BENEFICIAL INTERACTIONS OF COCONUT–CACAO CROP COMBINATION

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ABSTRACT

A study on the amount of cacao litter added to the soil in a coconut-cacao crop mix was conducted at the Central Plantation Crops Research Institute, Kasaragod. Shed leaves collected at fortnightly intervals for a one year period amounted to 818 and 1785 kg/ha/year (oven dry) under single and double hedge systems of planting, respectively. The organic carbon content and the soil fertility improved considerably under the crop mix, and was reflected in the enhanced yield of coconut.

Soil temperature at 30 and 60 cm depths was 3 to 6°C lower and the variation in the mean monthly soil temperature was least in the mixed cropping system compared to the monoculture of coconut. The yield increase noticed in coconut when cacao was grown as mixed crop is discussed.

INTRODUCTION

In humid tropics, higher efficiency of utilisation of the basic resources of crop production viz. land, solar radiation and water can be achieved by adopting intensive cropping systems like multi-storeyed cropping (Nelliat, 1973). Problems and prospects associated with such an intensive system have been enumerated and discussed by Nelliat *et al.* (1974), Nair *et al.* (1975) and Nair and Varghese (1976). Trials conducted at CPCRI, Kasaragod have shown that cacao (*Theobroma cacao* L.) could be a compatible mixed crop with coconut in the humid tropics. Light interception pattern and utilisation by the canopies of these two crops and the ecoclimate developed inside such a crop mix have been reported by

Nair and Balakrishnan (1976). Nair and Rao (1977) observed the enhanced activity of microbes in the rhizosphere of the crop mix compared to pure stand of coconut.

The present investigation was aimed at estimating the organic matter addition to the soil through the leaf fall from cacao and comparing the differences in soil temperature, if any, in such a crop mix with that of a pure stand of coconut.

Material and Methods

The coconut palms were planted 7.5 m apart in 1955 in a sandy clay loam soil, having 68.0% coarse sand, 3.6% fine sand, 7.8% silt and 21.0% clay. Seedlings of the Forestero variety cacao were planted as mixed crop in 1971. There were three treatments viz. (1) control (no mixed crop), (2) single hedge of cacao (one row of cacao between coconut rows) and (3) double hedge of cacao (two rows of cacao between coconut rows). Randomised block design with seven replications was adopted. Spacing along the row for cacao was 3.5 m in both systems. In double hedge, the rows were 3 m apart and by adopting staggered planting, the plant to plant distance in adjacent rows was also kept at about 3.5 m. Coconut palms were fertilised at 1000 g N+640 g P_2O_5+2400 g K_2O/palm/year, applied in four equal splits at quarterly intervals. The cacao plants were fertilised at 100 g N+40 g P_2O_5 and 140 g K_2O/plant/year, applied in two equal splits in May and November. The experimental fields were irrigated with sprinklers at weekly intervals @ 28 mm from December to May.

For collecting shed leaves, circles with 1.75 m radius were marked round the base of 12 randomly selected cacao plants in single hedge. In double hedge planting, 24 plants were selected and the outer semicircular areas with 1.75 m radius were marked for the purpose. Leaves and prunings which fell in these areas were collected at fortnightly intervals during twelve months from August 1975 to July 1976. Care was taken to avoid sheddings from the inner side of the double hedge and border plants. After removing all extraneous matters, the leaves were dried in the air oven and the weights recorded.

Soil temperature

Sheathed soil thermometers were buried 30 and 60 cm deep at four locations viz. (1) open area where no crop is raised, (2) one metre away from the base of coconut palms in an unirrigated pure stand of coconut, (3) one metre away from the base of coconut in an irrigated pure stand of coconut and (4) in between cacao plants in a coconut+cacao+pepper+pineapple crop mix. The soil temperature was recorded every day during 1977 at 0800 hrs and 1430 hrs. The evaporation was recorded using cup evaporimeters during the rainless months.

Results and Discussion

Organic matter

The biomass added to the soil through shed leaves and prunings of cacao under the single hedge and double hedge systems of planting of cacao was found to be 818 kg and 1785 kg/ha/year, respectively. Mean dry weight of leaf materials collected during different months is depicted in the Fig. 1. Alvim (1975) reported that flushing and leaf fall are closely related as it helps in the physiological balancing of the plant and the pattern of leaf fall in cacao remains almost the same, year after year. Under Kasaragod conditions, the main flush occurs in April–May, immediately after the receipt of adequate summer showers and also in August–September, after pruning. Thus, the maximum leaf fall observed between April–May (Fig. 1) synchronises with the intensive flushing time. During other months, leaf fall is limited as the plants are in a steady state of growth.

Organic carbon content of the soil was 0.2% prior to the taking up of the trial in the coconut+cacao+pepper+pineapple crop combination experiment. Soil temperature was also recorded in this plot. Because of the very low organic matter status of the soil, to ensure satisfactory establishment of cacao, 5 and 10 t/ha of organic manures were applied in planting pits (60 cm^3) before planting cacao. The present organic carbon status of 0–15 and 15–30cm depth layers of soil in the different plots is given in Table 1.

The data showed that the organic carbon status of the soil in the coconut–cacao mixed cropped plots was markedly higher than

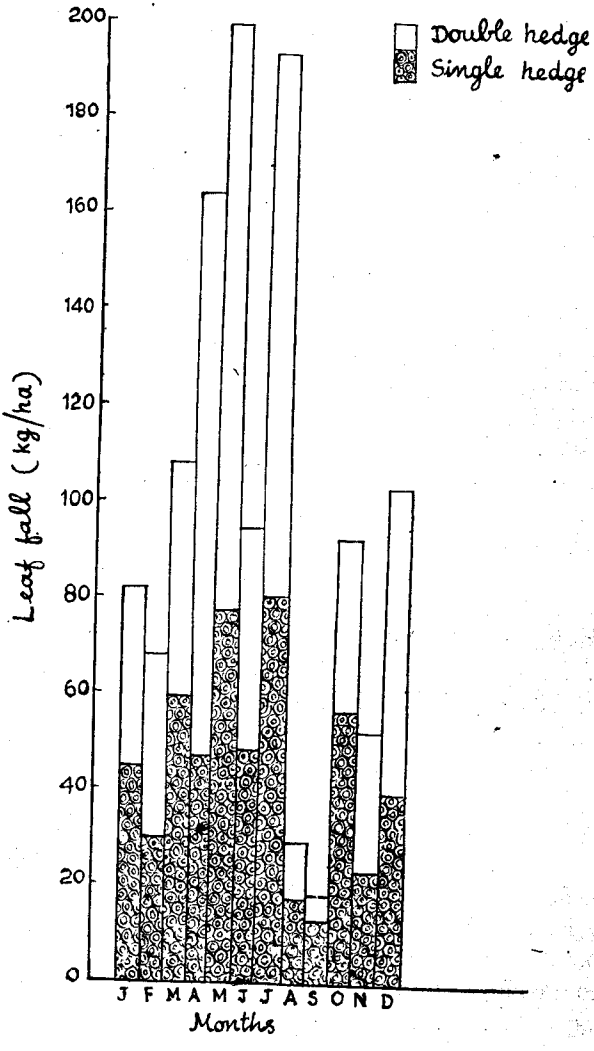
Double hedge
Single hedge
Leaf fall (kg/ha)
200
180
160
140
120
100
80
60
40
20
0
J F M A M J J A S O N D
Months

Table 1. *Organic carbon content of the soil*—1978

Treatment	Organic carbon (%)		
	Pre-experimental period	Experimental period	
	0–30 cm	0–15 cm	15–30 cm
1. Unirrigated coconut	0.2–0.3	0.36	0.27
2. Irrigated coconut	0.2–0.3	0.56	0.56
3. Coconut + cacao in single hedge + pineapple + pepper	0.2–0.3	0.61	0.56
4. Coconut + cacao in double hedge + pineapple + pepper	0.2–0.3	0.70	0.58

that of pure coconut stands, especially in the top 15 cm depth where it was 9 to 25% higher than that of the irrigated coconut plots.

Eernstman (1968) reported that the nutrient concentration in cacao leaves was of the order of 2.84% N, 0.26% P, and 1.73% K, on dry weight basis. It means that a sizeable amount of major nutrient elements gets recycled into the soil. Under the double hedge system about 50 kg N, 11 kg P_2O_5 and 35 kg K_2O/ha/year were returned to the soil through leaf fall.

An intense microbial activity in the rhizosphere of coconut, where cacao was grown as mixed crop, was reported by Nair and Rao (1977). The shed leaves of cacao provided a favourable substrate for the growth of microorganisms. The activity of the beneficial organisms like nitrogen fixers and P solubilisers also enhances the soil productivity. The yield of coconut in the single hedge cacao plots increased by 68% and that in double hedge cacao plots by 116% over the pretreatment yield (Nair *et al.*, 1975). It is, therefore, evident that the mixed crop combination of coconut and cacao had resulted in the building up of soil fertility which is a very important aspect in multiple cropping systems. This had been brought about by the direct effect—the biomass addition and the resultant indirect effect—enhanced activity of beneficial microorganisms. This could also be designated as nonmonetary input.

Soil temperature

The favourable ecoclimate developed inside the coconut-cacao crop mix had been reported by Nair and Balakrishnan (1976). The mean monthly evaporation from the coconut+cacao crop mix and an irrigated pure stand of coconut was 19% and 40%, respectively of that recorded in an open area (Table2). Evaporation from soil surface and soil temperature are inter-related to a large extent.

Table 2. *Mean monthly evaporation from different cropping systems (mm/day)*—1977

Months	Open	Un-irrigated coconut stand	Irrigated coconut stand	Irrigated coconut-cacao mix
February	5.4	4.1	2.5	1.0
March	6.3	4.6	2.0	1.1
April	7.3	6.1	2.9	1.3
May	6.0	4.4	2.9	1.3
Total	25.0	19.2	10.3	4.7
On percentage basis*	100	76	41	19

*Evaporation at the open area is taken as 100/–

Data on the mean monthly soil temperature observed at 30 and 60 cm depths under the different cropping systems are presented in Table 3, Fig. 2 and Fig. 3. Irrespective of the season, the soil temperature was lowest and the variation in the mean monthly soil temperature was least in the coconut+cacao+pepper +pineapple crop-mix. In the pure stand of coconut the fluctuation in soil temperature during summer months was 3 to 6°C; although the variation during the rainy season was lower. This is in contrast to the situation obtained in crop-mix plots. The ground cover provided by the leaf mulch not only reduced the soil temperature during summer but also was responsible for narrowing the range of the temperature fluctuation during the different seasons.

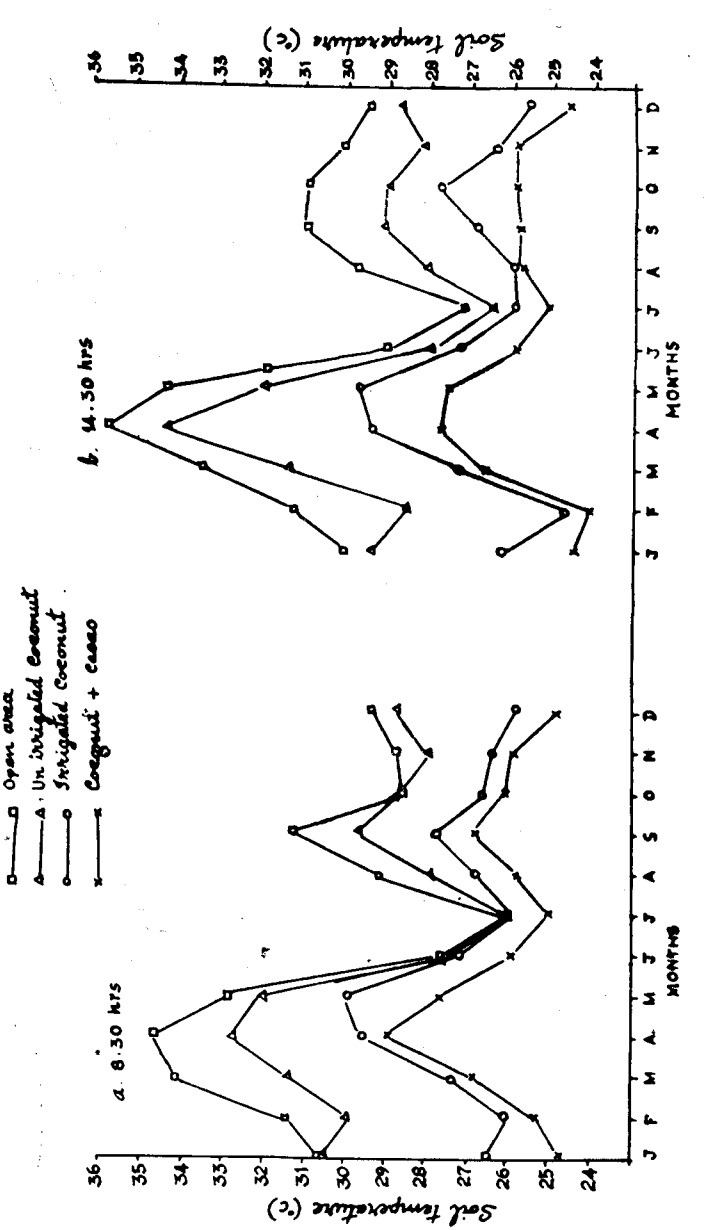

FIG.2. SOIL TEMPERATURE AT 30 cm DEPTH

FIG. 3. SOIL TEMPERATURE AT 60 cm DEPTH

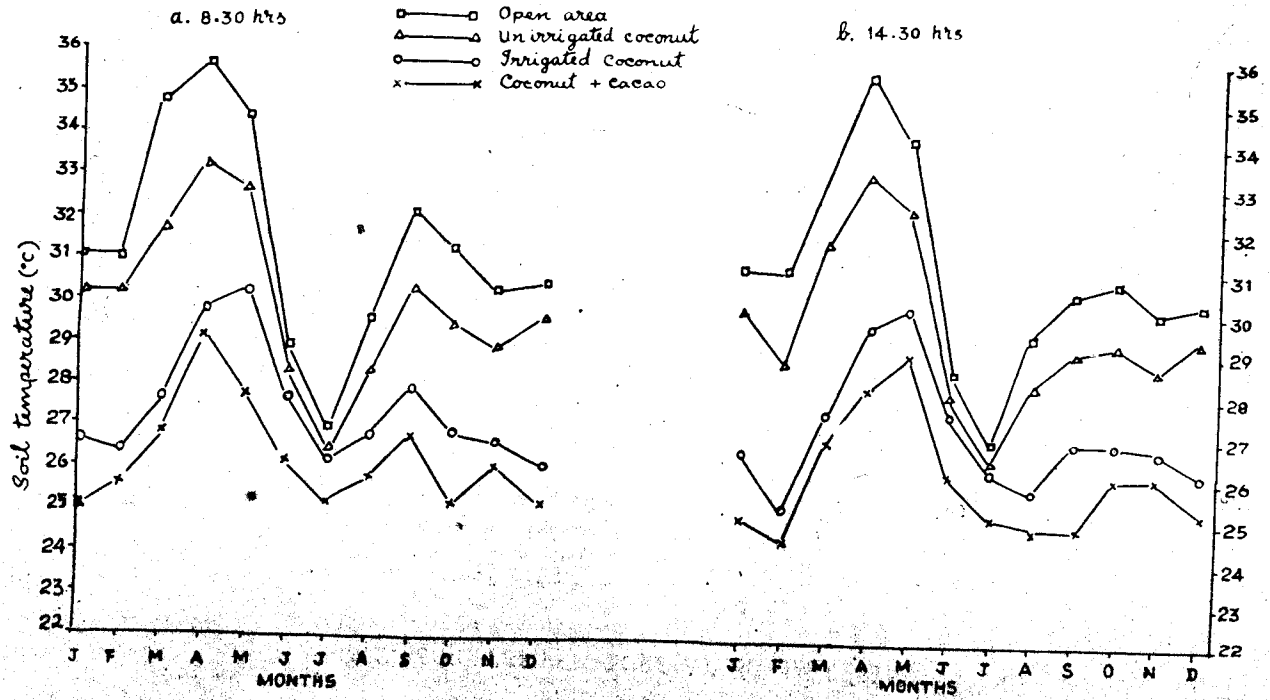

Table 3. *Mean monthly soil temperature under different cropping systems*—1977

Months	30 cm depth				60 cm depth			
	Open	Un-irrigated coconut stand	Irrigated coconut stand	Irrigated coconut cacao mix	Open	Unirrigated coconut stand	Irrigated coconut stand	Irrigated coconut cacao mix
January	30.3	30.1	26.4	24.6	31.0	30.1	26.7	25.0
February	31.4	29.3	25.9	24.7	30.9	29.4	25.8	25.0
March	34.4	31.5	27.3	26.7	34.1	31.7	27.7	26.9
April	35.3	33.4	29.5	28.4	35.7	33.3	29.7	28.7
May	33.7	32.1	29.9	27.7	34.3	32.6	30.2	28.4
June	28.3	27.8	27.3	25.9	28.7	28.1	27.6	26.1
July	26.5	26.1	25.9	25.1	26.9	26.5	26.2	25.1
August	29.6	28.1	26.3	25.8	29.5	28.4	26.3	25.3
September	31.3	29.5	27.3	26.3	31.3	29.7	27.5	25.9
October	29.8	28.9	27.2	26.0	31.1	29.4	26.9	25.7
November	29.5	28.1	26.4	25.9	30.1	28.9	26.7	26.1
December	29.5	28.7	25.7	24.7	30.3	29.5	26.2	25.3
Mean	30.8	29.5	27.1	26.0	31.2	29.8	27.3	26.1

The crop combination of coconut and cacao has brought about favourable alterations in the factors affecting crop production, viz. the soil temperature and soil fertility. The enhanced production of these crops, when grown in combination, may be due to this.

REFERENCES

ALVIM, DE T. 1975. Ecophysiology of cacao tree. In: *Conference Internationale sur les Recherches Agronomiques*, Cacaoyers, Abidjan, 1965. Paris, Jonve pp. 23–25.

EERNSTMAN, T. 1968. Chemical analysis of leaves and other organs of *Theobroma cacao* L. as means of diagnosing fertiliser requirements Pub. No. 54, PUDOC Wageningen, 55 p.

NAIR, P. K. R. AND BALAKRISHNAN, T. K. 1976. Pattern of light interception by canopies in a coconut+cacao crop combination. *Indian J. agric. Sci.* **46**: 453–462.

NAIR, P. K. R., VARMA, R., NELLIAT, E. V. AND BAVAPPA, K. V. A. 1975. Beneficial effects of crop combination of coconut and cacao. *Indian J. agric. Sci.* **45**: 165–171.

NAIR, P. K. R. AND VARGHESE, P. T. 1976. Crop diversification in coconut plantations. *Indian Fmg.* **25**(11): 17–21.

NAIR, S. K., AND RAO, N. S. S. 1977. Microbiology of the root region of coconut and cacao under mixed cropping. *Plant and Soil* **46**: 511–519.

NELLIAT, E. V. 1973. Multiple cropping or multi-storeyed cropping in plantation crops. *J. Plant. Crops* **1** (Suppl): 204.

NELLIAT, E. V., BAVAPPA, K. V. A. AND NAIR, P. K. R. 1974. Multistoreyed cropping—new dimension of multiple cropping in coconut plantations. *World Crops* **26**: 262–266.