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LONG TERM PERFORMANCE OF SOME PRIMARY AND HYBRID CLONES UNDER THE AGROCLIMATE OF SUB-HIMALAYAN WEST BENGAL, INDIA

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Twenty six clones from India, China, Malaysia, Indonesia and Sri Lanka, cultivated under the agroclimate of Sub-Himalayan West Bengal were evaluated for girth (over 24 years) and yield (over 19 years). A wide range of variability in terms of girth, timber volume, annual yield, yield in different panels and monthly yield was observed. The Chinese clone SCATC 88/13 ranked first with significantly high timber volume, biomass and high yield over different years and months compared to RRIM 600, the widely planted clone in the region SCATC 88/13 can be considered as a suitable clone for this region.

Key words: Clone evaluation, Chinese clone, *Hevea brasiliensis*, Natural rubber, Sub-Himalayan West Bengal, Yield

INTRODUCTION

Cash crop farming, also called as commercial farming / cash cropping, is enthusiastically accepted by the farmers because of its good return. Rising demand of natural rubber and scarcity of land in the traditional belt of India led to expansion of diverted rubber cultivation in non-traditional area, especially northeastern India. To get a profitable income from rubber, cultivating high yielding clones is inevitable; and adaptation to agroclimate of the region is also one of the characters to be highlighted. However, secondary characters like tolerance to major diseases, timber volume, incidence of tapping panel dryness syndrome, wind damage *etc*. are also important. With all these in the background, large scale clone trials were initiated in 1990 in Northern part of West Bengal to evaluate clones specific for the region. Effort was taken to initiate multidisciplinary clone evaluation trials in this region to explore scope for maintaining clonal diversity, ensuring better ecological sustainability and appreciable economic return.

MATERIALS AND METHODS

The present study was conducted at Nagrakata in Jalpaiguri district of sub-Himalayan West Bengal situated at the latitude of 26^{0}432 N, longitude of 88^{0}26′ E

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and altitude of 69 m MSL. With low winter temperature of below 8°C and mean annual rainfall being 3790 mm (Fig. 1), this region experiences severe cold stress. Moreover, number of sunshine hours per day prolonged (5.8 to 7.2 hour) during winter period. It is reported that low winter temperature with prolonged sunshine affects rubber plants adversely (Alam *et al.*, 2005).

Four trials were initiated in 1990, 1992 and 1994 with 26 different clones in RBD with 4.5 x 4.5 m spacing in three replications with a plot size of 36 plants. As all the trials completed more than 24 years and distance between the trials was not more than 100 m. The recommended clone for NE India, RRIM 600 was used as the check clone along with clones originated from India, China, Malaysia, Indonesia and Sri Lanka (Table 1). The clones used were primary as well as hybrid clones of different parent combinations. Girth during tapping stage was recorded annually and dry rubber yield of clones was recorded on monthly basis. Rainguard was fixed for conducting tapping during rainy season.

Biomass was estimated from girth following the equation developed by Shorrocks *et al.*, (1965) and timber volume was computed based on girth and first branch height following true volume method (Chaturvedi and Khanna, 1982) 24 years after planting. Trees were tapped in S/2 d2 6d/7 system. Pre-winter yield contribution (from October to December) was calculated from the monthly yield. Yield improvement over RRIM 600 (check clone), wind damage and TPD incidence was calculated on percentage

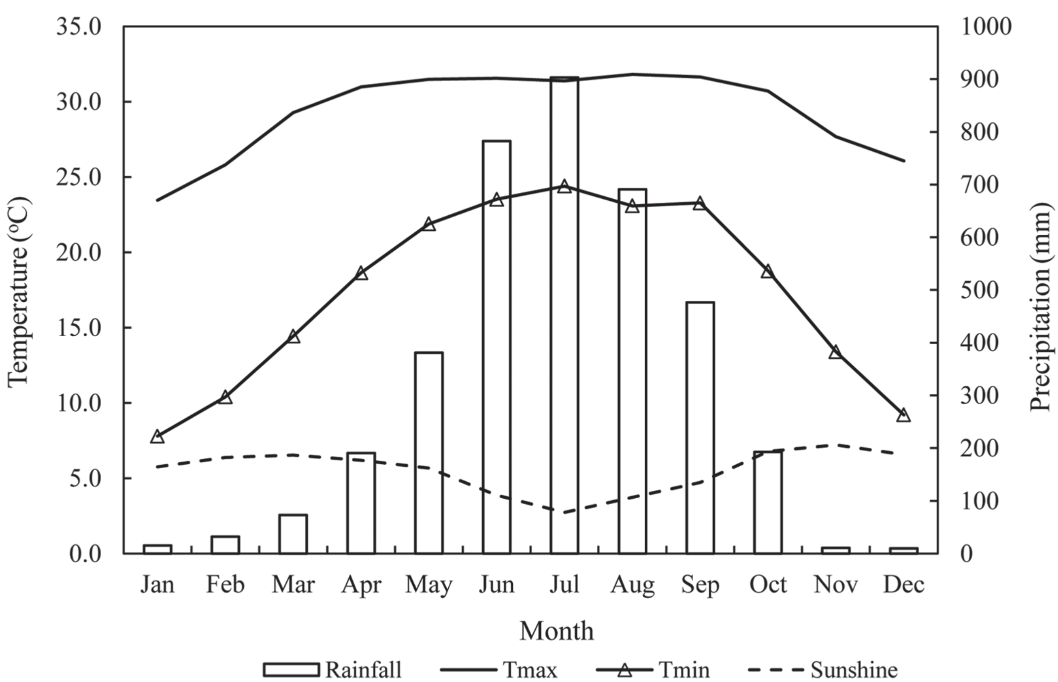

Fig. 1. Monthly mean weather variables in Nagrakata, Jalpaiguri under Sub-Himalayan West Bengal over 20 years

Table 1. **Details of experimental clones in Nagrakata, Jalpaiguri, West Bengal in 1990-94**

Name of clones	Country of origin	Parentage	Name of clone	Country of origin	Parentage
Gl 1	Malaysia	Primary clone	PR 107	Indonesia	Primary clone
PB 235	Malaysia	PB 5/51 x PB S/78	PR 261	Indonesia	Tjir 1 x PR 107
PB 260	Malaysia	PB 5/51 x PB 49	RRIC 102	Sri Lanka	RRIC 52 x RRIC 7
PB 280	Malaysia	Primary clone	RRIC 104	Sri Lanka	RRIC 52 x Tjir 1
PB 310	Malaysia	PB 5/51 x RRIM 600	RRII 105	India	Tjir 1 x GL 1
PB 311	Malaysia	RRIM 600 x PB 235	RRII 118	India	Mil 3/2 x Hil 28
PB 5/51	Malaysia	PB 56 x PB 24	RRII 203	India	PB 86 x Mil 3/2
PB 86	Malaysia	Primary clone	RRII 208	India	Mil 3/2 x AVROS 255
RRIM 605	Malaysia	PB 49 x Tjir 1	RRII 300	India	Tjir 1 x PR 107
RRIM 612	Malaysia	AVROS 157 x PB 49	RRII 308	India	GL 1 x PB 6/50
RRIM 703	Malaysia	RRIM 600 x RRIM 500	SCATC 88/13	China	RRIM 600 x Pil B 84
RRIM 600	Malaysia	Tjir 1 x PB 86	SCATC 93/114	China	TR 31-45 x HK 3-11
GT 1	Indonesia	Primary clone	Haiken 1	China	Primary clone

Table 2. **Growth characteristics of different clones 29 years after planting**

Clone	Girth (cm)	Biomass (kg tree^{-1})	Bole Vol (m^3 tree^{-1})	Clone	Girth (cm)	Biomass (kg)	Bole Vol (m^3)
GL 1	71.3	542 *	0.	RRIC 104	69.3	374	0.1
GT 1	80.8	749 **	0.2	RRII 105	69.5	528	0.1
Haiken1	81.5 *	446	0.2	RRII 118	91.6 **	498	0.2 **
PB 235	81.5 *	441	0.2	RRII 203	76.0	457	0.2 *
PB 260	72.2	542 *	0.1	RRII 208	75.7	450	0.1
PB 280	76.3	465	0.1	RRII 300	79.5	345	0.1
PB 310	76.7	645 **	0.1	RRII 308	72.7	387	0.1
PB 311	77.1	573 **	0.1	RRIM 605	86.9 **	797 **	0.2 **
PB 5/51	77.2	448	0.2 **	RRIM 612	93.6 **	651 **	0.2 **
PB 86	86.8 **	394	0.2 **	RRIM 703	86.8 **	646 **	0.2 **
PR 107	83.2 **	505	0.2 **	SCATC 88/13	79.1	524 **	0.2 **
PR 261	76.1	463	0.1	SCATC 93/114	87.1 **	646 **	0.2 **
RRIC 102	80.5	347	0.2 *	RRIM 600	77.6	472	0.1
				CD ($P \geq 0.05$)	3.7	68.6	0.0

* = Significant at 5 per cent level; ** = Significant at 1 per cent level

basis. Cumulative yield was calculated converting the monthly yield to Kg per hectare (per 400 trees). Powdery mildew caused by *Oidium*, the major disease of this region, was scored visually following the standard method under sulphur dusted condition. Analysis of variance and ANOVA was done adopting standard proceedure.

Table 3. **Yield over 19 years of tapping**

Clone	Annual yield ($g\ t^{-1} t^{-1}$)	Winter yield contribution (%)	Yield improvement over RRIM 600 (%)
GL 1	26.1	45.9 **	(-) 33.6
RRIM 612	27.5	50.8 **	(-) 30.2
RRIC 102	29.0	45.0 **	(-) 26.3
RRIC 104	29.4	45.1 **	(-) 25.3
PB 5/51	29.5	47.8 **	(-) 25.1
PB 260	29.9	47.3 **	(-) 24.1
PR 107	30.2	48.0 **	(-) 23.4
SCATC 93/114	31.1	42.6	(-) 20.9
PB 86	32.0	45.9 **	(-) 18.6
RRII 203	34.4	42.8	(-) 12.6
RRII 105	35.3	46.0 **	(-) 10.3
RRII 118	35.5	44.9 **	(-) 9.9
RRII 300	35.6	45.3 **	(-) 9.5
Haiken1	36.0	43.9	(-) 8.4
RRII 308	36.9 #	44.1 *	(-) 6.1
PB 310	37.2 #	45.5 **	(-) 5.4
GT 1	37.6 #	47.0 **	(-) 4.6
PB 311	39.4 #	40.8	(+) 0.2
PB 235	39.8 #	45.4 **	(+) 1.3
RRIM 605	39.8 #	48.7 **	(+) 1.2
PR 261	39.8 #	42.3	(+) 1.3
RRIM 703	39.9 #	43.3	(+) 1.4
RRII 208	41.6 #	45.0 **	(+) 5.8
PB 280	42.2 #	39.5	(+) 7.3
SCATC 88/13	46.3 **	42.7	(+) 17.6
RRIM 600	39.3	42.5	
CD (P≥0.05)	3.0	1.5	

* = Significant at 5 per cent level; ** = Significant at 1 per cent level; # = At par with RRIM 600

RESULTS AND DISCUSSION

Significant clonal variation was observed in girth (Table 2). Nine clones showed significant higher girth at 24th year than RRIM 600 while 11 clones were at par with the check clone. Nine clones showed significant higher biomass than RRIM 600. Clear bole volume of 11 clones was significantly higher than the check clone. It was observed that girth, biomass and timber volume of RRIM 605, RRIM 612, RRIM 703 and SCATC 93/114 were significantly higher than the check. Girth and clear bole volume of PB 86, PR 107 and RRII 118 was higher than that of RRIM 600, but their biomass was not significantly higher. Better girth and timber volume was reported earlier for Haiken 1 and SCATC 93/114 by Das *et al*. (2010) but such girth vs. timber volume correlation was not observed for many other clones, (Kumar *et al*., 2015) though clones with high girth and high timber volume was favoured (Viswanathan *et al*., 2002). This must be because bole height has a greater bearing on timber volume than girth of the tree.

Out of 26 different clones, only one clone *viz*. SCATC 88/13 showed significantly higher yield than RRIM 600 over 19 years of tapping. Eleven clones yielded at par with that of the check clone (Table 3). Winter yield contribution of this prospective clone was not significantly higher indicating that it gave fairly uniform yield throughout the year; with an overall annual yield improvement of 17.6 per cent over RRIM 600. RRII 208 and PB 280 were the other high yielders with 5.7 to 7.3 per cent yield improvement over RRIM 600 (Table 3). Winter yield contribution of 17 clones was significantly higher than RRIM 600.

Distribution of yield in virgin panels (BO.1 and BO.2) and renewed panels (B1.1 and B1.2) were calculated from the yearly yield data (Table 4). In virgin panel, SCATC 88/13 showed higher yield than RRIM 600; this was followed along with PR 260 in BO.1

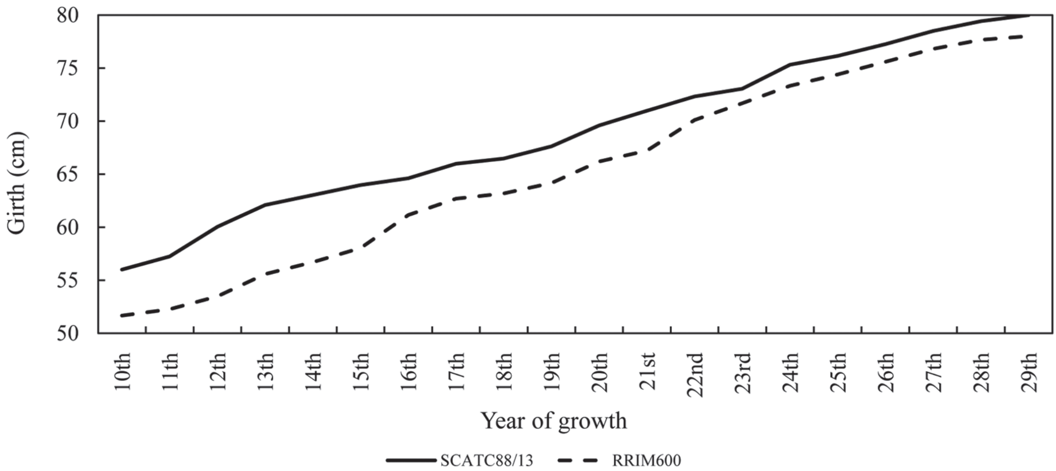

Fig. 2. Growth pattern of clone SCATC 88/13 on tapping compared to RRIM 600

and, RRIM 605 and RRII 208 in BO.2 panels. In renewed panels *i.e.* B1.1 and B1.2 panels, SCATC 88/13, RRIM 703, PB 311, PB 280, and PB 235 showed higher yield than the check clone; RRII 208 showed higher yield in B1.1 panel also. In terms of the panel wise mean yield, the Chinese clone SCATC 88/13 showed its superiority in virgin as well as renewed panels with almost uniform yield improvement in both the panels.

Progressive growth and temporal yield variations of the highest yielding clone SCATC 88/13 compared to RRIM 600 is depicted in Figures 2 and 3. Girth of the clone after tapping showed a progressive increase (Fig. 2); throughout the year, which was more pronounced especially in the initial years of tapping. While comparing the yield patterns, it was observed that yield contribution of SCATC 88/13 was higher than RRIM 600 all through the tapping months. During July, August and September (Fig. 3a), there was not much difference between the yield of the two clones but during winter months (October to December) SCATC 88/13 produced higher yield than RRIM 600. While considering the annual mean yield (Fig. 3b), in almost all the years the annual yield of SCATC 88/13 was higher than that of RRIM 600. Cumulative yield over 19 years (Fig. 3c) of the potential clone showed consistently higher yield from first year of tapping itself compared to RRIM 600. The supremacy of SCATC 88/13 over RRIM 600 for high dry rubber yield and adaptation under the agroclimate of Sub-Himalayan West Bengal could be confirmed in the long term from the present results.

Secondary characters like wind fastness, TPD incidence and severity of powdery mildew disease was assessed at the end of study period (Table 5). In 16 clones wind damage was higher than RRIM 600; per cent wind damage of other clones was at par with RRIM 600. Wind damage was not observed in clones PB 260, PB 5/51 and RRIC 104. In PB 280, RRII 203 and RRIM 612, incidence

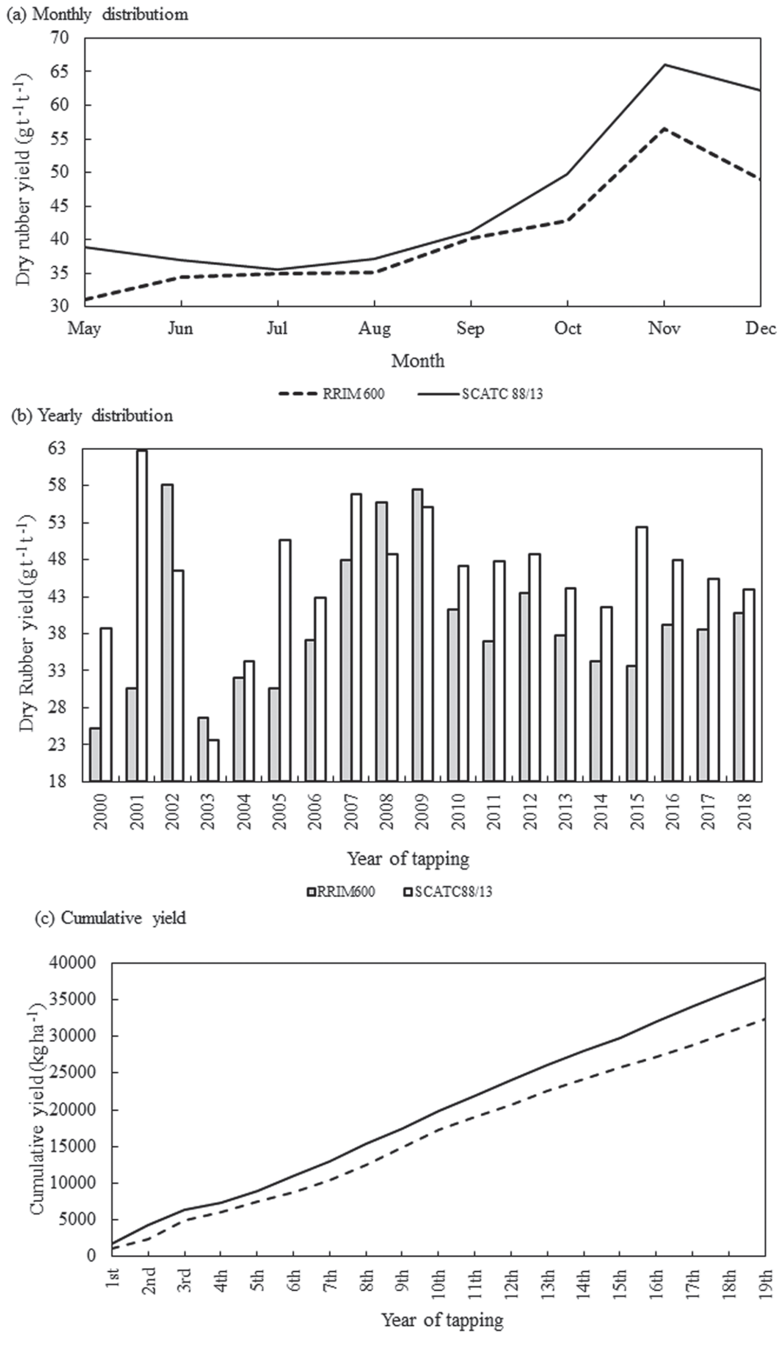

Fig. 3. Yield pattern in potential clone SCATC 88/13 over 19 years a. Monthly distribution b. Yearly distribution C. Cumulative yield

Table 4. **Yield distribution in different panels over 19 years of tapping**

Clone	Yield in BO.1 panel ($g\ t^{-1} t^{-1}$)	Yield in BO.2 panel ($g\ t^{-1} t^{-1}$)	Yield in B1.1 panel ($g\ t^{-1} t^{-1}$)	Yield in B1.2 panel ($g\ t^{-1} t^{-1}$)	Per cent yield improvement from virgin panel (BO.1&BO.2) to renewed panel (B1.1&B1.2)
GL 1	21.7	30.5	25.6	26.8	(+) 0.5
GT 1	25.4	43.0	41.2	41.3	(+) 20.5
Haiken1	28.1	39.7	39.4	37.1	(+) 12.8
PB 235	29.4	45.7	43.2 **	41.4 *	(+) 12.7
PB 260	22.1	33.9	32.2	29.8	(+) 10.9
PB 280	29.5	45.0	44.3 **	45.6 **	(+) 20.8
PB 310	22.1	42.6	41.3	40.5	(+) 26.5
PB 311	32.0	39.9	42.7 **	44.0 **	(+) 20.4
PB 5/51	22.3	29.8	32.6	34.2	(+) 28.1
PB 86	22.8	35.8	34.7	35.3	(+) 19.9
PR 107	19.2	30.3	35.3	37.2	(+) 46.4
PR 261	46.9 **	37.4	40.3	37.4	(-) 7.5
RRIC 102	22.1	30.5	31.5	30.9	(+) 18.7
RRIC 104	21.5	28.7	33.2	31.4	(+) 28.6
RRII 105	28.7	43.3	37.9	30.1	(-) 5.5
RRII 118	23.4	39.2	40.4	39.6	(+) 27.8
RRII 203	27.6	38.6	34.6	37.2	(+) 8.3
RRII 208	31.4	50.5 *	43.6 **	40.9	(+) 3.2
RRII 300	26.3	36.6	41.1	39.2	(+) 27.7
RRII 308	31.8	38.8	39.3	35.5	(+) 5.9
RRIM 605	31.0	54.5 **	39.4	33.1	(-) 15.3
RRIM 612	21.2	32.1	31.5	24.6	(+) 5.3
RRIM 703	28.8	43.6	44.8 **	42.9 **	(+) 21.4
SCATC 88/13	41.1 **	50.8 **	45.9 **	47.5 **	(+) 1.5
SCATC 93/114	23.6	31.5	35.4	34.8	(+) 27.5
RRIM 600	34.5	45.8	38.8	38.0	(-) 4.3
CD ($P \geq 0.05$)	3.8	4.2	2.9	3.3	

* = Significant at 5 per cent level; ** = Significant at 1 per cent level

of tapping panel dryness was higher than RRIM 600. Incidence of TPD in nine clones including SCATC 88/13 was at par with the check clone. This Chinese clone was moderately tolerant to powdery mildew disease (PMD). Eleven clones showed moderate tolerance to PMD. Two clones *viz.* PB 5/51 and RRII 300 were highly susceptible to PMD whereas ten clones including the check clone were susceptible to PMD.

Table 5. **Secondary characters of clones 23 years after planting**

Clone	Wind damage (%)	TPD %	PMD susceptible / tolerance	Clone	Wind damage (%)	TPD %	PMD susceptible / tolerance
GL 1	4.3	9	S	RRIC 104	0.0	4	S
GT 1	15.6 **	4	MT	RRII 105	14.3 **	6	HS
Haiken1	8.3	6	MT	RRII 118	12.9 **	4	S
PB 235	11.0 **	1	HS	RRII 203	3.6	15 **	MT
PB 260	0.0	0	S	RRII 208	12.1 **	3	MT
PB 280	20.6 **	15 **	MT	RRII 300	12.9 **	2	HS
PB 310	20.6 **	7	MT	RRII 308	15.6 **	7	S
PB 311	27.0 **	0	MT	RRIM 605	17.9 **	4	S
PB 5/51	6.9	0	HS	RRIM 612	12.9 **	10 *	S
PB 86	17.2 **	6	MT	RRIM 703	9.4 *	7	MT
PR 107	6.5	1	S	SCATC 88/13	6.3	7	MT
PR 261	12.9 **	4	MT	SCATC 93/114	8.0	2	MT
RRIC 102	10.0 **	7	S	RRIM 600	5.3	7	S
				CD ($P \geq 0.05$)	3.8	2.3	

* = Significant at 5 per cent level; ** = Significant at 1 per cent level; S = Susceptible; MT = Moderately tolerant; HS = Highly susceptible

The long term study on performance of clones under the agroclimate of Sub-Himalayan West Bengal revealed a wide range of variability with regards to all aspects of growth and yield performance of clones. Superiority of SCATC 88/13 was very prominent in terms of growth and yield. With significantly higher biomass and higher timber volume and better girth than the check, SCATC 88/13 showed its potential to be a good timber clone also. Superiority of this clone in terms of dry rubber yield, annually as well as in virgin and renewed bark compared to that of RRIM 600 was worthy. The yielding period in this region was mainly from May to December (8 months). The winter contribution (October to December) of SCATC 88/13 was 42.7 per cent which means the contribution over six non-winter months was 57.3 per cent - which explained that the yield over months was comparatively uniform. Under the agroclimate of Tripura, one of the states in NE India, potential of SCATC 88/13 was reported earlier (Priyadarshan *et al.*, 1998). Evaluation of half-sib progenies under the agroclimate of Sub-Himalayan West Bengal, revealed prepotency of this Chinese clone (Das *et al.*, 2019). This clone is a moderate yielder in the traditional rubber growing region of South India also (Varghese *et al.*, 2006). Considering all the aspects explained above, SCATC 88/13 emerges as a suitable clone planting in cold prone North Eastern states. Further evaluation under on farm trials is needed for considering this clone for evaluation on a commercial scale.

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