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Early evaluation of wild *Hevea* germplasm for drought tolerance in north Konkan region

M.A. Mercy and Meena Singh*

Rubber Research Institute of India, Kottayam - 686 009, Kerala, India
**Regional Research Station, RRII, Dapchari, Maharashtra, India*

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Abstract

The expedition conducted by International Rubber Research and Development Board (IRRDB) in 1981 in the Amazon forests of Brazil, resulted in a collection of 4548 wild germplasm accessions of *Hevea brasiliensis* in India. Being a likely repository of genes conferring tolerance to various biotic and abiotic stresses, early evaluation of this germplasm accessions at a drought prone area can provide an indication towards their drought tolerance potential. Hence, a preliminary field screening in a set of 130 wild accessions was conducted along with four check clones for a period of six years at the drought prone area of Dapchari in Maharshtra. Growth performance of these accessions in the drought prone situation was assessed in terms field observations of plants. Test tapping was done at the age of four years to assess their yield potential under drought. Wide variability was noticed in growth and yield of plants among the accessions indicating the scope for selection of potential accessions. Out of 130 accessions evaluated, fourteen potential accessions could be identified as drought tolerant plants for further detailed field evaluation.

Keywords: Accessions, drought tolerance, *Hevea* germplasm, provenance

Introduction

India received 4548 wild germplasm accessions of *Hevea brasiliensis* as a result of the expedition conducted by International Rubber Research and Development Board (IRRDB) jointly with EMBRAPA (Brazilian Agricultural Research Corporation) of Brazil in 1981, in the Amazon forests of Brazil. This venture resulted in the collection of more than 64000 seeds and 194 ortets from 3 states in Brazil, namely Acre (AC), Rondonia (RO) and Mato Grosso (MT), covering a total of 64 locations in 16 districts (IRRDB, 1982). Acre has an equatorial climate whereas Rondonia state experiences a tropical climate with dry season for one or two months. Mato Grosso too experiences a tropical climate, with a dry period of three to four months every year (Chevallier, 1988). This wild germplasm collection is conserved at Rubber Research Institute of India (RRII) and is now under evaluation. Genetic diversity in this collection is closely related to the geographical provenance of the accessions (RRII, 2002) and considerable genetic variation among the accessions from Acre, Rondonia and Mato Grosso provenances has been reported by Varghese *et al.* (2002). Wide variability observed in this large collection indicates that this collection has a broad genetic base, potentially important in broadening the existing narrow genetic base of cultivated rubber. Being a likely repository of genes conferring tolerance to various biotic and abiotic stresses, this wild collection would be useful in developing *Hevea* clones tolerant to stresses.

In order to extend rubber cultivation to marginal and non-traditional areas in India which are confronted with various agro-climatic constraints limiting plant growth and productivity, it is highly essential to develop location-specific rubber clones. This can be achieved by identifying potential wild

**Corresponding Author: mamercy@rubberboard.org.in*

accessions through field screening for the specific objectives, and including them in breeding programmes. Regional Research Station (RRS), Dapchari located in Maharashtra state in India, is a drought-prone region experiencing high temperature (exceeding 40 °C in April), high light intensity and very low soil moisture during the summer months. It has a rainfall pattern limited only to four months in a year, with an average annual rain fall of 7.5 mm per day and an average of 90 rainy days in a year. Preliminary field screening of a set of wild germplasm in this drought prone region was conducted to identify potential drought tolerant accessions.

Materials and methods

A set of 130 wild accessions were planted along with the check clones RRII 105 (standard clone), RRIM 600 and RRII 208 (drought tolerant clone) and Tjir 1 (drought susceptible clone) in the field at RRS, Dapchari, during the year 2003. There were 27 accessions from Acre, 62 from Rondonia and 41 from Mato Grosso provenances. These accessions were randomly selected from the conservation nurseries maintained at Central Experimental Station of RRII, Chethackal in Kerala. They were field screened for six consecutive years for assessing their growth and clonal response towards drought stress experienced from February to May, at RRS, Dapchari. The statistical design adopted was augmented RBD with five plants per plot at a spacing of 2.5 x 2.5 meters planted in nine blocks by repeating the four check clones in each block. Standard cultural practices were followed. Plant height, girth at 30 cm height from collar region, number of whorls and number of leaves were the growth parameters studied and leaf senescence (as percentage) was recorded after exposure to summer period as a measure of drought stress tolerance. From third year onwards the observation was concentrated on girth of the plants by recording month wise girth. To evaluate the yielding potential of these accessions, a test tapping was done at the age of four years during the summer months under S/2 d2 system. Potential wild accessions showing better growth performance under Dapchari conditions were finally identified for further field evaluation in the same region.

Results and discussion

Initial growth performance of the accessions at the age of 6 months (pre-drought) is shown in Table 1. Wide variability among the accessions was observed for all the characters studied as indicated by the wide range in the values obtained. During the initial growth stage, the accession MT 1681 showed highest girth, the lowest leaf senescence in the accession MT 47 and the lowest rate of senescence in the accession MT 1589. Accession MT 3686 had good foliage. Among the four check clones, the drought tolerant clone RRIM 600 showed highest girth and low rate of leaf senescence as expected. There were accessions superior to all the four check clones, with respect to growth parameters recorded. Analysis of data from the various field trials, and preliminary observations on sets of

Table 1. First year pre- drought data on growth characters

Characters	Minimum	Maximum	General Mean	CD	Growth of check clones (mean)			
				(P=0.05)	RRII 105	RRIM 600	Tjir 1	RRII 208
Height (cm)	75.0 (AC 1797)	284.0 (MT 1697, RO 2889)	187.29	55.85	139.90	191.20	149.98	174.30
Girth (cm)	2.8 (RO 2809)	6.4 (MT 1681)	4.69	1.08	4.12	4.27	4.02	4.06
No. of whorls	1.0 (MT 49)	4.0 (RO 1526)	2.59	0.86	2.57	3.51	2.87	2.81
No. of leaves	3.3 (RO 1301)	56.8 (MT 3686)	34.64	15.79	30.13	50.03	45.21	38.35
No. of leaves fallen	11.8 (MT 47)	70.4 (MT 1697)	38.15	16.58	31.49	38.96	35.22	45.94
Senescence (%)	24.4 (MT 1589)	92. 5 (RO 1301)	51.66	13.33	47.66	43.58	43.83	50.72

The names of accessions are shown in parenthesis

accessions from the nurseries, has revealed similar variability and significant differences among the accessions for most of the agro-morphologic traits, bark structural characters and juvenile yield indicating the scope for selection of accessions with desirable characters (Varghese *et al.,* 1989; Abraham *et al.,* 1992, 2000; Madhavan *et al.,* 1993; Mercy *et al.,* 1993, 1995; Rao *et al.,* 1996; Reghu *et al.,* 2012). The Shannon-Weaver Diversity indices (SDI) estimated for the 22 morphological qualitative traits during characterization of 195 accessions, also showed high levels of diversity for most traits (Suma *et al.,* 2006).

After experiencing the first summer period from February to May at RRS, Dapchari the accessions were observed for their post-drought performance (Table 2). The accession MT 1697 ranked first for vigor and the rate of leaf senescence was the lowest in the accession MT 4222. Among the check clones, RRIM 600 showed better performance in terms of vigor, foliage and low rate of senescence. The mortality rate among the accessions, after experiencing first summer period at Dapchari was assessed (Table 3) and out of 130 accessions, MT 3714 and RO 1784 were completely dried and the next affected accession was RO 1322. In seven accessions the mortality rate was more than 50 per cent. This indicates the extent of genetic variability for reaction to drought stress among the wild accessions and the scope of selection for drought tolerance. The list of top ranking accessions for each character observed after the exposure to first summer period is given in Table 4. Four accessions (MT 1697, MT 4222, MT 1623 and RO 2889) showed superiority for more than one character. This indicates potential for selection of these accessions for a drought prone area. Girth was highest in accession MT 1697 and the lowest leaf senescence was in the accession MT 4222 after the exposure to first summer period. Similar genotypic variability among the wild accessions under drought stress condition has been reported earlier by Mercy *et al.* 2006, 2010a, 2010b, 2011 and Nair *et al.* 2011. While assessing the performance of the accessions during the second year of growth it was found that the potential accessions of previous year of growth maintained their superiority in the following year also. The top five accessions for characters height, girth, number of whorls and total number of leaves in the second year of growth is shown in Table 5. The accession MT 1681 had the highest girth during

Table 3. List of accessions with high mortality after experiencing first summer

Accession/Check clone	Mortality rate (%)
MT 3714	100
RO 1269	60
RO 135	60
RO 100	60
RO 1322	80
RO 1342	60
RO 1784	100
MT 49	60
MT 195	60
AC 172	60
RRIM 600	20
RRII 105	26
RRII 208	8
Tjir 1	3

Table 2. First year post-drought data on growth characters

Characters	Minimum	Maximum	General mean	CD	Growth of check clones (mean)			
				(P=0.05)	RRII 105	RRIM 600	Tjir 1	RRII 208
Height (cm)	90.0 (AC 4861)	304.0 (RO 2387)	213.78	60.71	162.74	227.44	170.50	197.35
Girth (cm)	3.1 (RO 1322)	8.2 (MT 1697)	6.32	1.30	5.25	5.99	5.06	5.49
No. of whorls	1.0 (MT 195)	5.6 (RO 3660)	3.33	0.92	3.62	4.64	3.78	3.89
No. of leaves	12.0 (MT 195)	71.2 (MT 1623)	42.33	16.87	41.17	62.40	53.44	52.76
No. of leaves fallen	23.0 (RO 1322)	167.0 (RO 93)	46.86	18.25	41.02	47.10	44.38	54.73
Senescence (%)	32.7 (MT 4222)	77.4 (RO 93)	52.44	12.86	49.70	42.83	45.27	49.63

The names of accessions are shown in parenthesis

Table 4. Top five accessions for each trait after experiencing first drought period

Height (cm)	Girth (cm)	No. of whorls	No. of leaves	Senescence (%)
RO 2387 (304)	MT1697 (8.17)	RO 3660 (5.6)	MT 47 (167)	MT 4222 (32.7)
MT1697 (300)	RO 3626 (8.07)	RO 1526 (5.0)	AC3329 (140.67)	MT 1623 (35.5)
RO 2889 (293)	RO 1260 (8.05)	RO 96 (4.7)	RO 24 (131.2)	RO 3660 (37.6)
RO3229 (284)	RO 2889 (7.98)	MT1623 (4.6)	MT 60 (125.5)	RO 2889 (38.1)
AC 1495 (281)	MT 1681 (7.88)	MT 4222 (4.6)	RO 1509 (124.2)	MT 60 (39.2)

the second year of growth. The top ten accessions for girth from second year to sixth year of growth is given in Table 6. Those accessions which showed superiority in terms of girth right from the initial years of growth maintained superiority throughout the growth period and hence there is scope for selection of these accessions. Test tapping of these accessions at the age of four years revealed their yield potential. Accessions which gave good yield are shown in Table 7. Accession RO 1769 gave higher yield than the check clones RRIM 600 and RRII 105 and juvenile yield of RO 2976 was also very promising. The promising yield obtained from the wild accessions even in an adverse climatic condition highlights the merit of these accessions clearly indicating the genetic potential of this wild gene pool. Finally, after experiencing drought stress for six years, eight accessions showing good growth performance combined with juvenile yield and six accessions having good vigor under Dapchari conditions were identified for further detailed field study. Field screening of the wild accessions in the drought prone area in Dapchari, Maharashtra, helped to throw light on the genetic diversity and scope for selection among these wild accessions towards drought stress tolerance.

Natural rubber cultivation in India faces adverse effects of drought and cold stresses especially in the non-traditional rubber growing areas (Jacob *et al*., 1999). As the genetically divergent germplasm accessions are an excellent repository of various useful traits including stress tolerance, systematic screening of wild germplasm for drought and cold tolerance with the ultimate objective of developing location specific clones for non-traditional rubber growing areas holds much

Table 5. Top five accessions for each trait during second year of growth

Height (cm)	Girth (cm)	No. of whorls	No. of leaves
RO 1234 (516.0)	MT 1681 (13.5)	RO 1526 (5)	RO 2387 (72.6)
RO 1761 (508.0)	RO 2387 (12.9)	RO 224 (4.8)	MT 3686 (63.3)
MT1697 (502.0)	RO 2976 (12.7)	MT2229 (4.5)	RO 1526 (60.3)
RO 2387 (492.0)	AC 512 (12.7)	MT1660 (4.4)	RO 224 (60.3)
MT 1645 (487.5)	RO 1737 (12.5)	MT 60 (4.3)	MT 1660 (55.8)

Table 7. Accessions with promising juvenile yield

Accession	Test tap yield (g per 10 tappings)	Accession	Test tap yield (g per 10 tappings)
RO 1769	33.34	MT 62	11.06
RO 2976	21.67	RO 3626	11.05
AC 173	15.14	MT 1660	9.47
MT 915	14.72	RRII 105	21.99
MT 2229	11.09	RRIM 600	24.08
		CD (P=0.05)	13.31

Table 6. Top ten accessions for girth from May 2005- May 2009

Year				
2005	2006	2007	2008	2009
MT 1681 (14.04)	MT 681 (16.14)	RO 2976 (20.28)	RO2976 (20.41)	RO 2976 (21.83)
RO 85 (13.34)	RO 2976 (15.73)	MT1681 (19.16)	MT 1681 (20.35)	MT 1081 (21.76)
RO2387 (13.35)	MT 1710 (15.10)	RO 1769 (16.9)	RO 1769 (18.84)	RO 1769 (20.3)
RO 1313 (13.19)	RO 1737 (14.92)	MT 1660 (16.68)	AC 3057 (17.58)	MT 1660 (19.18)
RO 1761 (13.06)	RO 1761 (14.84)	RO 1348 (15.8)	RO 85 (17.22)	RO 2387 (17.8)
AC 512 (13.06)	RO 85 (14.65)	MT 72 (15.7)	MT 1660 (17.05)	RO 2153 (17.82)
MT 72 (13.03)	RO 1769 (14.6)	RO 2387 (15.72)	MT 1710 (17.02)	MT 1710 (17.74)
RO 2976 (13.03)	RO 2387 (14.32)	RO 2153 (15.7)	RO 2153 (15.7)	RO 1348 (17.37)
MT 1623 (12.8)	RO 2153 (14.32)	MT 1710 (15.62)	RO 96 (16.72)	MT 4379 (16.8)
AC 1814 (12.17)	AC 3057 (14.29)	RO 85 (15.47)	AC 173 (16.7)	RO 85 (16.27)

Table 8. Drought tolerant accessions selected for further evaluation based on girth and yield

Accessions for yield	Accessions for girth
RO 1769	MT 1668
RO 2976	MT 1681
AC 173	MT 1710
MT 915	RO 2387
MT 2229	RO 2153
MT 62	RO 85
MT 1660	
RO 3626	

importance. Fourteen potential accessions identified out of 130, belonging to three provenances can be used for identifying candidate genes based on the drought tolerance attribute they possess after detailed evaluation at the drought prone area.

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