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PERFORMANCE OF *HEVEA* SEEDLINGS FROM DIVERSE REGIONS IN THE AGROCLIMATE OF SUB-HIMALAYAN WEST BENGAL

Gitali Das, Sandeep Kumar*, Shammi Raj, R. Krishnakumar** and James Jacob****

Rubber Research Institute of India, Regional Research Station, Guwahati - 794 001, Assam, India
*Rubber Research Institute of India, Regional Research Station, Nagrakata - 735 225, West Bengal, India
**Rubber Research Institute of India, Kottayam - 686 009, Kerala, India

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A study was initiated on performance of seedlings collected from diverse regions under the agroclimate of sub-Himalayan West Bengal. Seeds were collected from different agroclimatic zones *viz.* Kanyakumari in Tamil Nadu (South India), Tura in Meghalaya, Kamrup in Assam (North East India) and Jalpaiguri in sub-Himalayan West Bengal. The climate in these regions differed in different aspects, especially in temperature and precipitation patterns. Seedlings were affected by severe cold during early establishment phase in sub-Himalayan West Bengal; the damage being high in seedlings from Kamrup and minimum in those from Kanyakumari. The growth performance during immature phase showed that seedlings from Kanyakumari were better during the early establishment phase. Juvenile yield at the 5th year of planting was higher in seedlings obtained from Kanyakumari compared to that of the other locations. Fourteen seedling trees were screened on the basis of their juvenile yield (above 0.7 g $cm^{-1} t^{-1} t^{-1}$). Ten trees of Kanyakumari region showed yield above 0.7 g $cm^{-1} t^{-1} t^{-1}$, whereas, only one seedling from Tura and three seedlings from Nagrakata showed high juvenile yield. In general, the performance of seedlings from Kanyakumari region was comparatively better in the sub-Himalayan region than the polyclonal seedlings from North East India.

Keywords: Growth, *Hevea brasiliensis*, Juvenile yield, Seeds, Seedlings, Selection, Sub-Himalayan climate

INTRODUCTION

Polycross seeds are highly heterogenic (broad genetic variation) in nature due to which they perform well in diverse agroclimatic conditions. In tree species, characteristic with an extraordinary flexibility and adaptive potential, the chances of seeds to adapt to a wide array of adverse environmental conditions are high. Hence, a study on the performance of seedlings raised from seeds produced in diverse agroclimates has been undertaken with the aim of identifying good source of polyclonal seeds capable of producing seedlings with vigorous growth and high yield under the prevailing adverse climatic conditions of sub-Himalayan West Bengal.

MATERIALS AND METHODS

Rubber seeds were collected from four different regions *viz.* Kanyakumari (Tamil

Correspondence: Gitali Das (Email: gitalidas@rubberboard.org.in)

Nadu), Tura (Meghalaya), Kamrup (Assam) and Nagrakata, (West Bengal). The agroclimate of these four regions vary in many aspects and weather parameters during the year of seed collection in different regions are shown in Figure 1 expressed in Standard Meteorological Weeks. The tropical weather in Kanyakumari is quite different from that of the other three regions. It has rainfall both during the South West and the North East monsoons. The rainfall is nearly distributed over four seasons. In the other three regions, the maximum temperature (T max) went below 25 ^{0}C from the second week of December to the third week of March (Fig.1) while the minimum temperature (T min) was continuously below 10^{0}C during this period. In Kanyakumari, rainfall was observed for almost every week in the post-monsoon season while little rain was experienced in the other locations. This shows that the regions in the sub-Himalayan West Bengal experienced low temperature stress with mild drought stress during the late post monsoon and winter season.

The time of seed maturity differs in these four regions according to the agroclimate. In Kanyakumari, mature seeds were available during August, whereas in Nagrakata it was only available during the last week of September, while it was available in Guwahati and Tura duirng the first week of September 2008. Seeds sourced from the above locations were germinated just after procurement in Nagrakata, West Bengal, situated in the sub-Himalayan region of Dooars area. In this experiment, the germination percentage was recorded and seedlings with high vigour (germinated within 48 hours of first sprouting) were directly planted in the field during the last week of October in Randomised Block Design with four replications and 50 plants per replication with a spacing of 5m x 5m. Two seedlings were planted in each planting point to ensure the survival of the plant and one of the seedlings was removed six months after field planting. Data on casualty and survival was recorded eight months after field planting. After 16 months, data on number of plants affected by severe low winter temperature stress as indicated by yellowing/dry leaves and growth parameters *viz.* number of leaf-whorls, number of mature green and immature brown leaves, plant height and girth were recorded during the fourth week of January. Juvenile yield and girth at 50 cm height on the fourth and fifth year of planting was recorded. In the fourth year, only trees showing above 20 cm girth at 30 cm height were tapped, whereas during the fifth year, all the trees were tapped irrespective of girth class. Juvenile yield was recorded at 30 cm height in the S/2 d2 system of tapping during pre-winter (November - December) period. The yield of first five tappings were discarded and yield data from the sixth to fifteenth tapping were collected as fresh cup lumps, which was dried in the smoke house and yield data of each plant was recorded. The dry cup lump weight was converted to dry sheet weight following the regression equation $Y = 0.913x+0.656$ ($R^2 = 0.95$), where 'x' denotes the dry cup lump weight and 'Y', the sheet weight (Das *et al.*, 2008). Yield above 0.4 g $cm^{-1} t^{-1} t^{-1}$ and that below 0.3 g $cm^{-1} t^{-1} t^{-1}$ were screened and tabulated. Best performers were selected on the basis of girth and juvenile yield potential.

RESULTS AND DISCUSSION

Germination of seeds varied according to the source of seeds and time of seed availability. The seeds from Kanyakumari, which was collected in August, showed highest germination (Table 1) followed by that of Assam, Tura and Nagrakata. Survival

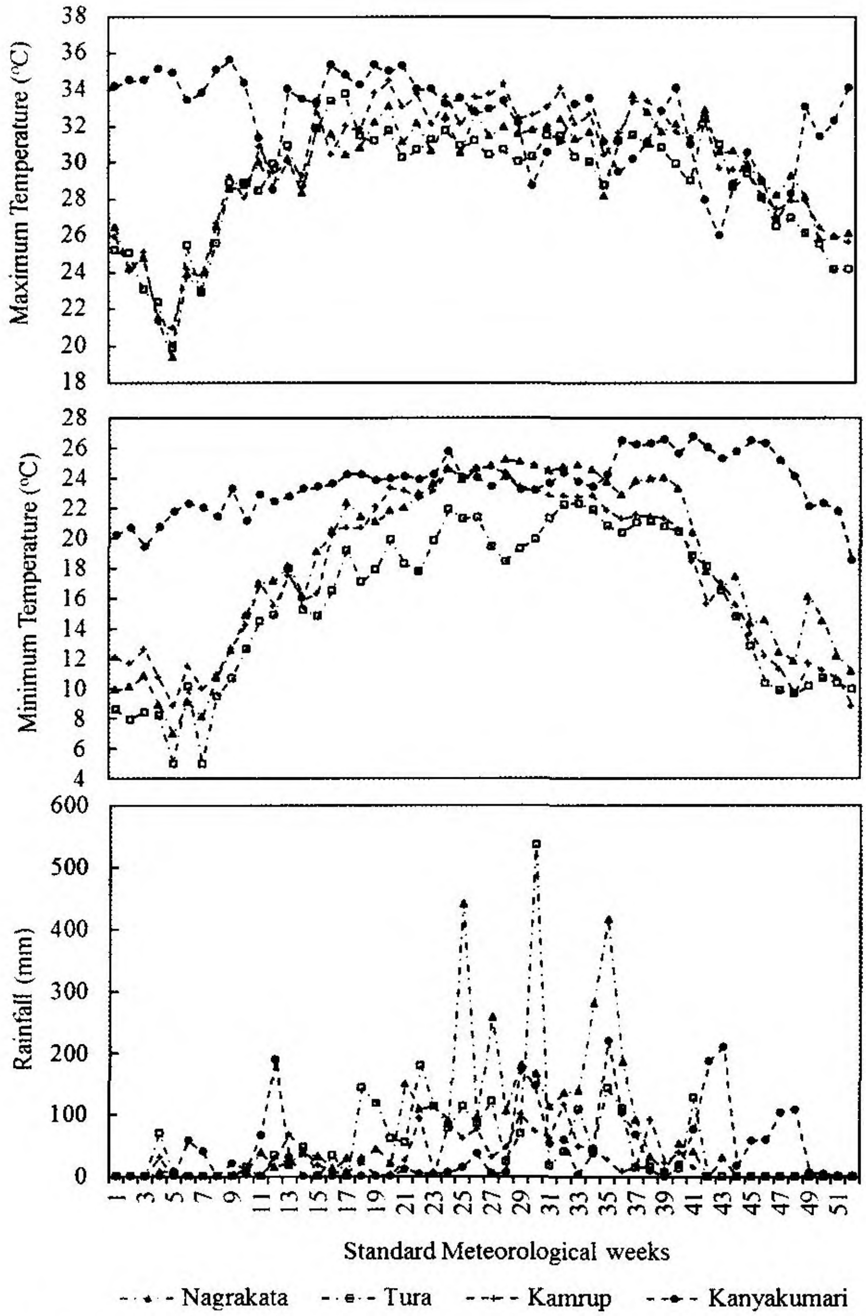

Fig. 1. Weekly mean maximum and minimum temperature and rainfall for the four regions form where the seeds were collected.

rate of seedlings after five months of field planting was highest in seedlings from Tura followed by that of Guwahati, Kanyakumari and Nagrakata.

Severe cold was experienced during the next winter period; the weather parameters depicted on 12th and 13th January (Fig. 2) T_{max} and T_{min} were 15.6 and 12.0 °C, and 17.5 and 11.4 °C respectively, and the difference between the maximum and minimum temperature was as low as 3.6 °C and 6.1 °C. The mean temperature was 13.8 °C and 14.5 °C for the respective days with cloudy weather and the plants experienced severe cold stress. Further T_{min} came down below 8 °C thereafter, for 7 consecutive days.

Photosynthesis in *Hevea* was found to impair at the range of 10 °C and below 5 °C there was irreversible frost-damage (Wenxian and Yanqing, 1990). Growth was also found to be affected in rubber when monthly mean temperature went below 20 °C in China (Jiang, 1988) and temperature below 18 °C was found to impart stress which may affect the normal growth of the plants (Alam *et al.*, 2005). Effect of severe cold experienced sixteen month after field planting (Table 2) was high in seedlings of Kamrup region followed by that of Nagrakata and Tura and the lowest effect was seen in the Kanyakumari seedlings. Maximum seedling girth, girth increment and plant height twenty months after plantning were observed from seedlings of Kanyakumari region followed by that from Tura, Nagrakata and Kamrup region. No difference was observed in the number of leaf whorls and number of immature apex leaves between the locations. However, number of mature green leaves was high in the seedlings of Kanyakumari region compared to that of the rest of the locations. Number of leaves in the apical whorl did not show any significant difference for the different seedlings. But the number of leaves in the apical whorl was few indicating severe stress to the plant. Studies on freeze induced damage to specific regions of oat crowns confirmed that the apical meristem was the tissue which responded to freezing (Livingston *et al.*, 2005). In *Miscanthus*, frost sensitivity was determined by high susceptibility of apical meristems (Plazek *et al.*, 2009).

The girth of seedlings from Kanyakumari and Tura region at 50 cm height during fourth year was significantly higher than that of Nagrakata and during fifth year, girth of Kamrup and Kanyakumari seedlings was higher than that of Nagrakata (Table 3). One of the popular screening tests practiced for evaluating promising *Hevea* seedlings is the juvenile yield efficiency recorded at immature stage where a positive correlation was found between juvenile yield and early mature yield (Das *et al.*, 2009). Table 3 shows that the fourth year juvenile yield potential in seedlings of Kanyakumari and Tura region was higher compared to that from Nagrakata and

Table 1. **Seed germination and seedling survival under field condition**

Source	Germination (%)	Five months after planting	
		Vacancy (%)	Survival (%)
RRS, Sarutari, Kamrup, Assam	65	3	97
RES, Nagrakata, Jalpaiguri, W. B.	50	16	85
HBSS, Kanyakumari,Tamil Nadu	85	6	94
RRS, Tura, Meghalaya	60	-	100

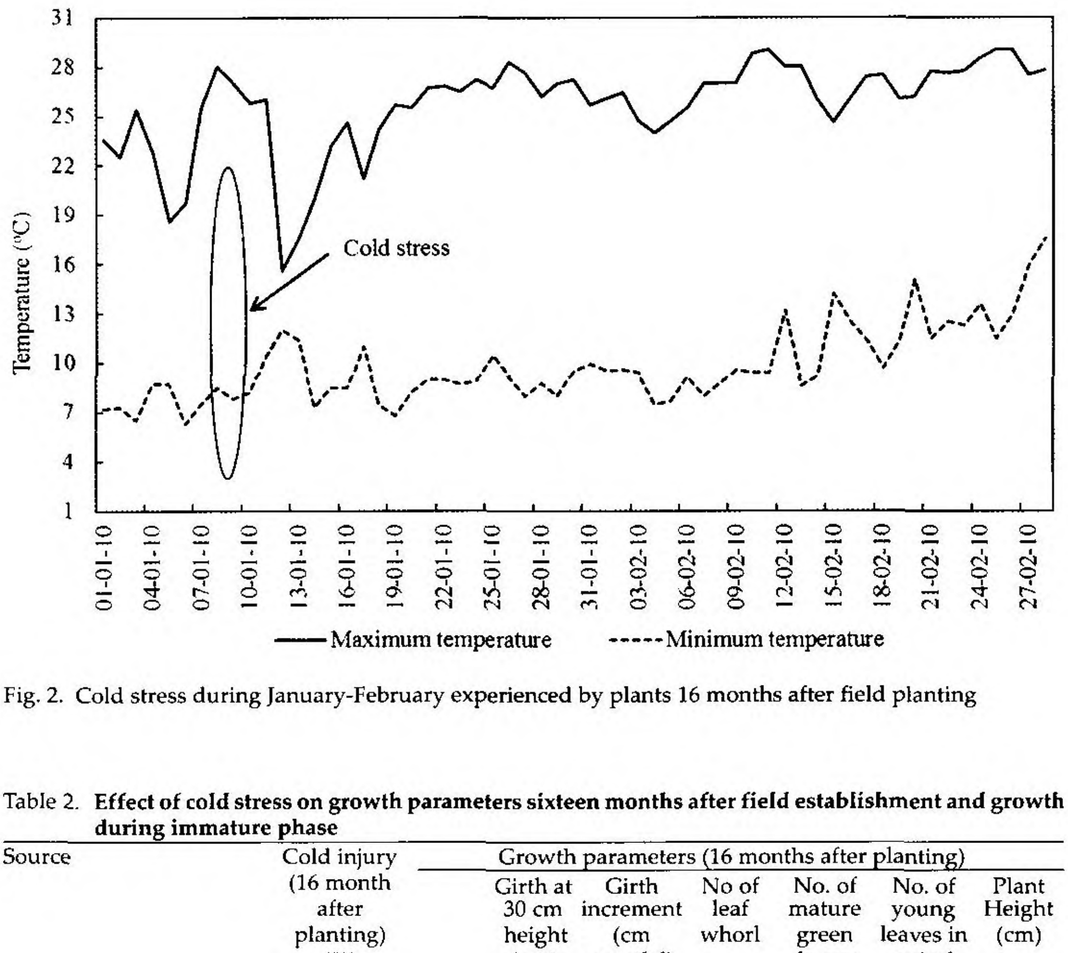

Fig. 2. Cold stress during January-February experienced by plants 16 months after field planting

Table 2. **Effect of cold stress on growth parameters sixteen months after field establishment and growth during immature phase**

Source	Cold injury (16 month after planting) (%)		Growth parameters (16 months after planting)					
			Girth at 30 cm height (cm)	Girth increment (cm month^{-1})	No of leaf whorl	No. of mature green leaves	No. of young leaves in apical whorl	Plant Height (cm)
Kamrup, Assam	65	Mean	5.3	0.25	3.6	11.2	1.9	145.5
		SE	3.2	0.06	0.9	4.1	0.8	12.9
Nagrakata, West Bengal	55	Mean	7.9	0.38	2.9	11.8	2.3	185.2
		SE	4.3	0.14	1.1	6.7	1.2	20.9
Kanyakumari,Tamil Nadu	20	Mean	19.0	0.89	4.3	20.1	2.4	276.0
		SE	12.4	0.17	1.0	10.6	1.3	13.0
Tura, Meghalaya	52	Mean	10.4	0.44	2.9	10.8	2.5	193.2
		SE	6.9	0.06	1.0	8.5	1.3	9.3
CD(P≤0.0 5)	NS		5.7	NS	1.9	5.7	NS	20.8

NS: Non significant

Table 3. **Growth and juvenile yield of seedlings during the fourth and fifth year of field planting**

Source	Parameters	Mean girth at 50 cm height (cm)		Mean juvenile yield (g t^{-1} 10 t^{-1})		Mean juvenile yield potential (g cm^{-1} t^{-1} t^{-1})	
		Fourth year	Fifth year	Fourth year	Fifth year	Fourth year	Fifth year
Kamrup, Assam	Mean	18.6	30.4	32.1	87.7	0.17	0.37
	SE	1.1	1.7	2.7	4.1	0.02	0.01
Nagrakata, West Bengal	Mean	17.4	27.9	30.2	80.5	0.17	0.34
	SE	1.0	0.3	0.3	2.6	0.01	0.01
Kanyakumari, Tamil Nadu	Mean	30.0	50.0	47.2	113.1	0.22	0.43
	SE	0.6	0.7	3.0	6.9	0.02	0.02
Tura, Meghalaya	Mean	19.4	29.5	44.6	82.3	0.23	0.35
	SE	0.1	0.9	4.7	4.8	0.02	0.02
CD(Pd≤0.0 5)		2.8	2.3	6.5	12.5	0.03	0.04

Kamrup. In the fifth year also, seedlings of Kanyakumari region maintained their superiority but seedlings from Tura decreased in its yield potential and was at par to that of Nagrakata and Kamrup possibly due to less number of seedlings attaining tappable girth during the fourth year in Tura.The juvenile yield potential during the fourth year of planting ranged from 0.08 g cm^{-1} t^{-1} t^{-1} to 0.54 g cm^{-1} t^{-1} t^{-1}, whereas, during the fifth year, it ranged from 0.08 g cm^{-1} t^{-1} t^{-1} to 0.94 g cm^{-1} t^{-1} t^{-1}.

Plants with juvenile yield potential above 0.4 g cm^{-1} t^{-1} t^{-1} during the fifth year were categorized into six groups (Table 4) The plants showing high yield potential under the upper category, were from Kanyakumari and Nagrakata seed sources but from Tura and Kamrup, it was nil.

In order to understand the best and worst performers, all the seedlings were screened and fourteen seedling trees were promising. The yield of best seedlings ranged from 0.70 g cm^{-1} t^{-1} t^{-1} to 0.94 g cm^{-1} t^{-1} t^{-1} (Table 5a); the girth of these plants were above 40 cm at 50 cm height. Three seedling trees were found which showed high yield during fourth year also. Interestingly, three seedling plants showed low girth (35.8 to 37.4 cm) but appreciable high yield (0.61 to 0.63 g cm^{-1} t^{-1} t^{-1}); this showed that these three plants had remarkable prospective (Table 5b). The lower group (Table 5c) was considered on the basis of appreciable girth

Table 4. **Per cent distribution of plants based on juvenile yield potential above 0.40 g cm^{-1} t^{-1} t^{-1}**

Source	Juvenile yield distribution (%)					
	0.4-0.49	0.5-0.59	0.6-0.69	0.70-0.79	0.80-0.89	0.90-0.99
Kamrup, Assam	21.8	12.8	7.7	0.0	0.0	0.0
Nagrakata, West Bengal	12.3	16.9	4.6	3.1	1.5	0.0
Kanyakumari,Tamil Nadu	11.7	20.8	3.9	6.5	3.9	2.6
Tura, Meghalaya	20.5	10.2	3.4	1.1	0.0	0.0

Table 5a. **Best performers for juvenile growth and yield at fifth year showing above 0.7 g $cm^{-1} t^{-1} t^{-1}$ yield efficiency**

Seedlings	Girth at fifth year at 50 cm height (cm)	Juvenile yield of 10 taps at fifth year ($g\ cm^{-1} t^{-1}$ 10 tap^{-1})	Juvenile yield potential at fifth year ($g\ cm^{-1} t^{-1} t^{-1}$)
WBN 282	51.0	234.4	0.70
WBT 113	48.6	197.9	0.71
WBK 227	52.8	224.9	0.72
WBK 22	44.0	181.4	0.72
WBK 259	51.5	233.6	0.75
WBN 150	44.5	183.3	0.77
WBK 170	43.8	198.8	0.77
WBK 23	51.5	222.5	0.78
WBK 351	53.5	255.2	0.81
WBN 173	47.8	205.3	0.82
WBK 359	48.5	228.7	0.87
WBK 256	51.6	262.3	0.88
WBK 252	53.5	271.3	0.90
WBK 357	50.5	270.3	0.94

WB: West Bengal; N: Nagrakatta, T: Tura; K: Kanyakumari

(above 40 cm) but low yield. Fourteen seedling plants were found in this group where the girth ranged from 40.2 cm to 55.4 cm and the yield potential ranged from 0.16 g $cm^{-1} t^{-1} t^{-1}$ to 0.29 g $cm^{-1} t^{-1} t^{-1}$.

Screening from assorted offspring in mature phase mostly on the basis of yield and finally selecting mother trees considering secondary characters like girth, disease incidence *etc.* is a common practice in *Hevea* crop improvement programme. Accordingly, screening mother trees from the data on long term performance of seedlings raised from seeds of Kanyakumari under the agroclimate of North East India and North Bengal was also reported. Comparing the performance of seedling mother trees (Kanyakumari origin) grown in Kamrup and Nagrakata, it was inferred that selected mother trees were better adapted to the climatic shifts of Kamrap, Guwahati than that of Nagrakata where climate extremities was more severe (Das *et al.*,

Table 5b. **Plants showing low girth with high yield potential**

Seedlings	Girth at fifth year at 50 cm height (cm)	Juvenile yield of 10 taps at fifth year ($g\ cm^{-1} t^{-1}$ 10 $taps^{-1}$)	Juvenile yield potential at fifth year ($g\ cm^{-1} t^{-1} t^{-1}$)
WBG 181	35.8	123.0	0.61
WBG 189	36.0	145.0	0.61
WBG 184	37.4	136.2	0.63

WB: West Bengal; G: Guwahati

Table 5c. **Low performers with high girth but low juvenile yield**

Seedlings	Girth at fifth year at 50 cm height (cm)	Juvenile yield of 10 taps at fifth year ($g\ cm^{-1} t^{-1} 10\ taps^{-1}$)	Juvenile yield potential at fifth year ($g\ cm^{-1} t^{-1} t^{-1}$)
WBT 391	40.2	39.0	0.16
WBG 390	41.1	73.5	0.28
WBT 66	42.0	54.5	0.23
WBG 49	43.2	66.2	0.25
WBT 319	43.5	73.7	0.27
WBK 285	43.9	75.9	0.28
WBN 201	44.0	70.8	0.25
WBT 122	44.5	68.2	0.28
WBK 353	45.5	55.7	0.20
WBN 374	46.0	68.4	0.25
WBT 111	46.0	75.1	0.27
WBG 244	48.0	63.7	0.22
WBK 21	50.1	65.7	0.22
WBT 124	55.4	90.5	0.29

WB: West Bengal; N: Nagrakatta, T: Tura; K: Kanyakumari; G: Guwahati

2013). In Agartala, also, such selections with promising characters were evaluated (Sasikumar *et al.*, 2001) and initiated large scale trial with these selections for further testing. Comparing the performance of offspring raised from seeds of different agroclimatic zone, it was observed that though initially the growth of seedlings of Kanyakumari origin was better compared to that of Tura, Nagrakata and Kamrup but after five years, the effect minimized. The mean juvenile yield of seedlings of Kanyakumari during fifth year was higher than the others. When 10 seedling trees of Kanyakumari origin showed above 0.07 $g\ cm^{-1} t^{-1} t^{-1}$ yield, only one tree of Tura and three trees of Nagrakata showed such high yield; this indicated that performance of seedlings raised from seeds of traditional belt of Kanyakumari was better than that of its non-traditional origin. The selected seedlings would be further evaluated in clonal nursery trials.

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