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Contour and East-West row planting systems of rubber (*Hevea*) for intercropping Part 1. Effects on growth and yield of component crops

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Abstract

Light availability in the in the inter-row is one of the main constraints to the productivity of intercrops. East-west oriented rubber rows were expected to allow more light into the inter-row and this planting system was compared with contour planted rubber in an experiment involving three species of intercrops viz.; coffee, cinnamon and a grass (Brachiaria brizantha). *The yield of all intercrops declined with time with the increase of competition from rubber. Growth of rubber was reduced in the presence of grass after the third year. The yield too was low in grass plots. Growth and yield of rubber was favoured by the presence of cinnamon as the intercrop.*

Reduction in the yield of intercrops was high and occurred at an early stage in rows closest to rubber whereas it took 2-2 ½ years for this to occur in the rows in the middle. Yield of cinnamon and coffee was better under rubber planted in east-west rows than those under contour plated rubber in the 7th and 6th years after planting respectively.

Key words: *Brachiaria brizantha*, *Cinnamom verum*, *Coffea arabica*, inter cropping, light availability, plant density, yield

Introduction

One of the main factors that limit the sustained production by intercrops in the rubber inter rows is the progressive reduction in light availability resulting from the expanding rubber canopy. Except for the shade tolerant species (*eg.* coffee, pepper, *etc.*) crops requiring high level of irradiance for light saturation are affected by the shade from the rubber tree canopy even before they are closed fully (Dissanayake & Waidyanatha, 1987). Even the shade tolerant crops suffer from light stress under the intense shade from rubber planted with normal spacings (Pathiratna & Perera, 1998).

The tree crops in intercropping systems always have the advantage of extending their canopy and roots into the inter row region and reduce the growth and yield of intercrops (Cannel 1983). Light stress and consequent reduction of root growth gradually weakens the intercrops (Connor 1983 & Schroth 1999). Removal of photosynthetic biomass also has severe effects (Schroth 1999).

One of the methods that could be used to improve light availability in

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the inter row space is by planting trees in east west oriented rows. This will give a better chance for the light to reach the intercrops in the inter row for a longer period during the day as has been discussed by Connor (1983) and Allen (1974).

The intention of this experiment was to study the effect of rubber planted in east west oriented rows and in contours on the growth and yield of three species of intercrops.

Materials and Methods

Site

The experiment was located in a 3.0 ha. block of land in an estate in the Kalutara district. The mean annual rainfall in the area was about 2300 mm well distributed during most part of the year and rains receiving in both monsoons. The land was flat to undulating and the soil type is red yellow podzolic.

Experimental design

A split plot design was developed with two spatial arrangements i.e. contour planting and east west oriented row planting as the main treatments. Contours were in different directions with respect to the path of the sun. Each main treatment was split to accommodate three intercrops and a control. These treatments were replicated four times. The intercrop plots were 70 m^2 on either side of the effective rubber row consisting of 8 rubber plants.

Crops

Rubber

Polybagged plants of the rubber clone RRISL 100was planted with a spacing of 8.1m x 2.4m.

The intercrops were selected on the basis that (1) grasses, requiring high irradiance for light saturation (2) coffee, a shade tolerant species and (3) cinnamon, a species which can grow under moderate shade yielding satisfactorily (Pathiratna & Perera, 1998).

Cinnamon

Cinnamon was planted as six months old poly bagged seedlings with a spacing of 1.2m x 0.91. There were five rows of cinnamon within the inter-row giving about 8000 plants/ha intercropping.

Coffee

Six months old coffee seedlings of the variety robusta in four rows were planted with a spacing of 2.4 x 1.8 m. This gave about 2000 plants/ha intercropping. Single stem plant training method was practiced.

Grass

The species of grass was *Brachiaria brizantha* planted as tillers.

All intercrops were planted leaving a space of 1.5 m to the rubber row. The planting of crops was done in July 1992.

The control plots had *Pueraria* mixed with weeds established soon after planting of crops.

Agro-management practices

Plots of cinnamon and coffee were kept weed free throughout. Weeds were also removed from grass plots but those present along with *Pureria* in control plots were not removed. All leaves and twigs of cinnamon that remained after harvests amounting to about 8000 kg/ha were returned to the same plots. Entire grass crop was removed every two months.

Fertilizer

Rubber was fertilized at the rate of 400 kg/ha with a mixture containing 12:14:14 up to the 7th year.

The fertilizer for cinnamon was a 14:11:14 NPK mixture applied at the rate of 15.0g per bush in the first year, 30.0g per bush in the 2nd year, and 60.0g per bush (480 kg/ha) there after and after the 2nd year this amount was applied as two split doses.

Grass was given a 14:11:14 NPK fertilizer mixture every two months at the rate of 800 kg/ha/year.

Coffee was fertilized at the rate of 120 g/bush in the first year and 240 g/bush (480 kg/ha) there after with a mixture consisting of 14:11:14 NPK applied in two doses.

Measurements

Rubber

Growth of rubber was measured as girth at a height of 90 cm above the graft union and was tapped ½S d/3 in the 6th year of planting and the yield of every effective tree was measured twice a month as grams of dry rubber per tree per tapping (g/t/t).

Cinnamon

First harvest of cinnamon was taken 32 months after planting. Three bushes from each row were sampled. The mature sticks in each bush were cut and the bark yield was determined.

Coffee

The first harvest of coffee was taken three years after planting. All mature berries were harvested and the fresh weights were taken.

Grass

Grass yield was determined by cutting 1.0m squares from 6 places in three rows parallel to the rubber rows on both sides of the effective row every 60 days. Grass in the whole plot was cut and removed after every harvest.

Results

Growth and yield of rubber

The growth of rubber measured as girth was not affected by spatial arrangement during the eight year period, but was significantly affected by the intercrop (Fig 1). The presence of grass as the intercrop significantly reduced the growth of rubber after the 3rd year. The other two intercrops and the cover +weeds in the control treatment did not show such an effect. The growth of rubber at the end of 8th year was highest in the presence of cinnamon followed by coffee (Fig 1).

The g/t/t yield of rubber on the 1st year of tapping was also lowest when grass was the intercrop (Table 1).

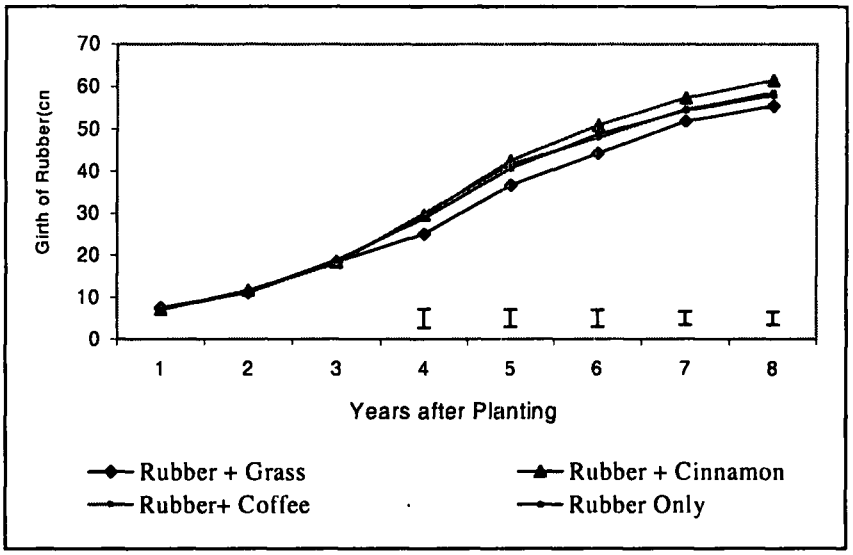

Fig. 1. The effect of grass, coffee, and cinnamon on the growth of rubber during the eight year period (vertical bars= LSD values)

Table 1. *The effect intercrops on the yield of rubber during the 1st two years of tapping*

Intercrops	Rubber yield (g/t/t)	
	1st year of tapping	2nd year of tapping
Rubber +grass	15.2 [b]	33.1 [a]
Rubber +Cinnamon	22.4 [a]	40.0 [a]
Rubber + Coffee	22.0 [a]	39.1 [a]
Rubber only	21.0 [a]	36.1 [a]
LSD	5.3	ND

(Figures with the same letter are not significantly different)

Yield of Cinnamon

The first harvest of cinnamon was taken 32 months after planting and there was a continuous decline in yield through the harvests. During the first four harvests any influence of spatial arrangement of rubber on the yield of cinnamon was not significant. But after the fifth harvest cinnamon under rubber planted in east west rows had a significantly higher yield than under the contour planted rubber (Fig.2).

Closeness to the rubber row also showed some influence on the yield of cinnamon at early stages. The cinnamon in the row closest to the rubber row showed a significantly lower yield than the row next and the one in the middle of the rubber inter-row at the first harvest (Fig.3).

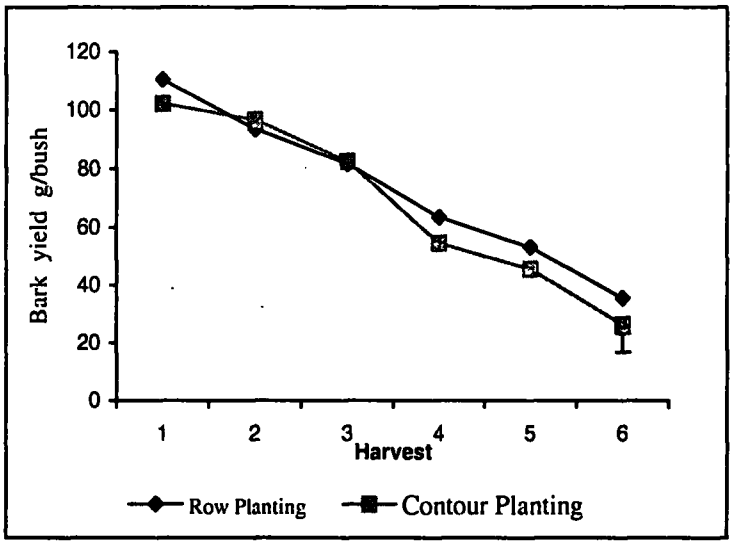

Fig. 2. The effect of row and contour planting of rubber on Cinnamon bark yield

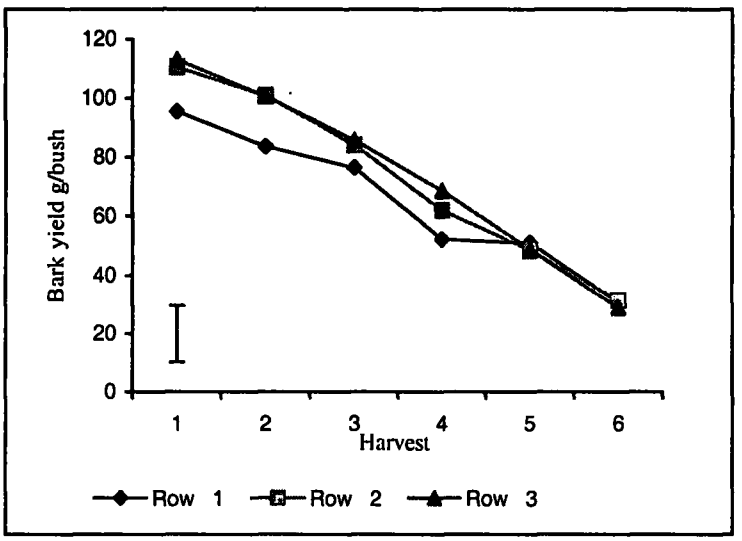

Fig.3. Effect of proximity to rubber on the yield of cinnamon. Row 1 was closest ie. 1.5 m away from the rubber row, Row 2- row next, Row 3- row in the middle of the rubber inter-row)

Growth of coffee

Growth of coffee when measured as diameter at a height of 15.0 cm was not affected either by the spatial arrangement or proximity to the rubber rows.

Coffee yield

The first harvest of coffee was taken 3 years after planting and there was a decline in yield after the first harvest. The yield was significantly low in the two rows of coffee close to rubber in the first harvest but not after. (Fig. 4).

Coffee yield was also affected by spatial arrangement after the 3rd harvest and was significantly high under rubber planted in rows (Fig.5).

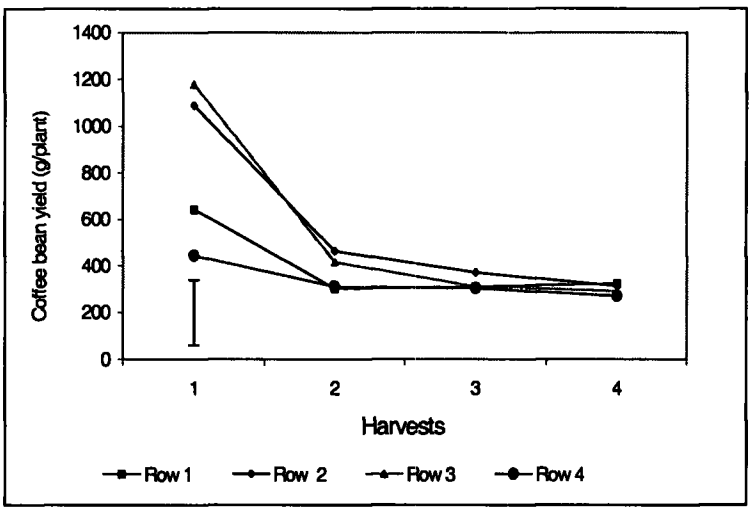

Fig. 4. Effect of proximity to rubber on coffee yield. Row 1 was closest to the rubber row *i.e.* 1.5 m to the rubber; Row 2-row next; Row 3 – row in the middle of the inter row

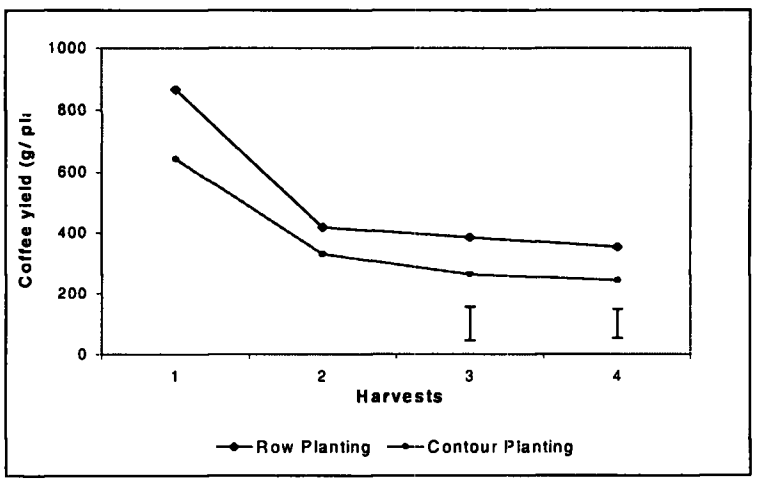

Fig. 5. Effect of row and contour planting on coffee yield in the four harvests (vertical bars = LSD values)

Yield of grass

There was a general decline in grass yield through out. However significant differences either due to spatial arrangement or closeness to the rubber trees were not observed (Table 2).

Discussion

This experiment was conducted during a period of 8 years and discontinued prematurely due to unavoidable circumstances. Nevertheless the data collected during this period have provided useful information on the influence of spatial arrangements and crop competitions.

In this experiment no change was made in the standard agro-management practices used for a particular crop and the data is considered in that context

Rubber trees in this experiment reached tappable girth in five years (Table 1) except in the grass treatment. Due to the poor growth of rubber in the grass plots, commencement of tapping had to be postponed by an year. The yield of all intercrops during this period showed a regular decline (Figures 2-5) although fertilizers were applied to all crops as recommended. The increasing effects of below and above ground competition from rubber with time could be a reason for this. The data on light availability and root growth in the inter-row space substantiate this observation (Pathiratna & Perera 2003 a & b).

The growth and yield of rubber irrespective of the spatial arrangement were affected by the presence of *Brachiaria brizantha* as the intercrop and also its management method employed (Fig.1). The removal of the harvested grass crop every 60 days takes off considerable quantities of nutrients in spite of the regular addition of fertilizer to grass. This is an effect evident in rubber from the 4th year of planting and this could be the cumulative effect of depletion of soil. This agrees with the findings of Dissanayake & Waidyanatha (1987). The abundance of grass roots in the inter row (Pathiratna & Perera 2003 a) provides evidence for this observation. Grasses are considered inferior to dicots even as weeds due to their shallow root spread (Scroth & Zech 1995).

The adverse effects of *Brachiaria* on growth of rubber is reflected in the canopy growth and the resulting increase in light availability into the inter row for an extended

Table 2. *The annual yield of* Brachiaria brizantha *as affected by row and contour planting of rubber*

	Yield of grass kg/ha					
	1st year	2nd year	3rd year	4th year	5th year	6th year
Row	3970.0	723.6	525.2	1475.5	1550.0	392.4
Contour	3760.0	699.5	658.8	1653.8	1587.0	306.8
	NS	NS	NS	NS	NS	NS

NS= not significant

period is seen. However, this amount of light does not seem to be sufficient for optimum growth of grass (Pathiratna & Perera 2003 b).

In the other treatments, the growth and yield of rubber was greater (Fig.1). Fertilizer for cinnamon and coffee was added on a per bush basis and was about 480 kg/ha in two split applications in the case of cinnamon. These applications did not coincide with fertilizer applications to rubber and the availability of nutrients in the inter-row space at different times could have been an advantage.

In cinnamon plots only a part of the biomass produced was removed and a large quantity of leaf and twigs in the range of 8000 kg/ha (data not presented here) were returned to the plot after every harvest and this could have had favorable effects in soil.

In the control treatment too, the growth and yield of rubber was higher than that in the grass plot. Though no fertilizer was added to the cover crops and weeds, nothing was harvested or removed from these control plots. This suggests that the removal of biomass produced in the inter-row as in the case of grass is more harmful and planting such intercrops where large quantities biomass is removed should be considered with caution.

The first affected row of the intercrop under rubber, whether planted in rows or contours was the one closest to the rubber row. In the first harvest which was taken 2 ½ years of planting of cinnamon and coffee showed this effect (Figs 3& 4.) The two cinnamon and coffee rows in the middle of the inter row gave a higher yield. At this stage there was sufficient light and roots also have not invaded middle of the inter row space. However, this effect has disappeared in later years showing that all rows of the intercrop were equally affected. Though there is some light available in these later years, the invasion of roots into the inter row space must have had considerable effects (Pathiratna & Perera 2003 a & b). Another reason particularly in the case of cinnamon could be the effect of high cinnamon density that resulted in intra species competition (Pathiratna, 2001).

These data also indicates an advantage of row planting on the yields of coffee and cinnamon and it was evident after about 4 years of planting. Light availability in the middle of the inter row was little higher in these treatments even at the 6th year and this could be the reason for such an effect. This advantage seen in later stages suggests that east west oriented wider inter rows would yield more light into the inter row for a longer period than the present 8.1m resulting in sustajned yields by inter crops.

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