PERFORMANCE OF SOME *HEVEA* CLONES UNDER THE COLD PRONE CLIMATE OF SUB-HIMALAYAN WEST BENGAL

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Multidisciplinary evaluation of eleven clones of *Hevea* was initiated in 1993, at Nagrakata a cold prone Sub-Himalayan region of West Bengal. Among the clones evaluated RRII 208 and Haiken 1 exhibited the highest girth at the time of panel opening closely followed by the check clone RRIM 600. However, clones RRIC 104 and SCATC 93/114 showed maximum girth increment after twelve years of tapping. Haiken 1 and RRII 208 were the top rankers in terms of annual yield closely followed by PB 280 and RRIM 600 over the twelve years of tapping period. Haiken 1 ranked first in BO-1 and BI-1 panels followed by PB 280 whereas RRII 208 ranked first in BO-2 panel followed by Haiken 1 in terms of panel wise yield. The performance of these clones with respect to winter yield contribution varied from 56 – 62 %. Incidence of tapping panel dryness (TPD) was the minimum in PB 235 followed by Haiken 1 and RRII 300. In general, *Oidium* incidence was observed in all the clones but the lowest level was recorded in Haiken 1, RRII 208, SCATC 93/114 and RRIM 600. The intensity of wind damage varied from 0-18% among the clones. Shoot biomass accumulation was higher in SCATC 94/114 followed by Haiken 1 while the highest clear bole volume was recorded in RRII 308 followed by RRII 300 and PB 235. Results of this study revealed that among the 11 clones Haiken 1, RRII 208 and PB 280 were better adapted to the cold prone climate and found to be the most suitable clones for this region.

Keywords: Clone, Cold stress, *Hevea*, Rubber, Yield

INTRODUCTION

Agro-climatically best suited lands for natural rubber (NR) cultivation in almost all major NR producing countries are nearly saturated and existing rubber plantations in the world will not be sufficient to meet the increasing global demand of NR. Supply of NR from the traditional areas is also more or less stabilized. Therefore, NR cultivation is being extended to less suitable lands in non-traditional areas (Sethuraj and Jacob, 2012). Rubber (*Hevea brasiliensis* Muell. Arg.) has emerged as a new plantation crop for cultivation in certain traditionally tea growing areas also *i.e.,* Terai and Dooars of Sub-Himalayan West Bengal (Das *et al*., 2013). The topographic variation of this

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region is very high and climatic conditions vary in different locations. Rubber plantations experience an assortment of environmental stresses such as extreme variability in temperatures, heavy rain, high wind velocity and alkalinity. The major environmental constraint for growth and productivity of rubber for this region is the prolonged winter with low temperature from December to February, which affect the growth and increase the gestation period by one or two years as compared to traditional zone (Mondal *et al*., 2007). Climate change is affecting NR plantations in different regions of India (Jacob and Satheesh, 2010). A recent study showed that one degree rise in temperature can reduce 9-16 per cent NR yield in the traditional region. On the other hand, in cold prone North East India, it is likely to show a positive stimulatory effect on NR productivity (Satheesh and Jacob, 2011). Very limited information is available on the effect of low temperature on the growth and productivity of *Hevea* clones (Das *et al*., 2010; 2013). It is necessary to evolve low temperature tolerant clones which would be suitable for the cold prone area of Sub-Himalayan West Bengal. Thus, the present study was undertaken to evaluate the growth and yield performance of eleven clones under the prevailing agro-climatic conditions of Northern West Bengal.

MATERIALS AND METHODS

The study was initiated in 1993 at the Regional Experiment Station (RES), Nagrakatta (Latitude: $26^0 43'$N, Longitude: $88^0 26'$E, Altitude: 69 above MSL), Jalpaiguri, West Bengal, India. Eleven *Hevea* clones (Haiken 1, PB 235, PB 280, PR 261, RRIC 104, RRII 105, RRII 208, RRII 300, RRII 308, SCATC 93/114 and a check clone RRIM 600) were evaluated. Planting was done employing randomized block design with three replicates, and nine plants in each replicate (16x16 ft.) on plain land with uniform soil fertility status.

The trees were opened for tapping ninth year of planting under half spiral alternate daily tapping with Sunday tapping rest (S/2 d2 6d/7). Three month tapping rest from mid-January to mid-April was given to avoid/escape from the cold stress at the time of defoliation and refoliation period. All cultural and management practices were followed as per the recommendation of the Rubber Board. Mean girth increment over 7 years of gestation period followed by 12 years of tapping period was calculated. Clear bole volume was estimated based on girth and first branching height from the bud union using the quarter girth method of Chaturvedi and Khanna, (1982). Yield data was recorded as fresh cup lump weight and computed into dry rubber yield by using regression equation $Y = 0.4355X+1.1428$ where Y= the dry weight and X is the fresh cuplump weight (Das *et al*., 2010). For winter yield contribution, yield data for non-winter (May to September) and winter (October to December) period was segregated. Tapping panel dryness (TPD) was recorded during November/December and a tree with 90 to 100 per cent dryness was considered as TPD affected trees. Standing dry shoot biomass was calculated using the Shorrocks regression model (Shorrocks *et al*., 1965) $W=0.002604\ G^{2.7826}$ where, G is the mean trunk girth at 150 cm from bud union. Incidence of powdery mildew disease was scored visually following the standard method.

RESULTS AND DISCUSSION

The mean seasonal meteorological data of the region over twenty two years (1991 to 2013) is provided as non-winter and winter period in order to understand the climatic constraints experienced by the clones (Table 1). The mean monthly minimum temperature (T_{min}) at the experimental site ranged from 12.5 ^{0}C during winter to 22.8 ^{0}C during non-winter, a greater seasonal range than for mean monthly maximum temperature (T_{max}) which ranged from 27.3 ^{0}C during winter to 31.6 ^{0}C during non-winter indicating that the fluctuation in minimum temperature is more pronounced in this region. The mean annual rainfall was concentrated mainly during non-winter months that cover May to September with 3,450 mm precipitation compared to winter which was only 311 mm. The range of monthly rainfall during summer was wider (59.3 mm to 1738 mm) than the winter period (0 mm to 522 mm). The mean monthly sunshine hour was 6.3 h during winter and 4.5 h in summer. The low sunshine hour in summer was mainly due to more cloudy days during the rainy months (May to September). The minimum temperature dropped below 8 ^{0}C during peak winter season (mostly during 2nd to 3rd week of January) indicating a severe cold weather prevailing in this region. The RH was not differing much during morning in winter and non-winter seasons; however, the difference was drastic during evening hours in between 57.0 to 72.5 per cent.

The growth performance of the clones with respect to girth and girth increment before and after tapping is presented in Table 2. At the time of panel opening girth of most of the clones was on par with that of the check clone RRIM 600 (51.2 cm). However, relatively higher girth was observed in RRII 208 (52.4), Haiken 1 (51.5) and SCATC 93/114 (51.0) and low girth in RRIC 104 (40.5 cm). After twelve years of tapping, maximum girth was observed in SCATC 93/114, followed by Haiken 1, PB 280, RRII 300 and PR 261. The annual mean girth increment during immature phase was significantly higher in Haiken 1 and PB 280 than the check clone RRIM 600. Contrary to that, RRIC 104 showed significantly higher girth increment in the mature stage after tapping. The rest of the clones were either on par or lower in girth increment than RRIM 600.The clear bole volume was high in RRII 308 followed by RRII 300 and PB 235. Haiken 1, PR 261, RRIC 104 and RRIM 600 showed similar bole volume and rest of the clones showed lower bole volume than the check clone. Clones with high girth and more bole volume are preferred for timber yield (Das *et al*., 2010). Although, no significant difference was observed in standing biomass the highest biomass accumulation was recorded in SCATC 93/114 followed by Haiken 1. In general, rubber clones loose their shoot biomass upon tapping. Recently, it is reported that various physiological factors are involved in tapping induced shoot biomass loss

Table 1. **Weather pattern at Nagrakata, Jalpaiguri, West Bengal (1991 to 2013)**

	T_{max}(^{0}C)		T_{min}(^{0}C)		Mean annual rain fall (mm)		Sunshine (hrs)		Relative Humidity (RH)(%)			
	Non-winter	Winter	Non-winter	Winter	Non-winter	Winter	Non-winter	Winter	Non-winter		Winter	
									RH I	RH II	RH I	RH II
Mean	31.6	27.3	22.8	12.5	3450	311	4.5	6.3	93.2	72.5	93.4	57.0
Range	27.9-33.6	19.2-36.6	15.7-26.8	5.5-23.5	59.3-1738	0.0-522	1.3-7.9	0.0-9.3	84.0-99.0	43.0-87.0	86.5-98.0	32.4-90.0

T_{max} -Maximum temperature; T_{min} - minimum temperature

Non-winter: April to September; Winter: October to December

Table 2. **Growth characteristics of different *Hevea* clones**

Clone	Girth				Clear bole volume at 21^{st} year (m^3)	Standing dry shoot biomass (kg $tree^{-1}$)
	At opening (cm)	At 21^{st} year (cm)	Girth increment before tapping (cm yr^{-1})	Girth increment after tapping (cm yr^{-1})		
Haiken 1	51.5	73.6	3.8*	1.8	0.13	408.4
PB 235	48.7	70.4	2.8	1.8	0.14	359.8
PB 280	49.9	73.0	3.8*	1.9	0.12	398.0
PR 261	48.8	71.5	3.4	2.0	0.13	376.7
RRIC 104	40.5	66.0	2.4	2.1*	0.13	301.6
RRII 105	51.0	65.9	2.8	1.2	0.11	299.7
RRII 208	52.4	68.7	3.2	1.4	0.10	336.5
RRII 300	48.7	72.2	3.1	2.0	0.16	386.1
RRII 308	42.9	67.1	2.2	2.0	0.17	315.1
SCATC 93/114	51.0	75.2	3.1	2.0	0.12	433.5
RRIM 600	51.2	70.6	2.7	1.6	0.13	363.5
Mean	48.7	70.4	3.0	1.8	0.12	364.3
SE	1.7	2.7	0.3	0.1	0.14	40.7
CD (P= 0.05)	NS	NS	0.93	0.43	NS	NS

(Annamalainathan *et al*., 2013). A large amount of ATP, sugar and proteins are lost through latex and all these putative factors account for the missing biomass in tapped trees.

The yield of Haiken 1 (45.3 g $tree^{-1}$ tap^{-1}), RRII 208 (42.4) and PB 280 (42.2 g $tree^{-1}tap^{-1}$) was superior to all other clones over the twelve years of tapping (Table 3) though they were statistically on par with RRIM 600 (40.6 g $tree^{-1}$ tap^{-1}). The clones RRII 105 and PR 261 showed better yield potential above grand mean yield. The lowest yield was recorded in SCATC 93/114 followed by RRIC 104. The superior yield potential of Haiken 1 was recorded in BO-1, BO-2 and BI-1 panel followed by PB 280 in BO-1, and RRII 105 in BI-1 panel while RRII 208 ranked first in BO-2 followed by Haiken 1. In general clones like PR 261, RRII 208 and RRII 105 showed higher yield potential in BO-2 panel than the mean yield in BO-1 panel. In BO-2 panel, RRII 208, Haiken 1 and RRII 105 were superior to the check clone and registered higher yield potential than mean yield. However, in BI-1 panel only Haiken 1 showed significantly higher yield compared to check clone. The yield of clones PB 235, RRII 208, PR 261, PB 280 and RRII 105 were on par in BI-1 panel (Table 3).

The coefficient of variation (CV) for yield potential over the 12 years (Table 3) varied from 25.4 to 38.3 per cent. Among the high yielding clones the CV for Haiken 1 and RRII 208 was on par with that of the check clone. Significantly higher CV was observed in RRII 308, PB 235, RRIC 104 and RRII 105 as compared to check clone. Low CV with high yield is considered to be a good indicator of stable yield (Das *et al*., 2010).

Winter yield contribution per cent varied significantly among the clones and ranged from 56.7 to 62.5 per cent (Table 3). Among the high yielding clones, RRII 208

Table 3. **Yield pattern of different clones**

Clone	Average yield over 12 years (g tree^{-1}tap^{-1})	CV for yield (%)	Panel wise yield (g tree^{-1}tap-^{1}) BO-1 over 5 years	BO-2 over 5 years	BI-1 over 2 years	Winter yield contribution (%)
Haiken 1	45.3	29.3	34.8	50.7	58.1 **	58.1
PB 235	36.3	38.1 *	23.5	44.9	46.7	58.7
PB 280	42.2	27.5	34.5	47.8	47.5	56.7
PR 261	37.4	25.4	29.9	40.8	47.2	62.5 **
RRIC 104	26.9	36.9 *	17.5	32.4	36.8	62.3 **
RRII 105	40.2	36.1 *	28.4	48.8	48.4	59.5
RRII 208	42.4	33.9	29.4	53.6	46.9	58.4
RRII 300	34.9	33.8	23.9	42.5	43.7	60.2
RRII 308	34.8	38.3 *	23.0	42.6	44.4	61.5 *
SCATC 93/114	25.7	34.6	17.8	30.1	34.6	58.0
RRIM 600	40.6	25.5	32.2	48.0	43.4	58.3
Mean	37.0	32.7	26.8	43.8	45.3	59.5
SEM	1.8	3.3	1.9	2.8	2.7	0.9
CD	NS	9.7	NS	NS	8.1	2.5

* significant at P<0.05; **significant at P<0.01

showed highest winter yield contribution (58.4%), whereas Haiken 1 and PB 280 showed better yield than the check clone. Conversely, PR 261, RRIC 104 and RRII 308 being poor yielders, showed better winter yield contribution. These results indicated that all the high yielding clones were not contributing better yield during winter. For the agro-climate of North East areas like Nagrakata, preference should be given to those clones whose performance is consistent in both winter and non-winter seasons for further recommendation. Under the same agro-climate, Das *et al*. (2010) reported that RRII 208 showed stable yield potential both in winter and non-winter seasons. Similarly, Priyadarshan *et al*. (2000) reported consistent performance of several clones from Tripura. Studies on relationship between long term yield of several *Hevea* clones with climatic parameters such as sunshine hours, rain fall, RH, T_{min} and T_{max} in Kerala indicated moderate level of decrease in yield with increasing T_{max} (Gireesh, *et al*., 2011). Modulation in activities of chloroplast and its structure in Haiken 1 and SCATC 88/13 may confer cold tolerance in these clones (Sarkar *et al*., 2013).

The yield performance of Haiken 1, RRII 208 and PB 280 was found to be better than RRIM 600 and the growth performance of SCATC 93/114, Haiken 1 and PB 280 found better than all the other clones. Although, SCATC 93/114 attained highest girth, its crop yield was the lowest among the clones over twelve years of tapping. Haiken 1 and PB 280 were superior in growth as well as yield potential. These results indicated that growth and yield potential are not always related but independently controlled (John *et al*., 2004; Das *et al*., 2010). Gireesh *et al*. (2011) reported that RRII 208 did not show any response to temperature fluctuation while RRIM 600 showed a varied response in yield with time over seasons under the climatic conditions of Kerala. Major factors limiting the growth and productivity of rubber trees in North eastern states were studied (Meti *et al*., 1999; Priyadarshan and Goncalves, 2003; Das *et al*., 2013). Rubber trees suffered from cold stress when temperature went down below 5 ^{0}C or remain below 10 ^{0}C for a prolonged period of time (Priyadarshan *et al*., 2005) and reduced the latex production for one to three months per year (Jacob *et al*., 1999). On the other hand, a reduction in rubber yield was observed when temperatures was above 28 ^{0}C (Priyadarshan and Clement-Demange, 2004). Recently, Mondal *et al*. (2012) evaluated several clones under the agro-climate of Assam and found that RRII 208 and RRIM 600 showed above average yield potential under two different tapping system.

The production potential of any crop is an integrated effect of weather attributes along with soil environment. In non-traditional areas due to the stressful weather and depletion of essential micronutrients as well as organic carbon adequate fertilizer application is mandatory at the early stage of establishment of the crop (Jacob *et al.*, 1999). Rubber, being a perennial crop, has a long economic life span undergoing environmental interaction which manifests variation in yield pattern. These variations may be due to physiological and biochemical changes which are regulated by climatic factors (Alam *et al*., 2003; Dey *et al*., 1999).

The incidence of TPD is as old as the commencement of commercial rubber plantation industry though its intensity has increased in recent decades, due to close association between high yield potential and susceptibility to TPD (Jacob and Krishnakumar, 2006). A clone with high yield potential with low incidence of tapping panel dryness (TPD) is more preferable. In the present study high TPD incidence was observed in SCATC 93/114 followed by RRIC 104 and RRII 105. Conversely, TPD incidence was minimum in PB 235, Haiken 1 and RRII 300, whereas it was moderate in RRII 208 and RRIM 600 (Table 4). Seasonal variation of TPD was also reported under the climatic conditions of Tripura (Das *et al.,* 2005).

The percentage of wind damage ranged from 0 to 18 per cent. Maximum wind damage was observed in RRII 208 followed by PB 280, PR 261 and RRII 308 and minimum in RRIM 600. At the time of refoliation all the clones were affected by powdery mildew disease with varying intensity (Table 4). Among the high yielding clones Haiken 1, RRII 208 and the check clone showed certain degree of tolerance to

Table 4. **Incidence of tapping panel dryness (TPD), wind damage and incidence of powdery mildew disease in different clones**

Clone	TPD affected plants (%)	Wind damage (%)	Powdery mildew disease incidence* (%)
Haiken1	4.0	7.4	10
PB 235	3.9	3.7	20
PB 280	5.0	11.1	20
PR 261	9.1	11.1	20
RRIC 104	15.4	3.7	30
RRII 105	13.0	7.4	30
RRII 208	6.3	18.5	10
RRII 300	4.0	7.4	30
RRII 308	4.4	11.1	20
RRIM 600	11.1	0.0	10
SCATC 93/114	18.5	3.7	10

*visual observations

Oidium infection while rest of the clones were moderate to highly susceptible. Mondal *et al*. (2007) also reported varying levels of *Oidium* infection from North East.

CONCLUSION

In conclusion, it can be stated that among the eleven clones included in this study Haiken 1 was the highest yielder over twelve years of tapping followed by RRII 208 and PB 280. Although, the clones PR 261, RRIC 104 and RRII 308 showed significantly higher winter yield contribution, the clones Haiken 1, RRII 208 and PB 280 were also found to be performing better under low temperature condition and identified as the most suitable clones for the region from the present study. However, for further confirmation, these clones need to be tested in grower's field.

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