EFFECT OF TREE DENSITY ON GROWTH OF RUBBER IN NORTH EASTERN REGION OF INDIA

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A trial on planting density was conducted in clone RRII 429 with six densities *viz.* 408, 445, 489, 544, 613 and 699 in rectangular planting. Growth of the plants was significantly influenced by the different densities sixth years after planting. The density up to 544 trees ha^{-1} attained required tappable girth by the end of seventh year. The percentage of tappable trees was low in the denser plantings. Plants at the lower density showed high girth increment in all the years. Seasonal variation in growth was observed. Highest girth increment was observed in monsoon season followed by post monsoon and lowest in winter season. Lower planting density produced higher tree girth and thick virgin bark.

Key words: Planting density, *Hevea brasiliensis*, Growth, North-East India

INTRODUCTION

Natural rubber (*Hevea brasiliensis*) cultivation is being extended to north eastern regions of India to meet the increasing demand. The north eastern states have great potential for natural rubber (NR) cultivation. The crop has gained popularity due to its easy acceptability of native people and high return. About 1,79,850 ha area is under NR cultivation in this region in 2015-16 (Rubber Board, 2017), of which more than 80 per cent of area is in the small holding sector with an average holding size of one hectare. Since loss of trees due to high velocity wind is prevalent in this region, small holders always tend to adopt high density planting to improve the productivity of his land. Plant density is one of the major factors in rubber production and varies depending upon other parameters. The growing space largely influences tree growth and yield of a stand as a whole. In rubber, the girth of the tree is the most important parameter based on which the degree of maturity of plantation is decided for harvesting of latex (Sethuraj and George, 1980). In general, the plantation considered mature and tappable if 50-70 per cent of trees have attained a girth of 50 cm at height of 125 cm from bud union (Sethuraj and George, 1980) and latex harvested subsequently. Experiment on high density planting of rubber was conducted with clone RRII 429 to study the effect of tree density on immature growth and other associated parameters.

MATERIALS AND METHODS

The experiment was conducted at the experimental farm of Rubber Research

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Institute of India, Regional Research Station, Agartala (91°15′E; 23° 53′N; 30 m above MSL). Climate of this location is warm perhumid and annual mean rainfall of seven years was 1803 mm. The mean annual temperature was 25.3°C, the mean maximum and minimum temperature was 30.6°C and 19.9°C, respectively during experimental period. The soil of experimental site is clay loam in texture, medium in organic carbon (0.98 %), available phosphorous (2.9 mg100g^{-1}) and available potassium (5.1 mg100 g^{-1}) with a pH of 4.6.

Clone RRII 429 was planted during 2007 in RBD design with five replications. Six densities, *viz*. 408 (D1), 445 (D2), 489 (D3), 544 (D4), 613 (D5) and 699 (D6) trees ha^{-1} was accommodated in rectangular planting of 22 feet line to line distance with different tree to tree spacing (Table 1). The number of plants accommodated in a plot was 24 in four rows at all densities. Tree girth at height of 150 cm from bud union was measured quarterly interval from third year to seventh year and the increment of girth was worked out. Crotch height and bark thickness was measured at the seventh year of planting. Thickness of the virgin bark was measured using a bark gauge. Photosynthetically active radiation (PAR) was measured in seventh year inside plantation and open space in clear sunny days using AccuPAR (model LP 80).

Table 1.**Treatments details**

Treatment	Spacing (feet)	Tree no. ha^{-1}
D1	22 x 12	408
D2	22 x 11	445
D3	22 x 10	489
D4	22 x 9	544
D5	22 x 8	613
D6	22 x 7	699

RESULTS AND DISCUSSION

It was observed that density of planting had significant effect on annual growth of plant from six years of planting which is due to saturation of canopy at higher density (Table 2). Plants in the highest density of 699 trees ha^{-1} showed an increase in girth till the fourth year of planting which could not be sustained probably due to the intense competition among plants which set in subsequently. Plants in the lower densities of 408 and 445 trees per ha were observed to perform comparatively better after the fifth year. By the seventh year of planting, plants in the lowest density (408 trees ha^{-1}) were attained higher girth as compared to all other densities. The better growth could be the result of relatively reduced competition for nutrients, moisture and sunlight.

Table. 2. **Effect of plant density on girth of plants**

Treatment	Girth (cm)				
	3rd year	4th year	5th year	6th year	7th year
D1	18.3	29.4	40.3	47.8	54.4
D2	17.8	28.9	39.7	47.2	53.6
D3	17.9	28.7	39.2	46.1	51.9
D4	18.5	29.8	38.9	45.3	50.8
D5	18.6	29.2	38.8	45.1	50.5
D6	19.2	29.3	38.8	44.4	49.5
Mean	18.4	29.1	39.2	45.9	51.7
CD ($P<0.05$)	NS	NS	NS	1.92	2.09

Girth increment was declined with increase of age of plants in all densities (Fig.1). Increment of girth was lower in higher density compared to lower density. The density of planting did not have any effect on girth increment of the rubber trees up to the fourth year of planting. The superior growth rate in the lower densities

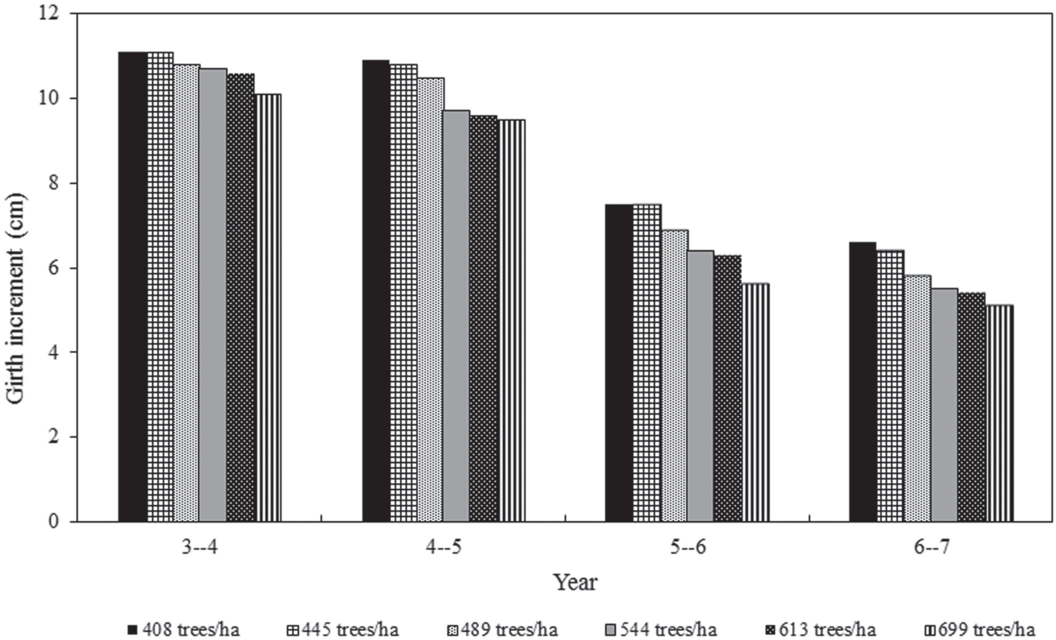

Fig 1. Effect of plant density on annual girth increment in different years

from fifth year onwards is a result of optimum growth factors available to these plants. Competition between rubber trees increases with the increase in tree density and reduced the growth as has been reported earlier (Westgrath and Buttery, 1965; Obouayeba *et al.*, 2005). Depression in growth was not high in young trees, but retardation in growth was more and was greater with the increase in tree densities and age (Rodrigo *et al.*, 1995). Competition under high tree densities is greater with the increase in age, the number and closeness of trees (Makinan, 1996).

All densities showed a similar pattern of seasonal growth (Fig. 2). In general, average seasonal girth increment was highest during monsoon or rainy season (July to September) followed by post monsoon (October to December), pre-monsoon (April to June) and lowest during winter season (January to March). Seasonal growth was varied among the densities of the total growth in a year 40 per cent occurred in monsoon, 29.5 per cent in the post monsoon, 26 per cent in pre-monsoon and 4.5 per cent in the winter season. Comparison of the seasonal growth pattern of trees in different densities showed that the lower densities exhibited higher growth in all the seasons. Seasonal growth trend was low in higher densities and lowest in highest density. Similar pattern of seasonal growth of rubber was reported in the traditional and Konkan region of western India (Dey *et al.*, 1998).

Crotch height is the vertical distance from ground to first branch developed in trunk, which increased with increase in density. Higher density showed higher crotch height as compared to low densities (Table 3). When the canopy grows, there was overlapping and competition for light at higher densities.

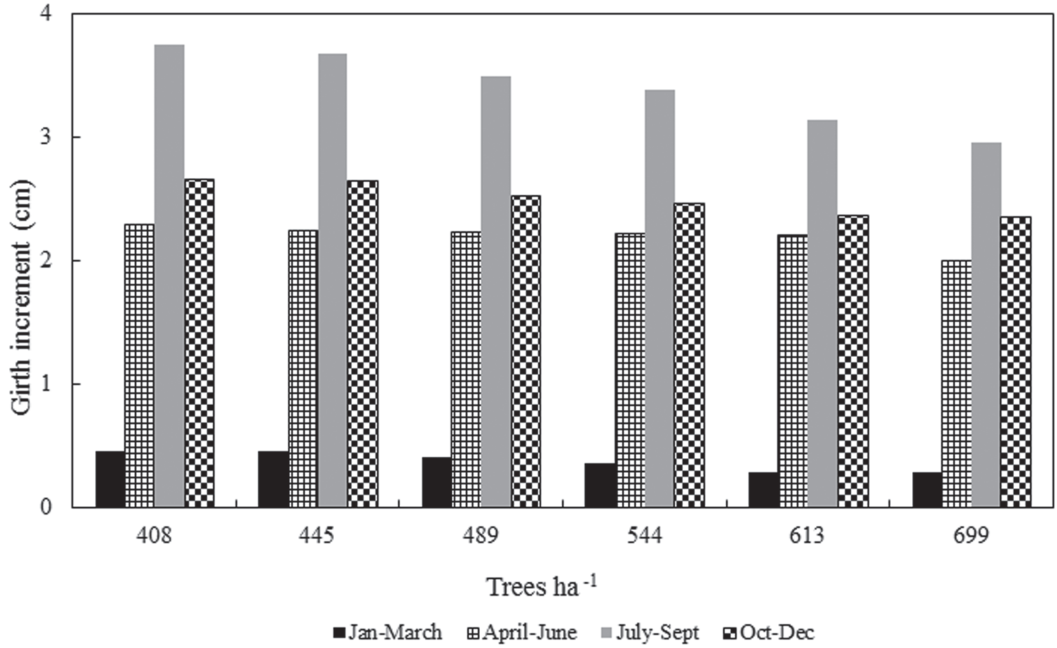

Fig. 2. Effect of season on average (four years) girth increment of trees

Under such circumstances trees undergo certain modifications like increase in height with higher crotch height and reduced canopy. The trees tend to grow taller and thinner in order to harvest more sunlight (Webster, 1989) a type of plant response referred to as co-operative interaction (Yoda *et al.*, 1957). It was observed that plants in the lower densities had higher bark thickness though not significant (Table 3). Trees planted at lower density had thicker virgin bark compared to high density planting. A similar trend has been reported in traditional region (Varghese *et al.*, 2006) and non-traditional region of India (Dey and Datta, 2013).

Table 3. **Effect of plant density on crotch height and bark thickness**

Treatment	Crotch height (m)	Bark thickness (mm)
D1	2.02	3.35
D2	2.17	3.33
D3	2.27	3.28
D4	2.56	3.25
D5	2.63	3.21
D6	2.68	3.20
CD(P<0.05)	0.26	NS

The percentage of transmitted PAR recorded in plantation were 9.6, 8.2, 6.5, 5.5, 3.2 and 3.1 in 408, 445, 489, 544, 613 and 699 trees ha^{-1}, respectively. The percentage of light transmission through the canopy declined with increase of plant density. In the closed canopy, the amount of light diffused to the ground level was significantly lower compared to that under the lower plant densities as reported by Devakumar *et al.* (1995) in non-traditional region. The higher percentage of light in lower density of

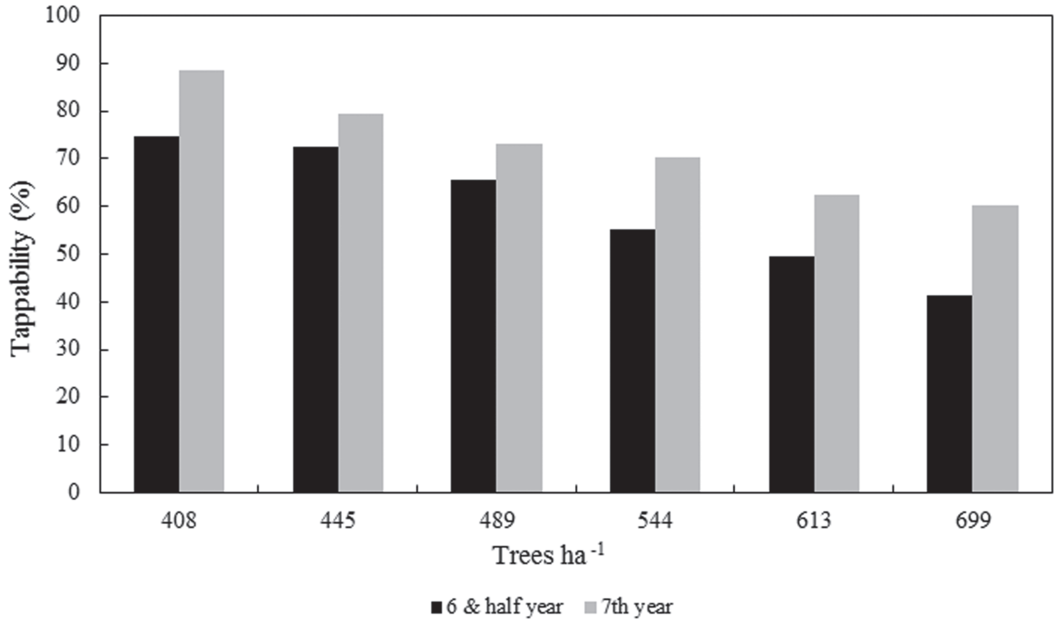

Fig 3. Effect of plant density on percentage of tappable trees

planting was due to the wider spacing adopted resulting in less overlapping of canopies in traditional region (Varghese *et al.*, 2006).

The lower densities had a higher number of trees that attained tappable girth at six and half years after planting (Fig. 3). Lowest density (408 trees ha^{-1}) of planting had higher number of tappable trees when compared to the higher densities and were on par with the density of 445 trees ha^{-1}. Lowest percentage of plants that attained tappable girth was in the highest density of 699 trees ha^{-1}. This study revealed that the density of 408 trees ha^{-1} favour early tappability and was comparable to densities up to 544 trees ha^{-1}, above which growth was adversely affected. A similar trend has been reported in traditional region (Varghese *et al.*, 2006) and non-traditional region of India (Ray *et al.*, 2005).

CONCLUSION

In high density treatments, the percentage of trees that came into tapping at the end of the seventh year was low because of retarded growth which was due to competition from larger trees. At optimum stand density where there is complete canopy closure, the growth of tree is expected to decline. Density of real stands fluctuates around a certain equilibrium level and may approach the maximum during favorable growth conditions when most of the canopy gaps are closed. In our observation the density of 408 and 445 trees ha^{-1} attended tappability in six and half years. However, 544 trees ha^{-1} attained required tappable girth by the end of seventh year. North-East India is a wind prone region and high density stand will help to maintain a reasonable tree stand in the long term.

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