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EFFECT OF PLANTING DENSITY AND FERTILISERS ON GROWTH AND EARLY YIELD OF RUBBER IN TRIPURA

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A field experiment was conducted with two rubber (*Hevea brasiliensis*) clones, RRII 105 and RRII 118, planted at three different densities and using three fertiliser regimes. Plants at low density showed higher girth increment and higher yield per tree as well as per unit length of tapping cut. However, the highest mean annual yield was estimated for a population density of 824 trees per hectare under S/2 d/3 system of tapping. The casualty due to wind damage and the estimated loss of yield were lowest in the highest density planting. The plant stand of 606 trees per hectare with the clone RRII 105 may be suitable as the plants reach tappability within nine years. The percentage of casualty due to wind was also lower in this density compared to that in the lowest density. No increase in yield was observed with higher doses of fertiliser application during the period of the study. Significantly higher content of available phosphorus and potassium in soil under higher doses of fertiliser (60:60:30 and 80:80:40 kg/ha of N, P_2O_5 and K_2O) was evident in the eleventh year.

Key words: Growth, *Hevea brasiliensis*, Nutrition, Planting density, Tripura, Wind damage, Yield.

INTRODUCTION

Tripura now occupies the second position among the states in terms of area under rubber (*Hevea brasiliensis*) cultivation in India. High wind velocity is one of the important constraints in this region. The plant stand per hectare declines gradually due to wind damage over the years. This situation warranted a study to identify the optimum planting density that can help in withstanding high velocity wind and also compensate for the reduction in crop due to loss of trees. Heubel (1939) observed that the wind damage to *H. brasiliensis* was more at lower densities of planting. Dijkman (1951) reported reduction in damage in wind susceptible clones by increasing the planting density. In the wind-prone areas of China a planting density of 630 trees per hectare is recommended (Zongdao and Xaegin, 1983). However, increasing the number of plants per unit area beyond an optimum may lead to poor growth and yield due to competition among the plants. Devakumar *et al.* (1995) observed that the effect of closer planting on growth becomes evident from as early as the fourth year. Application of higher doses of fertilisers may be necessary to reduce the competition for nutrients and to get optimum yield.

The main objective of this study was to identify the optimum planting density at which plants reach tappable size quickly, suffer the least wind inflicted casualty and give maximum yield per unit land in Tripura. The study also envisaged ascertaining the requirements of N, P and K for such population density.

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MATERIALS AND METHODS

The experiment was laid out during 1988 at the experimental farm of the Rubber Research Institute of India, Regional Research Station, Agartala, at Taranagar (91° 15'E; 23° 53'N; 30 m above msl) in split-split-plot design with four replications. Three densities, *viz.* 420 (D1), 606 (D2) and 824 (D3) trees/ha, were imposed as main plot treatments while three fertiliser combinations, *viz.* 40:40:20 (M1), 60:60:30 (M2) and 80:80:40 (M3) kg/ha of N, P_2O_5 and K_2O were the sub-plot treatments. A popular clone, RRII 105 (C1) and a fast growing clone, RRII 118 (C2) were used as sub-subplot treatments. The details of treatments are given in Table 1. The gross plot size was 595 m^2. The number of plants accommodated in a plot was 25, 36 and 49 for D1, D2 and D3, respectively. Fertilisers were applied in two equal doses as pre- and post-monsoon applications. Tapping was initiated in July 1996 adopting ½ S d/3 system. The percentage of tappable trees at opening was worked out. Thereafter, other trees were brought under tapping in subsequent years as and when the plants attained a girth of 50 cm at a height of 150 cm from the bud union. The girth at 150 cm height of individual trees was recorded once in a year during March. The yield of individual trees was recorded at fortnightly intervals following cup coagulation method. Since all plots were not tapped during 1996, the yield data from the year 1997 onwards were only used for the analysis. The yield data were recorded only from the net plots. The vacancies due to wind damage were assessed in 1999 by plot-wise enumeration and the percentage of casualty worked out. Soil samples were collected from each plot and

Table 1. **Treatment combinations**

D1M1C1	D2M1C1	D3M1C1
D1M1C2	D2M1C2	D3M1C2
D1M2C1	D2M2C1	D3M2C1
D1M2C2	D2M2C2	D3M2C2
D1M3C1	D2M3C1	D3M3C1
D1M3C2	D2M3C2	D3M3C2

Density D1: 420; D2: 606 D3: 824 trees/ha
Fertilizer M1: 40:40:20; M2: 60:60:30;
M3: 80:80:40 N, P_2O_5, K_2O kg/ha
Clone C1: RRII 105; C2: RRII 118

Table 2. **Change in soil (0-60 cm) nutrient status**

Treatment	Organic carbon (%)		Available P (mg/100g)		Available K(mg/100g)	
	1990	1999	1990	1999	1990	1999
D1	0.67	1.07	0.10	2.78	4.33	4.54
D2	0.63	1.05	0.12	2.81	4.28	4.38
D3	0.61	1.09	0.11	2.67	4.50	4.64
M1	0.64	1.05	0.11	2.20	4.37	4.20
M2	0.63	1.12	0.11	2.81	4.21	4.50
M3	0.64	1.04	0.11	3.24	4.54	4.76
C1	0.63	1.06	0.11	2.80	4.36	4.54
C2	0.65	1.07	0.11	2.70	4.38	4.43
CD (P≤0.05)						
D	NS	NS	NS	NS	NS	NS
M	NS	NS	NS	0.39	NS	0.31
C	NS	NS	NS	NS	NS	NS

Interactions not significant

analysed for organic carbon, available P and K. The leaves were collected prior to post-monsoon fertiliser application for N, P and K analysis. Soil samples were analysed for organic carbon by Walkley and Black's method (Jackson, 1973). Soil available phosphorus and potassium were estimated using Bray II and Morgan's reagent respectively (Morgan, 1941).

RESULTS AND DISCUSSION

In general, the soil organic carbon, available P and K increased after eleven years of cultivation (Table 2). Higher doses of fertiliser resulted in significant increase in available P and K in the eleventh year. Build-up of available P in the soil and higher leaf nutrient levels under higher doses of fertiliser application has been reported (Krishnakumar and Potty, 1989; Varghese *et al.*, 1993).

Sufficient leaf N, P and K concentration were observed before initiation of tapping (Table 3). While the leaf N and P increased after initiation of tapping, the K content decreased. The clone RRII 105 exhibited higher leaf nutrient concentration than RRII 118. Higher leaf N, P and K concentration in RRII 105 compared to RRII 118 at seven years after planting has been reported (Mercykutty *et al.*, 1997) from Kerala in South West India.

The mean girth of trees in different years after commencement of tapping is presented in Table 4. Trees in the lowest plant-

Table 4. **Effect of different planting densities and fertiliser doses on girth of rubber**

Treatment	Girth (cm)			
	1997	1998	1999	2000
D1	55.6	59.1	63.1	65.9
D2	51.8	54.9	58.2	60.7
D3	48.8	51.0	53.9	55.8
M1	51.3	54.3	57.7	60.2
M2	52.8	55.7	59.2	61.5
M3	52.1	55.0	58.3	60.7
C1	50.6	53.0	55.8	57.5
C2	53.5	57.0	61.0	64.2
CD (P≤0.05)				
D	1.0	1.1	1.2	1.1
M	NS	NS	NS	NS
C	1.2	1.2	1.3	1.4

Interactions not significant

Table 3. **Change in leaf nutrient status**

Treatment	N (%)		P (%)		K (%)	
	1996	2000	1996	2000	1996	2000
D1	3.20	3.30	0.25	0.26	1.11	0.91
D2	3.15	3.23	0.25	0.28	1.10	0.86
D3	3.31	3.31	0.26	0.30	1.09	0.95
M1	3.20	3.27	0.24	0.28	1.07	0.90
M2	3.22	3.23	0.25	0.28	1.10	0.93
M3	3.24	3.33	0.26	0.28	1.12	0.90
C1	3.34	3.34	0.28	0.30	1.11	0.98
C2	3.10	3.21	0.22	0.25	1.08	0.84
CD (P≤0.05)						
D	NS	NS	NS	NS	NS	NS
M	NS	NS	NS	NS	NS	NS
C	0.10	0.11	0.02	0.02	NS	0.07

Interactions not significant

ing density showed the highest girth. Greater tree vigour at low density planting was also observed by Ng *et al.* (1979), which could be due to lower competition for light and water. The clone RRII 118 showed higher girth throughout.

During the eighth year of planting, D1 had 76 per cent tappable trees while D3 had only 67 per cent even in the tenth year (Table 5). In D2, 77 per cent trees reached tappable stage by the ninth year. More than 76 per cent trees of clone RRII 118 reached tappable size at this stage. The effect of fertiliser levels and interactions were not significant.

No difference was observed in per tree yield with increase in density in the first year, however, significantly higher yield was observed in low density planting in the subsequent years (Table 6) with the trees under lowest density yielding the highest. Westgarth and Buttery (1965) reported that six different densities ranging from 48 trees to 435 trees per acre did not show any yield difference in the first year. However, after 22 years of planting, the plants at the lowest density produced five times more yield per tree than those at the highest density. The trees which received a fertiliser dose of 60:60:30 yielded marginally higher than the others but the differences were not significant. The clone RRII 105 showed significantly higher yield than the clone RRII 118 during 1998-99 and 1999-2000. Fertiliser combinations and treatment interactions did not show any significant effect on yield.

Table 5. **Tappability (%) under different densities and clones**

Treatment	Tappable plant (%)		
	1996	1997	1998
D1	64.4 (76.4)*	74.4 (87.0)	84.4 (97.0)
D2	47.7 (55.4)	62.5 (77.0)	68.4 (84.8)
D3	37.0 (37.0)	44.1 (48.3)	55.4 (67.0)
C1	45.5 (49.8)	55.9 (65.1)	66.6 (79.3)
C2	53.9 (62.6)	64.7 (76.4)	72.2 (86.5)
CD (P≤0.05)			
D	9.1	7.7	5.2
C	4.4	5.2	4.3

* Figures in parentheses are actual percentage of plants that attained 50 cm girth at 150 cm height. Fertiliser levels and interaction not significantly different.

Table 6. **Effect of density, fertiliser dose and clone on yield**

Treatment	Per tree yield (g/t)			Projected annual yield (kg/ha)				Yield/cm of tapping cut (g/tap)
	1997-98	1998-99	1999-2000	1997-98	1998-99	1999-2000	Mean	
D1	21.5	37.6	42.5	434	979	1159	857	1.10
D2	20.7	33.7	35.1	603	1265	1384	1084	1.00
D3	19.4	29.9	27.8	766	1526	1487	1260	0.86
M1	20.6	32.9	34.9	603	1231	1343	1059	0.98
M2	21.3	34.9	36.7	619	1296	1398	1104	1.03
M3	19.7	33.3	33.8	581	1244	1289	1038	0.94
C1	19.6	39.5	38.9	576	1482	1496	1185	1.14
C2	21.5	27.9	31.3	626	1031	1191	949	0.84
CD (P≤0.05)								
D	NS	2.1	3.7	173	96	98	-	0.06
M	NS	NS	NS	NS	NS	NS	-	NS
C	1.5	2.5	2.3	38	88	89	-	0.07

* Projected yield based on yield/tree/tap and initial stand/ha. Interactions not significantly different.

The highest mean annual yield per hectare was estimated for the highest planting density. Garanad and Sintharahat (1996) recommended 625 trees per hectare as optimum planting density in Thailand for both latex and rubber wood yield as the girth of the rubber trees reached tappable size within seven years at this density. However, it has been reported that under Malaysian climatic conditions, the yield per hectare varied relatively little over a wide range of planting densities (Webster, 1989). Yield per unit length of tapping cut was highest in the lowest density. Clone RRII 105 gave significantly higher yield per unit length of tapping panel compared to clone RRII 118 showing its genotypic superiority.

The month wise yield performance of plants at different densities illustrated that the plants at lowest density had higher per tree yield throughout the year (Fig. 1) and that the yield was highest during December. The difference in yield between the trees under different densities of planting increased during November and December.

The casualty due to wind damage was the lowest in the highest density (Table 7). The compact nature of the plantation in the highest density resisted the high velocity wind. Though the casualty in RRII 118 was higher, the difference between the two clones was not significant. The projected annual yield per hectare as per the initial stand was higher (1486 kg/ha) in the highest density while the estimated loss of yield due to wind damage of trees was the lowest (125 kg/ha) in this density (Table 8). However, the actual yield per hectare could have been higher

Table 7. **Effect of density and clone on wind damage**

Clone	Wind damage (%)			
	Density			Mean
	D1	D2	D3	
C1	24.1 (18.5)*	22.7 (16.7)	11.8 (6.7)	19.6 (14.0)
C2	24.3 (22.2)	23.2 (17.1)	18.5 (10.7)	22.0 (16.7)
Mean	24.2 (20.4)	23.0 (16.9)	15.2 (8.7)	

CD ($P \leq 0.05$) Density : 7.6 Clone : NS
*Figures in parentheses are the percentage of casualty. Fertiliser doses and treatment interactions not significantly different.

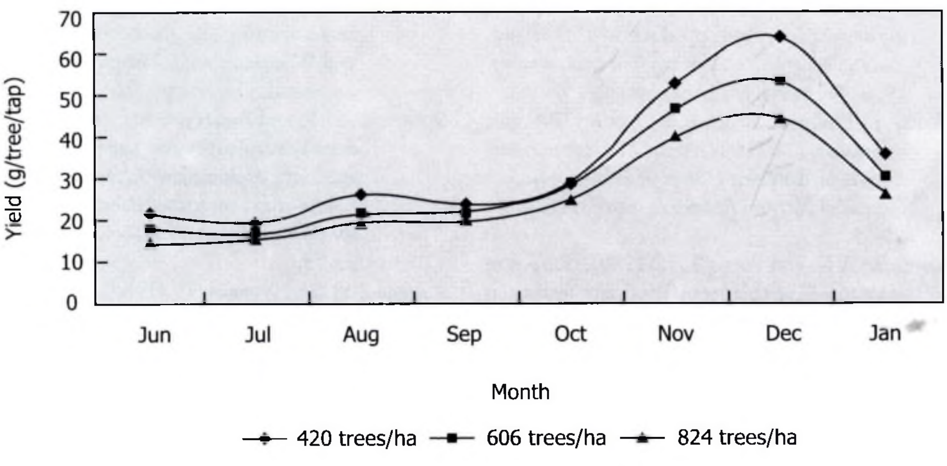

Fig. 1. Yield performance at different densities

Table 8. **Effect of wind damage on yield of rubber at different densities (1999-2000)**

Treatment	Yield (kg/ha/year)		
	Projected yield as per initial stand	Actual yield as per present stand	Loss due to wind damage
D1	1159	921	238
D2	1384	1150	234
D3	1486	1361	125
CV (%)	10	11	-
CD (P≤0.05)	97	86	-
CD (P≤0.01)	148	131	-

Interactions not significantly different.

had there been no wind damage.

It can be concluded that the optimum planting density could be 606 plants per hectare where the rubber trees reach tappability (77%) in the ninth year. Plants in this density produced higher yield per tree per tap, even though the wind damage and loss in yield were higher compared to the highest density. As there was no significant effect for higher doses of fertiliser application, the lowest dose (40:40:20 N, P_2O_5 and K_2O kg/ha) appears to be significant.

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