

Contour and East-West row planting systems of rubber (*Hevea*) for intercropping Part III. Light availability in the inter row space

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Abstract

*Growth and yield of crops grown in the inter-row space are always affected by limiting light and root competition from rubber. In order to study the changes in the light availability, PAR in the inter-row was measured during a period of eight years in an experiment where three species of intercrops viz.; coffee, cinnamon and grass (*Brachiaria brizantha*) were planted in east west oriented rows and in contours. There was a continuous reduction of available light in the inter-row in all treatment combinations with time and was reduced to low levels by the 8th year. The advantage of the row planting system with respect to light availability in the inter-row during the 1st 6 years was evident and the low light availability in the contour system was mainly due to the scattered nature of rubber trees with respect to the path of the sun. Although the expansion of the rubber canopy was independent of the planting system, light interception was a combined effect of both the type of inter crop and the planting system. Rubber in coffee plots had a wider canopy growth and the reduction of available light occurred earlier than in cinnamon plots and thus the advantage of having row planted rubber in coffee plots lasted only for the 1st 3 years. But in the case of cinnamon and grass, this effect was there for about 6 years.*

Key words: *Brachiaria brizantha*, *Cinnamom verum*, *Coffea arabica*, contour planting, intercropping, light availability, row planting, rubber (*Hevea*)

Introduction

Light availability is one of the main limitations to intercropping and its stress greatly reduces crop yields (Connor, 1983). Presently practiced inter-cropping systems under mature rubber always suffer from low light conditions in the inter-row. The period that intercrops can be grown in systems involving immature rubber is also limited to few years due to this reason.

To alleviate these situations such methods as crop selection (Ong *et al.*, 1999), changing plant population densities (Cannel, 1983), plant spacing (Schroth, 1999) have been suggested and attempted.

East-west row planting of the tree component of the system is another method suggested (Allen, 1974) to facilitate more light into the inter row space during most part of the day.

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The data on the availability of light in the inter-row of east-west oriented row and contour planted rubber intercropped with three species are presented here. The data on the yield of component crops and root distribution of this experiment are published elsewhere (Pathiratna & Perera, 2002 and Pathiratna & Perera, 2003a).

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 throughout the year and rain receiving in both monsoons. The land was flat to undulating and the soil belonged to the red yellow podzolic group.

Experimental design

A split plot design with two spatial arrangements i.e. contour planting and east-west oriented row planting as the main treatment was developed. 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 m² on either side of the effective rubber row consisting of 8 rubber plants.

Crops

Rubber

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

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 1.2 m × 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 × 1.8 m. This gave about 2000 plants/ha intercropping. Single stem plant training method was practiced.

Grass

The species of grass planted was *Brachiaria brizantha* planted as tillers spaced 30 cm × 30 cm.

The control plots had *Pueraria phasioloids* mixed with weeds.

All intercrops were planted leaving a space of 1.5 m to the rubber row.

The planting of all crops was done in July 1992.

Agro-management practices

Plots of cinnamon and coffee were kept free of weeds throughout. Weeds were also removed from grass plots but those present along with *Pueraria* in control plots were not removed.

All leaves and twigs of cinnamon that remained after harvests amounting to about 8000kg/ha were returned to the same plots annually.

Entire grass crop was removed every two months.

Fertilizer

Rubber was fertilized as recommended at the rate of 400 kg/ha. with a mixture containing 12:14:14 NPK throughout 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 with a mixture containing 14:11:14 NPK at the rate of 120 g/bush in the first year and 240 g/bush (480 kg/ha) there after applied in two doses.

Light measurements

Measurement of light transmitted by the rubber canopy was measured above the intercrops using a Delta -T Canopy Analysis system with a Beam Fraction Sensor that enabled to take a measurement of light at an open place with every reading taken. The measurements were in PAR (μ mols m^2s^{-1}) and the transmission of light through the canopy was recorded as a percentage of incident light at an open place.

Measurements above the intercrop at two distances *i.e.* 2.0m, position 1 (P1) and in the middle of the inter-row, position 2 (P2) parallel to the effective rubber row and three measurements from each distance were taken at 9.00 am, 12.00 and 15.00 hrs of the day and was repeated for 3 days. Such measurements were taken in the 3rd, 6th and 8th years.

Canopy spread

The growth of the canopy of the trees of the effective rubber row was measured in the 7th year and was recorded as the radius of the canopy.

Results

Spread of rubber canopy

The growth in width of the rubber canopy into the inter-crop area was influenced by the type intercrop and was significantly high in coffee plots compared to either grass or control plots (Table 1).

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Table 1. *The growth in width of the rubber canopy with each intercrop measured in the seventh year*

Intercrop	Canopy radius (m)
Coffee	3.8 ^a
Cinnamon	3.5 ^{ab}
Grass	3.1 ^c
Control (cover/naturals)	3.4 ^{bc}

(Figures with the same letter are not significantly different)

Light availability in the interrow space

The light availability in the inter-row in all treatments declined with time and was lowest in the 8th year (Figs. 1-8). However, the light transmission from the rubber canopy was affected by the spatial arrangement and the intercrops. These differences were only seen in the measurements of light in the 3rd and 6th years. In the 8th year there were no differences in the light transmission from the rubber canopy in all treatments and in all places in the inter-row.

Effect of the spatial arrangement on light availability

Light availability at a place 2.0m away from the rubber row (P1) and in the middle of the inter row (P2) was significantly higher in cinnamon

plots under the row planting system than under the contour planting system during the 3rd and 6th years (Fig. 1).

When coffee was the intercrop there was significantly more light in both positions (P1 and P2) in the row planting than in the contour system in the 3rd year and at P2 in the 6th year but not there after (Fig. 2).

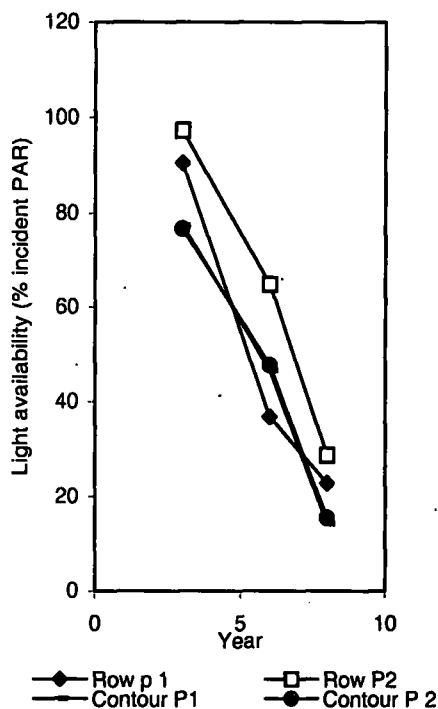
In grass intercropped plots there was significantly more light in both positions during the 3rd and 6th years under the row planting system than in the contour planting system (Fig.3). The control treatment had more light in both positions in the 3rd and 6th years under the row planting system than in the contour planting system (Fig. 4).

Effect of intercrop on light availability

Contour planting system

The light availability at P1 in grass plots was the highest and was more than either in coffee or cinnamon plots in the 3rd year (Fig 5) while that in coffee plots at P1 was further reduced in the 6th year and was lowest compared to all other intercrop plots.

When position 2 is considered, grass plots received more light in the 3rd year and were significantly higher than either in cinnamon or in coffee. No such differences were observed in the 6th year (Fig. 6).

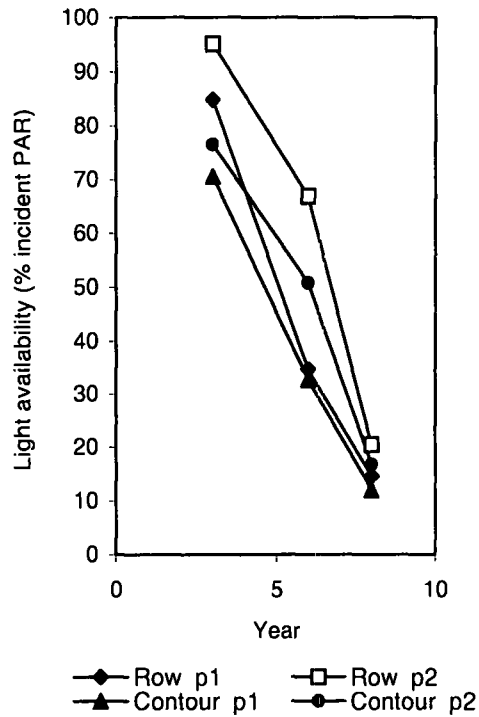


LSD to compare position			
	Year 3	Year 6	Year 8
Contour- P1 vs P2	NS	NS	NS
Row - P1 vs P2	4.2	4.5	NS

LSD to compare spatial arrangement			
	Year 3	Year 6	Year 8
Position 1-row vs contour	11.7	7.6	NS
Position 2-row vs contour	2.9	3.7	NS

Fig. 1. Effect of spatial arrangement on light availability at positions 1 and 2 in the 3rd, 5th and 8th years after establishment in cinnamon plots (Tables above gives LSD values to compare the differences in light availability in the two positions and planting systems).

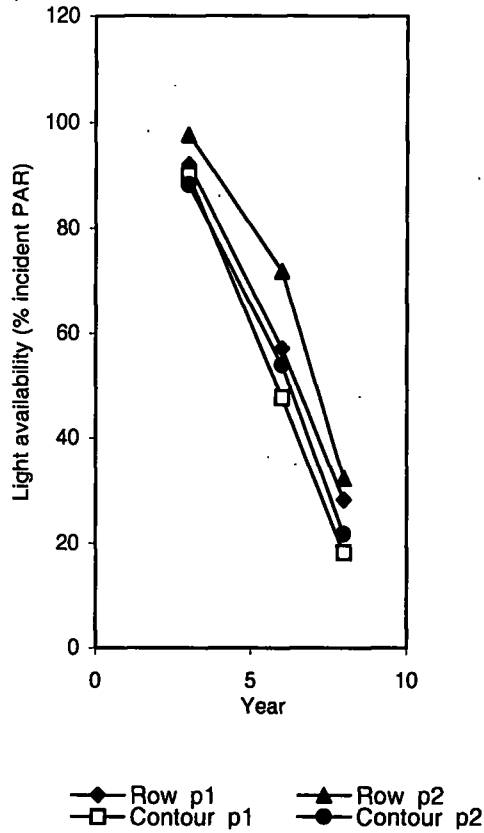
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LSD to compare spatial arrangement			
	Year 3	Year 6	Year 8
Position 1-row vs contour	2.6	NS	NS
Position 2-row vs contour	9.7	8.2	NS

LSD to compare position			
	Year 3	Year 6	Year 8
Contour-P1 vs P2	5.1	15.4	NS
Row - P1 vs P2	4.9	5.0	NS

Fig. 2. Effect of spatial arrangement on the light availability at positions 1 and 2 in coffee plots 3, 5 and 8 years after establishment (Tables above gives LSD value to compare the differences in light availability in positions and planting systems)

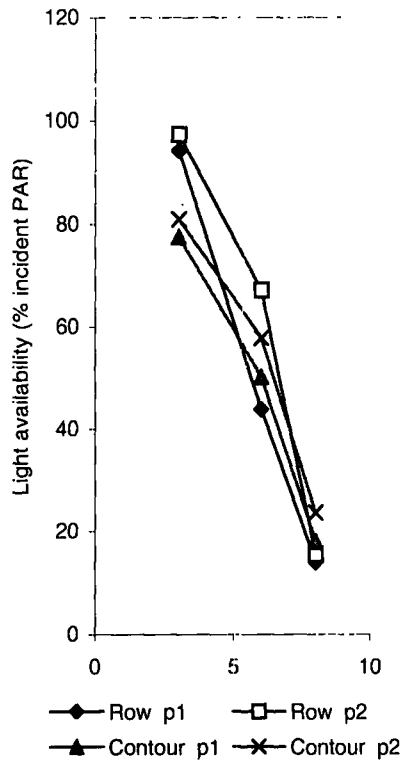


LSD to compare position			
	Year 3	Year 6	Year 8
Contour - P1 vs P2	NS	NS	NS
Row- P1 vs P2	NS	7.5	NS

LSD to compare position			
	Year 3	Year 6	Year 8
Position 1- Row vs contour	6.1	10.2	NS
Position 2 - Row vs contour	7.7	14.0	NS

Fig.3. Effect of spatial arrangement on the light availability at positions 1 and 2 in grass plots 3 ,5 and 8 years after establishment.
 (Tables above gives LSD values to compare the differences in light availability in the two positions and planting system)

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LSD to compare position			
	Year 3	Year 6	Year 8
Contour – P1 vs P2	NS	NS	NS
Row – P1 vs P2	NS	3.6	NS

LSD to compare spatial arrangement			
	Year 3	Year 6	Year 8
Position 1- Row vs contour	2.1	1.3	NS
Position 2- Row vs contour	14.5	17.9	NS

Fig. 4. Effect of spatial arrangement on light availability at positions 1 and 2 in control plots 3.5 and 8 years after establishment. (Tables above gives LSD values to compare the differences in light availability in the two positions and planting systems)

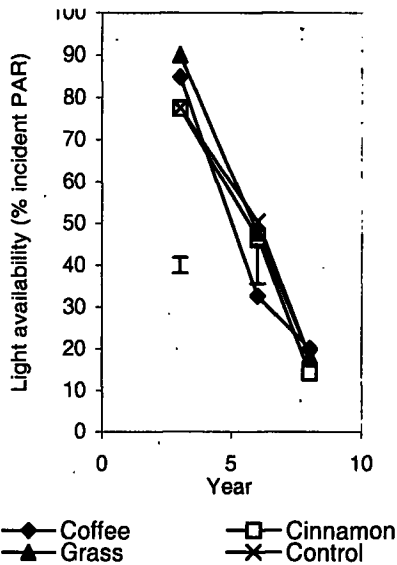


Fig. 5. Effect of intercrops on the light availability at a position 2.0m away from the rubber row (P1) in contour planting system, 3,6 and 8 years after establishment. (vertical bars=LSD values).

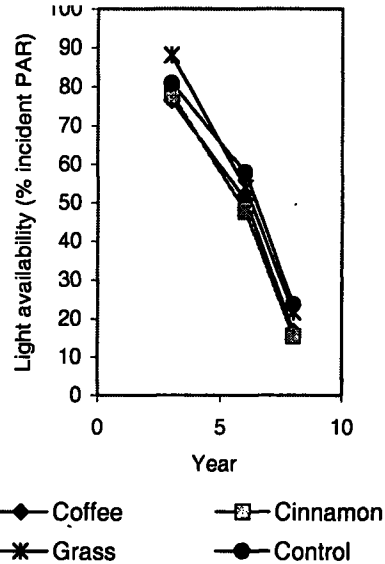


Fig. 6. Effect of intercrops on the light availability at a position 4.0m away from the rubber row (P2) in contour planting system after 3,6,and 8 years of establishment. (vertical bars=LSD values)

Row planting system

In the row planting system there were no differences in light availability in any of the intercrop plots at P2 throughout. (Fig. 8) while that at P1 in cinnamon and coffee plots was significantly lower than in the control plots in the 3rd year. In the 6th year light received at P1 in cinnamon and coffee plots was lowest and was significantly lower than in grass plots (Fig 7).

Discussion

The light availability in the inter row space showed a continuous decline with time. This is the effect of the gradual growth of the rubber canopy into the inter row space. Despite this decline the influences of planting system and of the intercrops on light availability in the inter-row were evident in these results.

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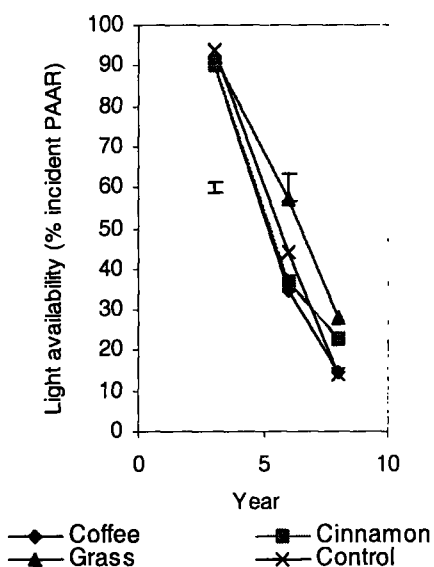


Fig. 7. Effect of intercrops on the light availability at a position 2.0m away from the rubber row (P1) in row planting system after 3,6,and 8 years of establishment. (vertical bars= LSD values)

East west row planting of trees was expected to provide more light to the crops grown in the inter-rows throughout the day (Allen *et al.*, 1974). In this experiment light was equally available to intercrops in both planting systems during the first few years of growth because the rubber trees were small and there was no interference to incident light.

However, the advantage of having rubber planted in east west rows was seen later. There was a higher level of available light in the whole inter-row of row planted rubber in all treatments

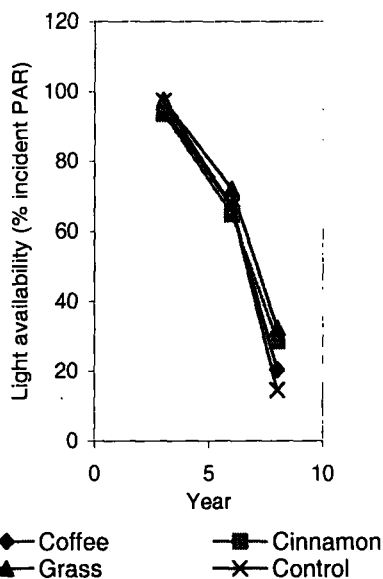


Fig 8. Effect of intercrops on the light availability at a position 4.0m away from the rubber row (P2) in row planting system after 3,6,and 8 years of establishment

up to the 3rd year compared to the counter system (Figs. 1-4). The possible reason for this effect is the scattered nature of the rubber trees in contour planting system in relation to the path of the sun and its effect on the interception of light during the day. But in the 6th year, the presence of the same trend in the cinnamon (Fig.1) grass (Fig. 3) and control (Fig. 4) plots and its absence in coffee plots (Fig. 2) is an effect that can be attributed to the combined effect of the scattered nature of the rubber trees in the contour planting system and the differences in canopy growth (Table 1).

The only possible way the intercrops can influence the light availability in the inter row is by their effect on the growth of the rubber trees. This seems to depend on the extent of the influence of intercrop on the growth of rubber with the exception that the canopy growth was widest in rubber trees growing with coffee (Table 1), though they were not the ones with the highest growth (Pathiratna & Perera 2002). It is also possible that coffee had some influence on inducing canopy growth of rubber. Plants use light signals for detecting, responding to proximity to neighbors and warning of impending competition to trigger morphological responses (Ballare *et al.*, 1995).

The grass, *Brachiaria* on the other hand had greater root length densities during the 1st 5 years (Pathiratna & Perera 2003). Due to this, competition could have been severe on rubber resulting in reduced growth (Pathiratna & Perera 2002) which consequently produced a smaller canopy and allowed more light to pass into the inter-row space even at a place 2.0m away from the rubber trees (P1) for a longer period than in coffee (Figs. 5 & 7).

The combined effect of the inter-crops and of the planting system is further indicated when the light levels of the two positions are considered. A place 4 m away from the rubber trees (P2) in cinnamon plots under the row planting system, there was more light in both 3rd and 6th years due to the

greater exposure of P2 through out the day (Fig.1).

In the case of grass the absence of a difference in light received at P1 and P2 in both planting systems in the 3rd year is obviously due to the smallness of the rubber canopy. But the effect shown in the 6th year in the row planting system, that is the higher light availability at P2 compared to the contour system was due to the effect of the planting system. The situation in the control plots was also very similar (Figs. 1-4).

The data as a whole show that the light availability in the inter-row of rubber was influenced by both factors considered in this trial namely the planting systems and the intercrops, but was not a simple function of either. The direct effect of the scattered nature of rubber trees with respect to the path of the sun has its major influence in the case of the contour planting system. The indirect influence of intercrops and their management practices that had their effect on the growth of rubber also seems to be great.

The advantage of the row planting system with regard to light availability was considerable even during the 6th year and its influence on the growth and yield of coffee and cinnamon was also seen (Pathiratna & Perera 2002). Although the differences seen in the 8th year were not significant there was always more light at P2 in the row system under all inter crops.

This implies that in an intercropping system where the growth

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of rubber is encouraged there is the tendency for a quicker reduction of light in the inter-row due to the faster spread of the rubber canopy.

The data also pointers to the fact that east-west row planting system of rubber could be more successful in wider inter rows that will improve light availability and to last for a longer period.

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