PERFORMANCE EVALUATION OF RUBBER UNDER DIFFERENT PLANTING INTENSITIES

By

M. G. SATHEES CHANDRAN NAIR

DISSERTATION

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Faculty of Agriculture

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Department of Plantation Crops & Spices

COLLEGE OF HORTICULTURE

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1994

DECLARATION

I hereby declare that this dissertation entitled **"Performance evaluation of rubber under different planting intensities"** is a bonafide record of original work done by me during the course of placement/training and that this dissertation has not formed the basis for award of any degree, diploma, associateship, fellowship or other similar titles of any other University or Society.

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M.G.SATHEES CHANDRAN NAIR

CERTIFICATE

Certified that this dissertation entitled "Performance evaluation of rubber under different planting intensities" is a record of research work done independently by **Mr.M.G.Sathees Chandran Nair** under our guidance and supervision and that it has not previously formed the basis for the award of any degree or diploma to him.

We, the undersigned members of the Advisory Committee of Mr.M.G.Sathees Chandran Nair, a candidate for the Post Graduate Diploma in Natural Rubber Production, agree that the dissertation may be submitted by him in partial fulfilment of the requirements of the diploma.

Dr.E.V.Nybe
Associate Professor & Head i/c
Department of Plantation
Crops and Spices
College of Horticulture
Vellanikkara
(Major Advisor)

Shri.M.Mathew
Deputy Director
Rubber Research Institute
of India
Kottayam-9
(Co-Chairman)

28/1/1995

Dr.P.A.Nazeem
Associate Professor
Department of Plantation
Crops and Spices
College of Horticulture
Vellanikkara
(Member)

Smt.M.R.Shylaja
Assistant Professor
Department of Plantation
Crops and Spices
College of Horticulture
Vellanikkara
(Member)

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M.G. SATHEES CHANDRAN NAIR

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INTRODUCTION

Rubber is an important industrial raw material, indispensable to modern man in times of both war and peace. At present there are two sources of rubber - the natural and the synthetic.

Hevea brasiliensis Muell. Arg., the para rubber tree, is the major source of natural rubber. This tree is a native of Amazon forest in South America. It was domesticated in the latter half of the 19th century and the species is now being grown on commercial basis in 22 countries of the world, most of them in the tropics.

In early days rubber trees in estates were planted wider apart than they are at present. In Malaysia an initial stand of 270 trees/ha (i.e. with a spacing of 6.1 m x 6.1 m) was common. But the yield per hectare was found to be less than that from holdings with higher densities, as the yield of rubber is a function of the number of trees under tapping, the average yield per tree and the frequency of tapping.

It is evident that wider spacings will give better growth and high yield per tree, whereas higher total yields can be realised from closer spacings. However, there is no unanimity of opinion regarding the optimum stand that can be recommended for realising the maximum yield. Obviously, this varies with the cultivar also.

Apart from this, maximum yield per hectare may not always mean maximum profitability when one takes into account the other variants like tapping costs, price of rubber etc. A higher stand always demands higher investment for management as well as exploitation.

With increasing density, yield per tree decreases, but yield per hectare increases upto an optimum density. This optimum density varies considerably with clone. Competition for sunlight, soil nutrients and moisture is essentially a problem of space. The ideal spacing is one which will give the highest income per hectare with optimum yield relative to the bark renewal, competitive tapping costs and lowest cost of development.

The rubber plantation scenario in India is predominated by small holdings, numbering about eight lakhs. Another notable feature is that most of the plantations in India are under a single clone, viz. RRII 105. Not much work has been done on the effect of planting densities on the vegetative growth as well as yield of this variety.

In the case of seedlings, because of the need for thinning out owing to genetic variability, a higher initial stand than that for budgrafts is recommended. The planting density recommended per hectare is 420-445 plants for buddings and 445-520 plants for seedlings. The common spacings to give such a stand under varying conditions were worked out by Potty (1980).

Majority of the rubber growing areas in India are situated on sloping hill sides and the spacing popular with the small holders in such terrain is 3 m x 6 m (539 plants/ha). This stand is slightly higher than what is recommended by the Rubber Board. Of late, the Board has been suggesting that in no case should the stand exceed 500 plants/ha.

In this context, the present study was undertaken to evaluate and quantify the effect of varying planting densities on the vegetative growth, yield and drc of rubber.

Review of Literature

REVIEW OF LITERATURE

In India not much work has been done to study the effect of planting densities on growth and yield of rubber. However, a number of experiments on this aspect were done in the 1920s and 1930s in Malaysia. The resuts of these investigations revealed that there was no competition among young plants for a year or two after planting, but as the crowns developed they began to compete for light, nutrients and water. It was experimentally proved that at greater densities crotch heights were higher and crowns smaller (Leong and Yoon, 1982). However, Ng (1993) reported that the height appeared to be reduced as the density was increased above 750 trees/ha.

The results from an experiment conducted by Buttery and Westgarth in 1965 with densities from 110 to 1074 trees/ha showed that 90 per cent of trees reached tappable girth three years after planting when planted at 119 trees/ha whereas at 1074 trees/ha 31 per cent remained untappable even after 19 years. A study conducted by Nair (1992) in Kerala revealed that, wherever normal spacing was adopted, 90 per cent of the trees recorded a girth of 45 cm and above by the eighth year.

Lateral roots in rubber have been found to cut across adjoining areas of planting rows and those lying close to the soil surface attain the greatest horizontal spread. In soil excavation studies conducted in Malaysia, the tap root was observed to be about 2.4 m deep in trees of seven to eight years of age. The laterals were seen extending beyond 9 m in mature trees. Radiotracer studies indicated that the maximum root activity was concentrated within 3.7 m from the tree trunk and the uptake was more from the sub soil than from the top soil (Krishnakumar, 1993).

It was seen that virgin and renewed barks were thinner with higher planting density (Dijkman, 1951; Ng, 1993). Heubel (1939) kept a record of trees severely damaged by storms and results showed that the percentage of broken trees was the largest in the widest spacing. This was also confirmed by Ng (1993).

The drc of the latex decreased from wide planted trees to dense planted trees (Schmole, 1940). Also individual tree yields decreased with increasing density but the total production per hectare increased with an increase in density upto a certain maximum limit (Schmole, 1940, Ng, 1993). But this optimum density varied with clones. Eschbach (1974) reported that maximum yield in the fourth and fifth years of tapping was obtained from densities of 650/ha for clone PB 86 and 550-600/ha for PR 107. Samsuddin and Impens (1977) attributed the differences in yield to differences in total photosynthetic activity of the crown at different densities and to differences in allocation of photosynthates during latex formation.

However, over a limited range of densities, the change in growth and yield parameters is not quite considerable. In an experiment with GT 1 planted at 476, 500 and 555 trees/ha there were no significant differences in growth, yield or drc (Saleh and Purwadi, 1982).

The earlier findings on crotch height, girthing and yield as influenced by population density were confirmed by Karthikeyan (1993). The experiments conducted by him showed that branching height was higher, girthing lower and per tree yield less with increasing densities.

Ng (1993) found that canopy closure was earlier in high densities. This had the effect of increasing humidity, which in turn favoured the attack of panel diseases. The severity of the disease was higher in higher densities. However, assessment of pink, root disease and dry tree incidence showed that there was no clear cut effect of high density on incidence of these diseases.

Materials and Methods

MATERIALS AND METHODS

The study was conducted at the College of Horticulture, Vellanikkara, Thrissur, during the period from November 1993 to May 1994 as a continuation of the study initiated during 1993. The trees in the 'Suhasini' block of the Kerala Agricultural University were utilised. The area was located at 10° 31' N latitude and 70° 13' E longitude, at an altitude of 40 m above MSL. Data on temperature, rainfall and relative humidity of the locality collected from the Agrometeorological Department of the Kerala Agricultural University are given in Appendix I.

The trial plot was with slightly sloping topography. The experiment was laid out in Randomised Block Design with six treatments and four replications. Two clones viz. RRII 118 and RRII 105 were planted with the following three spacings:

Spacing	Population density (per ha)
D_1 4.87 m x 4.87 m	420 trees
D_2 4.06 m x 4.06 m	606 trees
D_3 3.48 m x 3.48 m	824 trees

Altogether there were 24 plots, each with an area of 0.142 ha. With the prescribed spacings there were 60 trees in D_1, 86 trees in D_2 and 118 trees in D_3.

The trees were planted in 1983 and were in the second year of tapping in the ½S d/2 system.

Cultural operations were being done as per Rubber Board's recommendations (Rubber Board, 1992). Intercropping was not done during the initial years. Leguminous covercrop established had almost faded. Manuring was being done on per tree basis and so unit area of different treatments received varying quantities of fertilizers depending on the number of trees present.

From each plot, three trees at random were selected and marked for taking the observations. The following observations were recorded.

3.1 Girth of the trunk at tapping height

The girth of the main trunk of the sample trees at 125 cm above bud union was measured using a non elastic tape and recorded in centimetre.

3.2 Length of tapping cut

The actual length of the tapping cut of each of the sample tree was measured using tape.

3.3 Bark thickness

The thickness of the bark of the sample trees at 125 cm height from the bud union was measured using Schlieper's gauge and expressed in millimetre.

3.4 Leaf area

A mature leaf with three leaflets was collected from one sample tree from each plot. The leaf area was estimated using graph paper and expressed in square centimetre.

3.5 Latex yield

The sample trees were tapped between 6 am and 8 am and the latex collected in polythene cups. After the dripping was over, the total yield was measured using a measuring jar and expressed in millilitre.

3.6 Dry rubber content

Ten millilitre of latex from each tree was taken and coagulated using 5 per cent formic acid. The coagulum was separated from the cup after three hours, washed, pressed, dried in an electric oven and weighed to express the weight in gram of dry rubber in 100 ml of latex.

3.7 Sunlight penetration

The Photosynthetically Active Radiation (of wave-length 320 nm to 720 nm) infiltrating through the canopy and falling on the ground was measured using a Line Quantum Radiation Sensor and expressed in micromole/sec/m^2.

3.8 Diseases

The sample trees were observed periodically during the study period for recording the incidence of any diseases.

3.9 Weed growth

The ground was observed throughout the course of study for the presence of any weeds.

3.10 Foliar nutrient status

Composite leaf samples representing each clone and each treatment were collected during the month of October. From the sample trees, four basal leaves from the terminal whorl of low branches in shade were collected. There were 100-120 leaflets in each composite sample, which were dried and analysed for the level of nitrogen, phosphorus and potassium following the procedure decribed by Karthikakuttyamma (1989).

3.11 Field survey

A survey was conducted in four small rubber holdings which were planted in 1972, for finding out the long term effects of different planting densities on the growth and casualties of trees. The survey was conducted in Chirakkadavu village of Kottayam district, Kerala state. All the four areas were planted with budded stumps of RRIM 600. The list of holdings surveyed is given in Appendix II.

Details regarding the initial and present stands and average girth of trees were recorded by measuring 25 trees from each plot. Composite samples of top soil (0-15 cm) were collected from each plot and analysed for pH, organic carbon, phosphorus, potassium and magnesium.

3.12 Statistical analysis

Data obtained were analysed statistically based on the methods outlined by Panse and Sukhatme (1978), for two factor Randomised Block Design.

Results and Discussion

RESULTS AND DISCUSSION

The data obtained from the study regarding the various parameters were subjected to statistical analysis and the results are furnished in Table 1 to 11 and are discussed.

4.1 Girth of the trunk at tapping height

The data furnished in Table 1 and depicted in Fig.1 reveal the influence of density on the girthing of trees.

With respect to trunk girth, clones as well as different population densities showed highly significant variation. However, the interaction effect was not significant. There was marked decrease in girth with increase in density. RRII 118 was found to have more girthing than RRII 105. The highest girth of 60.5 cm was recorded by RRII 118 at 420 trees/ha whereas the lowest, 46.75 cm was for RRII 105 at 824 trees/ha.

These findings are in conformity with the results obtained in similar studies by Buttery and Westgarth (1965), Nair (1992) and Karthikeyan (1993). It is quite natural that when the number of plants per unit area is more, the solar energy as well as moisture and nutrient

Table 1. Plant girth as influenced by different population densities and clones

Clone	Plant girth at population densities (cm)			
	D_1	D_2	D_3	Mean
RRII 118	60.50	56.25	51.50	56.08
RRII 105	54.50	49.00	46.75	50.08
Mean	57.50	52.63	49.13	

CD for clone - 2.57** D_1 - 420 plants/ha

CD for density - 3.14** D_2 - 606 plants/ha

CD for clone x density - NS D_3 - 824 plants/ha

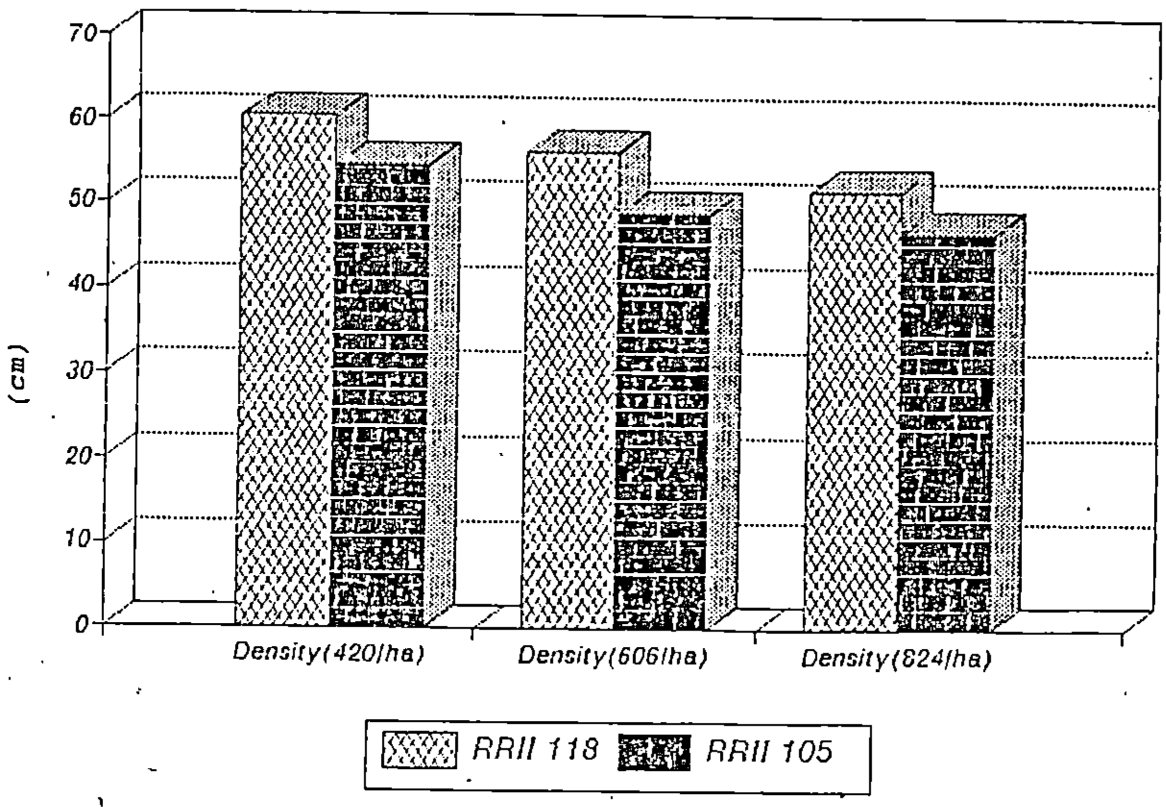

Fig. 1. TRUNK GIRTH AS INFLUENCED BY DIFFERENT POPULATION DENSITIES AND CLONES

availability to the individual plant get reduced which in turn result in the comparatively lesser growth. Due to higher shade effect in the plantation at higher population density, the plants tend to become lanky in growth. The differential performance of the clones may be due to the varietal characteristics.

4.2 Length of tapping cut

Table 2 gives the data on the length of tapping cut. As the length of the cut is proportional to the girth, it also exhibited highly significant variation with respect to density and clone. The length of the cut was maximum in clone RRII 118 at 420 trees/ha (35.17 cm) and minimum in RRII 105 at 824 trees/ha (27.17 cm).

4.3 Bark thickness

The thickness of the virgin bark varied at highly significant level with population density (Table 3). Bark thickness was found reduced with increasing density (Fig. 2). The highest value of 7.84 mm was obtained in clone RRII 118 at the density of 420 trees/ha and the lowest value of 6.50 mm was obtained in clone RRII 105 at 824 trees/ha.

Though there was highly significant relation among the different densities, differences within the clone and

Table 2. Length of tapping cut as influenced by different population densities and clones

Clone	Length of tapping cut at population densities (cm)			
	D_1	D_2	D_3	Mean
RRII 118	35.17	32.84	30.00	32.67
RRII 105	31.75	28.67	27.17	29.20
Mean	33.46	30.75	28.58	

CD for clone - 1.50** D_1 - 420 plants/ha

CD for density - 1.84** D_2 - 606 plants/ha

CD for clone x density - NS D_3 - 824 plants/ha

Table 3. Bark thickness as influenced by different population densities and clones

Clone	Bark thickness at population densities (mm)			
	D_1	D_2	D_3	Mean
RRII 118	7.84	7.25	6.58	7.22
RRII 105	7.33	7.08	6.50	6.97
Mean	7.58	7.17	6.54	

CD for clone - NS

CD for density - 0.60**

CD for clone x density - NS

D_1 - 420 plants/ha

D_2 - 606 plants/ha

D_3 - 824 plants/ha

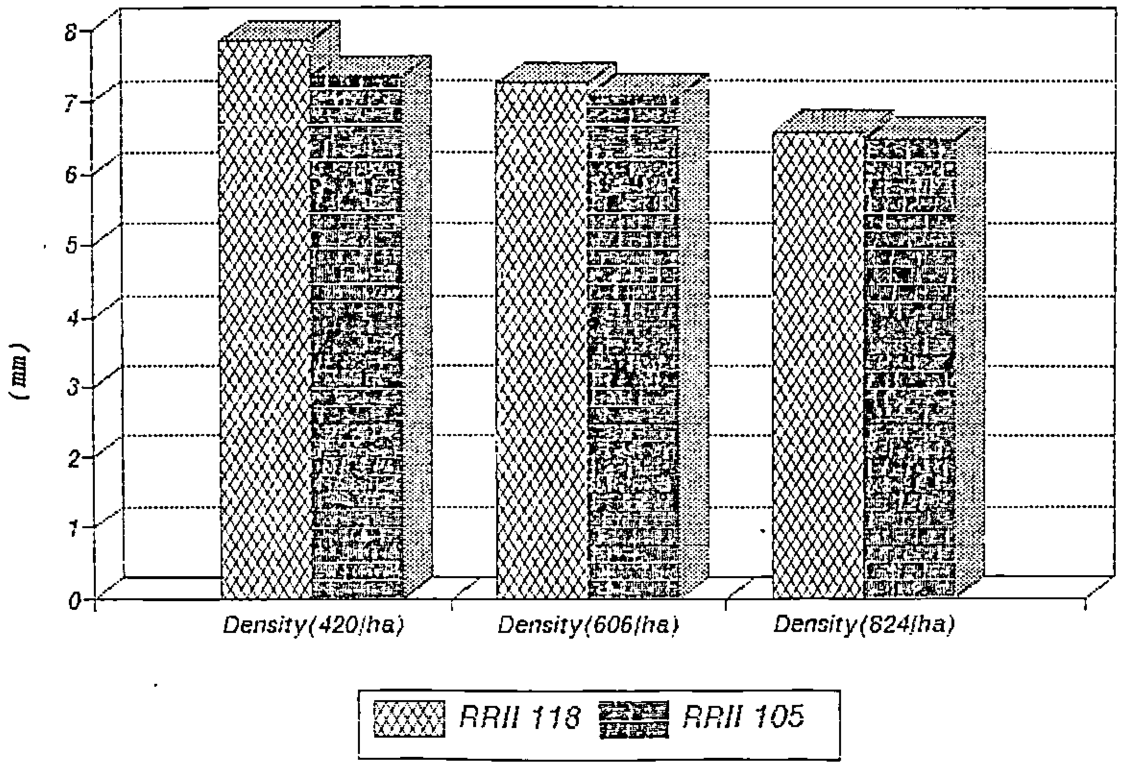

Fig. 2. BARK THICKNESS AS INFLUENCED BY DIFFERENT POPULATION DENSITIES AND CLONES

the interaction effect of clones and densities were not significant. But between the clones, RRII 118 had the thicker bark with an average of 7.22 mm whereas RRII 105 recorded a mean value of only 6.97 mm.

The results confirm the earlier findings of Dijkman (1951), Karthikeyan (1993) and Ng (1993).

4.4 Leaf area

The results pertaining to the leaf area are furnished in Table 4 and Fig. 3. It could be observed that among the different densities, there existed highly significant variation in respect of this parameter, i.e. the leaf area declined with increase in density for both the clones. There was also significant variation between the clones. The highest leaf area of 273.5 cm^2 was recorded by RRII 118 at 420 trees/ha and the lowest 151.25 cm^2 for RRII 105 at 824 trees/ha. The interaction effect of clone and density was not significant. On an average the total leaf area was higher for the clone RRII 118 compared to RRII 105.

The results agree with the findings of Leong and Yoon (1982) who had reported that greater densities resulted in smaller crowns. Karthikeyan (1993) had also observed that leaf area decreased with increasing popula-

Table 4. Leaf area as influenced by different population densities and clones

Clone	Leaf area as influenced by population densities (cm^2)			
	D_1	D_2	D_3	Mean
RRII 118	273.50	215.13	163.13	217.25
RRII 105	260.88	183.00	151.25	198.38
Mean	267.19	199.06	157.19	

CD for clone - 17.58** D_1 - 420 plants/ha

CD for density - 21.53** D_2 - 606 plants/ha

CD for clone x density - NS D_3 - 824 plants/ha

tion density. The higher leaf area recorded by RRII 118 can be considered as a varietal character.

4.5 Latex yield

From the data furnished in Table 5 it could be seen that the volume of latex per tree per tap decreased with increasing density in both the clones. But the difference was not statistically significant. However, between the clones, there existed a highly significant difference regarding latex yield, irrespective of the densities.

Though, in general, volume of latex decreased with increasing density, an exception was noticed in clone RRII 105. In this case the highest volume was obtained, not at the lowest, but at the medium density. But the difference was only negligible and not statistically significant.

Accordingly, the highest volume of latex per tree was 88.77 ml recorded by RRII 105 at the density of 606 trees/ha whereas the lowest was 43.46 ml in RRII 118 at 824 trees/ha.

The general trend of decrease in latex yield with increasing density supports earlier findings by Dijkman (1951) and Karthikeyan (1993) who had reported similar trends. In the present experiment, the plants have just

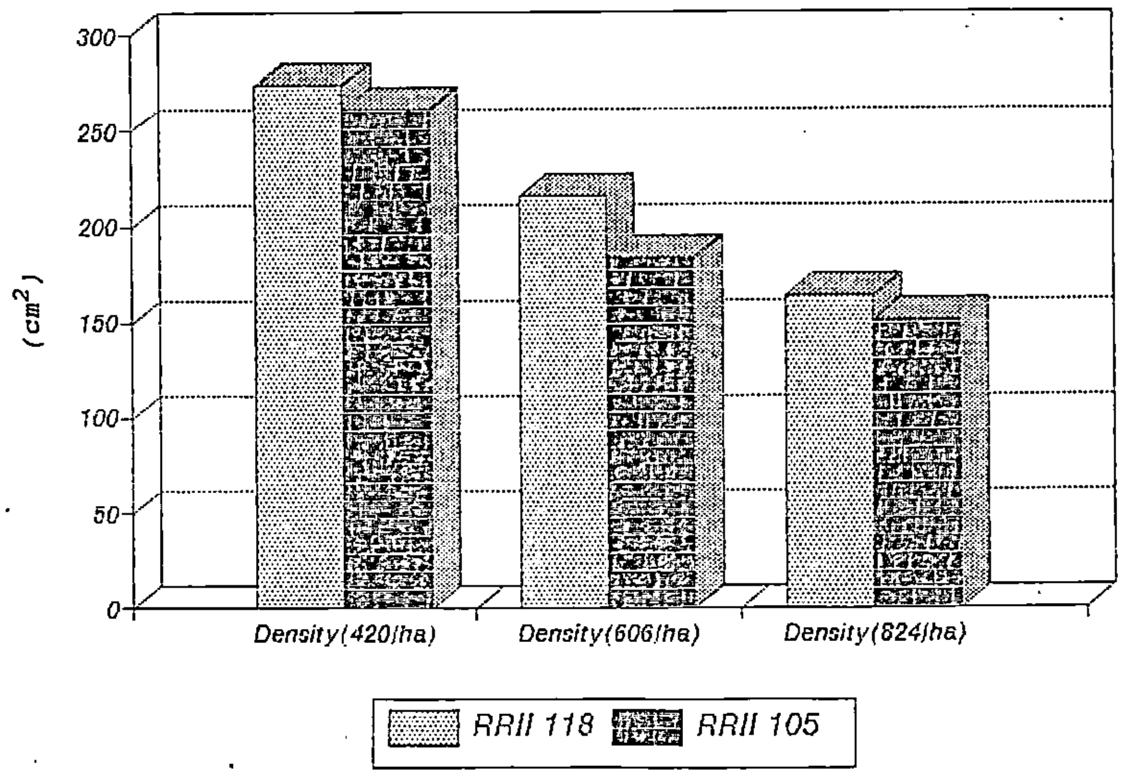

Fig. 3. LEAF AREA AS INFLUENCED BY DIFFERENT POPULATION DENSITIES AND CLONES

Table 5. Volume of latex/tree/tap as influenced by different population densities and clones

Clone	Volume of latex/tree/tap at population densities (ml)			
	D_1	D_2	D_3	Mean
RRII 118	48.44	47.17	43.46	46.35
RRII 105	83.31	88.77	74.83	82.30
Mean	65.87	67.97	59.15	

CD for clone - 18.98** D_1 - 420 plants/ha

CD for density - NS D_2 - 606 plants/ha

CD for clone x density - NS D_3 - 824 plants/ha

started yielding and a conclusive result could be obtained only after the yield gets stabilized.

4.6 Dry rubber content

As per Table 6, the differences in drc among different densities were not statistically significant. But the general trend observed was that, within each clone the drc decreased with increasing density. However, a highly significant difference was obtained between the two clones. The average drc for RRII 118 was 40.37 per cent whereas that for RRII 105 was only 35.85 per cent. The highest drc of 42.33 per cent was obtained in RRII 118 at the lowest density and the lowest drc of 33.75 per cent was recorded in RRII 105 at the highest density. The higher drc of RRII 118 may be considered as a varietal character.

The results are in agreement with the findings of Schmole (1940), Dijkman (1951) and Karthikeyan (1993) who had reported that dry rubber content decreased with increasing density.

4.7 Dry rubber yield per tree per tap

This was calculated using the values for total volume and drc of latex, actually measured.

Table 6. Dry rubber content as influenced by different population densities and clones

Clone	Dry rubber content at population densities (%)			
	D_1	D_2	D_3	Mean
RRII 118	42.33	39.08	39.70	40.37
RRII 105	37.55	36.25	33.75	35.85
Mean	39.94	37.66	36.73	

CD for clone - 3.21** D_1 - 420 plants/ha

CD for density - NS D_2 - 606 plants/ha

CD for clone x density - NS D_3 - 824 plants/ha

In this case also, the difference between clones was significant, but the densities as well as the interaction were not statistically significant (Table 7). However, the trend was that the dry rubber yield per tree per tap decreased with increasing density, except that RRII 105 showed a slightly higher yield at 606 trees/ha than that at 420 trees/ha. Actually this is due to the contributory effect of the higher volume of latex recorded at this density.

In all the spacings, RRII 105 was found to be much superior to RRII 118 regarding per tree yield, in spite of its lower drc. The average yield of these two clones were 28.72 g and 18.57 g respectively. The highest per tree yield of 31.45 g was recorded in RRII 105 at 606 trees/ha whereas the lowest was 17.12 g in RRII 118 at 824 trees/ha.

The results are in conformity with the findings of Schmole (1940) and Karthikeyan (1993).

4.8 Sunlight penetration

The data with respect to the infiltration of Photosynthetically Active Radiation (PAR) through the canopy in different densities are presented in Table 8.

Table 7. Dry rubber yield/tree/tap as influenced by different population densities and clones

Clone	Dry rubber yield/tree/tap at population densities (g)			
	D_1	D_2	D_3	Mean
RRII 118	20.43	18.15	17.12	18.57
RRII 105	30.35	31.45	24.38	28.72
Mean	25.39	24.80	20.75	

CD for clone	- 5.29**	D_1 - 420 plants/ha
CD for density	- NS	D_2 - 606 plants/ha
CD for clone x density	- NS	D_3 - 824 plants/ha

Table 8. Sunlight penetration through the canopy as influenced by different population densities and clones

Clone	Sunlight penetration at population densities (micromole/sec/m²)			
	D_1	D_2	D_3	Mean
RRII 118	44.75	36.40	25.73	35.62
RRII 105	38.56	30.73	30.40	33.23
Mean	41.66	33.56	28.06	

CD for clone - NS D_1 - 420 plants/ha

CD for density - NS D_2 - 606 plants/ha

CD for clone x density - NS D_3 - 824 plants/ha

The variations were not significant but the general trend was that the infiltration decreased with increasing density in both the clones. The highest quantum of PAR penetrated was 44.75 micromole/sec/m^2 in RRII 118 at 420 trees/ha and the lowest was 25.73 micromole/sec/m^2 again in RRII 118 at 824 trees/ha. From the results regarding leaf area, the parameter was found to decline with increasing density. At lower densities the area of individual leaflets was more. Also at wider spacings, the trees may show a tendency to overgrow. These two factors might have resulted in the non-significant difference in infiltration of PAR among the different densities.

The trend observed is in agreement with the findings of Karthikeyan (1993).

4.9 Dry rubber yield per hectare per tap

The dry rubber yield/ha/tap at the different densities was computed based on per tree yield per tap and number of trees/ha in different spacings. The results are furnished in Table 9 and Fig. 4.

Regarding the per hectare yield per tap there was highly significant variation between the clones and among different densities. Yield/ha increased with increasing stand and there was no tendency of any decline even at 824

Table 9. Dry rubber yield/hectare/tap as influenced by different population densities and clones

Clone	Dry rubber yield/ha/tap at population densities (kg)			
	D_1	D_2	D_3	Mean
RRII 118	8.58	11.00	14.11	11.23
RRII 105	12.75	19.06	20.09	17.30
Mean	10.66	15.03	17.10	

CD for clone - 3.13** D_1 - 420 plants/ha

CD for density - 3.83** D_2 - 606 plants/ha

CD for clone x density - NS D_3 - 824 plants/ha

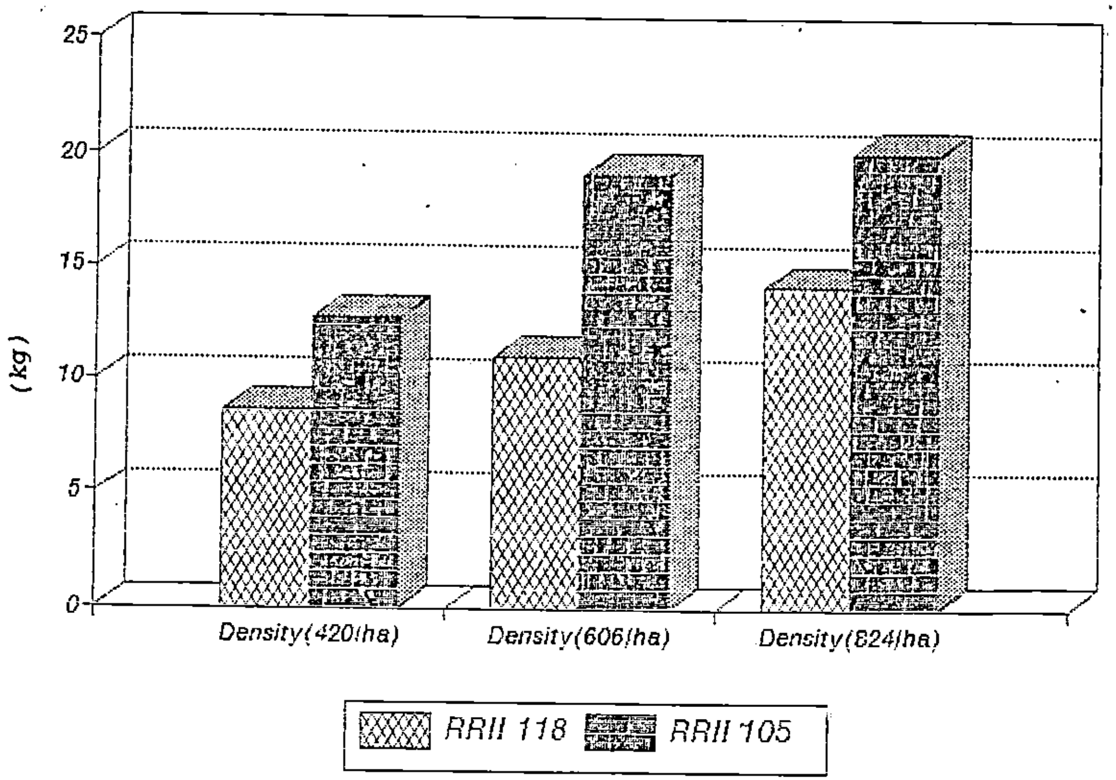

Fig. 4. DRY RUBBER YIELD/HECTARE/TAP AS INFLUENCED BY DIFFERENT POPULATION DENSITIES AND CLONES

trees/ha. It means that the optimum stand for maximum yield in both the clones is higher than 824 trees/ha.

The highest yield/ha/tap, i.e. 20.09 kg was recorded in RRII 105 at 824 trees/ha and the lowest, 8.58 kg for RRII 118 at 420 trees/ha.

It was also seen that RRII 105 was much superior to RRII 118 in yield. The average yield of RRII 105 was 17.30 kg whereas that of RRII 118 was only 11.23 kg. Such variations may be attributed to the varietal characteristic.

4.10 Diseases

During the period of study no diseases were noticed on the sample trees. This may be due to the fact that major diseases of mature rubber trees occur during rainy season and the present study was conducted during dry months. However, the foliage retention of both the clones was good, suggesting that there had been no considerable attack of *Phytophthora*. However, Ng (1993) in Malaysia had observed that higher densities favoured the incidence of panel diseases by way of increased humidity in the plantation due to early canopy closure.

4.11 Weed growth

No noticeable weed growth was present in any of the plots during the period. Leguminous covercrop had only just faded and the ground was well covered by the fallen litter. Another reason for absence of any weeds may be that the study was conducted during summer months.

4.12 Foliar nutrient status

The results of analysis of foliar nutrient status, presented in Table 10 had showed no uniform pattern of variation except for nitrogen and phosphorus in clone RRII 105. Here the contents of these nutrients in the leaf was found to decrease with increasing density. But potassium in RRII 105 was highest in the medium density and lowest in the highest density. However, in clone RRII 118, potassium content in leaf was found to increase with increasing density.

In this particular experiment, fertilizers were being applied on per tree basis irrespective of the density and as a single dose during south west monsoon period. The plot is slopy without effective soil and moisture conservation structures. This might have contributed to the erratic results obtained.

Table 10. Foliar nutrient status as influenced by different population densities and clones

Treatment	Nutrient (%)		
	N	P_2O_5	K_2O
RRII 118 at 420/ha	2.80	0.19	0.90
RRII 118 at 606/ha	3.29	0.16	0.92
RRII 118 at 824/ha	3.18	0.16	0.96
RRII 105 at 420/ha	3.83	0.23	1.30
RRII 105 at 606/ha	3.52	0.20	1.46
RRII 105 at 824/ha	3.46	0.19	1.06

4.13 Field survey

The data of the field survey are furnished in Table 11.

The results regarding the mean girth of trees were seen to agree with the findings of the main project. There was profound difference for this parameter in different densities. Generally the mean girth was higher in lower stands.

No correlation was observed between the number of casualties, soil nutrient status and stand per hectare.

Table 11. Girth, casualties and soil nutrient status as influenced by different population densities

Density	Average girth (cm)	No. of casual-ties	pH of soil	Soil nutrient status(%)			
				Org.C	P_2O_5	K_2O	Mg
I (381/ha)	80.84	55	5.2	1.75 (H)	1.20 (M)	7.50 (M)	7.77 (H)
II (418/ha)	76.56	70	5.1	1.05 (M)	0.40 (L)	10.00 (M)	2.77 (H)
III (634/ha)	70.12	49	4.7	1.43 (M)	0.60 (L)	9.00 (M)	5.55 (H)
IV (760/ha)	61.68	94	4.8	1.56 (H)	3.50 (H)	6.25 (M)	4.99 (H)

(L - Low; M - Medium; H - High)

Summary and Conclusion

SUMMARY AND CONCLUSION

Results of the present investigations on the "Performance evaluation of rubber under different planting intensities" are in agreement with the findings of earlier studies conducted in India and abroad. Individual tree growth parameters like girthing and bark thickness are affected by higher densities. Per tree yield and drc are higher at lower population densities.

Yield of rubber is a function of the number of trees in tapping, the average yield per tree and the frequency of tapping. Hence per hectare yield will increase with increasing density upto a certain limit. However, the estimation of the optimum stand per hectare that will maximise profit over the whole productive period of the holding is rather difficult. This involves the difficult task of attempting to predict the future level of variables such as tapping costs, selling price of rubber etc.

When rubber prices are high and when family labour is employed for tapping, higher yield per hectare realised from higher stands may be profitable. But when tapping cost is higher compared to price of rubber it is desirable to have higher per tree yield. In Malaysia, a stand of 750 trees/ha is recommended for small holders who work on their own estates. But in India such recommendations based on scientific budgeting are lacking. However, the experiment results point to the necessity for reviewing our present recommendations and a modification to allow for a higher stand for small holdings in which family labour can be employed.

The salient findings of the study are as follows:

Girth increment was higher in low density planting and vice versa.

Thickness of virgin bark decreased with increasing density.

Leaf area was more at wider spacings.

Volume of latex/tree/tap was less at higher stands.

The drc was found to decrease with denser plantings.

Per hectare yield was more at closer spacings.

Sunlight penetration through the canopy was more in stands with wider spacings.

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APPENDIX-I

Weather data of Vellanikkara

Temperature in °C, Rain in mm and RH in %

Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
						Year 1991						
Max. tem.	33.6	35.9	36.4	35.6	35.1	29.7	29.1	29.0	31.5	30.9	31.5	31.9
Min. tem.	22.2	21.7	24.9	24.5	25.5	23.8	22.8	22.7	23.6	23.2	25.0	21.7
Rain	3.9	0.0	1.8	83.8	56.1	993.1	975.6	533.3	61.5	281.7	191.3	0.2
R. days	1	0	0	4	5	28	27	24	7	14	9	0
Mean RH (%)	57	51	66	68	70	88	86	87	78	82	75	64
						Year 1992						
Max. tem.	32.6	34.5	36.9	36.3	33.8	30.1	28.8	28.9	30.1	30.7	31.0	31.1
Min. tem.	20.9	21.8	22.8	24.4	24.8	23.7	22.7	23.3	23.1	22.9	23.1	22.3
Rain	0.0	0.0	0.0	48.6	90.6	979.8	874.5	562.9	302.9	386.7	376.7	2.0
R. days	0	0	0	3	6	22	26	25	17	14	12	0
Mean RH (%)	53	65	61	65	73	84	87	88	82	82	77	61
						Year 1993						
Max. tem.	32.6	34.1	35.4	34.5	34.4	30.1	28.5	29.6	30.6	30.7	31.5	31.6
Min. tem.	20.7	22.0	23.7	25.0	24.8	23.9	22.9	23.4	23.1	23.4	23.6	23.1
Rain	0.0	6.6	0.0	32.1	131.1	700.3	661.6	276.7	85.3	519.0	74.6	18.0
R. days	0	2	0	2	6	22	29	20	9	16	4	2
Mean RH (%)	53	62	63	69	74	86	87	87	81	83	73	66

Source: Department of Agrometeorology, College of Horticulture, Vellanikkara, Thrissur.

APPENDIX-II

Details of small rubber holders whose plots were selected for the survey

Name and address	Extent (ha)
1. Mrs.Padmavathiamma Thalavangattu. Cheruvally, P.O.	0.55
2. Mr.Chandrasekharan Nair Panthalattil Thekkethukavala, P.O.	0.43
3. Mr.K.J.Cherian Kurisummoottil Kanjirappally, P.O.	0.41
4. Mrs.Sudhakumari Arinchadath Thekkethukavala, P.O.	0.41