 5002, MT 4757, MT 5095 and MT 4707 and were identified as vigorous genotypes with high growth and yield in the juvenile phase which will be useful for reducing the immaturity period and have potential value for timber. These selections could be further evaluated and incorporated in breeding programmes for evolving new rubber clones.

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