SCREENING *HEVEA* CLONES FOR TOLERANCE TO DROUGHT IN THE INITIAL FIELD EXPOSURE

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Drought stress is one of the major factors that limit extension of rubber cultivation to the North Konkan region of Maharashtra and parts of eastern states of India such as Odisha. Seventeen pipeline clones produced through hand pollination and open pollination along with three check clones were planted in a clone evaluation trial at Dapchari in Maharashtra during August 2018. Dapchari experiences severe drought conditions during February- May every year. During May 2019, when the plants were experiencing severe soil moisture deficit, high temperature and high solar radiation, the extent of leaf damage in terms of leaf yellowing and drying was assessed as an indirect measure of their intrinsic tolerance to the environmental stress. Check clones RRII 430 and RRIM 600 which are already known as relatively drought tolerant clones showed 12.9 per cent and 13.4 per cent leaf drying, respectively. Check clone RRII 105 which is generally regarded as a drought susceptible clone showed more (18.5%) leaf drying. Pipeline clones such as P 114 (3.7%), P 192 (5.7%), P 200 (6.8%), P 225 (8.4%) and P 68 (8.9%) had considerably lesser leaf drying than RRII 430. Clones P 205 (17.8%), P 27 (18.3%), P 207 (21.4%) and P 196 (21.7%) showed the highest leaf drying among all the clones tested.The two top ranking clones in terms of less leaf drying *viz.* P 114 and P 192 also maintained relatively more number of whorls and leaves, and these clones had more height indicating their better initial growth in the field in a drought prone region.

Key words: Drought tolerance, *Hevea* clones, Large scale evaluation, Weather parameters

Developing tolerance to drought is an important breeding objective in *Hevea brasiliensis* which is necessitated by the need to expand Natural Rubber cultivation to drought prone regions in the non-traditional regions such as Odisha,and meet challenges posed by global climate change in traditional areas (Kerala). Variability in intrinsic drought tolerance traits can be exploited for genetic improvement of crops. Under Indian conditions drought and heat stress occur concomitantly with high light stress which aggravate the harmful effects (Jacob *et al.*, 2003; Jacob and Satheesh, 2010). Drought stress caused by water scarcity, and heat stress due to elevated temperature levels are the most critical limiting factors to plant growth and productivity. Plants experience drought condition when availability of water in the root zone is less and the water loss through transpiration is high (Anjum*et al.*, 2011). In *Hevea* breeding programs, clones developed through hybridizations and ortet selections are evaluated in clonal nurseries,

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small scale and large scale trials to develop pipeline clones. The objective of the present study was to screen clones, and identify intrinsically tolerant genotypes suited for drought prone regions.

The study was conducted at the Regional Research Station of the Rubber Research Institute of India at Dapchari (20^0 04′N, 72^0 04′E, and 48 m above MSL) in the North Konkan region of the Indian state of Maharashtra which is outside the traditional rubber growing region which falls between 74°48′33.10" to 77°38′35.43" East longitudes and 7°58′ 56.27" to 12°53′ 19.11" North latitudes. Seventeen pipeline clones which included 12 clones produced through hand pollination (HP) *viz.*P 21, P 27, P 83, P 192, P 196, P 200, P 202, P 204, P 205, P 207, P 210 and P 218, and five clones produced through open pollinations (OP) *viz.*P 63, P 68, P 112, P 114 and P 225 were tested in the trial along with three check clones *viz.* RRII 105, RRII 430 and RRIM 600 (Table 1). Polybag plants were used to plant the trial in the fields in the monsoon season of 2018. The trial was laid out in Randomized Block Design (RBD) with three replications and 16 plants per plot in 4.6 x 4.6m spacing.

The plants were given life-saving irrigation at fortnightly interval during summer months from March to May. Yellowing and subsequent drying of leaves

Table 1.**Clones and their origin and parentage**

Test Clones	Origin	Parentage
P 21	Hand Pollination (HP)	RRII 105 x RRII 118
P 27		RRII 105 x RRII 118
P 83		RRII 105 x RRII 208
P192		RRII 105 x RRII 118
P196		RRII 105 x RRII 118
P 200		RRIM 600 x RRIC 52
P 202		RRII 105 x RRII 118
P204		RRIM 600 x RRIC 52
P205		RRII 105 x RRII 118
P207		RRII 105 x RRII 118
P210		RRII 105 x RRII 118
P218		RRII 105 x RRIC 52
P 63	Open Pollination (OP)	Polycross progeny of PB 28/83 (Half Sib)
P68		Polycross progeny of RRII 105 (Half Sib)
P112		Polycross progeny of PB 5/51 (Half Sib)
P114		Polycross progeny of PB 242 (Half Sib)
P225		Ortet selection
Check Clones		
RRII 105		Tjir 1 xGl 1
RRII 430		RRII 105 x RRIC 100
RRIM 600		Tjir 1 x PB 86

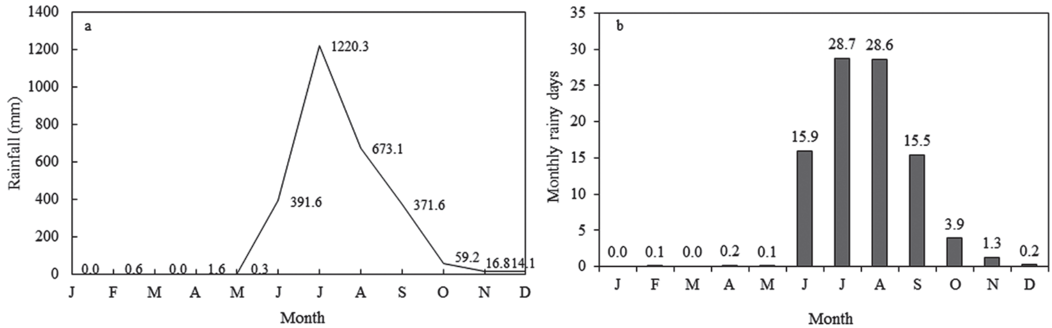

Fig.1. Rainfall pattern (Mean over 11 years 2008-2018) **a:** Monthly rainfall pattern **b:** Monthly rainy days

was recorded clone-wise from each plant. Height, number of leaves and whorls were also recorded. Data was analysed to estimate clonal variations. Weather parameters such as rainfall (mm), number of rainy days, atmospheric temperatures (^{0}C) and bright sun shine hours (BSSH)recorded from the trial location during the period from 2008 to 2019 were given to show that the region experiences drought, high temperature *etc*.

Dapchari in the North Konkan region generally experiences a long rainless spell from November to May where the temperature also rises steadily. Average annual rainfall recorded from the location was 2748.1mm. Annual rainfall varied from 1669.8 to 3518.5mm and the rainy days varied from 79 to 112. Although the total annual rainfall is not deficient for the establishment of rubber cultivation, its monthly distribution was uneven and restricted to the monsoon season (June-September). Rainfall during the monsoon months is peculiar in that, during the beginning of the monsoon season (June) and at the end of the monsoon season (September) the amount of rainfall (391.6mm in June and 371.6mm in September), and the number of rainy days were similar (15.9 days in June and 15.5 days in September) (Fig. 1). During monsoon, the highest rainfall was in July (1220.3mm) followed by August (673.1mm).

Heat stress was experienced during the summer months (March, April and May). The highest maximum temperature(T_{max}) was recorded in April (38.6^{0}C). Maximum temperature above 40.0^{0}C was recorded for 3.2 days in March, 7.6 days in April and 2.1 days in May (Fig. 2). Apart from high atmospheric temperatures, BSSH were also the highest in summer(9.8 hrs in May). The young rubber plants were exposed to the drought and heat stress conditions prevailing in the field during the rainless months (November to May). It is assumed that at this young stage, the clones with less leaf-drying, when exposed for the first time to heat and drought stress in the field are more tolerant to drought stress.

The test clones were pipeline clones earlier selected for better growth and yield during summer seasons from the traditional regions where drought is not as severe as in Dapchari. Check clones *viz.* RRII 430 and RRIM 600 are clones known for relative drought tolerance whereas RRII 105 is a known drought susceptible clone (Mercy *et al.*, 2011; Sumesh*et al.*, 2011; Krishan, 2017; Meenakumari*et al.*, 2018). During summer,

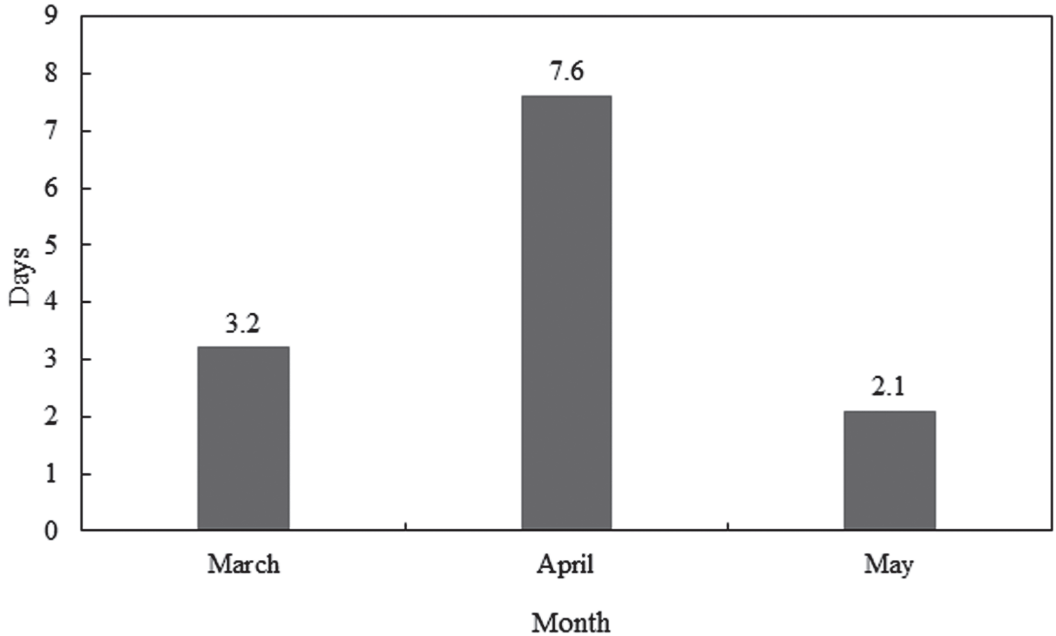

Fig.2.Number of very hot days (with temperature above $40^{0}C$)

yellowing and drying of leaves was visually observed and recorded for all clones. Leaf drying showed significant difference among the clones (Table 2). The number of leaves dried varied from 3.7 to 21.7 per cent. Leaf drying in RRII 430 was 12.9 per cent and it was 13.4 per cent in RRIM 600. Seven pipeline clones showed lesser leaf drying compared to RRII 430 and RRIM 600 *viz.* P 114 (3.7%), P 192 (5.7%), P 200 (6.8%), P 225 (8.4%), P 68 (8.9%), P 83 (10.1%) and P 204 (12.1%). Leaf drying in RRII 105 was 18.5 per cent. Among the pipeline clones, 10 clones showed leaf drying more than RRII 105 *viz.* P 63 (13.2%), P 218 (14.0%), P 202 (15.0%), P 21 (15.5%), P 112 (15.7%), P 210 (16.0%), P 205 (17.8%), P 27 (18.3%), P 207 (21.4%) and P 196 (21.7%). Clones that showed lesser drying compared to RRII 430 and RRIM 600 could be considered more tolerant to drought whereas clones that showed more drying compared to RRII 105 as more susceptible to drought.

Clonal variability in height, number of leaves and whorls were also recorded (Table 2). Height of the clones varied from 42.0 (P 196) to 80.3cm (P 225). Clones such as P 114, P 63, P 112, P 27, P 204, RRIM 600, P 218, P 21 and P 200 showed height on par with P 225. Highest number of leaves was recorded in P 225 (23.6). The other clones with number of leaves on par with P 225 were P 192, RRIM 600, P 218, P 21 and P 204. Highest number of whorls was recorded in P 21, P 225 and RRIM 600 (2.3 each). Other clones showed number of whorls between 1.6 and 2.1.

Clonal variability in leaf drying, plant height, number of whorls and leaves between the clones of HP origin and OP origin were estimated. Clonal variability in plant height showed significant variation

Table 2. **Growth parameters and leaf drying during drought**

Test Clones	Height (cm)	No. of leaves	No. of whorls	No. of dried leaves	% of dried leaves
P 21	72.0	19.0	2.3	2.9	15.5
P 27	76.5	16.0	2.0	2.9	18.3
P 83	66.5	16.0	1.7	1.6	10.1
P192	60.2	21.5	2.0	1.2	5.7
P196	42.0	12.1	1.6	2.6	21.7
P 200	67.4	18.2	2.0	1.2	6.8
P 202	63.9	17.5	2.0	2.6	15.0
P 204	76.2	18.9	2.0	2.3	12.1
P 205	49.4	11.6	1.7	2.1	17.8
P 207	56.0	13.3	1.6	2.8	21.4
P 210	64.4	15.8	1.9	2.5	16.0
P 218	74.2	19.2	2.1	2.7	14.0
P 63	76.7	18.6	2.1	2.5	13.2
P 68	62.4	15.9	1.8	1.4	8.9
P 112	76.7	18.4	2.1	2.9	15.7
P 114	77.0	18.3	2.0	0.7	3.7
P 225	80.3	23.6	2.3	2.0	8.4
Check Clones					
RRII 105	60.9	14.3	1.6	2.6	18.5
RRII 430	56.6	12.7	1.6	1.6	12.9
RRIM 600	75.1	19.7	2.3	2.7	13.4
Mean	66.7	17	1.9	2.2	13.5
Range	42.0-80.3	11.6-23.6	1.6-2.3	0.7-2.9	3.7-21.7
CD (P=0.05)	13.5	4.9	0.45	1.2	

between HP origin (64.1 cm) and OP origin (74.6 cm) clones. However, in leaf drying, number of whorls and leaves no significant variation was recorded between HP origin and OP origin clones (Table 3). This indicated that OP origin clones are as good as HP origin clones with regard to clonal performance in the initial stage as seen in the study but further confirmation is needed. Correlation of leaf drying with plant height,

Table 3. **Growth parameters based on origin of clones**

Origin of clones	Height	Leaves	Whorls	No. of dried leaves	Per cent of dried leaves
HP	64.1	16.6	1.9	2.3	14.6
OP	74.6*	19.0	2.1	1.9	10.0

*Significant at 5 per cent level

Table 4.**Correlation between parameters**

Parameters	r
Leaf drying – Height	0.043
Leaf drying – No. of leaves	0.113
Leaf drying – No. of whorls	0.184
Height – No. of leaves	0.773 *
Height – No. of whorls	0.781 *
No. of leaves – No. of whorls	0.858 *

*Significant at 5 per cent level

number of leaves and whorls showed insignificant relations which indicated that drought tolerance is a trait independent of growth parameters such as height, leaves and whorls in the initial stage (Table 4). However, correlations among the growth parameters were significant.

The trial undertaken at Dapchari was a conventional breeding approach to identify clones with better drought tolerance attributes in terms of comparatively lower levels of leaf drying during summer. Among the 17 pipeline clones tested in the trial, P 114, P 192, P 200, P 225, P 68, P 83 and P 204 showed relative tolerance to drought. OP origin clones were as good as HP origin clones for performance under drought. Drought tolerance was seen as a trait independent of the growth parameters studied. Existing genetic variability among polycross progenies and pipeline clones need to be tested under the drought-stress conditions to identify genotypes suitable for sub-optimal conditions.

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