Natural Rubber Research, **23** (1&2): 71-79, 2010

PRELIMINARY FIELD SCREENING OF WILD *HEVEA* GERMPLASM FOR TOLERANCE TO DROUGHT

M. A. Mercy, Meena Singh*, C. P. Reghu and Y. Annamma Varghese

Rubber Research Institute of India, Kottayam- 686 009, Kerala, India

*Regional Research Station, Rubber Research Institute of India, Dapchari- 401 610, Maharashtra, India

Mercy, M. A., Singh, M., Reghu, C. P. and Varghese, Y. A. (2010). Preliminary field screening of wild *Hevea* germplasm for tolerance to drought. *Natural Rubber Research*, **23**(1&2): 71-79.

The Rubber Research Institute of India has large collection of wild *Hevea* germplasm received from IRRDB which was collected in the 1981 expedition to the centre of origin of the crop in Brazil, covering the three states of Acre (AC), Rondonia (RO) and Mato Grosso (MT). Wild germplasm, being a rich source of genes conferring tolerance to various biotic and abiotic stresses, has an important role in broadening the existing narrow genetic base of cultivated rubber. For identifying the drought tolerance potential of this germplasm collection, a preliminary field screening of wild accessions along with the check clones RRII 105, RRIM 600 and Tjir 1 was conducted during 2001 and 2002 in the drought-prone area of Dapchari in Maharashtra. Response of these accessions towards drought stress was determined based on growth and drought-related parameters during pre - and post - drought periods. Plant height, girth, number of whorls and number of leaves were the growth parameters studied and senescence and relative water content of leaves were the drought-related parameters measured. Annual and summer period girth increments (as percentage) were also worked out to assess the drought tolerance potential of these accessions. Wide variability was noticed among the accessions for all the characters studied. The proportion of accessions with drought tolerance was more in MT and RO provenances than in AC provenance. Out of 105 accessions evaluated, 14 potential accessions could be identified for further detailed field evaluation.

Keywords: Accessions, Drought tolerance, *Hevea* germplasm, Provenance

INTRODUCTION

The Rubber Research Institute of India has a collection of 4548 wild *Hevea* germplasm accessions, received as part of an expedition conducted by IRRDB jointly with EMBRAPA 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 three 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 and Mato Grosso states experience a tropical climate with a dry season extending up to four months (Chevallier, 1988). 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 (Varghese *et al.*, 2002). Hence, this wild germplasm collection has an important role in broadening the existing narrow genetic base of cultivated rubber. The

Correspondence: M. A. Mercy (Email: mamercy@rubberboard.org.in)

accessions received in India are now in various stages of evaluation as they form the potential source of genes conferring tolerance to various biotic and abiotic stresses.

In order to extend rubber cultivation into marginal and non- traditional areas in India which are confronted with various agroclimatic constraints limiting plant growth and productivity, it is highly essential to develop location-specific rubber clones. This goal can be achieved by identifying potential wild 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 rainfall of 7.5 mm per day and an average of 90 rainy days in a year. Preliminary field screening of wild germplasm in this drought-prone region was conducted to identify potential drought tolerant accessions.

MATERIALS AND METHODS

Two sets of 63 and 42 wild accessions were planted along with the check clones RRII 105 (standard check), RRIM 600 (a drought tolerant check) and Tjir 1 (a drought susceptible check) in the field at RRS, Dapchari, during 2001 and 2002, respectively. In the first set of 63 accessions, there were 24 accessions from Acre, 17 from Rondonia and 22 from Mato Grosso provenances. Second set of 42 accessions comprised of 16 Acre accessions, six Rondonia accessions and 20 Mato Grosso accessions.

They were field-screened for three consecutive years for assessing the growth and response towards drought stress experiencing from February to May in that region. The statistical design adopted was augmented RBD with five plants per plot at a spacing of 2.5 x 2.5 m. There were five blocks in the first set and six in the second set. All standard cultural practices were followed for the maintenance of plants. Data recording on growth and drought-related parameters during pre-(first half of February) and post-drought (first half of June) periods was carried out for assessing the response of these accessions towards drought stress. Plant height, girth at 30 cm height from the collar region, number of whorls and number of leaves were the growth parameters studied in both sets. Relative water content (RWC) of leaves in both sets and leaf senescence in the second set were the drought-related parameters measured. Annual and summer period girth increments were also worked out to assess the growth rate of these accessions during the stress period. Potential wild accessions showing good growth under Dapchari conditions were identified for further field evaluation in the same region.

RESULTS AND DISCUSSION

Set I: Growth parameters such as height, girth, number of whorls and leaves, total leaf area and RWC of leaves were recorded in February and June representing respectively the pre- and post- summer periods. Growth performance of the accessions during pre-drought period at the age of eight months (February, 2002) is shown in Table 1. Wide variability among the accessions was observed for all the characters studied. During the initial growth stage, the accession

Table 1. **First year pre- drought data on growth characters – Set I**

Character	Accession minimum	Accession maximum	General mean	Check clone (mean)		
				RRII 105	RRIM 600	Tjir 1
Height (cm)	49.33 (RO 3461)	241.25 (MT 54)	133.31	134.20	195.48	58.53
Girth (cm)	2.36 (RO 3461)	6.23 (MT 54)	4.26	4.47	4.98	2.49
No. of whorls	2.00 (AC 405)	4.75 (MT 54)	3.52	3.51	4.63	2.73
No. of leaves	15.67 (RO 3461)	59.40 (MT 1627)	37.05	37.00	59.04	25.37
Total leaf area (cm^2)	2049.70 (RO 3461)	24427.49 (MT 1616)	4168.66	11759.80	12997.10	4131.30
RWC (%)	82.18 (MT 1589)	99.81 (RO 3461)	83.32	89.00	89.49	91.90

MT 54 registered good growth with the highest values for height, girth and number of whorls, whereas the performance of the accession RO 3461 was poor for height, girth, number of leaves and total leaf area. However, this accession (RO 3461) showed the highest relative water content at this age. There were accessions superior to all the three check clones, with regard to growth parameters recorded. Similar variability and significant differences among the accessions of the same germplasm collection have been reported for most of the agro-morphological traits, bark structural characters and juvenile yield, indicating scope for selection in the traditional area. (Varghese *et al.*, 1989;

Table 2. **Ten superior accessions identified for various characters after one year of drought - Set I**

Height	Girth	Number of whorls	Number of leaves	RWC
MT 1649	MT 54	MT 54	MT 1627	MT 1595
MT 54	MT 1579	MT 1668	AC 1609	MT 54
MT 1000	AC 4083	AC 404	MT 54	AC 2532
MT 1627	MT 1627	MT 2594	AC 3687	RO 3461
MT 1616	MT 1000	MT 1589	MT 1591	AC 587
MT 67	MT 1649	AC 4083	MT 1579	MT 899
RO 20	AC 4120	MT 1591	MT 1616	RO 268
MT 1579	AC 1609	MT 1579	MT 2594	MT 67
AC 1609	MT 67	MT 1649	MT 80	MT 1649
MT 1668	AC 570	RO 2828	MT 1668	AC 2692

Abraham *et al.*, 1992, 2002; Madhavan *et al.*, 1993; Mercy *et al.*, 1993, 1995 ; Rao *et al.*, 1996). The Shannon-Weaver diversity indices (SDI) estimated for 22 morphological qualitative traits during characterization of 195 accessions also showed high levels of diversity for most of the traits in this germplasm collection (Suma *et al.*, 2006). Among the three check clones, RRIM 600 was significantly superior for all the growth characters but for RWC, which was the highest in the check clone Tjir 1.

Potential drought tolerant accessions were identified from this set of 63 accessions, at the age of one year, after the plants experienced the first summer stress (February, 2002 - first half of June, 2002) (Table 2). Among the top ranking 10 accessions, MT 1668, MT 67, MT 1616, MT 1649, MT 1627 and MT 54 showed

Table 3. **Range in growth increment and RWC variation in the germplasm after the first year drought period- Set I**

Character	Accession	Increment % (minimum)	Accession	Increment % (maximum)	Check clone	Increment %
Height	AC 153	18.75	MT 1591	85.71	RRIM 600	50.5
	AC 4266	22.22	MT 899	85.00	RRII 105	39.14
	RO 31	22.73	RO 3461	81.1	Tjir 1	76.63
	AC 587	25.39	MT 1589	73.08		
	AC 570	27.29	MT 80	72.97		
Girth	AC 587	19.16	MT 80	86.36	RRIM 600	42.16
	AC 3934	21.39	RO 20	74.2	RRII 105	37.06
	MT 1616	25.03	MT 1668	72.48	Tjir 1	41.85
	AC 570	28.3	RO 1248	70.04		
	MT 2594	31.57	AC 157	68.38		
No. of whorls	AC 587	-37.5	AC 4083	83.33	RRIM 600	5.33
	MT 1629	-28.57	AC 405	80.00	RRII 105	14.48
	RO 31	-16.67	AC 3934	75.00	Tjir 1	34.86
	AC 2669	-11.76	RO 322	60.00		
	MT 1627	-9.52	MT 80	60.00		
No. of leaves	MT 1629	-24.59	MT 80	120.00	RRIM 600	18.68
	AC 587	-12.79	AC 153	118.75	RRII 105	19.92
	RO 31	-12.24	MT 3433	115.52	Tjir 1	29.6
	AC 609	-8.57	AC 4120	109.68		
	AC 3532	-4.17	AC 776	87.76		
RWC	MT 3687	-15.64	MT 54	-0.3053	RRIM 600	-4.49
	RO 31	-14.43	MT 1649	-0.6023	RRII 105	-4.90
	MT 1000	-14.28	AC 3532	-0.9521	Tjir 1	-5.18
	RO 3457	-13.82	AC 1609	-1.1149		
	AC 609	-11.76	AC 4083	-1.1712		

superiority for more than one growth character indicating their potential to survive in a drought-prone area. The same trend was observed when the growth performance of these accessions was assessed after one year also when the accession MT 54 continued to show stable performance. In general, accessions from the Mato Grosso provenance showed superiority for growth and survival in a drought-prone area compared to the accessions from the other two provenances. Comparatively prolonged dry season prevailing in the state of Mato Grosso might have resulted in better adaptability to drought for these accessions. Earlier, in a preliminary screening carried out in 100 wild accessions in the traditional region in Kerala based on various drought related morphological, anatomical, physiological and biochemical characters, Mercy (2001) reported the superiority of MT accessions. During pre-drought and post-drought periods and over one year growth in field, the superior accessions maintained their superiority for each growth character irrespective of the periods under observation. This indicates the stability in performance of these accessions which are the ideal candidates for selection for a drought-prone area.

While assessing the performance of accessions in terms of growth and RWC over the first year drought period (Table 3), certain wild accessions were found to have higher increment values than the drought tolerant check clone for all the parameters. Accession MT 80 fell in the group with the highest percentage increment over the first year drought period in the (June, 2002) for all growth parameters, while MT 54 had the least reduction in RWC. But at the end of pre-drought period in the second year (February, 2003), the superior accessions identified based on their growth performance were MT 1649 and MT 1579. These accessions showed maximum girth of 4.5 and 4.1 cm, respectively compared to 3.1 cm girth of the drought tolerant clone RRIM 600. Majority of the accessions identified as better performers for girth and height during stress period were of MT provenance, similar to the trend shown in the previous year. This again highlights the drought tolerance potential of the MT accessions. Provenance level

Table 4. **First year pre-drought data of growth characters –Set II**

Character	Accession minimum	Accession maximum	General mean	Check clone (mean) RRII 105	RRIM 600	Tjir 1
Height (cm)	60.00 (AC 643)	190.00 (MT 179)	102.63	111.24	145.87	105.96
Girth (cm)	2.70 (AC 774)	8.60 (MT 80)	3.80	3.97	4.08	3.96
No.of whorls	1.25 (AC 774, MT 193)	3.50 (MT 56, RO 4184)	2.32	2.32	2.92	2.32
No. of leaves retained	4.00 (AC 405)	39.75 (MT 56)	20.92	20.10	33.91	25.45

Table 5. **Accessions in the extreme classes for various characters after the first year drought period - Set II**

Character	Accessions with values in lower range		Accessions with values in higher range		Check clone	
Height (cm)	AC 161	65.00	RO 1248	180.00	RRIM 600	175.81
	AC 405	80.00	AC 765	177.50	RRII 105	127.50
	MT 73	85.00	MT 945	173.80	Tjir 1	146.18
	MT 43	85.00	MT 58	170.00		
	AC 730	90.00	RO 4184	165.00		
Girth (cm)	AC 730	2.76	AC 765	5.47	RRIM 600	4.32
	MT 184	3.20	MT 58	5.37	RRII 105	4.23
	MT 73	3.20	RO 3655	5.02	Tjir 1	4.51
	AC 405	3.30	MT 41	4.96		
	AC 161	3.45	RO 4184	4.84		
No. of whorls	MT 184	1.00	MT 41	4.00	RRIM 600	3.21
	MT 54	1.00	MT 56	4.00	RRII 105	2.57
	AC 651	1.00	AC 765	3.75	Tjir 1	3.17
	AC 730	1.00	RO 4184	3.75		
	AC 661	1.50	MT 191	3.67		
No.of leaves	MT 184	7.00	MT 41	64.00	RRIM 600	40.97
	MT 54	7.00	MT 56	53.00	RRII 105	26.63
	AC 730	8.00	AC 728	40.00	Tjir 1	36.32
	AC 661	11.50	MT 945	40.00		
	RO 300	13.00	AC 765	39.75		
RWC (%)	AC 620	71.82	MT 80	92.77	RRIM 600	83.12
	MT 78	75.89	RO 1248	90.07	RRII 105	81.44
	AC 686	77.74	RO 2524	88.78	Tjir 1	77.18
	MT 196	77.75	MT 191	88.43		
	MT 184	79.10	RO 300	88.00		

differences in response towards drought tolerance has been previously reported by Nair *et al.* (2005), utilizing a rapid screening procedure.

After two years of field screening of 63 accessions of Set I, eight potential accessions, *viz.* MT 54, MT 1579, MT 67, MT 1668, MT 1616, MT 1627, MT 164 and MT 80, which survived two years' stress period were identified and selected for further field evaluation for drought tolerance.

Set II: Field screening of another set of 42 accessions was started in 2002 and data recorded on initial growth performance. Growth performance of the accessions during pre-drought period is shown in Table 4. The accessions showed wide variability for all the characters studied as evident from the wide

Table 6. **Superior accessions in terms of growth characters after one year of drought - Set II**

Height (cm)	Girth (cm)	Number of whorls	Number of leaves
MT 41 (370.00)	RO 2524 (10.27)	MT 41 (1.25)	MT 41 (60)
RO 2524 (358.00)	MT 58 (9.99)	MT 40 (3.0)	MT 40 (43.5)
MT 945 (350.00)	AC 728 (9.89)	AC 676 (2.0)	RO 2524 (31.0)
MT 58 (345.00)	MT 41 (9.73)	RO 2524 (2.0)	MT 80 (30.5)
MT 179 (337.00)	MT 40 (9.39)	AC 650 (2.0)	AC 676 (29.0)
AC728 (305.00)	AC 765 (9.23)	RO 4184(1.75)	MT 58 (25.0)
RO 4184(300.00)	MT 945 (8.92)	MT 38 (1.5)	MT 38 (23.0)
MT 78 (275.00)	MT 179 (8.45)	MT 80(1.5)	MT 76 (22.5)
	MT 38 (8.26)	AC 765 (1.33)	MT 945 (21.25)
	RO 3655 (8.26)	MT 43 (1.25)	RO 3655 (20.5)
RRIM 600 (327.3)	RRIM 600 (8.10)	RRIM 600 (2.63)	RRIM 600 (25.12)
RRII 105 (207.0)	RRII 105 (6.28)	RRII 105 (1.0)	RRII 105 (8.8)
Tjir 1 (229.67)	Tjir 1 (6.60)	Tjir 1 (1.07)	Tjir 1 (14.77)

range of values obtained for each character. In an early evaluation of wild *Hevea* germplasm for drought tolerance based on growth and dry matter production, Mercy *et al.* (2006) reported similar growth difference among the accessions. While randomly selecting the accessions, accession MT 80 was included in this set also. As in the previous set, here also this accession showed good girth during the initial period. Among the check clones, RRIM 600 was superior for growth characters, compared to RRII 105 and Tjir 1. It had the maximum height and retained the maximum number of leaves, while leaf fall was minimum. Accessions like MT 179, RO 4184, MT 56 and MT 196 showed superiority for more than one character during the pre-drought period of the first year indicating their general superiority.

The performance of these accessions after experiencing one season of drought stress was also assessed and accession MT 41 was observed to produce more foliage, while accessions RO 1248 and AC 765 were superior for height and girth. Accession MT 80 recorded the highest RWC during this period. The accessions in the extreme classes were also identified for various growth parameters during first year pre - and post - drought periods. Table 5 shows grouping of accessions into extreme classes which helps to identify those accessions showing tolerance and susceptibility to the stress conditions in terms of their growth performance. In the group of accessions with high values indicating drought tolerance, majority of the accessions belonged to MT provenance whereas accessions from AC and RO provenances came under the low-value group. Among the check clones, RRIM 600 was superior for most of the characters. An assessment of growth performance of the accessions over 18 months under Dapchari conditions identified MT 41 and RO 2524 as the superior accessions (Table 6) for majority of the growth characters, followed by MT 945 and MT 58. At the age of 18 months, the accessions were ranked on the basis of girth increment and the change in RWC. Compared to the check clones, the superior

Table 7. **List of wild accessions selected for detailed field evaluation**

Set	Accession	Drought tolerant attributes
I	MT 54	Good height, girth, number of whorls, RWC and stable performance
	MT 1579	Good growth even after experiencing stress
	MT 67	Good growth (height and girth) and RWC
	MT 1668	More number of leaves, good growth (height and girth) and girth increment
	MT 1616	More number of leaves and whorls, good growth (height and girth) and RWC
	MT 1627	More number of leaves and whorls, good growth (height and girth) and RWC
	MT 1649	Good growth even after experiencing stress
	MT 80	Good growth increment and RWC even after experiencing stress
II	MT 41	Good foliar production, higher rate of girth increment and good RWC
	RO 1248	Good growth (height and girth) and good RWC in post drought period
	AC 765	More number of leaves and whorls, good growth (height and girth)
	RO 2524	More number of whorls and good growth (height and girth)
	MT 945	More number of leaves and good growth (height and girth)
	MT 58	More number of leaves and good growth (height and girth)

wild accessions had higher rate of girth increment with good RWC without much effect of drought stress. The accession MT 41 exhibited higher growth rate in terms of girth increment with a higher RWC, indicating its suitability for drought-prone areas. After experiencing drought stress for two years, six accessions, *viz.* MT 41, RO 1248, AC 765, RO 2524, MT 945 and MT 58, showing good growth performance (Table 7) under Dapchari conditions were identified for further detailed field study.

CONCLUSION

Field screening of the wild accessions for the first time in the drought-prone area of Dapchari, Maharashtra, helped to throw light on the genetic diversity among these wild accessions towards drought stress tolerance. Fourteen potential accessions identified out of 105, belonging to three provenances can be used for identifying candidate genes based on the drought tolerance attributes they possess after detailed evaluation in the drought-prone area.

REFERENCES

Abraham, S. T., Reghu, C. P., Madhavan, J., George, P.J., Potty, S.N., Panikkar,A.O.N. and Saraswathy, P. (1992). Evaluation of *Hevea* germplasm 1: Variability in early growth phase. *Indian Journal of Natural Rubber Research*, **5**(1&2): 195-198.

Abraham, S. T., Panikkar, A. O. N., George, P. J., Reghu, C. P. and Nair, R. B. (2002). Genetic evaluation of wild *Hevea* germplasm: Early performance. In: *Plantation Crops Research and Development in the New Millennium: PLACROSYM XIV*, 12-15 December 2000, Hyderabad, India (Eds. P. Rethinam *et al.*) pp. 274-279.

Chevallier, M. H. (1988). Genetic variability of *Hevea brasiliensis* germplasm using isozyme markers. *Journal of Natural Rubber Research*, **3**(1): 42-53

IRRDB (1982). Status report of primary nursery. In: *The 1981 Germplasm Project Reports*. Meeting of Senior Plant Breeders, Manaus, Brazil, 18 June 1982, International Rubber Research and Development Board.

Madhavan, J., Reghu, C. P., Abraham, S. T., George, P. J. and Potty, S. N. (1993). Resources of *Hevea.* Abstracts of papers, *ISPGR Dialogue 1993. Plant Genetic Resources: Developing National Policy,* Indian Society of Plant Genetic Resources, NBPGR Campus, New Delhi, p. 48

Mercy, M. A. (2001). *Genotypic evaluation and screening for drought tolerance in wild Hevea germplasm.* Ph.D. Thesis, Kerala Agricultural University, Trissur, India, 115 p.

Mercy, M. A., Abraham, S. T., George, P. J., Potty, S. N., Sethuraj, M. R. and Saraswathi, P. (1993). Preliminary observations of the 1981 IRRDB *Hevea* germplasm. II. Variability, dry matter and morphological characters. *Journal of Plantation Crops,* **21**(Supplement): 268-274.

Mercy, M. A., Abraham, S. T., George, P. J. and Potty, S. N. (1995). Evaluation of *Hevea* germplasm: Observations on certain prominent traits in a conservatory. *Indian Journal of Plant Genetic Resources,* **8**(1): 35-39.

Mercy, M. A., Babu, L. C. and Varghese, Y. A. (2006). Early evaluation of wild *Hevea* germplasm for drought tolerance based on growth and dry matter production. *Journal of Plantation Crops,* **34**: 631-638

Nair, D. B., Jacob, J., Mercy, M. A., Varghese, Y. A. and Alam, B. (2005). Screening of wild *Hevea* germplasm accessions for intrinsic drought tolerance traits. *Preprints of papers. International Natural Rubber Conference,*6-8 November 2005, Cochin, India. 62-67.

Rao, G. P., Reghu, C. P. and George, P. J. (1996). Evaluation of *Hevea* germplasm VIII. Variability in certain juvenile characters of wild *Hevea* germplasm. *Journal of Cytology and Genetics,* **34**(2) : 183-186.

RRII. (2002). *Annual Report* 2001-02. Rubber Research Institute of India, Kottayam, pp. 27-32.

Suma, K., Rao, G. P., Madhavan, J. and Varghese, Y. A. (2006). Variability in wild germplasm of natural rubber (*Hevea brasiliensis). Abstract of Papers, 2nd National Plant Breeding Congress,* 2006, TNAU, Coimbatore, India, p. 25.

Varghese, Y. A., Marattukalam, J. G., George, P. J. and Panikkar, A. O. N. (1989). Nursery evaluation of some exotic genotypes of *Hevea brasiliensis* Muell. Arg. *Journal of Plantation Crops,* **16** (Supplement): 335-342.

Varghese, Y. A., Abraham, S. T., Mercy, M. A., Madhavan, J., Reghu, C. P., Rao, G. P., Ammal, S. L., Idicula, S. P. and Joseph, A. (2002). Management of the 1981 IRRDB germplasm collection in India. *IRRDB Joint Workshop on Plant Breeding, Agronomy and Socio-economics,* 28 August - 7 September, 2002, Malaysia/ Indonesia, 20p.