Indian J. agric. Sci. 46 (10) : 453–62, October 1976

RP-69

Pattern of light interception by canopies in a coconut-cacao crop combination

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Received: 3 February 1976

ABSTRACT

The intensity of light falling on the ground at different times of the day in a coconut-cacao crop mix was measured during different seasons of the year. During the peak bright hours of the day (10.00–14.00 hr) an average of 44% light was intercepted by coconut in a pure palm stand. Of the 56% sunlight available for cacao, the crop was able to intercept 63% when it was planted in single hedge only, and at least 76% when planted in double hedges as a mixed crop with coconut. But the light available for cacao on a per-plant basis was less in double hedge, and this could be one of the reasons for less yield/plant in double hedge than in single hedge. (Coconut, *Cocos nucifera* L.; cacao, *Theobroma cacao* L.)

Cacao (*Theobroma cacao* L.) has been found to be suitable for mixed cropping with coconut (*Cocos nucifera* L.) in south India (Nair *et al.*, 1975). One of the basic principles of such crop combinations is the effective utilization of the available resources such as solar energy and land (Singh and Nair, 1973). Studies on the pattern of utilization of solar energy in pure plantation of coconut have indicated that there is considerable variation in the extent of interception of sunlight by canopies of palms of different age groups (Nelliat *et al.*, 1974). The yield of cacao (number of pods/plant) was reported to be significantly lower when planted in double hedges than in a single hedge between coconut rows (Nair *et al.*, 1975). This study was intended to determine the extent of light interception by coconut canopies as well as the diurnal and seasonal variations in the intensity of light available for other crops like cacao grown in the interspaces, and the relationship between the per-plant yield of cacao and availability of light when planted in the two systems.

MATERIALS AND METHODS

The study was conducted at the Central Plantation Crops Research Institute, Kasaragod (10.7 m above mean sea-level) 12° 30′ N latitude, 75° E longitude), in an area where a field experiment on coconut and cacao is in progress. Cacao was planted in July 1970 in an existing 16-year-old coconut plantation (spacing 7.5 m × 7.5 m). There were 3 treatments : (*i*) control, pure stand of coconut palms; (*ii*) cacao as a mixed crop in single hedges (single rows of cacao alternating with rows of coconut with a spacing of 3.5 m between cacao plants), and (*iii*) cacao as a mixed crop in double hedges (2 rows of cacao between rows of coconut with a spacing of 3.5 m between cacao plants in such a manner that cacao plants in adjacent rows alternate at triangular positions) (Nair *et al.*, 1975).

Measurements on light intensity were made during 1974-75 in the 3 plots as well as in an open area with no crop. The intensity of light falling on the ground was measured with a portable luxmeter at 07.00, 08.00, 10.00, 12.00, 14.00, 16.00, 17.30 and 18.30 hr every day for one week during March (21–27), July (22–27) and October (24–29) in 1974 and during January (20–25) in 1975. To 'sample' the light levels on the plantation floor in a systematic way with a regular grid of measurements, the measurements were

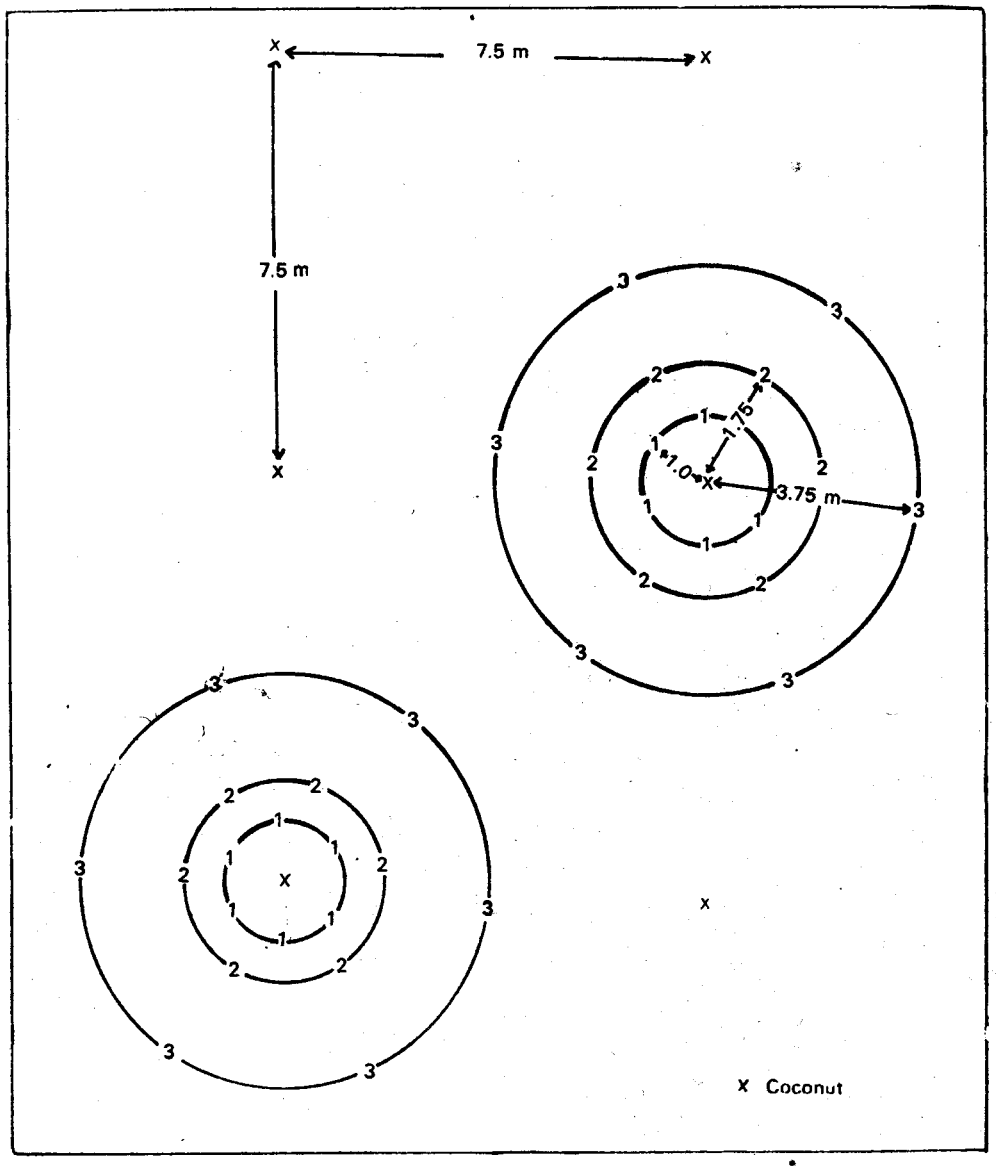
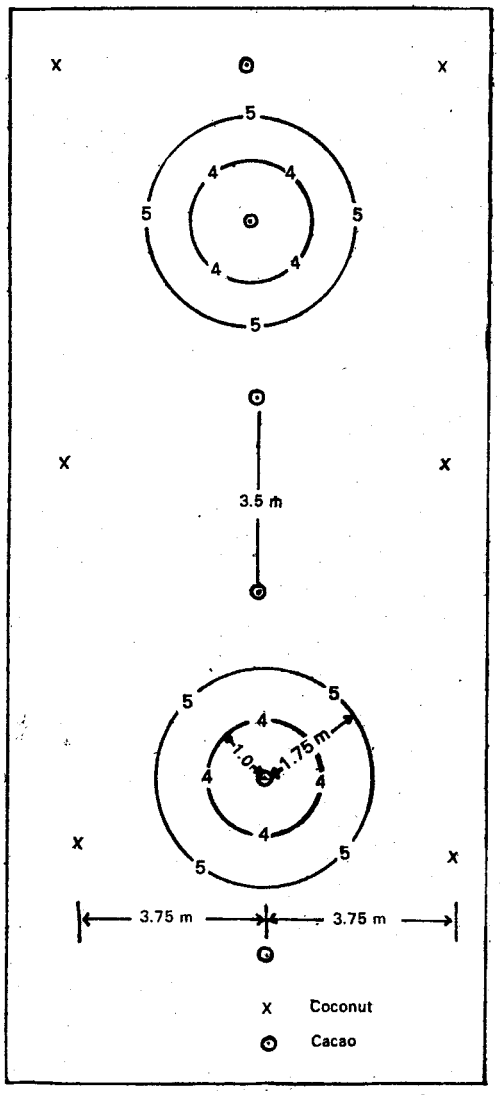


Fig. 1 (a). Lay-out of the experiment and various sites of measurement.

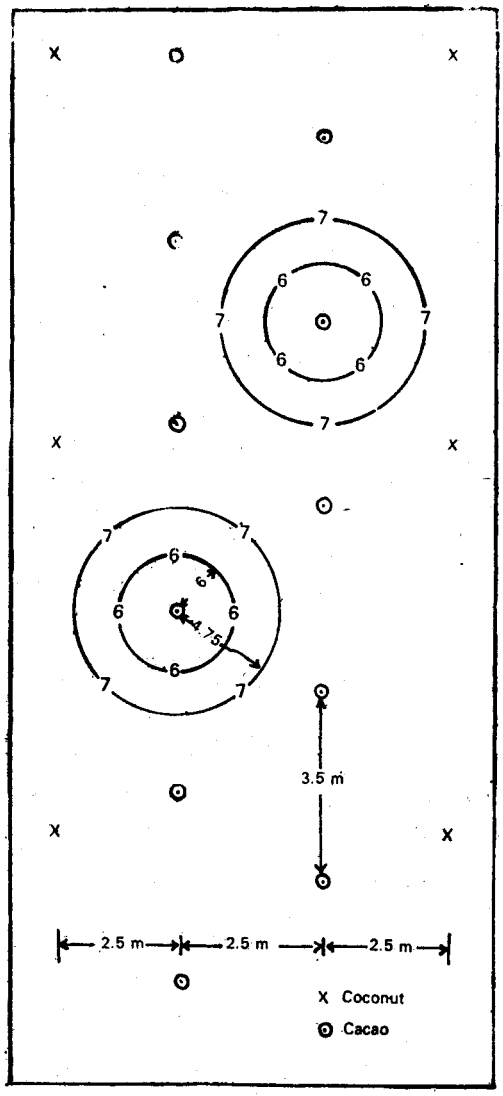
made at different distances from plants as shown in the diagram (Fig. 1), and each recorded measurement was the mean of 6 sites each for positions 1 to 3, and 4 sites each for positions 4 to 7. Measurements were made around 2 experimental trees in each plot. (There was no measurable light at 18.30 hr during October.)

The maximum intensity which the instrument could record was 30,000 lux. In a few cases where the intensity was above this range, the values were recorded



Coconut + single-hedge cacao

Fig. 1 (b)



Coconut + double-hedge cacao

Fig. 1 (c)

Fig. 1(b), (c). Lay-out of the experiment and various sites of measurement.

as 'full' and such values were considered as 30,000 lux for purposes of calculation.

RESULTS AND DISCUSSION

The intensity of light falling on the ground at 1.0, 1.75 and 3.75 m radial distances from the palms in pure stand of coconut is given in Table 1. The values at 1.0 m and 1.75 m were almost identical, but the values at 3.75 m (midway between palms) was considerably higher at all times. However, the values at these 3 positions were averaged to get a mean value

Table 1. Intensity of light (lux) falling on the ground at different positions of the canopy zone of coconut in a pure palm stand during 10.00–16.00 hr

Distance (m) from the palm	Time			
	10.00	12.00	14.00	16.00
	March 1974			
1.00	8500	9210	9240	5700
1.75	14220	12715	12228	6320
3.75	11860	30000	30000	7780
	July 1974			
1.00	3208	2604	2700	432
1.75	9612	6802	5234	1378
3.75	14727	11629	15539	2250
	October 1974			
1.00	4658	2818	6528	1218
1.75	6234	4860	6846	890
3.75	7893	12500	7600	2907
	January 1975			
1.00	4716	3826	10820	1054
1.75	8275	6468	9320	2210
3.75	12883	18155	7539	3828

for the intensity of light falling on the ground in the canopy zone of coconut. Similarly readings at positions 4 and 5 as well as at 6 and 7 were also averaged separately to get values for canopy zones of cacao under single hedge and double hedge respectively. These values for the 3 canopy zones as well as for open area are plotted in a semi-log scale to show the diurnal variations in intensity of light during different seasons of the year (Fig. 2).

In general, the shape of the curves was almost similar. There was a sudden increase during the early morning hours up to 10.00 hr, followed by an almost level portion of the curve during 10.00 to 16.00 hr and a steep decline thereafter. This pattern is almost independent of the season and little altered by the crops. However, there was considerable difference in the intensity of light falling on the ground in the canopy zones of the crop mixes, which is evidently a function of the magnitude of interception by the canopies.

The intensities of light falling on the ground at 10.00, 12.00, 14.00 and 16.00 hr during different seasons are plotted separately in a semi-log scale (Fig. 3).

The total amount of sunlight received was maximum during March and minimum during July because of the cloudy weather and the monsoon. The intensity of light was less at 16.00 hr in October because of a slight reduction in the length of the day. In view of these, the period from 10.00 to 14.00 hr can be regarded as the peak bright period of the day. Climatic parameters such as the number of sunshine hours/day, rainfall, and maximum and minimum temperature during the period of the study are given in Fig. 4.

To obtain the magnitude of interception by the canopies, the intensity of light falling on the ground of the canopy zones of coconut and cacao was expressed as the percentage of the light falling on the open area. The percentage of light intercepted was calculated as 100% falling on the ground. Diurnal variations in percentage interception under the 3 systems of planting are given in Fig. 5. In such a crop mix the coconut canopy is at a higher level because the palms are taller. Consequently, the palms are exposed to maximum available sunlight. The light falling on ground in pure palm stand indicates the light available for cacao. The percentage interception of light by coconut palms is maximum during the morning and evening hours; therefore, the peak period of light availablilty for cacao is from 10.00 to 14.00 hr.

Seasonal variations in light interception at 10.00, 12.00, 14.00 and 16.00 hr are given in Fig. 6. Seasonal influence is not significan except at 16.00 hr.

When the plantation was considered as a unit, an average of 55, 85 and 90% light was intercepted by canopies under coconut alone, coconut + single hedge cacao, and coconut + double hedge cacao, respectively, during the peak bright hours. The coconut palms were planted in a square system at a spacing of 7.5 m, whereas the canopy zone was defined in a circular pattern with a radius of 3.75 m. Therefore

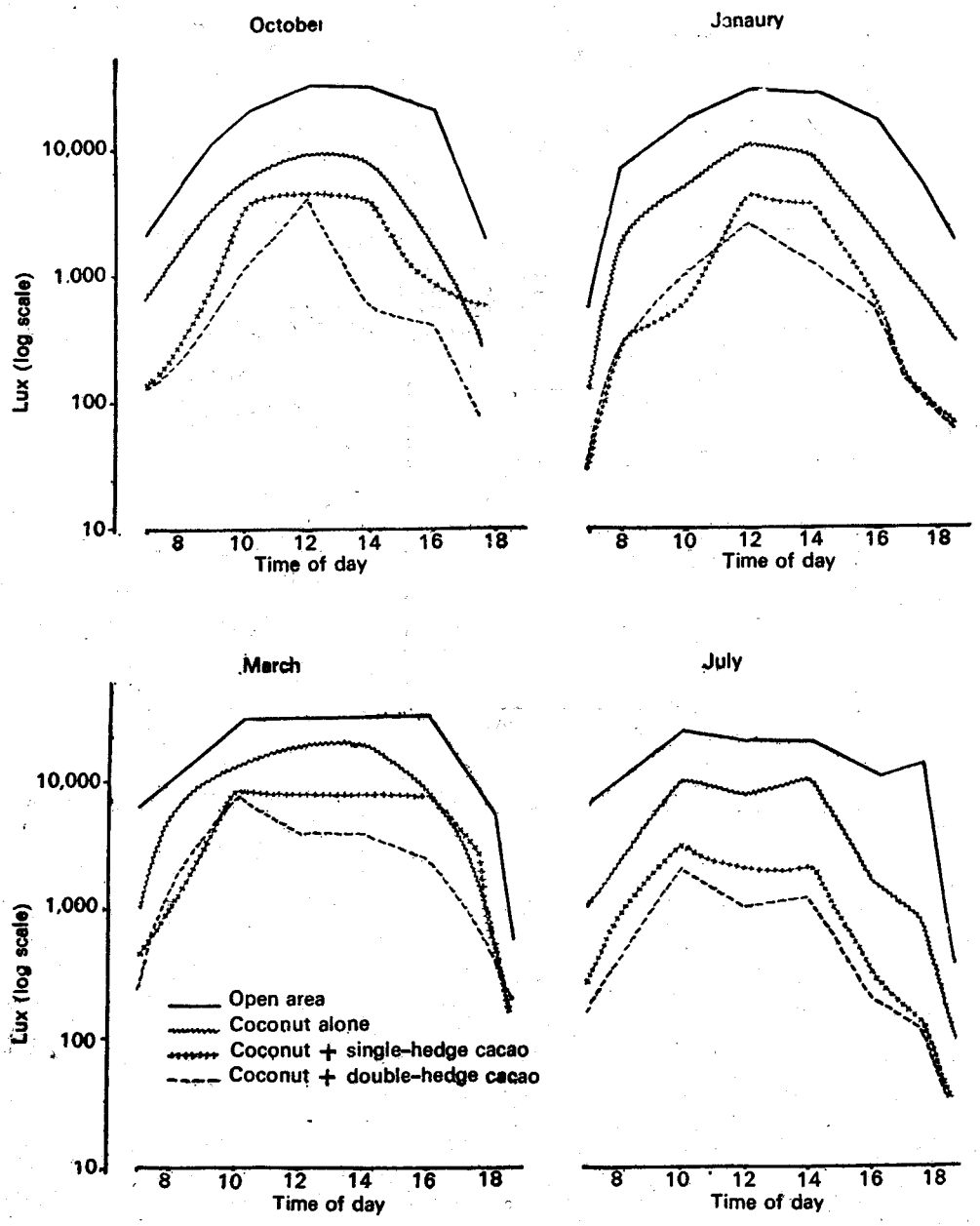


Fig. 2. Diurnal variations in the intensity of light falling on the ground in a coconut-cacao crop mix.

the area of canopy zone works out to 79% of the total area per palm. When this is accounted for, the percentage interception by coconut canopy in a pure palm stand works out to 44%. However this adjustment has not been made in the values

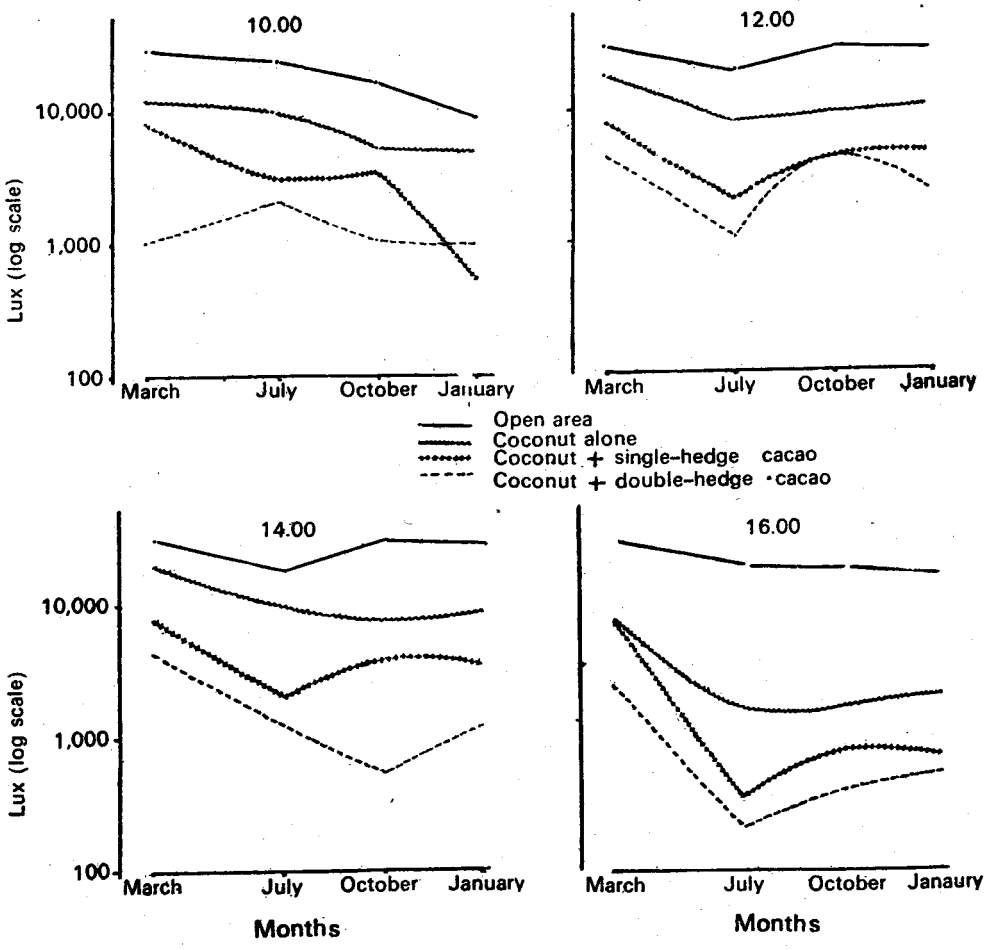


Fig. 3. Seasonal variations in the intensity of light falling on the ground in a coconut-cacao crop mix.

for the plot of coconut alone in Figs 5 and 6.

Taking the light falling on the ground in the pure palm stand as the maximum available (100%) for cacao, the percentage interception of available light by cacao canopies under the 2 systems of planting was also calculated (Table 2). During the peak bright hours, out of an average of 56% of total sunlight available for cacao, the crop is able to intercept 63.46% under single hedge and 76.23% under double hedge. This means that cacao under double hedge is 20% more efficient in intercepting the available sunlight. However, all the measurements were from within 1.75 m of the centre of a cacao tree so that the percentage of plantation floor farthest from the cacao trees which was not sampled was more for the single-row system. The very great effect of distance from the tree centre shown in Table 1 suggests that these biases in the measurement had some effect on apparent interception. Consequently, the interception by the single as opposed to the

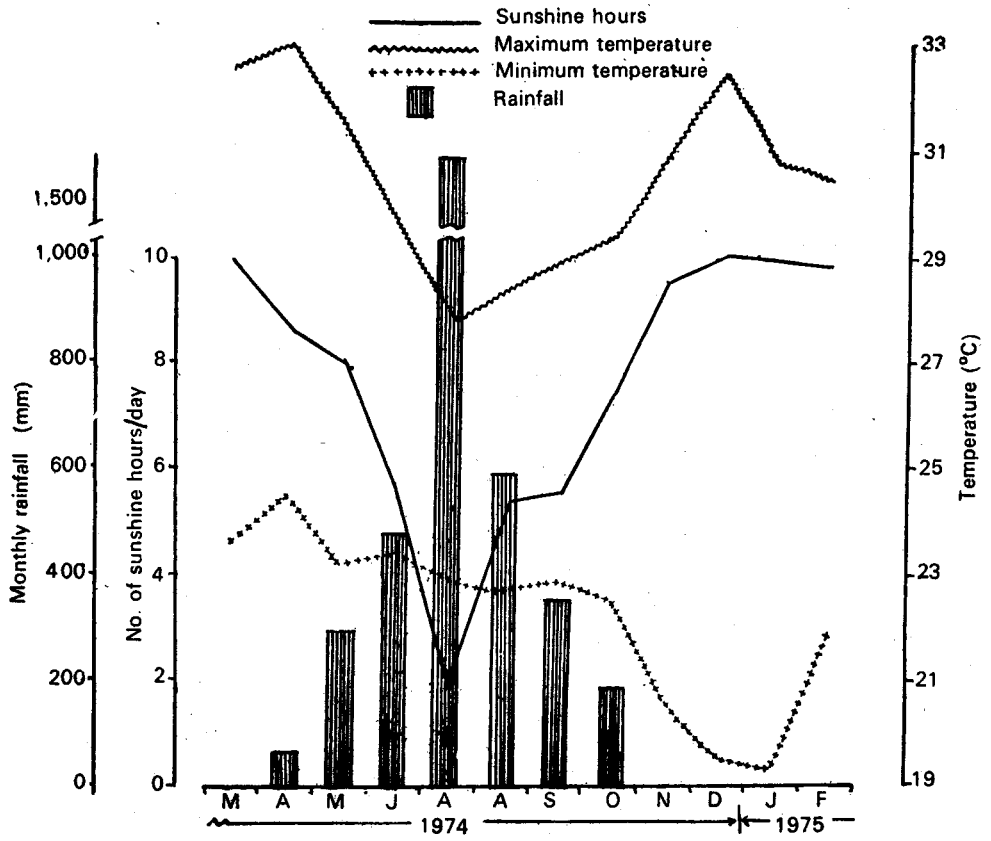


Fig. 4. Average meteorological data during the period of study.

Table 2. Percentage interception of available sunlight by cacao canopies under the two planting densities of cacao

Treatment	Time*					
	08.00	10.00	12.00	14.00	16.00	17.30
			March 1974			
Single hedge	81	73	57	61	60	65
Double hedge	85	57	62	78	83	77
			July 1974			
Single hedge	59	69	94	79	79	84
Double hedge	79	80	86	88	88	82
			October 1974			
Single hedge	85	32	54	49	55	83
Double hedge	86	81	72	88	78	77
			January 1975			
Single hedge	83	89	59	61	68	79
Double hedge	86	80	77	87	75	78
			Average for the year			
Single hedge	77	66	66	62	66	78
Double hedge	84	76	74	85	81	78

*Values at 07.00 and 18.30 hr are not presented.

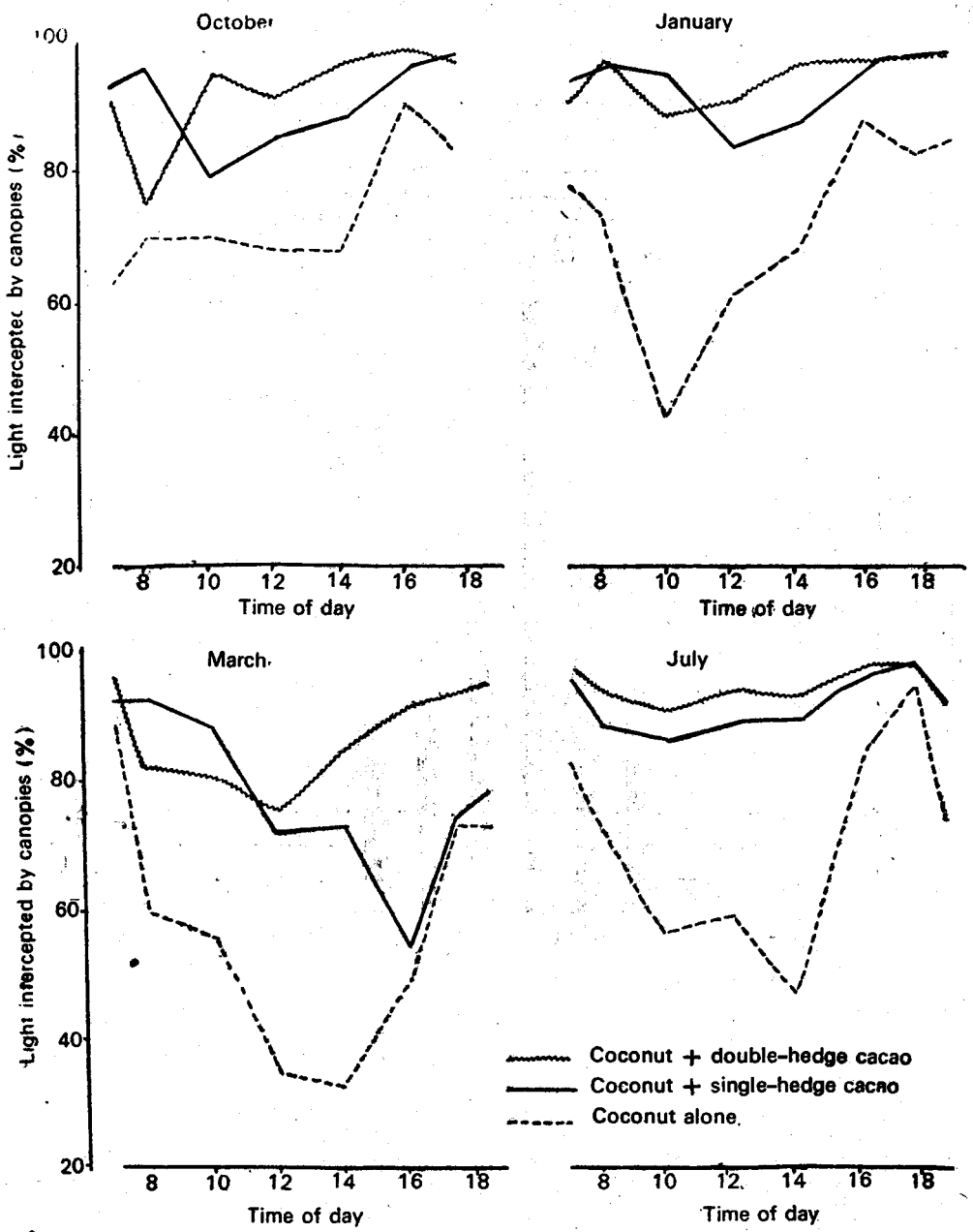


Fig. 5. Diurnal variations in the percentage of available light intercepted by the crop canopies in a coconut-cacao crop mix.

double row will be over-estimated, and this would explain the very slight differences in 'interception' in January and July (Fig. 5).

The number of cacao plants per unit area under double hedge is double that under single hedge; hence the availability

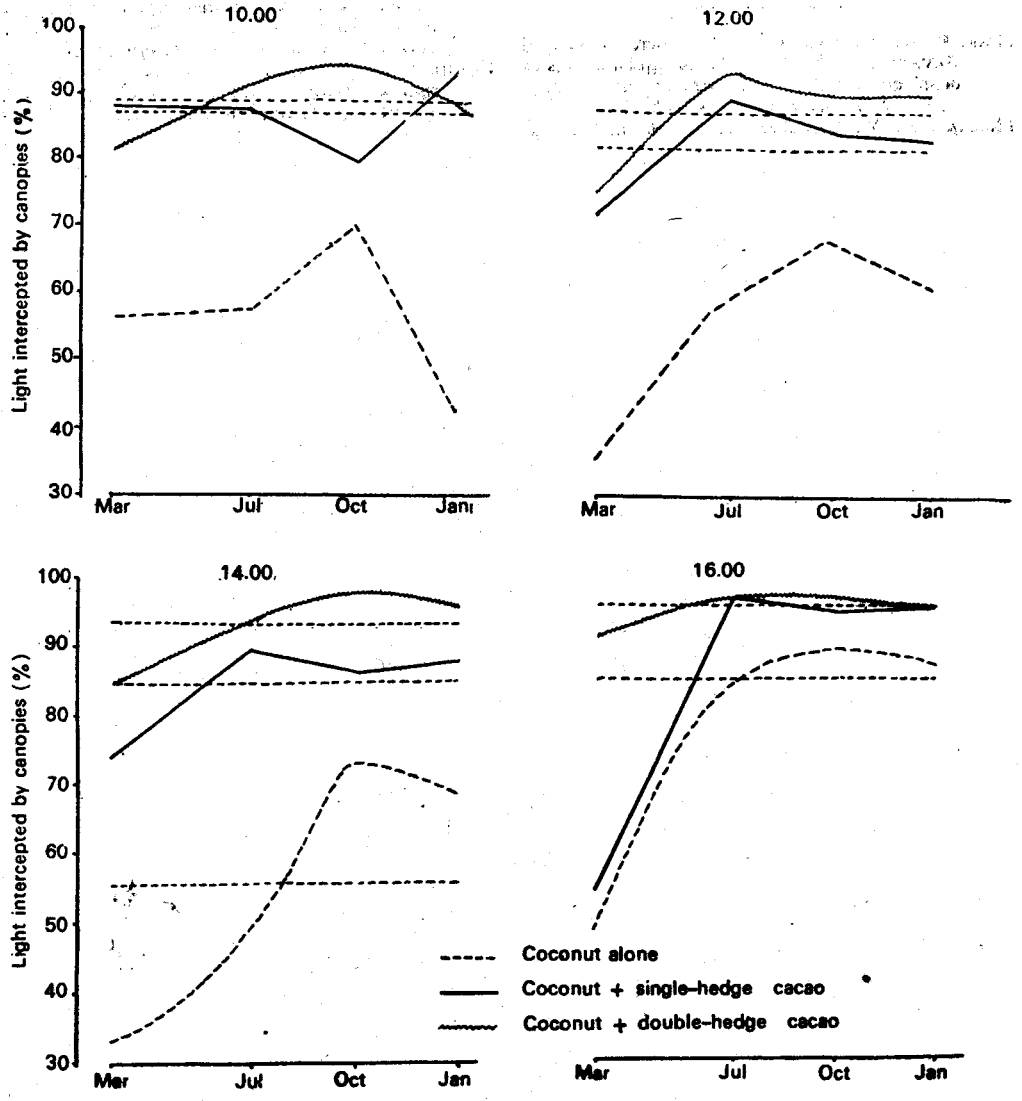


Fig. 6. Seasonal variations in the percentage of available light intercepted by the crop canopies in a coconut-cacao crop mix.

of light on a per-plant basis is more under single hedge. This could be one of the reasons for the significant increase in yield/plant under single hedge (19 pods) when compared with double hedge (14 pods) during 1974, as reported by Nair *et al.* (1975). However, the intensity of planting and availability of light have to be compromised with the requirement of shade for cacao plant and the yield per unit area.

ACKNOWLEDGEMENT

We are thankful to Dr M. Haridasan for critically reading the manuscript.

REFERENCES

NAIR, P. K. R., VARMA, R., NELLIAT, E. V. and BAVAPPA, K. V. A. 1975. Beneficial effects of crop combinations of coconut and cacao. *Indian J. agric. Sci.* 45 (4):165-71.

NELLIAT, E. V., BAVAPPA, K. V. A. and NAIR, P. K. R. 1974. Multistoreyed cropping : a new dimension in multiple cropping for coconut plantation.. *Wld Crops* 26 : 262.

SINGH, A. and NAIR, P. K. R. 1973. *Basis of Multiple Cropping*. Indian Society of Agronomy, Indian Agricultural Research Institute, New Delhi.