SHADE EFFECT OF OTHER TREE SPECIES ON THE GROWTH PERFORMANCE OF RUBBER

BY

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DISSERTATION

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1993

DECLARATION

I hereby declare that this dissertation entitled "**Shade effect of other tree species on the growth performance of rubber**" is a bonafide record of research work done by me and that this dissertation has not previously formed the basis for award to me of any degree, diploma, or other similar titles of any other University or Society.

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CERTIFICATE

Certified that this dissertation entitled "Shade effect of other tree species on the growth performance of rubber" is a record of research work done independently by Smt. N Vijaya Devi under our guidance and supervision and that it has not previously formed the basis for the award of any degree or diploma to her.

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1. INTRODUCTION

Rubber plantation industry occupies a unique position in the economic and social life of people all over the world. The produce, natural rubber, is a very versatile vegetable product and provides the principal raw material for the manufacture of varied products which are indispensable in modern world.

Rubber cultivation commenced in India a hundred years back. The Indian rubber plantation industry enjoys the distinction of having the highest rate of growth in comparison to other rubber growing countries of the world.

Rubber cultivation was started as monoculture by the estate sector. But later some enterprising farmers took the initiative to plant rubber. With the introduction of new planting subsidy scheme by the Rubber Board in 1979, many small holders were attracted and now majority of holdings are small and are interplanted with other trees such as coconut, anjili, jack, teak, vatta, tamarind, arecanut and pongilyam, at varying densities. This is mainly due to the fact that monoculture of rubber could not supplement the

diversified needs of the family and the growers are reluctant to remove the other trees from their holdings, while accepting rubber as the main crop.

Even though considerable research work on all the aspects of rubber cultivation and processing has been carried out, not much scientific data are available about the influence of retention of other trees in the rubber plantation on growth and performance of rubber or to what extent this will be profitable. As the growers are reluctant to remove the other trees from their holdings, Rubber Board has allowed to retain a limited number of other trees in their holdings. The maximum number of other trees permissible to be retained in a hectare of rubber plantation is 40 coconut palms and is considered as equivalent to 20 trees of anjili, jack, teak etc. or 80 arecanut palms. These limits are often violated and it has become imperative to study the influence of varying plant density of other tree species on growth and performance of rubber trees. With this objective, the present study was taken up and the findings will help to make necessary amendments of the rule pertaining to retention of other trees, if needed. The study will also pave the way to have a decision

whether monoculture or intercropping is suited to the rubber plantation industry.

2. REVIEW OF LITERATURE

Multiple cropping with a view to enhance agricultural production in field crops had received much attention. This is due to the imperative need to increase production and productivity from unit area of land consequent upon the increasing demand of food, clothing and shelter for increasing population because of the increasing difficulty to get more areas.

Intercropping, mixed cropping and multi-storeyed cropping are the three different ways of multiple cropping. The ultimate aim of the three is to increase production and productivity of the unit area. Intercropping in the broadest sense indicates the various cropping patterns involving the planting of two or more crops in various combinations in the same plot of land (Nelliat and Iyer, 1979). Mixed cropping as applied to plantation crops is a practice of growing other perennials in the interspaces of the commercial plantation crop species. Multistoreyed cropping is the system, growing of a number of annuals or perennials in the same area by utilising the solar energy and soil resources to the maximum extent. Crops having different

structure, light requirements and rooting pattern were selected to form compatible combinations (Nelliat and Bhat, 1979).

Survey of agricultural systems and agricultural origins indicated that interplanting was the first agricultural system to be practised since the beginning of agriculture. The most important factor to be considered in interplanting is the productivity of soil and the overall production from unit area of land. In multiple cropping the accepted principle is that although the individual crop yield may be lowered, the overall production per unit area should be enhanced.

Willey (1979) had identified three different situation under intercropping. These are (1) intercropping must give full yield of the main crop and some yield of the second crop (2) combined yield of the intercrops must exceed the higher sole crop yield and (3) combined intercrop yield must exceed the combined sole crop yield. In all intercropping system only the first situation has been considered. The emphasis was that the yield of the main crop should not decrease enormously due to growing of intercrops. It is reported that reduction in the productivity of the main crop as

well as that of the intercrop is due to incompatability of the crops choosen (Muralidharan and Nayar, 1979).

In mixed cropping, since a number of crops are grown over a given area of land, a greater depletion of the plant nutrients may occur in the soil. It is necessary that adequate inputs like fertilisers are supplied to replenish and maintain soil fertility. The crown shape and root system of each species plays an important role in multiple cropping. The studies on the rooting pattern of coconut showed that about 74 per cent of the roots have not produced laterals spread beyond 2 m from the bole and that the roots were confined mainly to 30 - 120 cm depth (Kushwah et al., 1973). In arecanut, Bhat and Leela (1969) reported that 61 to 67 per cent of roots were confined to 50 cm radius of the palm. With this root distribution, at the recommended spacing of 7.6 x 7.6 m for coconut and 2.7 x 2.7 m for arecanut, 75 per cent of the soil remain unutilised.

The structure and orientation of coconut and arecanut leaves permit sizeable amount of solar raditation incident on the crown to penetrate to the lower levels. The extent of this transmission varies with the age of the palms, distance between the plants and the system of planting. The light incidence in the

interspaces of coconut stands decreases with the increase in the age of the plantation (Muralidharan and Nayar, 1979).

Rubber trees grown as seedlings or as buddings on seedling root sticks, develop a strong tap root and extensive lateral roots, the whole root system forming about 15% of the total dry weight of the mature tree. Study of rooting habit on a range of soils revealed no marked differences. It was found that on deep soils without any impediments to root growth, three year old plants had tap root about 1.5 m long and laterals 6 - 9 m long. In trees of 7 - 8 years age, the tap roots were about 2 - 4 m in length and the laterals over 9 m. The laterals normally extend well beyond the spread of the branches so that in plantations at the usual spacing the roots grown through the adjacent planting rows. The roots of neighbouring trees intermingle and some may become grafted together. The major lateral roots almost invariably arise from the tap root and are mostly confined to 30 cm of the soil surface. These are arranged more or less in a whorl and grow horizontally. Further minor laterals are commonly produced at a depth of 40 to 80 cm, but these do not extend horizontally like the ones nearer to the soil surface. All laterals ultimately give rise to unsuberized yellow-brown roots

of about 1 m diameter, possessing root hairs and are known as feeder roots since they are mainly responsible for absorption of nutrients (Webster & Baulkwill, 1989). The massive and surface feeding root system did not entertain any inter-cultural operations since any injury to the roots may result in the exudation of latex and reduction in yield.

Annual crops were usually intercropped in young rubber and this is a common practice even now with many of the small farmers. Studies on intercropping were undertaken by several workers. Based on economic evaluation Srinivasan et al. (1987) found banana to be the most profitable intercrop. Rajasekharan (1989) reported that pineapple is a highly profitable intercrop in the immature stage of rubber. Simon (1992) reported that intercropping with banana and ginger is possible in the immature stage. In small holdings the cost of cultivation may be lessened further by intercropping during the first two years after planting.

Possibilities of intercropping rubber with perennials are even more limited than those with annual food crops. At normal tree spacing there is only sufficient useful light for interrow crops during the first three years after planting and thereafter canopy of the rubber trees closes over virtually until it is

time for replanting. The conditions may become lighter towards the end, but the situation is never to the extent observed under coconuts where mixed cropping of old palms with cocoa and a variety of other perennials is followed (Nair and Varghese, 1980). In several cases however a few trees may be lost due to natural calamities, leading to more light penetration.

Many small-holders plant a few fruit trees in and around rubber. The rubber plants are very latter competitive in nature and it was found to over-shade the companion crop on the farm (Webster and Baulkwill, 1989).

Rubber and oil palms were planted together in the early years of oil palm cultivation in Indonesia. These crops were found obviously incompatible. Since rubber will overtop the oil palm and its canopy will spread out and shade the palms, competition for nutrients will be fierce. (Hartely, 1977)

Several attempts have been made to grow coffee and cocoa under young rubber (Dijkman 1951: Blencowe & Templeton, 1970). Favourable results were reported from China on interplanting tea in widely spaced rubber (Feng et al., 1982). Tea is also benefited from shade of

rubber and it comes into production earlier than in monoculture. It has been suggested that mixed plantation of tea and rubber can be cultivated successfully upto 1000 m. No economic data are available, however, and the system is likely to find only local acceptance.

While there is evidence that perennials may be intercropped successfully in avenue planted rubber for a time, management problems are formidable (Webster and Baulkwill, 1989).

Webster and Baulkwill (1989) opined that intercropping with perennials is unlikely to develop significantly. With a second crop interplanted in rubber it is virtually impossible to provide optimum conditions for both the crops and better returns will be obtained from monoculture. Where a diversity of income is required it would seem more profitable to establish the additional crops on separate dedicated plots so that all may receive appropriate management and attention.

In Kerala, perennial crops like jack, coconut, tamarind, anjili are seen in rubber plantation. They are not planted along with rubber or as intercrops. But

when new planting of rubber was done few of the trees which are having economic value are not removed but retained. This happened when land near forest areas are converted to rubber or when coconut plantations are converted to rubber and so on. This type of situation is very common in the small-holdings especially in the homesteads (personal communication).

3. MATERIALS AND METHODS

The present study aims to assess the influence of varying plant density of other tree species on growth and performance of the para rubber tree (Hevea brasiliensis). The study was conducted in Kooropada village, a major rubber growing locality in the middle of Kottayam taluk.

3.1 Selection of rubber holdings

Hundred holdings of different age group planted from 1979 to 1991 were selected for the study. Under each age group 10 holdings were surveyed, of which five units were interplanted with different other tree species in various proportion and the rest five units comprised of mono crop of rubber. The selected units were scattered throughout the village. The entire units were planted with the clone RRII 105, a cultivar included in category I of the planting material approved by the Rubber Board. The other trees located in the holdings were the existing ones retained through selective felling.

3.2 Collection of data

Names and addresses of the holdings were collected from the office records of the Field Officer, Kooropada.

The details pertaining to the sample holdings were collected through personal interview with the owner and the particulars regarding growth and performance of rubber and the trees retained in the estate were collected through periodic field observations as per the proforma designed for the purpose (Appendix I).

3.3 Observations recorded

a. Rubber

i. Girth of rubber plants

The girth was measured using a tape at a height of 125 cm from the bud union and expressed in cm. In order to find out the girth of rubber as influenced by proximity of other trees, five units each with major intercrop anjili and coconut were selected. The girth of rubber plants in three rows standing next to the intercrop was measured.

ii. Branching height

Branching height was measured using a pole and expressed in cm.

iii. Type of branching

Branching was categorised as heavy/light by visual observation.

iv. Type of canopy

Canopy was categorised as dense and medium by visual observation.

v. **Weed count**

Using a wooden frame, a field of one square metre was measured and the number of weeds in this area was counted.

vi. **Wind damage**

Wind damange was categorised into two, uprooting and branch snap, which was observed visually and expressed as percentage.

vii. **Incidence of diseases**

Diseases caused by Phytophthora and Oidium and Pink disease, panel disease etc. were observed visually. Phytophthora incidence was ascertained on the basis of percentage of leaf retention. Pink and panel diseases were noted on the basis of number of plants actually affected and was expressed as percentage. Oidium incidence was categorised as mild/severe.

viii. **Number of years taken for attaining tapping standard**

The year in which tapping was started was ascertained from the office records, which was further verified by observing the bark consumption of the tree. The number of trees under tapping at the time of field verification was also taken into consideration.

ix. Percentage of trees attained tapping girth

The number of trees that attained the tapping girth was noted from the records maintained by the Rubber Board and was further verified in the field by checking the girth of the randomly selected plants.

x. Yield of rubber

The quantity of rubber obtained from both the types of situations as per study were recorded separately. The calculation was based on the average quantity of dry rubber obtained in each day and the tapping system adopted and the number of tapping days obtained in each year.

xi. Net income from rubber

Net income from rubber was calculated on the basis of average price of RMA 4 for the last 10 years which works out to Rs.20/- because the area surveyed comes under last 10 years planting.

xii.Cost of production

The production cost is taken as 50% of the price per kg of rubber.

xiii.Opinion of the farmer

The personal opinion of the farmer towards retaining other trees was gathered during the interview.

b. **Other trees**

i. **Other trees**

Number of other trees retained in the holdings was counted variety-wise. Anjili, teak, jack, coconut and arecanut found along the rubber trees were counted individually and stray occurrence of other species was brought under a separate category termed miscellaneous group.

ii. **Position**

Position of other trees was noted as inside the rubber plantation and on the boundary.

iii. **Distance from the rubber plants**

The average distance of the other trees from the rubber tree was measured using a tape and expressed in metre.

iv. **Girth of trees**

Average girth of other trees having good timber value was measured at breast height and expressed in cm.

v. **Economic returns**

Timber value was estimated through local enquiry and the transportation facility available was also considered in computing the value.

Income from economic produce was also noted in the case of coconut. The income from coconut was taken as Rs.50/- per palm/year in the early period of rubber and as Rs.30/- per year in mature rubber wherein the coconut palm yields very less.

c. Cost benefit analysis

Gross income obtained from each unit was calculated by adding the value of rubber, timber value and value of economic produce in the case of interplanted units. In the case of monoculture, income from rubber alone was considered. The cost of production in each case was also considered to arrive at the net gain or loss.

4. RESULTS AND DISCUSSIONS

The observations from the study on the effects of shade of other tree species on growth and performance of rubber have given interesting results. The major findings on the influence of other trees on biometric characters of rubber plants, disease intensity, weed count, wind damage, tapping standard, growth retardation of rubber due to proximity of other trees, growth variation where anjili or coconut be the major intercrop, the cost benefit analysis of pure planting compared with interplanting are presented below along with other observations in brief.

4.1 General agro-climatic situation

The village has a total area of 2760 sq. ha., of which 60% is under rubber. Due to its proximity to the Rubber Board and its research department known as the Rubber Research Institute of India, most of the growers are aware of and are adopting almost all scientific methods of cultivation. Almost all the growers depend on the Rubber Board for technical advice.

Agro-climatic conditions in the locality is highly suitable for rubber. South West monsoon is more intense

in this region beginning in the end of May with peak the period during June-July. North East monsoon is comparatively weak and ends by about November. A few pre monsoon showers are usually received during March. Annual rainfall is above 300 cm.

The soil in the region is of the laterite type. Occasionally a few rocky patches are seen here and there. In general, soil is deep and 1.50 m. depth is very common in almost all the parts of the village. The soil is acidic in reaction with a range of 4.5 to 6.0 pH. Even though soil is poor in plant nutrients the physical condition of the soil is well suited for rubber cultivation. The soils have good aggregate stability which facilitate good aeration and free drainage. The terrain of the land is flat and undulating with gentle slope.

4.2 Size of holding

The data on area and planting density in pure planted and interplanted rubber are tabulated in table 1. The size of the holdings in pure planting ranges from 0.30 ha to 1.64 ha with an average of 0.59 ha, the range in the total number of plants being 188.7 to 460.6 with an average of 312.7. Out of the two spacing (6.10

Table 1 Area and planting density in pure planted and interplanted rubber holdings

Year of planting	PURE PLANTED Area (ha) Range	Average	Planting density/ha Range	Average	Percentage of holding as per the spacing 6.10x3m	4.90x4.90m	INTERPLANTED Area(ha) Range	Average	Planting density Range	Average	Percentage of holdings as per the spacing 6.10x3m	4.90x4.90m
1979	0.40-0.81	0.64	215-430	332	80	20	0.40-0.50	0.45	185-260	212	80	20
1981	0.34-0.56	0.45	185-300	247	100	-	0.49-1.60	0.99	205-882	515	100	-
1983	0.33-1.64	0.80	180-700	371	60	40	0.38-0.81	0.50	185-430	258	80	20
1984	0.40-0.83	0.57	215-450	296	100	-	0.30-0.92	0.58	165-500	286	60	40
1985	0.35-1.04	0.50	190-560	370	80	20	0.40-1.05	0.72	215-550	390	100	-
1986	0.30-0.62	0.44	160-300	252	100	-	0.30-1.00	0.56	150-545	294	80	20
1987	0.36-0.89	0.55	175-375	259	40	60	0.36-0.50	0.43	200-240	215	60	40
1988	0.40-1.33	0.71	180-616	354	80	20	0.40-1.00	0.57	180-540	297	60	40
1989	0.40-0.90	0.68	212-485	349	80	20	0.35-1.20	0.67	150-650	312	40	60
1991	0.32-0.72	0.52	175-390	297	100	-	0.32-0.78	0.55	170-420	296	100	-
Mean	0.36-0.93	0.586	188.7-460.6	312.7	82	18	0.37-0.936	0.60	180.5-501.7	307.50	76	24

x 3 m and 4.90 x 4.90 m), majority of the growers (82%) followed the former.

In interplanted area size of the holding ranged from 0.30 to 1.60 ha with an average of 0.60 ha. The range of plant population was observed to be 180.50 to 501.70. The average planting density adopted was little lower than pure planting (307.5). Similar to pure crop more preference was observed for 6.10 x 3 m spacing (76%).

4.3 Retention of other trees

The other trees retained in different interplanted units were counted and presented in table 2. The major interplants were coconut, anjili, jack, teak and arecanut and very rarely vatta, pongilyam, tamarind, palm were also found (Table 3). Variation was observed in the number of other trees retained in hundred units, the range being 10.8 to 28. The average number of other trees retained in the units was 19.58 of which coconut makes the major share (14.0). The relative count of other trees was anjili 2.48, jack 0.72, teak 0.64, arecanut 0.64, miscellaneous trees 1.10. The rubber plants were spaced at 2.34 m from other trees. Examination of the position

Table 2 Other trees retained in different age group of rubber trees

Year of planting	Total No.of other trees retained (Avg)	Anjili	Jack	Teak	Coconut	Arecanut	Miscellaneous	Average distance of other trees from rubber plants (m)	Average girth of other trees (m)	Position of other trees: Inside the rubber plantation (%)	Position of other trees: Along the border (%)
1979	17.2	3.2	2.0	0.4	8.8	2.4	0.4	3.00	1.04	60	40
1981	28.0	2.2	0.8	2.0	20.2	0.6	2.2	3.00	1.02	40	60
1983	20.0	1.0	0.8	1.4	15.2	0.2	1.4	2.00	0.97	80	20
1984	23.2	1.6	0.6	-	19.2	0.2	1.6	2.00	0.87	40	60
1985	26.2	4.6	1.0	0.2	19.6	-	0.8	2.00	0.61	100	-
1986	22.0	3.0	-	0.8	17.0	0.8	0.4	1.90	1.06	80	20
1987	14.4	1.2	1.2	0.2	10.0	0.8	1.0	2.00	1.02	100	-
1988	15.6	6.2	0.2	0.6	7.0	-	1.6	3.00	0.91	80	20
1989	18.4	0.8	0.2	-	15.4	1.4	0.6	2.00	1.32	100	-
1991	10.8	1.0	0.4	0.8	7.6	-	1.0	2.50	1.40	100	-
Mean	19.58	2.48	0.72	0.64	14.00	0.64	1.10	2.34	1.22	78	22

Table 3 Types of other trees retained in the holdings

Sl.No.	Common name	Botanical name	Family	Economic utility
1.	Anjili	Artocarpus hirsuta	Urticaceae	Timber, firewood
2.	Jack	Artocarpus integrifolia	Urticaceae	Timber, firewood culinary purpose
3.	Teak	Tectona grandis	Verbenaceae	Timber, firewood teakwood oil for treatment of animal disease
4.	Coconut palm	Cocoa nucifera	Palmae	Thatching, coir, culinary purpose, toddy, vinegar soap making, timber firewood
5.	Arecanut	Areca catechu	Palmae	Chewing and medicinal purpose
6.	Pongilyam	Ailantus excelsa	Simarubaceae	Match boxes, paperpulp packing cases, soft wood timber.
7.	Tamarind	Tamarindus indica	Leguminosae	Firewood, culinary purpose
8.	Vatta	Macaranga indica	Eurphorbiaceae	Gum, softwood, firewood
9.	Umbrella palm	Carypha umbraculifera	Palmae	Thatching, umbrella making

of other trees indicated that majority of other trees (78%) were located inside the plantation. (Plates 1 to 4).

4.4 Biometric characters of rubber

Biometric characters of rubber plants as influenced by other trees are presented in Table 4. Girthing of rubber plants was found to be affected by interplanting. The girth reduction observed was 3.61 cm and 3.05 cm in tapped and untapped interplanted rubber respectively. In untapped area the girth reduction was less pronounced and in early immature period (3rd and 4th year), there was no difference in girthing when compared with pure planting.

Branching height was enhanced by interplanting and the increase in height observed was 16.44 cm and 4.70 cm in tapped and untapped area. In pure planting branching height was low and in interplanting the branching height was high.

Heavy branching was induced by shaded condition due to interplanting (96.66%) when compared with open (86.66%) in tapped area. In untapped area pure planting recorded cent per cent heavy branching and it remained

Plate 1

Plate 2

Plate 3

Plate 4

Plate 3 Mature rubber with jack interplanting

Plate 4 Mature rubber with anjili interplanting

Table 4 Influence of retention of other trees on biometric characters of rubber plants

Year of planting	PURE PLANTED: Average girth (cm)	Branching height (cm)	Type of branching (%) Heavy	Light	Type of canopy (%) Dense	Medium	INTERPLANTED: Average girth (cm)	Branching height (cm)	Type of branching (%) Heavy	Light	Type of canopy (%) Dense	Medium
Tapped												
1979	68.8	316	100	-	100	-	65.8	337	100	-	40	60
1981	64.0	302	100	-	100	-	63.0	332	100	-	20	80
1983	59.8	262	100	-	100	-	53.8	276	100	-	60	40
1984	57.0	253	100	-	80	20	54.2	268.6	100	-	80	20
1985	54.4	250	60	40	40	60	51.4	256	80	20	40	60
1986	53.4	250	60	40	100	-	47.6	250	100	-	80	20
Mean	59.57	272.16	86.66	13.33	86.66	13.33	55.96	288.6	96.66	3.33	53.33	46.66
Untapped												
1987	48.6	248	100	-	100	-	43.4	250	100	-	-	100
1988	41.0	252	100	-	100	-	34.0	258	100	-	100	-
1989	29.0	243	100	-	100	-	29.0	254	100	-	100	-
1991	15.2	240	100	-	100	-	15.2	250	-	100	100	-
Mean	33.45	245.80	100.00	-	100.00	-	30.40	250.50	75.00	25.00	75.00	25.00

heavy in interplanting area (75%). In both pure and intercropped area high branching was related with dense canopy. Canopy was found to be more dense in pure planted area when compared to interplanted area.

4.5 Disease intensity

Disease intensity under pure planting and interplanting was compared as per Table 5. Pink disease and panel disease were found to be high in interplanted area. Panel disease affected plants averaged 19.36 per cent in pure crop mature units and 24.50 per cent in interplanted units. Oidium infection was not at all a problem in tapped units of the area surveyed. In untapped units oidium infection was found to be more (9.2%) in pure planted area compared to interplanted units (7.3%). The phytophthora disease intensity was aggrevated in interplanted area as indicated by low leaf retention (58.50%) in tapped area and 72.50 per cent in untapped area. In untapped area the disease intensity was less pronounced.

4.6 Girth of rubber as influenced by anjili or coconut interplant

Girth comparison of pure crop was made with interplanted rubber where anjili or coconut was the

Table 5 Influence of retention of other trees on incidence of diseases

Year of planting	PURE PLANTED				INTERPLANTED			
	Phytophthora leaf retention (%)	Pink disease (%)	Oidium infection (%)	Panel disease No. of plants average (%)	Phytophthora leaf retention (%)	Pink disease (%)	Oidium infection (%)	Panel disease (%)
1979	62	20.0	mild	30.2	57.00	18.40	mild	20.0
1981	67	14.0	"	20.0	56.00	32.80	"	35.8
1983	70	13.8	"	22.4	54.00	20.40	"	22.6
1984	70	12.8	"	27.0	69.00	17.00	"	24.0
1985	76	18.6	"	16.6	61.00	21.60	"	22.6
1986	71	14.2	"	–	54.00	11.20	"	22.0
Mean	69.33	15.56		19.36	58.50	20.20		24.50
1987	78	9.2	mild	–	60.00	11.40	mild	–
1988	70	11.4	14.6	–	70,00	8.80	7	–
1989	80	7.4	12.4	–	80.00	6.60	10	–
1991	80	–	9.8	–	80.00	–	13	–
Mean	77	7.00	9.2	–	64.10	6.70	7.30	–

major interplant (Table 6). Coconut was found to be the major intercrop in rubber (14.0) and this was followed by anjili (2.48). Least girth reduction (3.57 cm) was observed when coconut is the interplant compared to 5.49 cm reduction in girth with anjili as interplant. In immature areas the girth reduction was less pronounced but the same trend was noted. In immature period upto 4th year, no growth reduction was noticed in pure planted and interplanted area. During this period the canopy of rubber does not close and the shade of other trees does not affect the growth of young rubber plants. It was found that coconut is having less shade effect when compared with anjili. It is to be noted here that coconut allows good light infiltration and feeding roots are confined to 2 m radius which does not impart severe root competition to other companion crops. Even with more number of coconut (8.66) in tapped area and 18.25 in untapped area, the girth reduction was less pronounced than a low population of anjili, 7.83 in tapped area and 5.25 in untapped area.

4.7 Girth of rubber as influenced by proximity of other trees

Girth of rubber as influenced by proximity of other trees is presented in Table 7. Random selection of

Table 6 Comparison of girth of rubber plants when anjili or coconut is the major interplant

Year of planting	Major interplant anjili		Major interplant coconut		Pure crop of rubber
	No. of anjili	Girth of rubber (cm)	No. of coconut	Girth of rubber (cm)	Girth of rubber (cm)
Tapped					
1979	6	65	12	68	68.8
1981	8	60	25	63	64.0
1983	4	52	23	54	59.8
1984	5	53	31	50	57.0
1985	18	50	36	53	54.4
1986	6	45	25	48	53.4
Mean	7.83	54.17	8.66	56	59.57
Untapped					
1987	2	43	20	45	48.6
1988	14	33	20	35	41.0
1989	2	29	18	29	29.0
1991	3	15	15	15	15.2
Mean	5.25	30	18.25	31	33.45

Table 7 Girth of rubber trees as influenced by proximity of other trees

Year of planting	1st round of rubber		2nd round of rubber		3rd round of rubber		Girth of rubber
	Distance of rubber from interplant (m)	Girth of rubber (cm)	Distance of rubber from interplant (m)	Girth of rubber (cm)	Distance of rubber from interplant (m)	Girth of rubber (cm)	(cm)
				INTERPLANT ANJILI			
1979	2.00	40.00	6.90	55.00	11.60	65.00	68.00
1984	3.00	35.00	9.10	50.00	15.20	55.00	53.00
1987	2.00	30.00	8.90	37.00	15.00	45.00	42.00
1991	3.00	15.00	9.00	15.00	15.10	15.00	16.00
Mean	2.50	30.00	8.48	39.25	14.22	45.00	44.75
				INTERPLANT COCONUT			
1979	1.90	50.00	6.80	60.00	11.70	68.00	68.00
1984	2.00	44.00	8.20	50.00	14.30	54.00	53.00
1987	3.00	38.00	9.00	40.00	15.10	43.00	42.00
1991	2.50	15.00	8.60	15.00	14.70	15.00	16.00
Mean	2.35	36.75	8.15	41.25	13.95	45.00	44.75

units where anjili and coconut were planted were made. Distance of rubber plant from the other tree and the girth of rubber tree was measured. First round of rubber plants from interplant had great reduction in girth than the 2nd and 3rd rows of plants from the other tree species. The first round of rubber plants near the other trees become weaklings and did not attain tapping girth in later years also. When the distance from the other tree was 14 m, girth of rubber becomes almost same as that of other rubber plants' in the unit. It was also noted that when coconut alone was the interplant the average girth of rubber tree was almost similar to the pure crop. In the immature stage upto 4th year there was no girth reduction due to proximity of other trees.

4.8 Weed count and wind damage

Comparison of pure planting with interplanting of other trees was also made with respect to wind damage and weed count (Table 8). Regarding weed count remarkable difference between pure planting and interplanting was observed.

Wind damage was counted as uprooting of the plants and as branch snap. Uprooting was found to be high when compared to branch snap. Interplanted areas recorded more wind damage as indicated by uprooting and branch

Table 8 Weed count and wind damage as influenced by other trees

Year of planting	PURE PLANTED			INTERPLANTED		
	No. of weeds/ sq.m	Wind damage(%) Uprooting	Branch snap	No. of weeds/ sq.m	Wind damage(%) Uprooting	Branch snap
Tapped						
1979	8.50	18.60	1.00	10.00	16.20	4.00
1981	10.00	11.60	2.00	10.50	14.20	12.80
1983	11.50	5.00	3.00	11.00	16.80	-
1984	14.50	6.40	-	13.50	11.40	3.00
1985	15.00	3.00	6.00	13.50	1.80	16.40
1986	15.50	1.20	10.00	15.50	6.80	1.00
Mean	12.50	7.63	3.66	12.33	11.20	6.20
Untapped						
1987	12.00	3.20	-	13.50	5.20	-
1988	11.50	9.60	1.60	12.00	7.00	2.40
1989	13.50	4.40	-	16.00	4.60	-
1991	13.00	5.40	-	16.50	7.40	-
Mean	12.50	5.65	0.40	14.50	6.05	0.60

snap than in pure planting. This can be attributed to the increase in height under shaded condition which makes the stem weak.

4.9 Tapping standard

Tapping standard was found to be altered by interplanting (Table 9). Tapping started in trees raised upto 1986 and plants from 1987 onwards are in the immature stage. Tapping age was found to be enhanced by interplanting. In pure planted area tapping was started in the 7.09th year and 60.50% attained tappable girth. Whereas in interplanted units tapping commenced after 8.27 years and that too with lesser percentage of trees attaining tappable girth (44.66%).

4.10 Economic returns from mature rubber

Economic returns from pure and interplanted rubber were worked out (Table 10). For achieving uniformity in computing the values, calculations were made with pure planted area made similar to intercropped area of the corresponding year. Yield of rubber from each unit was estimated and the income worked out at the rate of Rs.20/- per kg of dry rubber and the cost of production was estimated at Rs.10/- per kg in either case and

Table 9 Tapping standard as influenced by interplanting

Year of planting	PURE PLANTED		INTERPLANTED		
	No. of years for tapping (YAP)	Trees attained tapping girth (%)	No. of other trees present	No. of years for tapping (YAP)	Trees attained tapping girth (%)
Tapped					
1979	7.60	50.00	17.20	9.60	40.00
1981	7.00	53.00	28.20	8.80	45.00
1983	7.00	55.00	20.00	8.80	38.00
1984	7.00	61.00	23.20	7.60	45.00
1985	7.00	65.00	26.20	7.80	63.00
1986	7.00	79.00	22.00	7.00	38.00
Mean	7.09	60.50	22.80	8.27	44.66

YAP - Year after planting

Table 10 Economic returns from pure and interplanted mature rubber

Year of planting	Area in ha.	PURE PLANTED		INTERPLANTED				
		Yield of rubber (kg)	Gross income(Rs)	Yield of rubber (kg)	Returns from rubber (Rs)	Return from other trees		Gross income
						Economic produce value (Rs)	Timber value (Rs)	
1979	0.45	4131.00	82620.00	2288.00	45760.00	450.00	21200.00	67410.00
1981	0.99	8009.00	160180.00	5430.00	108600.00	1030.00	29400.00	139030.00
1983	0.50	1995.00	39900.00	1009.00	20180.00	870.00	11600.00	32650.00
1984	0.58	1668.00	33360.00	741.00	14820.00	960.00	9200.00	24980.00
1985	0.72	1764.00	35280.00	840.00	16800.00	1570.00	21800.00	40170.00
1986	0.56	552.00	11040.00	120.00	2400.00	850.00	17200.00	20450.00
Mean	0.63	3019.83	60396.66	1738.00	34760.00	955.00	18400.00	54115.00

processing cost @ Rs.2.50 per kg of dry rubber was deducted for every unit reduction in dry rubber production in interplanted area. In the case of interplanted area the assessed value of timber and the value of economic produce in coconut was also considered. Average area is estimated as 0.63 ha and yield of rubber in pure crop was 3019 kg and gross income was Rs.60396/-. Whereas in interplanted area yield of rubber was only 1738 kg and returns from rubber was Rs.34760/-. In addition to the returns from economic produce from coconut (Rs.955/-) assessed timber value (Rs.18400/-) was also counted. The gross income in pure planted area comes to Rs.60396/- and that in interplanted units comes to Rs.54115/-.

4.11 Economic returns from immature rubber

Assessed value of timber and economic produce in immature area were worked out (Table 11). In the immature period there was no income from the pure crop whereas the assessed value of timber Rs.11800/- and value of economic produce (Rs.2100/-) is counted in the case of intercropped area and the total assessed value comes to Rs.13900/-.

Table 11 Assessed value of timber and economic produce in immature area

Year	Area (ha)	Return from other trees		Gross income (Rs)
		Economic produce value (Rs)	Timber value (Rs)	
1987	0.43	500.00	9600.00	10100.00
1988	0.71	550.00	23200.00	23750.00
1989	0.67	1272.00	5800.00	7072.00
1991	0.55	6080.00	8600.00	14680.00
Mean	0.59	2100.50	11800.00	13900.50

4.12 Cost benefit analysis

Economics was worked out and presented in table 12. Net income on a hectare basis from pure planting was Rs.47934/- and income from interplanted units was Rs.43049/-. The reduction in income due to interplanting was estimated to be Rs.4884/-. In the first few years after commencement of tapping the net income in the interplanted area is found high whereas in later years the pure planting showed high income.

Table 12 Economics of pure planted and interplanted mature rubber

Year	Area (ha)	Cost of production		Gross income		Net income		Profit	
		Pure (Rs)	Interplanted (Rs)	Pure (Rs)	Interplanted (Rs)	Pure (Rs)	Interplanted (Rs)	Pure (Rs)	Interplanted (Rs)
1979	0.45	41310.00	36702.50	82620.00	67410.00	41310.00	30707.50	10602.50	-
1981	0.99	80090.00	73642.50	160180.00	139030.00	80090.00	65387.50	14702.50	-
1983	0.50	19950.00	17485.00	39900.00	32650.00	19950.00	15165.00	4785.00	-
1984	0.58	16680.00	14362.50	33360.00	24980.00	16680.00	10617.50	6062.50	-
1985	0.72	17640.00	15330.00	35280.00	40170.00	17640.00	24840.00	-	7200.00
1986	0.52	5520.00	4440.00	11040.00	20450.00	5520.00	16010.00	-	10490.00
Mean	0.63	30198.33	26993.75	60396.66	54115.00	30198.33	27121.25	9038.13	8845.00
For	1.00	47934.00	42847.00	95868.00	85897.00	47934.00	43050.00	14346.00	14040.00

5 SUMMARY AND CONCLUSION

The survey was conducted in Kooropada village of Kottayam taluk with an intention to assess the shade effect of other tree species on growth and performance of rubber. The small holdings with area in the range of 0.30 to 1.64 ha were surveyed. The holdings differed very much in number of other trees retained (10.8 to 28.0) and the average number of other trees retained in the units was 19.58. Among the other plants coconut occupied the prime position (14.0) followed by anjili (2.48) jack (0.72) teak (0.64) arecanut (0.64) and miscellaneous trees (1.10). Also it was noticed that majority of other trees (78%) was located inside the plantation.

The data on biometric characters of rubber plants indicated that branching height was enhanced and girthing of rubber plants was found to be reduced by interplanting. In immature period upto 4th year there was no girth reduction due to proximity of other trees. In majority of cases the first round of rubber plants near the other tree became weaklings and did not attain tapping girth in later years also. Branching and canopy was not found to be influenced highly by interplanting.

Conditions favourable for phytophthora, pink and panel diseases were induced by shaded situation resulting from interplanting. The disease intensity was more aggrevated in tapped area when compared to untapped area.

Comparison made between coconut and anjili on girth of rubber plants, revealed that coconut palm with its special orientation of leaves is a more compatible combination than ever green trees like anjili. To ensure optimum growth and girthing of rubber plants, the other trees should be spaced at 14 m from the rubber plants. It was also observed that if coconut alone be the interplant the average girth of rubber plant was almost similar to the pure crop.

Interplanting was not beneficial in reducing wind damage and weed flora.

Tapping age was found to be enhanced by interplanting and that too with lesser percentage of trees attaining tapping girth. So cumulative yield and the income since the commencement of tapping was found to be high in pure planted area when compared to interplanted. In early years of tapping interplanted areas recorded higher income.

From the results it is deduced that the shade induced by interplanting adversely affects the growth and performance of rubber. From the economic point of view, yield of rubber was substantially reduced by interplanting and monoculture of rubber is more profitable and advantageous than interplanting. Disease intensity especially phytophthora, pink disease and panel diseases were aggrevated by interplanting. So the present study does not indicate the scope for further enhancing the limits of other trees permitted in rubber plantation.

Rubber is only an industrial crop and the production of food crops and timber crops are also equally important in a state like Kerala with over crowding population. Rubber plantation occupy nearly 15% of the cultivable area in Kerala. Hence this is a potential area to be utilised for companion cropping with least harm to the main crop. Considering this aspect, the other trees may be located along the road sides and boundaries at 14 m distance from rubber. Among the other trees coconut is to be preferred which impart minimum shade by the special orientation of leaves. Due to severe deforestation timber species are being exhausted and hence these tree species can also find a place in cultivation provided adequate distance is maintained from the rubber trees.

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ANNEXURE-I

QUESTIONNAIRE

1 Name and address of the owner including registration No. of estate :

2 Details of rubber planting :

Year of planting	Clone	Extent	Spacing/number of rubber trees	No. of other trees	Year of opening	Percentage of trees at the time of opening	Remarks

3 Girth of rubber plants :

4 Height of branching :

5 Type of branching : Heavy/Light

6 Nature of canopy : Dense/Medium

7 Yield of latex :

8 Weed count :

9 Wind damage :

10 Incidents of diseases : Phytophthora
Pink
Oidium
Panel diseases

11 Details on other trees species:
Planting - Existing/Newly planted

12 Type of other trees :

Timber species	Botanical name	Common name

Fruit trees

Others

13 Position : Border/in between rubber plants/road side

14 Distance from rubber plants :

15 Girth of trees :

16 Economic retuns : Timber value/economic produce

17 Opinion of the farmer regarding retention of trees :