EFFECT OF PLANTING DENSITY ON THE GROWTH OF RUBBER IN THE VELLANIKKARA ESTATE

BY

K. V. KARTHIKEYAN

DISSERTATION

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DEPARTMENT OF PLANTATION CROPS AND SPICES
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KERALA AGRICULTURAL UNIVERSITY
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1993

DECLARATION

I hereby declare that this dissertation entitled **"Effect of planting density on the growth of rubber in Vellanikkara Estate"** is a bonafide record of research work done by me and that this dissertation has not formed the basis for award to me, of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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K.V. KARTHIKEYAN

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Sri.K.V. Karthikeyan,** a candidate for the Post Graduate Diploma in Natural Rubber Production, certify that this dissertation entitled **"Effect of planting density on the growth of rubber in Vellanikkara Estate"** is a record of research work done independently by Sri.K.V. Karthikeyan under our guidance and that it has not previously formed the basis for award of any degree, diploma, associateship or fellowship to him.

We also agree that this dissertation may be submitted by him in partial fulfilment of the requirements of the diploma.

1. **Dr.E.V. Nybe,**
   Associate Professor,
   Dept. of Plantation Crops & Spices,
   College of Horticulture,
   Kerala Agricultural University
   Vellanikkara.
   (Major Adviser)

2. **Dr.C.K. Saraswathi Amma,**
   Deputy Director,
   Rubber Research Institute of India,
   Kottayam.
   (Co-Chairman)

3. **Dr.G. Sreekantan Nair,**
   Professor and Head,
   Dept. of Plantation Crops & Spices,
   College of Agriculture,
   Kerala Agricultural University,
   Vellayani.
   (Member)

4. **Dr.P.A. Nazeem,**
   Associate Professor,
   Dept. of Plantation Crops & Spices,
   College of Horticulture,
   Kerala Agricultural University,
   Vellanikkara.
   (Member)

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K.V. KARTHIKEYAN

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INTRODUCTION

The genus Hevea belonging to the family Euphorbiaceae consists of 11 species. Among these, the para rubber tree (Hevea brasiliensis Willd. ex Adr. de Juss.) Muell. Arg. is the most important commercial source of natural rubber. Natural rubber is one of the most versatile vegetable products having manifold uses. Over thirty million people in the world are dependent on natural rubber for their livelihood.

Rubber plantation industry provides the principal raw material for the rubber goods manufacturing industry which in turn produces a variety of products indispensable in modern life. The natural rubber production in India is 366745 t from an area of 466000 ha for the period 1991-'92 (Rubber Board, 1993). Of these, Kerala alone contributes 85 per cent of the area and 90 per cent of production. India is the fourth largest producer of natural rubber next to Thailand, Indonesia and Malaysia.

The average yield of rubber in our country is 1130 kg/ha/year which was only 898 kg in 1985-'86. India is one of the countries which uses maximum proportion of natural rubber. The consumption ratio of natural and synthetic rubber in India is 78:22, while the world pattern of use is 36:64.

The clone currently enjoying maximum popularity in the country is RRII 105, evolved by the Rubber Research Institute of India. More than 80 per cent of the plantation sector is occupied by this clone. Moreover, by the encouraging and efficient replanting and new planting schemes of the Rubber Board, almost the entire area is occupied by the rubber plantations. Due to the scarcity of land in the traditional areas, the rubber plantations are shifted to the non-traditional rubber tracts.

The rubber plantations in Kerala are predominated by small holdings numbering about seven lakhs, which accounts for 83 per cent of the total area under rubber.

The planting density recommended is 420 to 445 per hectare (i.e. 170 to 180 per acre) in the case of budgrafted plants. Whereas in the case of seedlings, the stand is 445 to 520 plants per hectare (180 to 210 plants per acre). However, with regard to small growers, since they are self managing the plantations, they used to plant higher stand than the recommended stand. At this juncture, it is worthwhile to generate information on the effect of different planting densities on the growth, secondary attributes and yield of the plants.

However, experimental evidences to elucidate the impact of high density planting on growth, and yield of rubber are meagre in India. Therefore, the investigations reported herein were carried out with an objective to find out the effect of different population densities on vegetative growth, yield and dry rubber content of high yielding rubber clones.

REVIEW OF LITERATURE

Under the prevailing agroclimatic conditions in India, indepth studies on the effect of different planting densities on the growth and yield of rubber are limited. However, extensive studies on these aspects are reported from countries like Indonesia and Malaysia.

Edgar (1958) reported that increase in number of plants per unit area would decrease the spread of canopy, size and spread of trees. A good account of growth, yield and diseases In relation to planting density was given by Dijkman (1951).

An experiment conducted by Buttery and Westgarth (1965) revealed that under wider spacings, plants attained tapping stage very much earlier than in dense plantings. Mani et al. (19[illegible]) reported that girth was reduced with increase in planting density. Studies on effect of planting density on growth of rubber were also reported by Ng et al. (1979). It was suggested that a more vigorous clone perform better at lower densities than a less vigorous clone (Yoon, 1980). Studies on effect of planting density on growth of rubber were reported by Leong and Yoon (1982). The merits and demerits of wider and narrow spaced planting were also reported by Saraswathi Amma (1985).

In the early days of rubber industry, trees in estates were planted wide apart than they are now-a-days. In Malaysia, spacing at 6.1 m square was common giving an initial stand of 270 trees per hectare. It was soon realised that while this gave strong growth and high yield per tree, larger yields per hectare could be obtained by close planting. A number of experiments comparing different planting densities were conducted in Indonasia and in Malaysia (Webster and Baulkwill, 1989).

In Malaysia, common spacings were 30' x 8', 24' x 10' and 20' x 12'. All these spacings gave 448 trees per hectare (Webster and Baulkwill, 1989).

Except on sloping land or where intercroping was intended, planting was commonly done in equitorial triangle system. This allowed each tree the same amount of space in all directions and was generally considered to give the most uniform growth and the shortest immaturity period. Spacing of 5.1 m to 4.9 m were suitable with initial stands of 444 to 481 trees per hectare (Webster and Baulkwill, 1989).

Hedge planting system was suggested by Webster and Baulkwill (1989) wherein the rubber plants were planted 2 to 3 m apart in lines and 8 to 9 m apart between lines which enabled coffee planting in between rows.

Conventional planting pattern adopted by the farmers depend on the lie and slope of the land. In general, rectangular, square and triangular systems were found to be best suited for flat and slightly undulating lands (Punnose, 1990).

In rectangular planting system, the distance between plants was higher than that of the distance between plants in a single row. In this system the spacing in the row varied between 6.1 m and 6.7 m and between the row varied from 3 m to 3.4 m (Punnose, 1990).

Cherian (1990) has reported that despite of better earlier growth in close spacings, the mean girth of plants at wider spacings was higher during later stages.

In square planting system, the distance between plants in a line and between lines were one and the same. The spacings in this system varied from 4.3 m to 4.9 m (Rubber Board, 1992). In triangular system, the spacing in a row varied from 4.3 m to 4.9 m and between rows varied from 4.3 m to 4.9 m (Punnose, 1990).

From the studies conducted by Nair (1992) it was reported that wherever normal spacings were adopted 40 per cent attained tapping stage by eighth year.

On sloping land, the trees will be normally planted along the contours on terraces. The planting system usually approximates to rectangular with the distance between contour rows greater than that between trees in the rows (Rubber Board, 1993).

MATERIALS AND METHODS

The study was conducted at the College of Horticulture, Vellanikkara during the period from April 1993 to June 1993. The plants in an ongoing experiment planted during 1983 in the 'Suhasini' block of the rubber estate of Kerala Agricultural University, Vellanikkara were utilized for the study. The trial plot was with more or less undulating topography. The area was located at 10 degree 31' N latitude and 70 degree 13' E longitude and at an altitude of 40 m above MSL. Data on temperature and rainfall of the location for the past three years are presented in Appendix I and II respectively.

The experiment was laid out in Randomised Block Design with six treatments and five replications. The following three spacings were tried in two promising clones i.e. RRII 105 and RRII 118:

	Spacing	Population density per hectare
S_1	4.87 m x 4.87 m	420 plants
S_2	4.06 m x 4.06 m	606 plants
S_3	3.48 m x 3.48 m	824 plants

There were 30 plots, each plot with an area of 0.142 ha. The total experimental area was 4.26 ha. The number of plants per plot varied with the treatments. There were 60 plants per plot in S_1, 86 plants in S_2 and 118 plants in S_3.

The plants were grown as per the package of practice recommendations of the Rubber Board. Intercropping was not done during the early stages of crop growth. Leguminous cover crop <u>Pueraria phaseoloides</u> was established luxuriently.

For recording the biometric observations, a sample of ten plants per plot were randomly selected. The following observations were recorded.

3.1. Branching height

The height upto the first branching level was measured using a pole and expressed in centimetres.

3.2. Branching angle and nature of canopy

The branching angle and nature of canopy were recorded by visual observation of the sample plants in each treatment. The degree of angle was classified as acute and obtuse and the canopy as dense, medium or low.

3.3. Number of branches

The number of primary, secondary and tertiary branches of the sample plants were counted and the sum total of them expressed as the number of branches.

3.4. Girth

The individual plant girth at 125 cm above budunion of the sample plants from each plot was measured using a tape and recorded in centimetres.

3.5. Bark thickness

The bark thickness was measured using Schlieper's guage and expressed in millimetres.

3.6. Leaf area

The leaf area was recorded using graph paper and expressed in square centimetres.

3.7. Latex yield

The sample plants were tapped between 6 a.m. and 7 a.m. and the latex collected in a fresh PVC collecting vessel until the dripping was over. The collected latex was measured by using a measuring glass jar and the volume expressed in millilitres.

3.8. Dry rubber content

Dry rubber content was recorded by taking 10 ml sample of the latex and coagulating with formic acid, drying in electric oven and by weighing in electronic weighing machine and expressed in percentage.

3.9. Light penetration

The photosynthetically active radiation penetrating through the canopy and falling on the ground was measured by using a Line Quantum Sensor placed one metre above the ground level. The quantum of PAR was expressed in micromole per second per square metre.

3.10. Statistical analysis

The data generated from the experiment were subjected to statistical analysis following the methods outlined by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

The data recorded on various parameters were subjected to statistical analysis and the results are furnished in Table 1 to 3 and are discussed.

4.1. Branching height

The data on branching height furnished in Table 1 revealed that in general, branching height increased under high density planting. Maximum branching height of 3.11 m was recorded by the variety RRII 118 under medium level of population i.e., 4.06 m x 4.06 m with 606 plants per hectare. The lowest branching height of 2.58 m was observed in RRII 105 variety at the widest spacing of 4.87 m x 4.87 m (420 plants per hectare). The results of the investigation showed that under high density planting, there would be more shade effect and the plants tend to be more lanky in growth in search of light thereby increasing the branching level. This is in agreement with the early findings by Edgar (1958) that increase in number of plants per unit area would decrease the spread of trees.

4.2. Branching angle and nature of canopy

The results of the study revealed the common trend that ching was acute angled in all the three treatments. But the varieties had influenced the nature of canopy much. The nature of canopy of RRII 105 was medium in all the three treatments, where

Table 1. Morphological characters of rubber as influenced by different population densities and clones

Treatment	Branching height (m)	No. of branches	Girth (cm)	Bark thickness (mm)	Leaf area (cm^2)
V_1 S_1 RRII 105 4.87 m x 4.87 m	2.58	25.0	62.2	7.1	274.6
V_1 S_2 RRII 105 4.06 m x 4.06 m	2.90	23.7	59.6	6.8	199.3
V_1 S_3 RRII 105 3.48 m x 3.48 m	2.99	22.6	56.8	6.7	153.6
V_2 S_1 RRII 118 4.87 m x 4;87 m	2.77	24.0	64.7	7.1	289.8
V_2 S_2 RRII 118 4.06 m x 4.06 m	3.11	21.2	58.7	6.7	253.0
V_2 S_3 RRII 118 3.48 m x 3.48 m	3.10	20.3	58.7	6.7	154.3
CD	NS	NS	4.5*	NS	NS

* Significant at 5% level NS - Not significant

as, RRII 118 showed dense canopy in all the three treatments.

4.3. Number of branches

The results obtained with regard to number of branches (Table 1) revealed that the number of branches increased with increase in spacing. A maximum of 24 branches were recorded by the variety RRII 105 with a spacing of 4.87 m x 4.87 m at a planting density of 420 trees per hectare, where as, a minimum of 20.3 were recorded by RRII 118 at a planting density of 824 trees per hectare with a spacing of 3.48 m x 3.48 m.

The above results of this study confirm the reports by Edgar (1958) that increase in number of trees will decrease the crown size and spread of trees.

4.4. Girth of trunk

The data with respect to girth of plants are furnished in Table 1 and Fig.1. It could be observed from the table that there existed significant variation among different population densities in respect of trunk girth. With increase in population density the girth of the plant decreased. The highest mean girth of 64.7 cm was recorded by RRII 118 at a population density of 420 plants per hectare which was significantly higher than all other treatments.

The above results are in agreement with earlier studies conducted in this regard. The findings of Mani *et al.* (1979) confirm this type of relationship in *Hevea*. Similarly, Cherian (1990) has

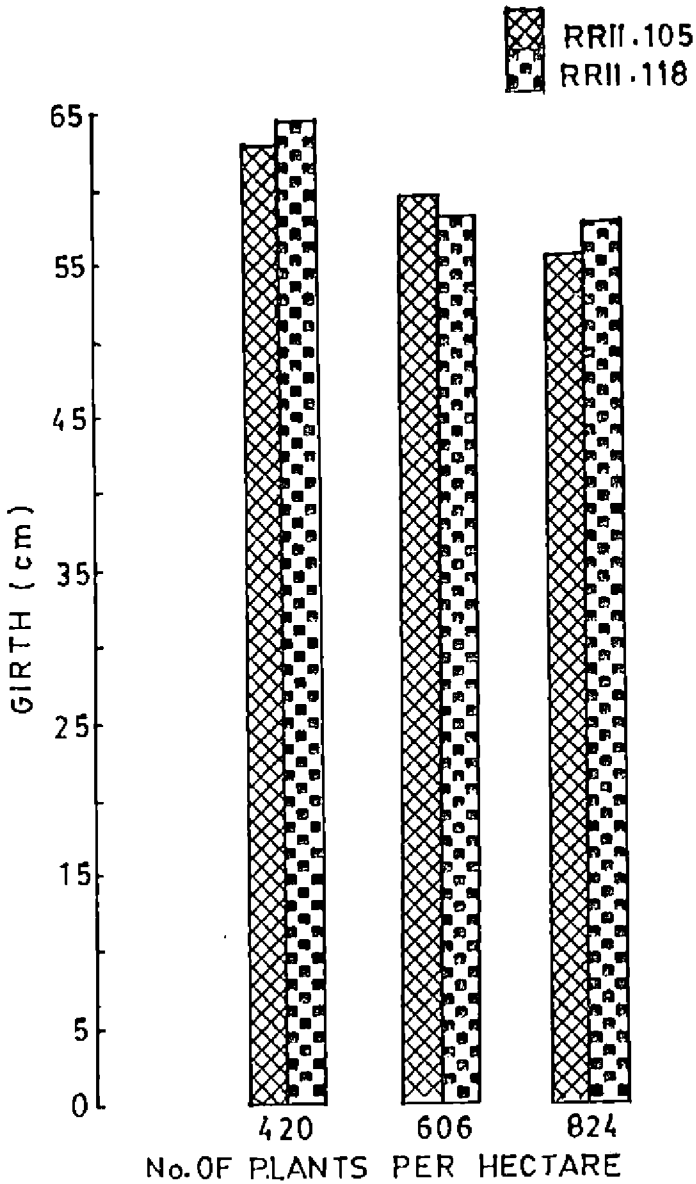

FIG.1. GIRTH OF TRUNK AS INFLUENCED BY DIFFERENT POPULATION DENSITIES AND CLONES

also reported that despite slightly better earlier growth in close spacings, the mean girth of plants at wider spacing was higher during later stages of growth (10th year). He observed that plants under a population density of 48 trees/acre recorded a girth of 30.2" and 47.5" respectively during 10th and 21st year of planting which was about double of those at higher density of planting with 435 trees/acre.

4.5. Barck thickness

With respect to bark thickness the general trend observed was that bark thickness decreased with increase in planting density.

The highest bark thickness of 7.1 mm was recorded by both the varieties RRII 105 and RRII 118 at a population density of 420 plants per hectare with a spacing of 4.87 m x 4.87 m. The lowest bark thickness of 6.7 mm was recorded by both varieties of RRII 105 and RRII 118 at a high planting density of 824 trees per hectare. The same thickness of 6.7 mm was also recorded by RRII 118 at a medium density of 606 plants per hectare with a spacing of 4.06 m x 4.06 m (Table 1).

Webster and Baulkwill (1989) have also reported that in Malaysia the renewed bark at the closer spacing was not thick enough for tapping by the time when virgin bark was consumed and that the rate of bark renewal and thickness of virgin bark would be low. In respect of virgin bark, the observation made by the above workers is in confirmity with the result of the present investigations.

Though it is too early to obtain a conclusive result from the present studies regarding the rate of bark renewal and its thickness, it can be remarked that the rate of bark renewal and thickness of renewed bark may be less in the case of high density planting.

4.6. Leaf area

The results of the data in Table 1 with regard to leaf area at different planting densities and varieties revealed that the leaf area decreased with increase in population density. The highest leaf area of 289.8 cm^2 was recorded by the variety RRII 118 at a population density of 420 plants per hectare. The lowest leaf area of 153.6 cm^2 was recorded by the variety of RRII 105 at a planting density of 824 plants per hectare.

The results agree with the reports by Edgar (1958) that increase in the number of trees would decrease the crown size and spread of trees.

4.7. Percentage of weaklings

The data with regard to percentage of weaklings is furnished in Table 2 and depicted in Fig.2. It revealed that influence of planting density on attainment of tapping stage was highly significant. The percentage of weaklings increased with increase in population density. The highest weakling percentage of 35.8 was recorded by the population density of 824 trees per hectare which was significantly superior to that of other lower population densities. The

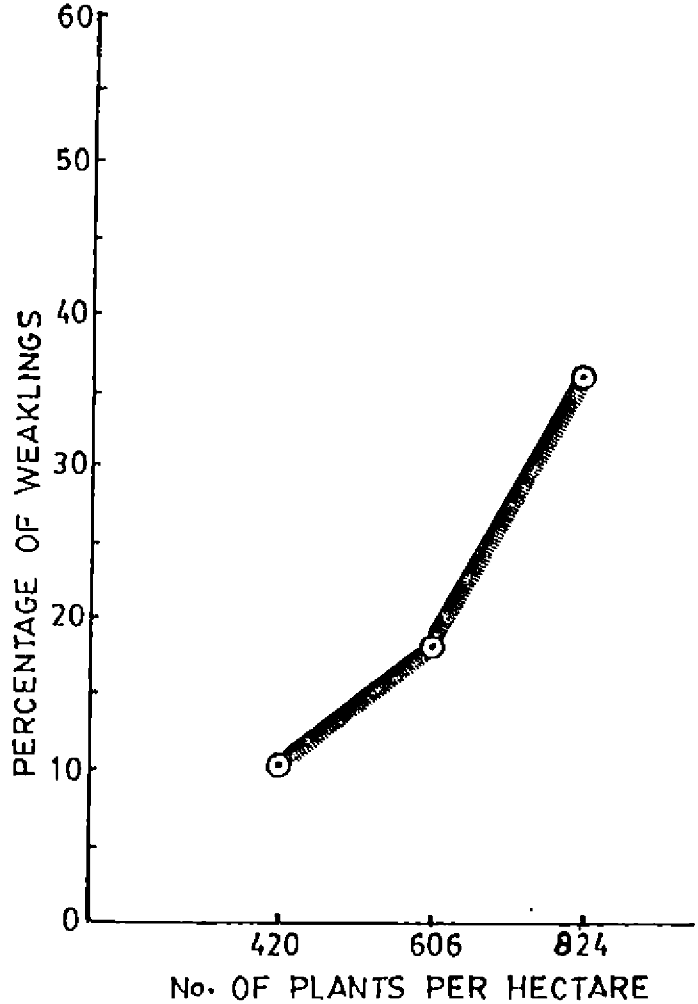

FIG. 2. PERCENTAGE OF WEAKLINGS AS INFLUENCED BY DIFFERENT POPULATION DENSITIES

Table 2. Percentage of weaklings and light penetration as influenced by different population densities

Treatment	Weaklings (%)	Light penetration $\mu/sec/m^2$
S_1 4.87 m x 4.87 m	10.4	110.9 (100 %)
S_2 4.06 m x 4.06 m	18.4	33.08 (30 %)
S_3 3.48 m x 3.48 m	35.8	22.5 (20 %)
CD	8.4**	55.5*

* Significant at 5% level
** Significant at 1% level

planting density of 420 plants per hectare with a spacing of 4.87 m x 4.87 m had the lowest percentage of weaklings (10.4).

An experiment conducted in Malaysia by Buttery and Westgarth (1965) with planting densities ranging from 110 to 1074 trees per hectare revealed that 90 per cent plants in the density of 110 plants per hectare reached tapping stage three years after planting, where as at 1074 plants per hectare 31 per cent remained untappable even after 19 years of planting.

Another study conducted by Nair (1992) revealed that wherever normal spacing was adopted 40 per cent attained tapping stage by eighth year, 10 per cent recorded an average girth less than 45 cm and 50 per cent plants recorded 45 to 49 cm.

4.8. Light penetration

The data furnished in Table 2 revealed that there was significant influence of planting density on light penetration (Fig.3). The maximum light penetration recorded was 110.9 micromole per second per sq. metre at a planting density of 420 plants per hectare with a spacing of 4.87 m x 4.87 m which was significantly higher than that of other population densities. The lowest light penetration recorded was 22.5 micromole/sec/m^2 at a planting density of 824 plants per hectare. The reduction in the photosynthetic active radiation was to the tune of 70 per cent and 80 per cent in the case of population densities of 606 plants/ha and 824 plants/ha

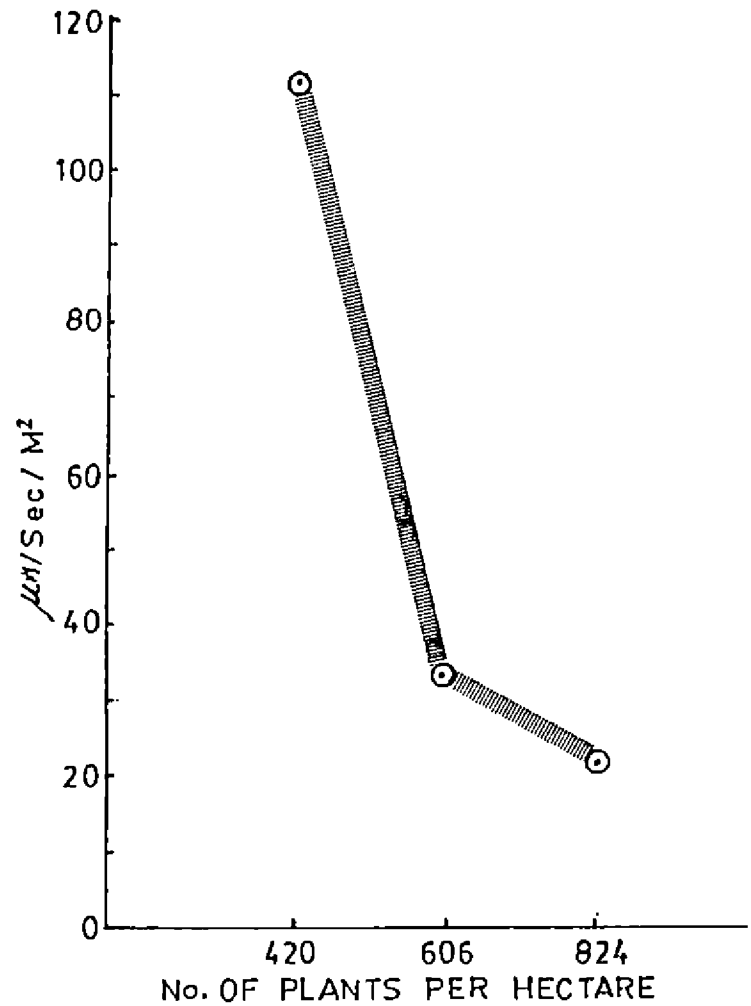

FIG. 3. LIGHT PENETRATION THROUGH THE CANOPY AS INFLUENCED BY DIFFERENT POPULATION DENSITIES

respectively as compared to the lowest population density of 420 plants/ha.

4.9. Latex yield per tree

The results of the data on yield are furnished in Table 3. Though not significant, the common trend observed was that the per tree latex yield decreased with increase in planting density. The highest per tree latex yield of 41.87 ml was recorded by RRII 105 at a planting density of 420 plants per hectare. The lowest yield of 25 ml was recorded by RRII 118 at a planting density of 824 trees per hectare.

The results are in support of the report by Dijkman (1951) who has reported that latex yield was linked with growth and planting density.

4.10. Latex yield per hectare

In respect of latex yield per hectare it could be seen from Table 3 that the yield increased with increase in planting density. The highest per hectare latex yield of 23.08 l was recorded by RRII 105 at a planting density of 824 plants per hectare. The lowest per hectare latex yield of 9.59 l was recorded by RRII 118 at a planting density of 420 plants per hectare.

Earlier studies in Malaysia showed that with increase in planting density annual yield per hectare and cumulative yield per

Table 3. Latex yield per tree and per hectare, drc and dry rubber yield per hectare as influenced by different population densities and clones

Treatment	Latex yield/ tree (ml)	Latex yield/ ha (l)	drc (%)	Dry rubber yield/ha (kg)
V_1 S_1 RRII 105 4.87 m x 4.87 m	41.87	17.58	43.0	7.54
V_1 S_2 RRII 105 4.06 m x 4.06 m	37.70	22.84	40.8	9.13
V_1 S_3 RRII 105 3.48 m x 3.48 m	27.92	23.08	37.0	8.53
V_2 S_1 RRII 118 4.87 m x 4.87 m	26.10	9.59	44.5	4.26
V_2 S_2 RRII 118 4.06 m x 4.06 m	25.56	15.52	39.0	6.05
V_2 S_3 RRII 118 3.48 m x 3.48 m	25.00	20.59	38.0	7.82
CD	NS	NS	2.3**	NS

** Significant at 1% level NS - Not significant hectare over a period of years was increased upto an optimum density (Webster and Baulkwill, 1989).

4.11. Dry rubber content

The data on dry rubber content (Table 3 and Fig.4) showed that there existed highly significant variation among treatments. The dry rubber content of 44.5 per cent recorded by RRII 118 with a spacing of 4.87 m x 4.87 m was significantly superior to all other population densities.

The above result was in confirmation with the findings of Dijkman (1951) who had reported that the rubber content decreased from wide planted trees to the dense planted trees.

4.12. Dry rubber yield per hectare

The data furnished in Table 3 and Fig.5 revealed that the dry rubber yield per hectare increased with increase in planting density. However, with regard to RRII 105 the highest dry rubber yield of 9.13 kg was recorded by the medium planting density of 606 plants per hectare with a spacing of 4.06 m x 4.06 m. The lowest dry rubber yield per hectare of 4.26 kg was recorded by RRII 118 at a planting density of 420 plants per hectare with a spacing of 4.87 m x 4.87 m.

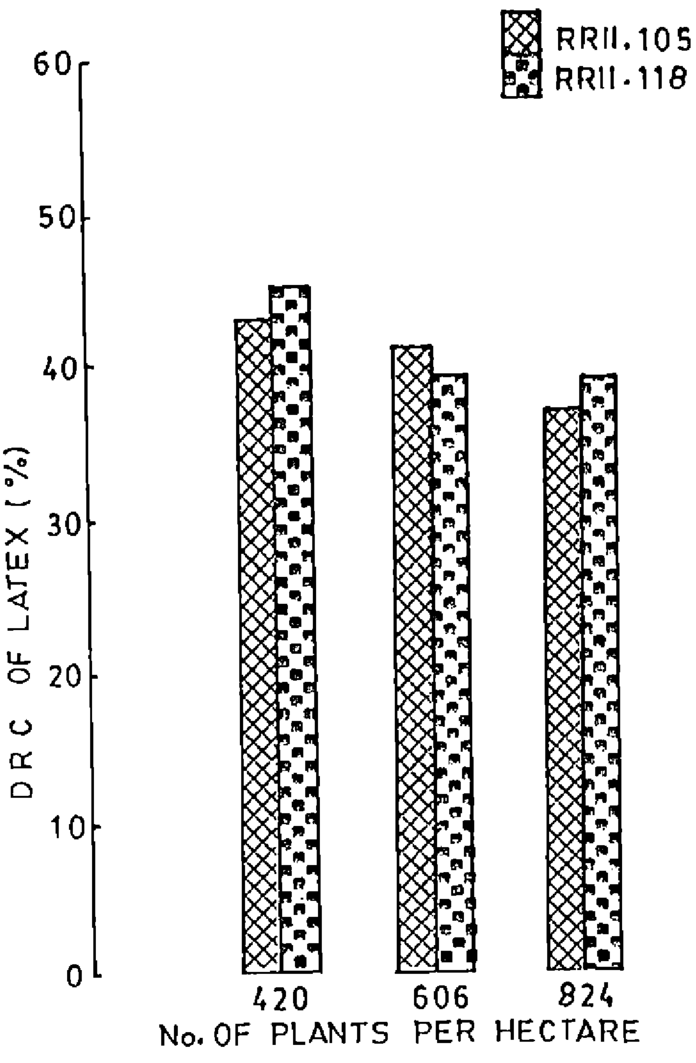

FIG. 4. DRY RUBBER CONTENT OF LATEX AS INFLUENCED BY DIFFERENT POPULATION DENSITIES AND CLONES

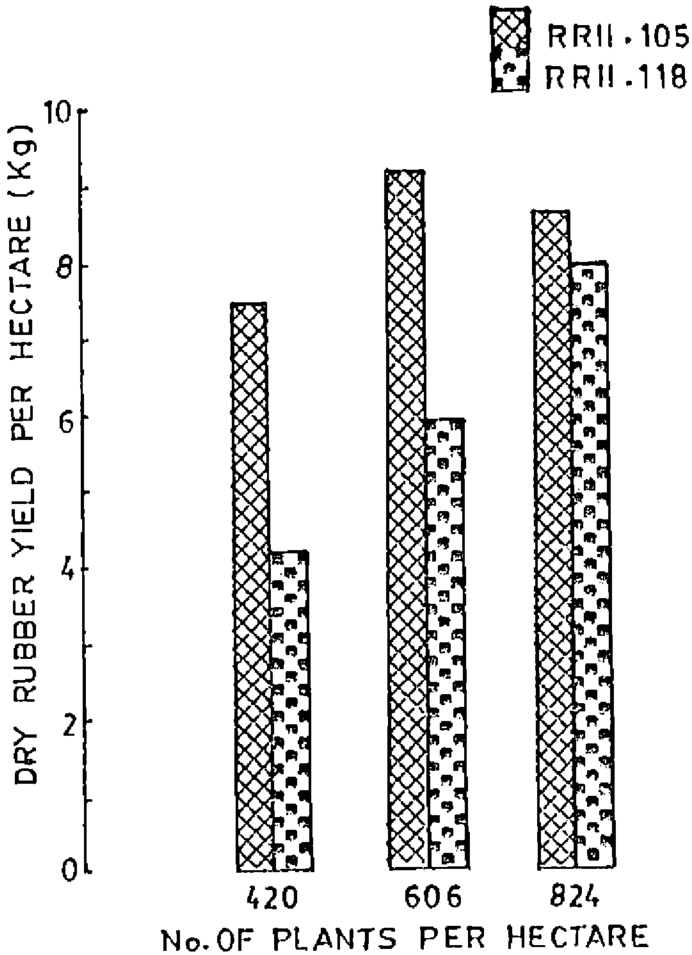

FIG. 5. DRY RUBBER YIELD PER HECTARE AS INFLUENCED BY DIFFERENT POPULATION DENSITIES AND CLONES

SUMMARY AND CONCLUSION

The present observations on the influence of different planting densities on the performance of two clones namely RRII 105 and RRII 118 are in confirmity with the results of other field experiments reported earlier. In lower planting densities, trees produced good girth, high yield per tree, thick virgin bark and high rubber content. Whereas, high planting densities contributed to poor tree girth, thin virgin bark and lower yield per tree. However, planting density is dependent on various other factors viz. topography of the land, system of planting to be adopted, the planting materials, cost of labour and price of rubber. Anyway, a compromise between labour cost and rubber price is needed. As far as small holders are concerned, a higher stand per hectare is preferred, since the question of labour does not arise. Therefore, for small holding sector a higher stand is recommended in order to get high per hectare yield. But there should be an optimum stand. In Malaysia, for small holders having available family labour, a planting density of approximately 740 trees per hectare is recommended. However, indepth studies are required for a meaningful recommendation in our country.

Salient results

* The trees were taller in high density pla

* The trees were more vigorous in low density planting. The highest mean girth of 64.7 cm was recorded by RRII 118 at a population density of 420 plants/ha. The percentage of weaklings increased with increase in population. The highest weakling percentage of 35.8 was recorded by the planting density of 824 plants per hectare.
* Poor bark growth in high density planting.
* Per tree yield was more for low density planting whereas per hectare yield was less. With regard to high density planting, per tree yield was less and per hectare yield was more.
* Dry rubber content (drc) was more in low density planting. The highest percentage of 44.5 was recorded by RRII 118 at a planting density of 420 plants/ha.
* Light penetration was more in low density planting. The maximum light penetration recorded was 110.0 micromole/sec/m^2 at a density of 420 plants per hectare.

REFERENCES

Buttery, B.R., Westgarth, D.R. 1965. The effect of density of planting on the growth, yield and economic exploitation of Hevea brasiliensis. I. The effect on growth and yield. Journal of the Rubber Research Institute of Malaya. 19:62-71

Cherian, P.P. 1990. Impact of initial stand for increasing rubber production. Planters Conference: 71-73

Dijkman, M.J. 1951. Hevea - Thirty Years Of Research In The Far East. University of Miami Press, Florida. pp.115-142

Edgar, A.T. 1958. Manual of Rubber Planting. The incorporated society of planters, Kuala Lumpur. pp.60-65

Leong, W. and Yoon, P.K. 1982. Modification of crown development of Hevea brasiliensis by cultural practices. Journal of the Rubber Research Institute of Malaysia. 30:128-130

Mani, J., Punnoose, K.I. and Mathew, M. 1990. Agromanagement techniques for reducing immaturity period of rubber. Paper presented at the Planters Conference. Rubber Board, Kottayam.

Nair, P.M. 1992. Adoption of Scientific method of cultivation of rubber by small growers in Mavelikkara Taluk. P.G.(Dip.) N.R.P. Thesis, Kerala Agricultural University, Vellanikkara.

Ng, N.P., Abdullah Sepien,, C.B., Ooi and Leong, W. 1979. Report on various aspects of yield, growth and economics of a density trial. Proceedings of the Rubber Research Institute of Malaysia:303-331

Panse, V.G. and Sukhatme, P.V. 1978. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, N. Delhi.

Punnoose, K.I. 1990. Rubber Krishi. Rubber Board, Kottayam. pp.20-22

Rubber Board, 1992. Plant Rubber and Prosper. Rubber Board, Kottayam. pp.13-15

Rubber Board, 1993. The Rubber Growers Companion 1993. Rubber Board, Kottayam. pp.1-5

Saraswathy Amma, C.K. 1985. Advanced planting materials, planting density and crown modification. Training Manual. The Rubber Board, Kottayam.

Webster, C.C. and Baulkwill, 1989. Rubber. Longman, Scientific and Technical, New York. pp.186-191

Yoon, P.K. 1980. The effect of density of planting and crown modification on growth, yield and other characteristics. Lecture Notes on Hevea Breeding Course. RRIM, Malaysia.

APPENDIX-I

Temperature recorded at Vellanikkara for the past 3 years (centigrade)

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1990												
Maximum	33.5	34.9	36.0	35.8	31.5	29.7	28.4	29.0	30.7	31.9	31.2	32.2
Minimum	20.8	21.9	23.8	25.4	24.1	23.3	22.5	23.0	23.4	23.2	22.6	23.1
1991												
Maximum	31.6	35.9	36.4	35.6	35.1	29.7	29.1	29.0	31.5	30.9	31.5	31.9
Minimum	22.2	21.7	27.9	24.5	25.5	23.8	22.8	22.7	23.6	23.2	23.0	21.4
1992												
Maximum	32.6	34.5	36.9	36.3	33.8	30.1	28.8	28.9	30.1	30.7	31.0	31.1
Minimum	20.9	21.8	22.8	24.6	24.8	23.7	22.7	23.3	23.1	22.9	23.1	22.3

Source: Meteorological Observatory, College of Horticulture, Vellanikkara

APPENDIX-II

Rainfall recorded at Vellanikkara for the past 3 years (mm)

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1990	3.5	0	4.4	38.8	583.9	467.3	759.3	356.4	87.5	313.3	69.8	1.8
1991	3.9	0	1.8	83.8	56.1	993.1	975.6	553.3	61.5	281.7	191.3	0.2
1992	0	0	0	48.6	90.6	979.8	874.5	562.9	302.9	386.7	376.7	2.0

Total rainfall

1990 - 2686 mm
1991 - 3202 mm
1992 - 3624 mm

Source: Meteorological Observatory, College of Horticulture, Vellanikkara