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INFLUENCE OF PLANT DENSITY ON GROWTH AND CANOPY ARCHITECTURE IN *HEVEA BRASILIENSIS*

Canopy architecture, the expression of the equilibrium between endogenous growth process and exogenous constraints (Edelin, 1984), determines leaf display and therefore, influences light interception and subsequent carbon assimilation. Architectural analysis is essentially a dynamic approach to study plant development.

A trial was undertaken with *Hevea brasiliensis* at three different planting densities and to assess the overall development of the plant in the juvenile phase, plant canopy architecture was studied.

Polybag plants of two clones (RRII 105 and RRII 118) of *H. brasiliensis* were field planted in the year 1988 at the Taranagar farm of the Regional Research Station of RRII at Agartala, India, situated at 23.53° N 91.15° E and at an elevation of 16.6 m MSL. Square planting was followed to obtain a population of 420, 660 and 840 plants per hectare (referred hereafter as D1, D2 and D3 densities, respectively). The data were analysed using the analysis of variance technique for a randominsed block design.

Girth and bark thickness at 150 cm from bud union, tree height, crotch height, crown width and light intensity were measured. Number of branches, branch length and circumference and angle of insertion of the branches were also recorded. Circumference was measured 6 cm above the branch union. Branching angle was recorded using a protractor devise (Norman and Campbell, 1989). A blunt hypodermic needle (21 g x 38 mm) with plastic guide was used for measuring bark thickness. All the branch characteristics were measured only on the first order branches, as they are dominant in terms of size, and their disposition determines the arrangement of branches of higher orders and ultimately results in the overall structure of the crown (Nelson, *et al.*, 1981).

Tree girth at 150 cm ranged from 33.80 to 39.59cm in RRII 105 and 33.95 to 43.72 cm in RRII 118. A significant difference in girth between the densities as well as clones (Table 1) was noted. In both the clones, girth increased with the higher plant density. The difference in the girth between the clones is mainly due to the inherited growth characters of these clones and RRII 118 is a remarkably vigorous clone. Recently Varghese *et al.* (1994) have shown that RRII 118 has a higher juvenile growth compared to RRII 105.

Generally girth tends to increase when the density is less (Sethuraj, 1985). However, in the north eastern part of the country where this trial was conducted, a similar trend was not apparent in the initial growth stages. The trial was carried out in virgin forest clearing highly infested with lalang (*Imperata cylindrica*) especially during the initial years. Lalang is a fast spreading weed which has drastic effect on growth of rubber in the early stages (Soedarsan, 1976). Therefore, it is likely that the initial growth of rubber has been affected by this weed irrespective of the plant density. After four years, when the canopy started closing

Table 1. **Growth parameters under three plant densities in two *Hevea* clones**

Density	Clone	Trunk girth (cm)	Plant height (m)	Crotch height (m)	Crown width (m)	Bark thickness (cm)	Light intensity ($\mu Em^{-2}S^{-1}$)
D1	RRII 105	36.60	7.75	5.42	6.39	0.77	112
	RRII 118	33.95	7.76	5.31	6.40	0.76	106
D2	RRII 105	37.78	8.19	5.75	5.28	0.69	72
	RRII 118	38.99	8.51	6.63	5.42	0.72	59
D3	RRII 105	39.59	9.48	7.53	5.00	0.62	50
	RRII 118	43.72	9.70	7.71	5.15	0.67	42
CD(P=0.05)							
	Density	0.80	1.53	0.23	0.26	0.03	6.90
	Clone	0.65	NS	NS	NS	NS	9.52

under high density, the amount of light diffused to the ground level was significantly lower when compared to that under the lower plant densities (Table 1). This condition may suppress the weed at an early stage in high density area than in the low density ones. Therefore, higher density plants had a better growth condition compared to low density plants. Lalang is found to be highly photosensitive (Moosavi-Nai and Dore, 1979) and therefore, its growth is suppressed in high plant density area. This naturally had enabled the rubber plants to face lesser competition from the weed. The plants at higher density also had the advantage of higher moisture and nutrients in soil which also is reflected in their growth. To ascertain the true picture of the girth in different densities, girth increment patterns were analysed for three years (Figure 1). This data clearly indicates that girth increment observed in the early years did not sustain in the highest density, while plants in the other two densities showed higher rates of girth increment. The decline in the rate of girth increment is very obvious in the last year under D3 density. Therefore, the girth variations seen in the initial stages (till the canopy closes) cannot be attributed directly to density factor.

Table 2. **Branch characteristics under different plant densities in two *Hevea* clones**

Density	Clone	Branch characters			
		Number	Length (m)	Circumference (cm)	Angle(degree)
D1	RRII 105	10.1	4.39	12.14	50.06
	RRII 118	10.7	4.52	13.15	46.70
D2	RRII 105	10.2	5.47	14.39	38.20
	RRII 118	10.7	5.94	15.20	41.00
D3	RRII 105	10.5	6.23	16.09	26.92
	RRII 118	10.5	7.36	18.30	29.30
CD(P=0.05)					
	Density	NS	0.24	0.69	2.30
	Clone	NS	0.20	0.58	1.88

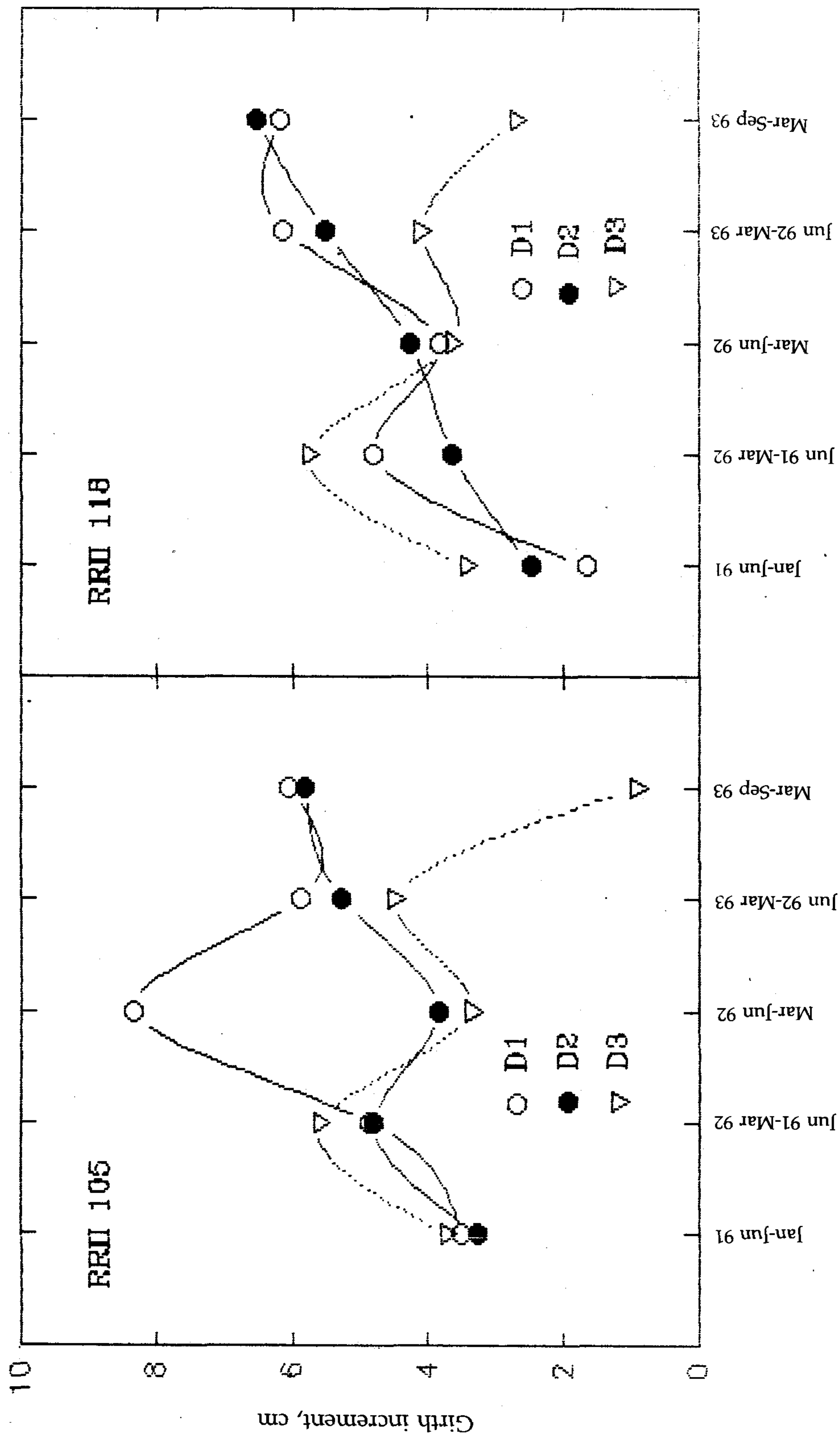

Fig. 1. Pattern of girth variations in two clones under three plant densities

Plant height did not vary significantly between the clones and also between Dl and D2 densities but there waș a significant difference observed between the plants belonging to the highest and the lowest densities. When the canopy covers completely, · there will be overlapping, and competition for light would start at the higher densities. Under such circumstances trees would prevail upon the situation by undergoing certain modifications. One such modification is increase in height. Usually the trees tend to grow taller and thinner in order to harvest more sunlight (Webster, 1969) and this type of plant response is referred to as co-operative interaction (Yoda *et al.*, 1957). The results in rubber plants also indicate such kind of response (Table 1). This co-operative interaction, not only increased the plant height but also increased crotch height and reduced the crown width (Figure 2). Increase in crotch height and crown width has already been reported in rubber when grown under high density (Sethuraj, 1985 and Webster, 1989).

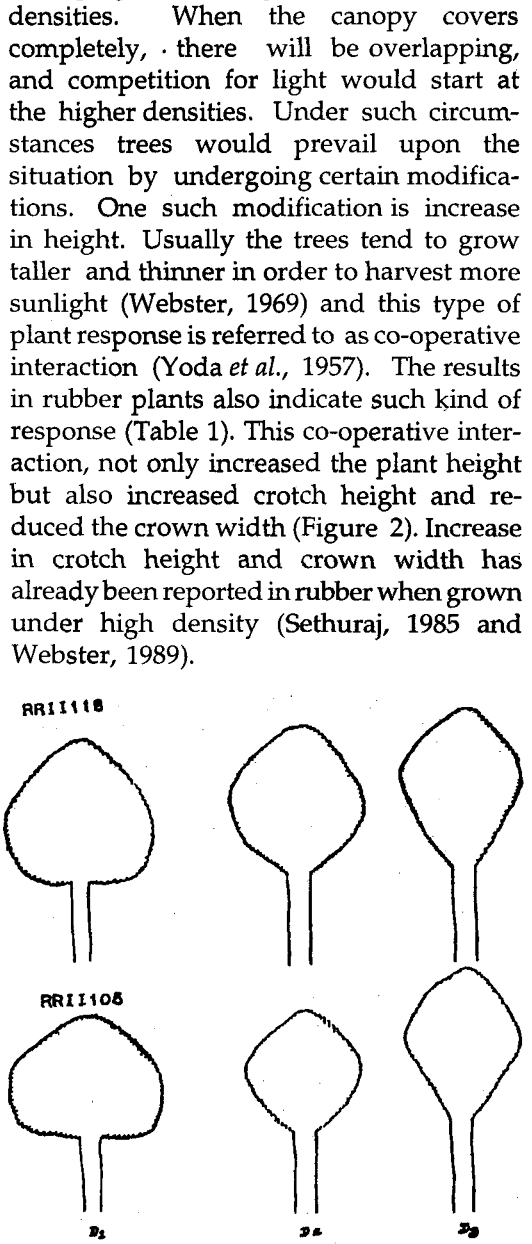

Fig. 2. Schematic representation of tree structure and crown architecture under different densities in two clones of *Hevea*

Among the branch characteristics studied, the number of first order branches did not show any remarkable change either between the clones or between the densities (Table 2). This is quite likely, because, majority of the first order branches seen on the trees will be there from the initial growth stage. In the early stages, density has little effect on plant growth, since the plants hardly face any competition for light or other resources.

Branch length and diameter are the other two parameters that determine canopy architecture. Both the characters vary significantly between densities as well as clones (Table 2). These two characteristics are positively related in both the clones (Figure 3) . There are a number of functional aspects of trees that are influenced by the length to diameter ratio of branches. Branch surface area is closely related to leaf surface distribution (Givinish, 1985). Larger branches can support more number of secondary and tertiary branches and can accommodate more foliage, which in turn, results in a denser canopy. This is more evident from the light intensity recorded on the ground surface under the canopies of different plant densities (Table 1). Canopies of the highest density allowed very little light to diffuse down to the ground, while it was significantly more in lower densities.

The positive relation (Figure 3) between length and diameter of branch is an evolutionary change to withstand the weight variation based on the bending strength (Castera and Morlier, 1991). This type of relation would help in retaining and maintaining large branches by the trees . Branching angle varied from D1 to D3, showing a significant variation between the densities as well as clones (Table 2). This character has greater role in regulating the overall shape of the crown. Crown width and crotch height had the same trend and

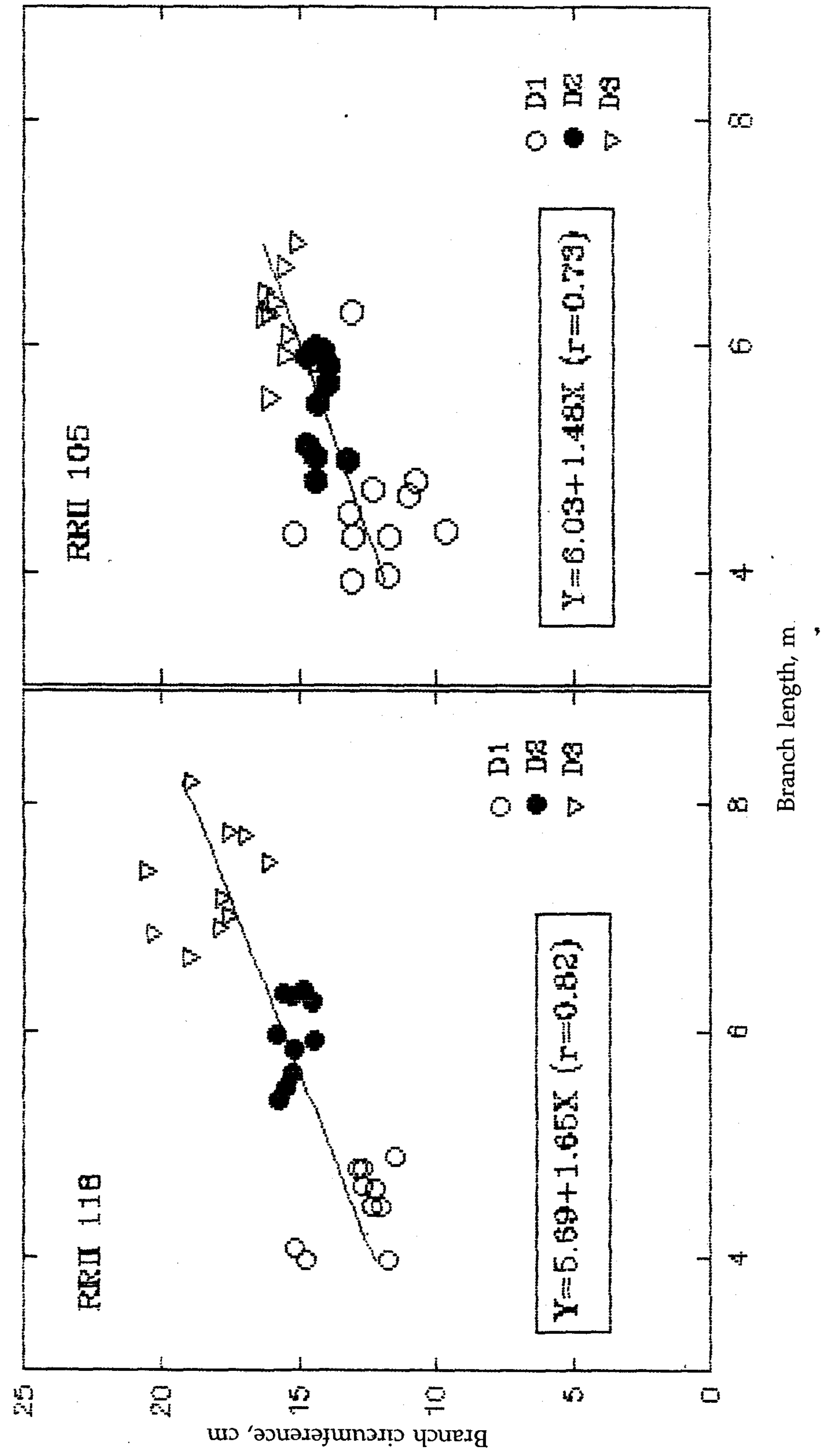

Fig. 3. Relationship between branch length and circumference in two *Hevea* clones at three densities

did not show any significant change between the clones (Table 1). Such a trend in *Hevea* has already been reported (Sethuraj, 1985). These modifications seen under different densities, are mainly to intercept maximum solar radiation effectively, and to reduce the competition within the crown (Ryajihashimoto, 1991).

Bark thickness, an important yield determinant, did not show any differences between the clones. However, a declining trend was noticed in bark thickness with increase in plant density (Table 1).

It can be inferred that plant girth is not completely determined by plant density alone, especially under the situations where there is competition for resources . Shape of the canopy is determined by the angle of insertion of branches to a large extent, while size of the canopy depends on branch length, branch circumference and plant height. The strength of the whole canopy depends on the relationship between length and circumference of the branches. Since these are more in higher densities, bending strength will be more for the branches at higher densities, which helps to withstand higher wind speeds. As the canopy is closer and denser at higher densities, greater resistance to high wind velocities can be expected.

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