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A CROPPING SYSTEM FOR REDUCTION OF GESTATION PERIOD AND ENHANCED YIELD OF RUBBER TREES (*HEVEA BRASILIENSIS*)

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A cropping system with altered spatial arrangement of planting that permits extended intercropping, reduced gestation period and enhanced yield of rubber was developed for smallholdings. Rubber was planted in paired rows of 9.0 m apart, at a spacing of 5.1 m between the rows within the paired row and 3.4 m between two plants within a row. The total number of rubber plants per hectare was 406 in the cropping system whereas it was 445 in the control. Diverse annual, short-term and perennial crops (banana, pineapple, *Amorphophallus*, *Dioscorea*, *Colocasia* and arrow root, coffee and pepper) were planted sequentially in the wider inter-row spaces, selecting the intercrops judiciously based on the light availability and shade tolerance. Legume cover crop, *Pueraria phaseoloides*, was established in the narrow inter-row spaces of rubber in the intercropped area and interspaces of rubber in the control plot. Intercrops were cultivated during the entire gestation period of rubber. Fodder grass (guinea grass) and teak were planted along the boundaries. In the cropping system, the soil nutrient status was maintained and soil moisture status was significantly higher during January. Altered spatial arrangement of planting and extended intercropping reduced the gestation period of rubber and enhanced yield by 25.6 per cent during the initial years of tapping compared to control plants under normal system of planting without intercropping.

Keywords: Cropping system, Gestation period, Intercrops, Rubber yield

INTRODUCTION

Rubber tree (*Hevea brasiliensis*) which yields one of the nature's most versatile raw materials plays an important role in the economy of India and other countries where it is cultivated. Rubber plantation industry has great socio-economic relevance in India with more than one million small growers cultivating rubber and providing about 3,50,000 job opportunities in the plantation sector and almost an equal number in the industrial sector (Krishnakumar, 2003).

In India, smallholdings (less than 0.50 ha.) accounting for more than 90 per cent of the total area dominate the rubber plantation industry. In India rubber has a long gestation period of about seven years with no income from the plantation. High development cost and absence of any income from the plantation in the initial years are the major problems faced by small growers. Under the normal planting system of rubber, intercrops can be cultivated during the initial three years only and in later years, sunlight is a limiting factor. Altering the planting

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geometry in a cropping system is a better management technique permitting intercropping in more area for a longer period which can easily be adopted by even the most resource poor farmers. The present study was taken up to find out whether by altering spatial arrangement of planting of rubber, intercropping period can be enhanced without adversely affecting the growth and yield of the main crop. Various aspects with regard to intercropping of annual and short-term crops from this experiment were published earlier (Jessy *et al.*, 1998; 2005 ; Vimalakumari *et al.*, 2001). In this article, the focus is on the cumulative effect of altered spatial arrangement of planting and extended intercropping on the sustainability of the system, in terms of continued growth of rubber after intercropping, yield, soil moisture and nutrient status.

MATERIALS AND METHODS

The experiment was started in 1993 at the Central Experiment Station of the Rubber Research Institute of India at

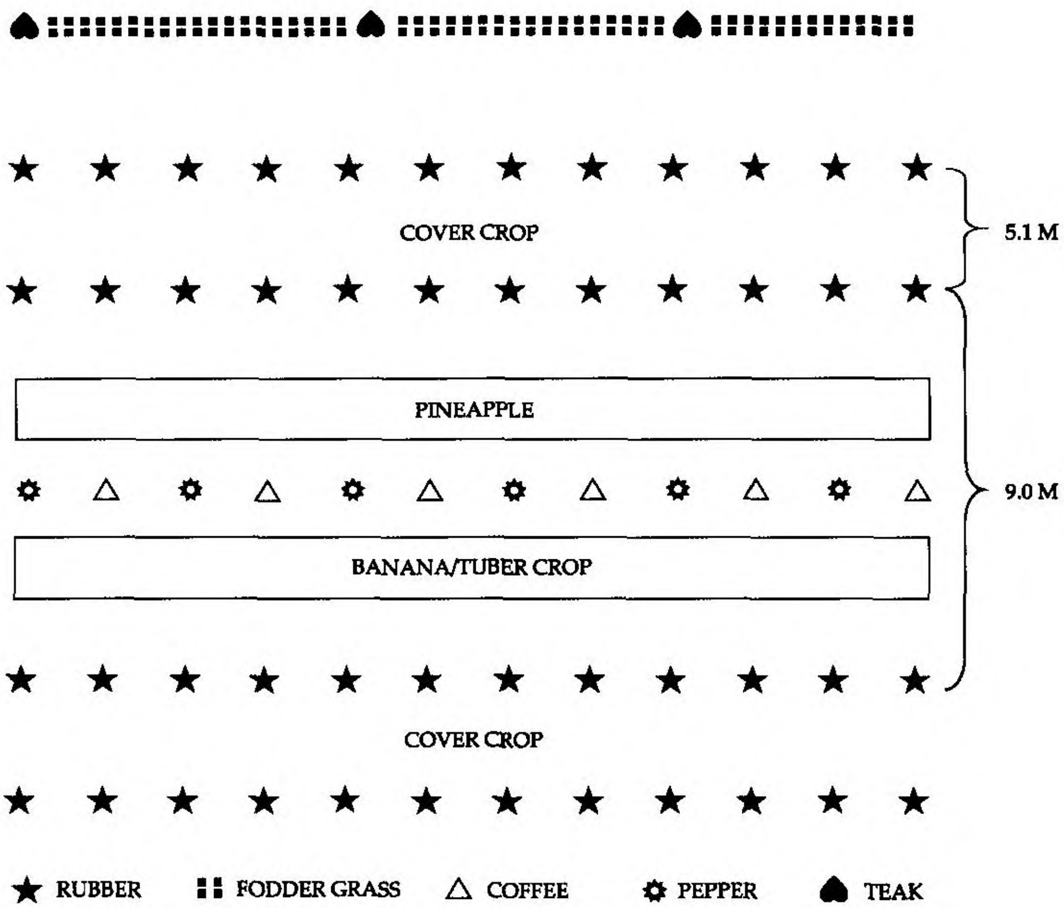

Fig. 1. Spatial arrangement of rubber and intercrops

Chethackal (9° 22′ N, 76° 50′E, an altitude of 50 m above MSL). The details regarding the experiment area are described by Jessy *et al.* (1998; 2005). The spatial arrangement of rubber and intercrops in the experimental field is given in Figure 1. Rubber was planted in June 1993. Banana (*Musa paradisiaca* var. Nendran) and pineapple (*Ananas comosus* var. Mauritius) were planted as the short duration crops and black pepper (*Piper nigrum* var. Karimunda) and cocoa (*Theobroma cacao*) were planted as intercrops along with rubber. *Erythrina* was planted as the standard for pepper. Teak (*Tectona grandis*) and fodder grass (*Guinea grass* var. Hamil) were planted along the boundaries where there was no adjacent plantation.

After cultivating banana for two years, tuber crops (*Amorphophallus, Dioscorea* and *Colocasia*) were planted in the space earlier occupied by banana. Since the establishment of cocoa was poor under the rainfed situation, it was replaced by coffee (var. Cauvery) during 1996. After the removal of pineapple and annual intercrops, coffee (var. Robust) was planted in the space earlier occupied by these crops during the seventh year at a spacing of 3.4 m between plants. Since performance of pepper was very poor, they were also replaced by coffee. The legume cover crop, *Pueraria phaseoloides*, was established in the narrow inter-row spaces of rubber. Year of planting and population/area allotted for rubber and intercrops per hectare are shown in Table 1. Adjoining this intercropped area, 100 rubber plants of the same clone were planted in 1993 as control at a spacing of 6.7 x 3.4 m and cover crop, *P. phaseoloides*, was established in the interspaces.

Table 1. **Year of planting and population of rubber and intercrops**

Crop	Year of planting	Density per ha
Rubber	1993	406
Banana	1993	250
	1994	250
Pineapple	1993	5000
Amorphophallus	1996	360
	1997	360
	1998	400
Dioscorea	1996	720
	1997	720
Colocasia	1996	360
	1997	360
Arrowroot	1998	510 m^2
Pepper	1993	110
Coffee	1996	110
	2000	500
Fodder grass	1993	120 m^2
Teak	1993	20

(Jessy *et al.*, 2005)

The general cultural operations and fertilizer application for rubber were done as per the recommendations of the Rubber Research Institute of India. For the other crops, the package of practices recommendations of the Kerala Agricultural University (KAU, 1989) were followed. All the intercrops were manured separately using urea, rock phosphate and muriate of potash. No fertilizer was applied to teak and guinea grass.

After the harvest, crop residues of all crops were retained in the field. *Erythrina* plants were pruned annually and loppings were applied as mulch in the plant basins. Soil sampling (0-30 cm) was done before the commencement of the experiment and at periodic intervals. Eight soil samples were collected from each situation and were analysed for pH (1:2.5 soil water ratio), organic carbon (Walkely and Black's method as described by Jackson, 1973) available phosphorus (Bray and Kurtz, 1945), available potassium (Morgan, 1941) and available magnesium (Vogel, 1969). The data were subjected to analysis of variance. Girth of rubber was recorded at 125 cm from the bud union and that of teak at 10 cm from the base.

Light interception by rubber in the cropping system and monoculture was measured by PAR Ceptometer (Decagon) and the light availability was expressed as percentage of the open area. Soil moisture was recorded gravimetrically during January 2004 and 2005 and expressed as percentage.

The exploitation of the trees for latex was commenced during 2000. The tapping system followed was S/2d3. Volume of latex and dry rubber content of 56 trees each in cropping system and monoculture was measured at monthly intervals and yield was expressed as grams per tree per tap ($gt^{-1}t^{-1}$). Growth and yield of trees in the cropping system and monoculture were compared by paired t test.

RESULTS AND DISCUSSION

Growth of plants

Growth of rubber in the cropping system was significantly higher than that in the monoculture throughout the period of the experiment (Fig. 2). The trees in the cropping system attained tappable girth six years after planting (50.66 cm), whereas in the monoculture where rubber was planted at normal spacing without intercropping, girth attained was 45.12 cm during this period.

Better growth of plants under intercropping was reported for rubber by earlier workers (Chandrasekhara, 1984; Rodrigo *et al.*, 1997). The biological activity in the rhizosphere of *Hevea* was higher in the cropping system where diverse crops were cultivated (Vimalakumari *et al.*, 2001) and this also might have contributed to the higher growth of plants in this system.

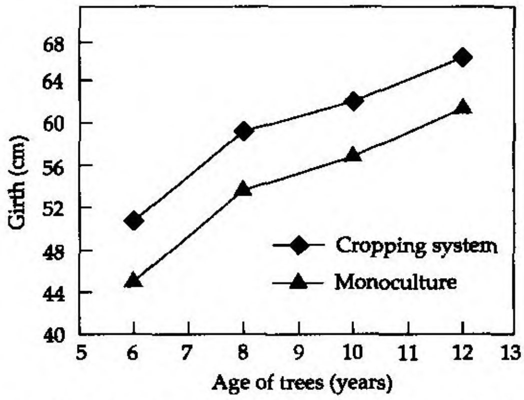

Fig. 2. Influence of intercropping and altered spatial arrangement of planting on growth of rubber trees

According to the authors, total microbial population and population of phosphorus solubilising bacteria were higher in the rhizosphere of rubber in the cropping system. The VAM colonization was also higher in the roots of rubber in the presence of intercrops.

The cultivation of annual crops needs tillage operations to varying degrees. Tilling the soil improves soil aeration and root penetration, which might have benefited rubber. However, this aspect needs further investigation.

In the monoculture where rubber was planted at normal spacing, canopy was closed by fifth year resulting in mutual shading. In the cropping system where rubber was planted at an altered geometry, a wide spacing of (9.0 m) was provided between two rows, which were separated by 5.10 m. The canopy closure took a longer period in this spatial arrangement of planting (Jessy *et al.*, 2005). The interception of sunlight was more with this altered geometry and this might also have contributed to the better growth of the plants. In Sri Lanka, Pathiratna and Perera

Table 2. **Influence of intercropping and altered spatial arrangement of planting on yield of rubber trees**

Situation	Yield ($gt^{-1} t^{-1}$)					Mean yield
	2001-02	2002-03	2003-04	2004-05	Mean (2001-05)	(kg ha^{-1})
Cropping system	34.61	75.25*	103.15*	81.88*	73.72*	2843
Monoculture	36.19	59.84	58.03	62.58	54.16	2264

(* t test significant at $P \leq 0.01$)

(2006) reported that wider inter row spacing has the advantage of providing more light and reduced competition from rubber for a longer period than conventional planting systems.

The comparatively long gestation period of rubber and the high development cost needed during the early years of the plantation are the constraints faced by the smallholders. Altered spatial arrangement of planting and extended intercropping enhanced growth and reduced gestation period. This is highly advantageous to the farmers since in the current cropping system, income was generated throughout the gestation period of rubber from intercropping with simultaneous reduction of gestation period, without any other management practice/additional input to enhance the growth of plants.

Performance of intercrops

Performance of annual intercrops was reported earlier (Jessy *et al.*, 2005). Performance of perennial intercrops in the cropping system was comparatively poor. Coffee established well, but yield was poor and it varied from 10 to 25 per cent of that in monoculture. Good vegetative growth and low fruit set was observed for pepper also in the initial years, however, the plants did not survive due to intense shade after the seventh year. Teak plants had a mean girth of 65.8 cm at the end of 12 years.

Soil nutrient status

Soil nutrient status 12 years after commencing the experiment showed an improvement in the organic carbon content of the soil, but no significant difference was observed between different situations (Table 3). The farm yard manure added to the intercrops, recycling of crop residues after harvest, mulching with *Erythrina* loppings and litter addition from rubber and coffee might have contributed to this increase. Soil samples collected 2 ½ and 6 years after planting also indicated an

Table 3. **Soil nutrient status in the control and cropping system (12 years after planting)**

Situation	Org C (%)	Av.P	Av.K	Av.Mg	pH
		mg/100 g soil			
Pre-treatment	2.12	0.30	8.82	1.78	5.20
Between rubber	2.63	1.97	10.50	2.08	4.50
Near coffee	2.81	3.86	11.89	1.97	4.63
Monoculture	2.51	1.14	11.39	1.65	4.04
SE	0.09	0.37	0.88	0.16	0.30
CD (P=0.01)	NS	1.09	NS	NS	NS

Table 4. **Influence of intercropping on leaf nutrient status (%) of 12-year-old rubber trees**

Situation	N	P	K	Ca	Mg
Rubber near to pineapple	4.14	0.24	1.02	0.76	0.26
Rubber near to annual crops	3.85	0.21	1.08	0.67	0.25
Monoculture	4.11	0.21	1.10	0.71	0.27
SE	0.11	0.008	0.05	0.05	0.007
CD (P=0.05)	NS	NS	NS	NS	NS

increase in organic carbon status (Jessy *et al.*, 1998; 2005). Maintaining or improving soil organic carbon content is necessary for the sustainability of any cropping system and the data indicated the beneficial effect of crop diversification on soil sustainability.

Soil available P status was low before the commencement of the experiment, but increased after cultivation of intercrops (Jessy *et al.*, 2005) and higher status was maintained after 12 years also. Available P status was highest near coffee, and it might be due to the higher dose of P applied to coffee and localised application. The data suggest a possibility of reducing the dose of phosphatic fertilizers to rubber and component crops under intercropping situations. There was no significant difference in soil available K, Mg and pH between the treatments.

Leaf nutrient status

Leaf nutrient status of rubber was not influenced by intercropping (Table 4). Leaf N status was maintained in the higher range and P and K status in the medium range. Competition for K was observed between rubber and banana as indicated by the lower K status of rubber trees during the early phase (Jessy *et al.*, 2005) but after 12 years, intensive intercropping during the gestation period and growing of coffee did not influence leaf nutrient status.

Soil moisture status

Soil moisture recorded during January was higher near coffee in both surface and subsurface soil layer (Table 5). Rubber trees shed their leaves during December- January and sunlight falls directly on the ground during this period. This increases evaporation from the soil surface and reduces soil moisture content in the surface soil layer. Canopy of coffee prevents the direct incidence of solar radiation to the ground leading to less evaporative loss of moisture and hence higher soil moisture content near coffee area.

Table 5. **Influence of intercropping on soil moisture status**

Situation	Soil moisture status (%)		
	2004	2005	
	0-30 (cm)	0-30 (cm)	30-60 (cm)
Cropping system	22.37	14.34	16.28
Monoculture	19.18	13.90	15.91

* t-test significant at P≤0.01

Availability of photosynthetically active radiation (PAR)

As age of the trees advanced, availability of photosynthetically active radiation in the centre of the wide inter row area steadily decreased (Jessy *et al.*, 2005) and it was 3.5 per cent during 2004 and then increased to

18 per cent during 2005. In the monoculture where trees were planted at the standard spacing, PAR availability was four per cent during 2004 and 14 per cent during 2005.

Yield of rubber

Yield during the initial years of tapping was significantly higher in the cropping system compared to monoculture (Table 2). Better growth of the trees in the cropping system, higher soil moisture status during the summer season, better aeration of the soil due to tillage operations, facilitation effect of intercropping during the immature phase *etc.* might have contributed to this higher yield. The planting arrangement with wider spacing between paired rows resulted in the interception of more solar radiation by the canopy, which also might have contributed to the higher yield.

In rubber plantations, tapping wages are usually calculated on a per-tree basis. Considering the number of trees in the cropping system being lower (406 trees ha^{-1}.) compared to monoculture (440 trees ha^{-1}.), the higher yield recorded in the cropping system is of greater economic advantage.

Thus, the cropping system developed reduced gestation period and enhanced yield of rubber significantly. It also generated income from intercrops throughout the unproductive period of the plantation cycle apart from improving soil moisture status during dry season.

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