Natural Rubber Research, **23**(1&2): 12-19, 2010

COMPARATIVE GROWTH AND YIELD PERFORMANCE OF *HEVEA* CLONES UNDER THE AGROCLIMATIC CONDITIONS OF TRIPURA

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Antony, P. D., Dey, S. K. and Meenakumari, T. (2010). Comparative growth and yield performance of *Hevea* clones under the agroclimatic conditions of Tripura. *Natural Rubber Research*, **23** (1&2): 12-19.

The growth and yield performance of 13 *Hevea* clones were evaluated in Tripura in North East India which experiences a non-traditional environment for rubber cultivation. Analysis of growth performance of the clones revealed that RRII 429 had the highest girth and girth increment during immature phase. Clone RRII 176 recorded significantly higher girth increment under tapping than the check clone, RRIM 600 and attained the highest girth after six years of tapping. Yield analysis showed that RRII 422, RRII 429 and RRII 417 had significantly superior yield compared to RRIM 600 after six years of tapping. Among the clones tested, RRIM 600 had the lowest yield reduction during both summer and winter periods indicating the adaptability of the clone to the climatic conditions of Tripura. The results of the present study will aid in the identification of potential clones for commercial cultivation in this region.

Keywords: Clone evaluation, *Hevea*, North East India, Tripura

INTRODUCTION

The demand for natural rubber (NR) is increasing concomitant with industrial growth and this necessitates enhancing its production. *Hevea brasiliensis* (Willd. ex A. Juss.) Muell. Arg., the Para rubber tree, which is the commercial source of NR, is indigenous to the forests of Amazon basin, located within 5^0 latitude of the equator, where the climate is dominantly of wet equatorial type (Strahler, 1969). Later, the crop was introduced to other regions of the globe. The growth of the Indian rubber plantation industry has been mainly through the expansion of rubber cultivation in Kerala (Thomas and Panikkar, 2000) and the major portion of rubber growing areas in India is confined to the West coast of the country (8^0 to 12^0 North). Growing demand for NR, coupled with the limited scope for area expansion in the traditional region has necessitated an increase in production from the non-traditional regions of rubber cultivation like North East India. Though genetically adapted to a tropical environment, rubber cultivation has proved to be commercially viable in subtropical environments of North East India and China (Vijayakumar *et al.*, 2000). The state of Tripura ($22^0 56'$-$24^0 32'$N and $91^0 10'$-$92^0 21'$E) in North East India represents a non-traditional environment for rubber cultivation. Tripura has subtropical warm humid climate with a

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conspicuous winter season limiting growth and yield of rubber (Sasikumar *et al.*, 2001) and this has resulted in low productivity. Average annual productivity in Tripura was 1097 kg/ha (Rubber Board, 2009) compared to the national average of 1867 kg/ha (Rubber Board, 2010), which warrants the development of high yielding clones for the region. *Hevea* breeding being an elaborate process spanning over 20 years, the evaluation of known high yielding clones under the climatic conditions of Tripura will accelerate the identification of promising clones. The present trial involving 13 clones was taken up as part of a multi-locational study to assess their growth and yield performance and to identify suitable clones for commercial cultivation in this region.

MATERIALS AND METHODS

The clone evaluation trial comprised of 13 clones (Table 1) including the RRII 400 series planted at the Research Farm of the Rubber Research Institute of India at Taranagar, Agartala (23°53'N; 91°15'E; 30 m above msl) during 1996 with RRIM 600 as the local check clone. Planting was done at a spacing of 4.9 x 4.9 m in randomized block design with three replications, each plot having 36 trees (gross plot) of which 16 were observational trees excluding border rows. Girth was recorded at a height of 150 cm from bud union in the month of February every year and annual girth increment was calculated. Trees were test-tapped during November 2000 following the standard method and the latex from 10 tappings was collected, coagulated, dried and weighed. Regular tapping commenced in August 2003 under S/2 d2 6d/7 system of tapping. Tree-wise yield data for each clone was recorded at fortnightly intervals and dried cuplump weight was recorded. Yield reduction during summer and winter period was calculated by deducting the summer (May) and winter (December- January) yields respectively from peak yield (November) obtained in that year and expressed as percentage. Since the region experiences low temperature stress, tapping rest was given for two months (February –March) every year. Data recorded up to January 2009 were statistically analysed using CROPSTAT version 7.2.

Table 1. **Percentage and country of origin of clones**

Clone	Parentage	Country of origin
RRII 51	Primary clone	India
RRII 105	Tjir 1 x Gl 1	India
RRII 176	Mil 3/2 x PB 5/60	India
RRII 203	PB 86 x Mil 3/2	India
RRII 414	RRII 105 x RRIC 100	India
RRII 417	RRII 105 x RRIC 100	India
RRII 422	RRII 105 x RRIC 100	India
RRII 429	RRII 105 x RRIC 100	India
RRII 430	RRII 105 x RRIC 100	India
RRIC 100	RRIC 52 x PB 86	Sri Lanka
RRIM 600	Tjir 1 x PB 86	Malaysia
PB 217	PB 5/51 x PB 6/9	Malaysia
PB 235	PB 5/51 x PB S/78	Malaysia

RESULTS AND DISCUSSION

Growth during the initial years is crucial for *Hevea* especially with respect to attainment of tappable girth. At the time of opening the trees for tapping, RRII 429 (53.6 cm), RRII 203 (51.3 cm) and RRII 417 (50.7 cm) had significantly higher girth than RRIM 600 (47.8 cm). Girth of all other clones was comparable to that of RRIM 600 (Table 2). Clones RRII 429 and RRII 105 recorded the highest and the lowest girth at opening, respectively. Analysis of girth at six years

Table 2. **Growth performance of the clones over twelve years after planting**

Clone	Girth (cm) at opening (August, 2003)	Girth (cm) on 6th year of tapping (February, 2009)	Trees (%) under tapping (February, 2009)
RRIM 600	47.8	62.9	88.9
RRII 429	53.6	67.7	89.8
RRII 203	51.3	65.7	98.1
PB 217	50.0	64.0	98.1
RRII 51	47.2	60.1	67.6
RRII 414	50.4	59.9	87.0
RRII 430	49.5	59.3	99.1
RRIC 100	50.1	65.7	78.7
RRII 422	48.7	60.3	89.8
RRII 105	46.5	60.0	77.8
RRII 417	50.7	61.3	94.4
RRII 176	48.2	67.9	78.7
PB 235	47.3	62.3	97.2
SE	1.0	1.1	
CD (P = 0.05)	2.9	3.3	

Table 3. **Mean annual girth increment of the clones over 12 years**

Clone	Immature period* (cm/year)	Mature period@ (cm/year)
RRIM 600	7.53	2.31
RRII 429	8.79	2.16
RRII 203	8.35	2.08
PB 217	7.91	2.09
RRII 51	7.54	2.09
RRII 414	8.43	1.53
RRII 430	8.04	1.61
RRIC 100	8.22	2.31
RRII 422	7.92	1.82
RRII 105	7.71	2.23
RRII 417	8.45	1.71
RRII 176	7.34	2.94
PB 235	7.57	2.50
SE	0.18	0.14
CD (P = 0.05)	0.53	0.41

*February 1998 to February 2003; @ March 2003 to February 2009

after commencement of tapping revealed that RRII 429 and RRII 176 had significantly higher girth and RRII 430 had significantly lower girth than RRIM 600. Results show that RRII 429 had high vigour during immature as well as mature phases of growth. High vigour of RRII 429 in traditional and non-traditional regions has been reported earlier (Meenattoor *et al.*, 2000). Twelve years after planting, the number of trees under tapping was the highest for RRII 430 (99.1%) followed by RRII 203 and PB 217 (98.1%) and the lowest was for RRII 51 (67.6%). Average vacancy percentage in the trial was 11.2 in the thirteenth year of planting.

In the immature phase, clones RRII 429, RRII 417, RRII 414, RRII 203 and RRIC 100 had significantly higher girth increment than RRIM 600 (Table 3). During this phase, RRII 429 (8.79 cm/year) and RRII 176 (7.34 cm/year) recorded the highest and the lowest annual girth increment, respectively. On the contrary, girth increment under tapping was the highest for RRII 176 (2.94 cm/year) and this was significantly higher than RRIM 600. RRII 422, RRII 417, RRII 430 and RRII 414 had significantly lower annual girth increment under tapping than the check clone. This indicates the difference in the capability of clones to synthesize and partition photosynthates. A change in the relative growth rate of clones after tapping has been reported earlier (Jayasekera *et al.*, 1994). Though the girth increment of the RRII 400 series clones during immature period is comparable with the published reports from the traditional zone (Mydin *et al.*, 2005), considerable reduction was observed under tapping in Tripura. This reduction in girth increment may be attributed to the adverse climatic conditions prevalent during winter period which follows the peak yielding period. Considerably low increment in girth in winter than in summer has been reported earlier (Meenattoor *et al.*, 1991).

Test tap yield has been identified as a good criterion for early selection of promising clones (Licy *et al.*, 1998). However, analysis of yield on test tapping at four and a half years after planting did not reveal any significant variation among the clones tested (Table 4). Mean test tap yield per tree for 10 tappings (g/t/10t) was the highest for clone RRII 417 (78.6) followed by RRII 105 (61.3) and the lowest was for RRIC 100 (39.6). Mature tree yield over six years of regular tapping (five years in panel BO-1 and one year in BO-2 panel) revealed that clones RRII 422 (44.2 g/t/t)), RRII 429 (42.4 g/t/t) and RRII 417 (38.2 g/t/t) had significantly higher yield than the check clone, RRIM 600 (33.8 g/t/t). The projected yield (kg/ha/year) of the high yielding clones RRII 422 and RRII 429 thus works out to 1770 and 1698, respectively. Clones RRII 422, RRII 429, RRII 417 and RRII 430 exhibited superior performance compared to RRII 105 in the present trial. Yield performance of these four clones is reported to be superior to RRII 105 in the traditional zone also (Mydin and Mercykutty, 2007). But clone RRII 414 which gave significantly higher yield than RRII 105 in the traditional zone (Mydin and Mercykutty, 2007) gave yield on par with that of RRII 105 and RRIM 600 in the present trial. In general, mean yield of the RRII 400 series clones was lower in Tripura than the yield realized in the traditional area. Yield of RRII 430, RRII 105, RRIC 100, RRII 414 and PB 235 was comparable to that of RRIM 600. Comparable yield of RRIM 600, RRII 105 and PB 235 has been observed in the other north-eastern states also (Mondal *et al.*, 1999). Clone PB 235 exhibited high yield in the north-eastern state of Mizoram (Dey *et al.*, 2004), while RRIM 600 gave the highest BO-1 panel yield in Meghalaya (Reju *et al.*, 2002).

Table 4. **Yield performance of *Hevea* clones under the agroclimatic conditions in Tripura**

Clone	Test tap yield (g/t/10t)	Mean annual yield over six years (g/t/t)*	Projected yield (kg/ha/year)@
RRIM 600	56.6	33.8	1353
RRII 429	60.7	42.4	1698
RRII 203	56.5	27.2	1090
PB 217	52.8	25.8	1034
RRII 51	57.0	24.4	976
RRII 414	42.0	32.2	1289
RRII 430	59.4	36.3	1452
RRIC 100	39.6	33.5	1342
RRII 422	50.7	44.2	1770
RRII 105	61.3	35.3	1412
RRII 417	78.6	38.2	1529
RRII 176	54.4	26.4	1058
PB 235	48.7	30.3	1213
SE	7.9	1.4	
CD (P = 0.05)	NS	4.0	

* August 2003 to January 2009; @ Yield projection based on average 108.2 tapping days/year and 370 trees/ha

In the present study, RRII 203, RRII 176, RRII 51 and PB 217 had significantly lower yield than RRIM 600. Earlier studies in Tripura have shown that the yield of RRII 203 was lower than that of RRIM 600 when mean yield of initial three years was considered (Vinod *et al.*, 1996), while it was higher when mean yield over 10 years was analysed (Priyadarshan *et al.*, 2005), indicating a delay in realization of yield potential of RRII 203. Comparative studies have shown that maximum yield realized in Tripura was in

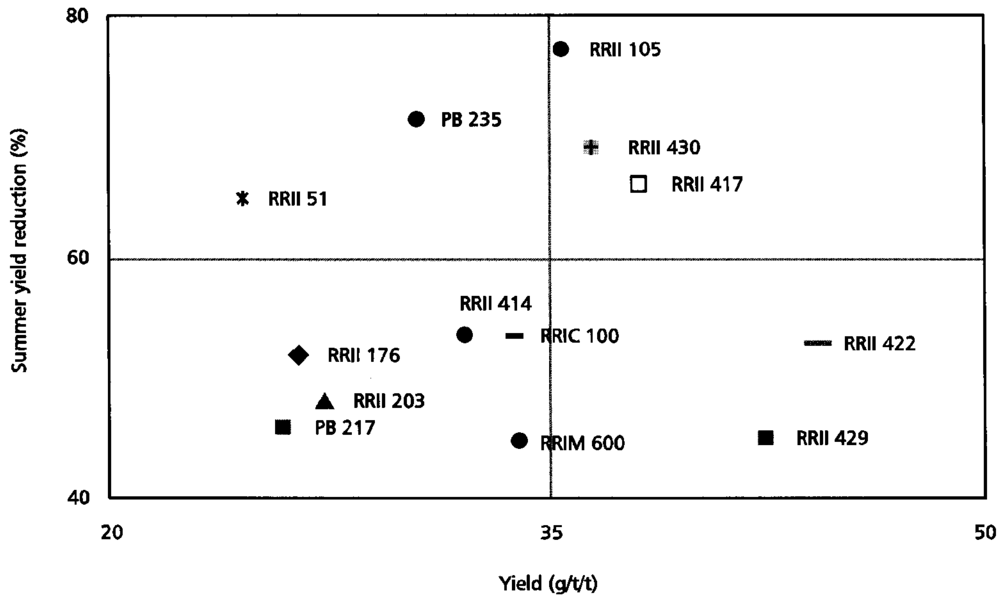

Fig. 1. Mean yield vs. summer yield reduction over five years of tapping

the eighth year compared to the seventh year in the traditional zone (Chandrashekar *et al.*, 2007). Hence, some of the clones may require a few more years to express their full yield potential in Tripura.

Mean summer drop in yield over five years (Fig.1) was the highest for RRII 105 (77.3%) followed by PB 235 (71.4%). RRII 105 is reported to show sharp yield decline in summer in traditional region also. Low summer yield drop observed in RRII 422 and RRII 429 is in agreement with the reports from the traditional zone (Mydin *et al.*, 2005). Winter yield reduction ranged from 26.9 (RRIM 600) to 45.8% (RRII 51) among the clones evaluated (Fig. 2). Reduction in the growth and yield of rubber during winter season due to low temperature and other adverse climatic conditions had been reported from other north-eastern states like Meghalaya (Reju *et al.*, 2001). Yield reduction during both summer and winter was the lowest for RRIM 600. Earlier studies in Tripura have indicated RRIM 600 as a widely adapted genotype that exhibited stable performance (Meenattoor *et al.*, 1991; Vinod, 2001). Clones RRII 51 and PB 235 showed high yield reduction under stress conditions. Clones RRIC 100 and RRII 422, which are reported to be cold susceptible in the immature stage (Meti *et al.*, 2003) exhibited low yield reduction in winter in this study. Priyadarshan *et al.* (1998) suggested the selection of clones with good yield potential and moderate cold endurance for moderately cold affected areas like Tripura. The present results indicate that RRII 422, RRII 429 and RRIM 600 with high yield and low summer and winter yield depression are promising.

Monthly yield pattern revealed that in general all clones in this study had maximum yield in November in Tripura. Contrary to

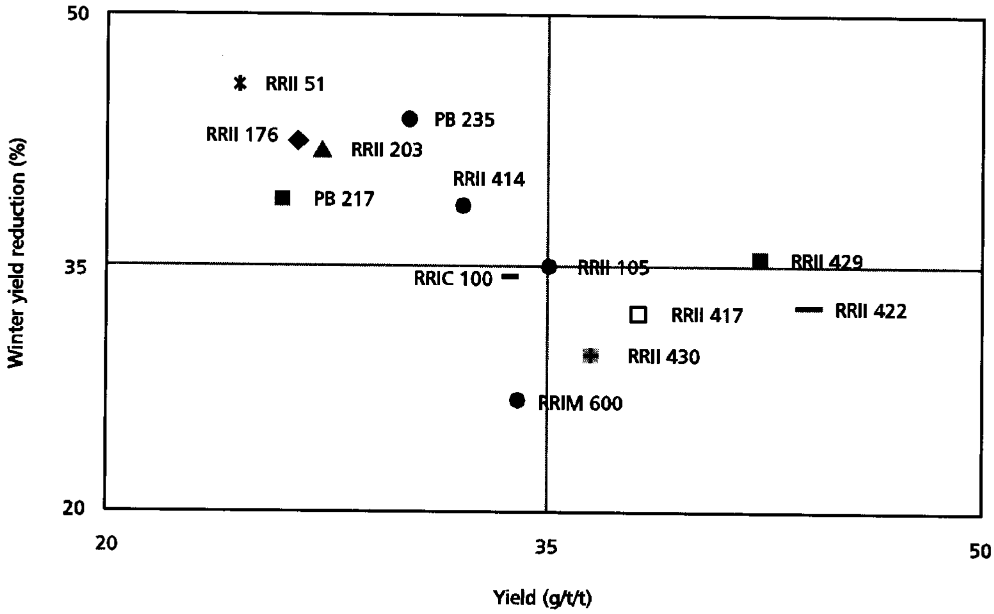

Fig. 2. Mean yield vs. winter yield reduction (%) over five years of tapping

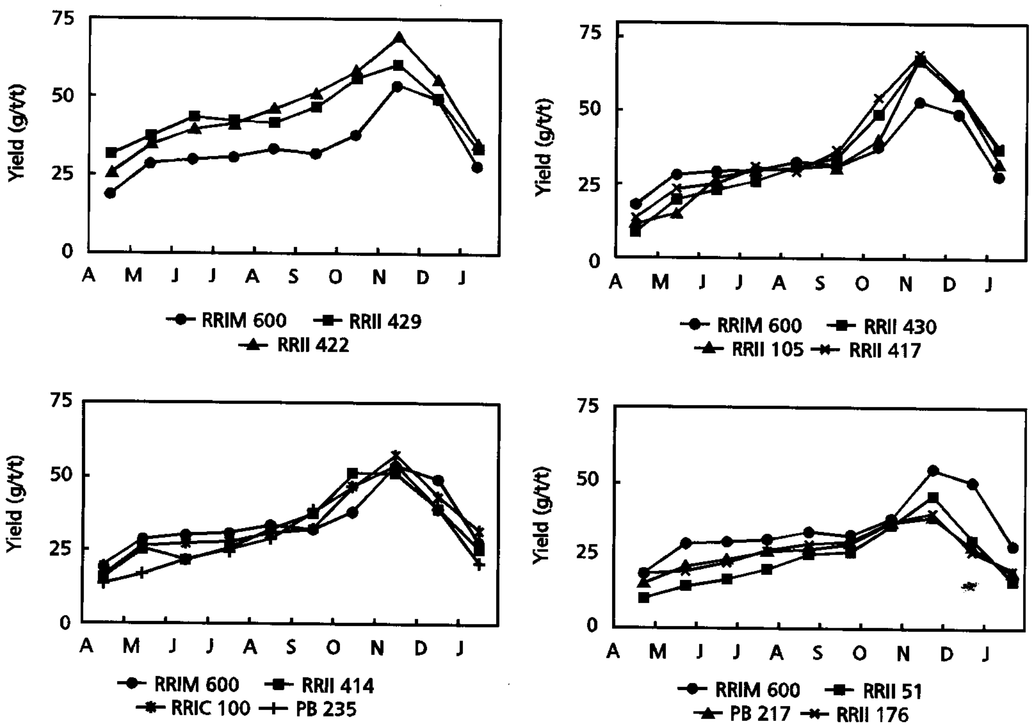

Fig. 3. Mean monthly yield trend (April to January) of clones in comparison to check clone RRIM 600

the pattern observed in the traditional zone with first peak yield in July and a next higher peak in November (Mydin *et al.*, 2005), a single peak was observed in November in Tripura. Mean monthly yield trend over six years revealed that the clones tested could be classified into four categories in comparison with the check clone RRIM 600 (Fig. 3). Clones RRII 422 and RRII 429 form the first category with the highest yield in the trial showing superior performance in all the months compared to RRIM 600. Clones RRII 417, RRII 430 and RRII 105 showed superior performance compared to RRIM 600 during peak yielding period and winter, but they had lower yield up to September and they can be grouped in the second category. Clones RRII 203, RRII 414, PB 235 and RRIC 100 with higher yield than RRIM 600 during optimum climatic conditions and lower yield during summer and winter represent the third category. The fourth category had clones RRII 51, PB 217 and RRII 176, which were the lowest yielding clones compared to RRIM 600 in all the months. The clones belonging to first two categories performed better than the check clone RRIM 600 in their mean yield over six years.

The wide adaptability and high yield of RRIM 600 have contributed to the popularity of this clone in Tripura. But it is critical to identify other potential clones for commercial cultivation for increasing production and to avoid monoculture. Identification of locally- adapted high yielding clones of *Hevea* is very crucial for the planters owing to the long juvenile period of seven to eight years and an economic life span of 25 to 30 years. The present clone evaluation revealed that RRII 422, RRII 429, RRII 417 and RRII 430 are high yielding clones with low yield reduction during winter and are promising clones for this region. The information obtained from this trial will help in identifying potential clones for commercial cultivation in Tripura.

ACKNOWLEDGEMENT

The authors thank Mrs. J. Rajeswari Meenattoor and Mr. S. Sasikumar for establishment and maintenance of the trial in the initial period. Authors also wish to acknowledge the efforts of all scientists and field staff associated with the project.

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