ıdian J. agric. Sci. 45 (4) : 165–171, April 1975

Beneficial effects of crop combination of coconut and cacao

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Received : 19 January 1975

ABSTRACT

A field experiment on mixed cropping of coconut and cacao was initiated in 1970–71 in an existing 16-year-old coconut plantation of high-yielding genotypes. Cacao was planted in 2 systems – single hedge (single row of cacao between rows of coconut) and double hedge (2 rows of cacao between rows of coconut). There was also a control plot of pure stand of coconut.

In 1973, the yield of cacao (number of pods/plant) was identical under both methods of planting, but in 1974 it was significantly more in the single hedge. The average increase in the yield of coconut under 'control', 'single hedge' and 'double hedge' worked out to 64.3, 68.1 and 115.9%, respectively, over the pre-experimental yield of the corresponding groups. The increase in the 'control' plot was due to better management practices. The additional increase in yield of coconut under mixed cropping with cacao could be due to the synergistic effect of crop combination.

Studies on the pattern of utilization of solar energy and soil mass in pure plantation of coconut have indicated the possibility of compatible combinations of other crops along with coconut (CPCRI, 1972; Nelliat *et al.*, 1974). Wood and Lass (1970) compared the climatic parameters of 2 typical cacao-growing countries, Ghana and Trinidad, with those of Kasaragod and Kulasekharam in south India and found analogy in the conditions, except that the cacao area of Ghana has a very well-distributed rainfall whereas in Kasaragod there is a heavy rainfall coupled with a sharp fall in sunshine and temperature, followed by a dry warm spell during November–April. However, irrigating coconut palms during the dry spell is a practice that is becoming popular. Planting cacao in the interspaces of coconut is being practised in other coconut-growing countries such as the Philippines (Rodrigo and Mangbat, 1964), Malaysia (Tam Tai Kin, 1968; Ng Siew Kee, 1968), and Papua and New Guinea (Urquhart, 1961). Bhat and Bavappa (1972) reported that interplanting of cacao with arecanut palms had no adverse effect on the performance of either crop. The micro-environment (soil moisture, shade, micro-climate, etc.) of an irrigated coconut plantation in south India also seemed favourable for the growth of cacao as a compatible mixed crop with coconut. Encouraged by reports, similar experiments were initiated at the Central Plantation Crops Research Institute, and this paper describes the initial results of the experiment.

MATERIALS AND METHODS

The experiment was laid out in a systematically planted coconut plantation consisting of high-yielding genotypes planted at a spacing of 7.5 m × 7.5 m in 1955–56. They were managed under normal package of practices till 1966. Thereafter the fertilizer dose was doubled to 1.0 kg N, 0.28 kg P and 2.00 kg K/palm/year. The fertilizers were applied in the entire circular areas of 1.8 m radius around the palm in 2 splits, ⅓ in April–May (pre-monsoon) and ⅔ in September (post-monsoon) till 1973. From the beginning of 1974, the total annual dose of fertilizers was applied in 4 equal doses at quarterly intervals. The soil is a sandy clay-loam with a mechanical analysis of 67.97% coarse sand, 3.60% fine sand, 7.85% silt and 21.05% clay.

Four-month-old seedlings of cacao variety 'Forastero' raised in the nursery at Vittal were obtained and planted in pits 0.75 m^3 in July 1970 in the interspaces of coconut palms.

The experiment was laid out on a 3×7 randomized-block design. The treatments were : (*i*) control (coconut alone, no mixed crop), (*ii*) cacao as a mixed crop in single hedge (single row of cacao at 3.5 m between plants, alternating with rows of coconut, thus having 350 cacao plants/ha of palms), and (*iii*) cacao as a mixed crop in double hedge (2 rows of cacao between rows of coconut at a spacing of 2.5 m between plants in such a manner that plants in adjacent cacao rows were alternating at triangular positions, thus having 650 cacao plants/ha of coconut plantation).

Fertilizers were applied to cacao plants from the third year of planting, @ 100 g N, 17 g P and 116 g K/plant/year, in 2 equal splits in May and September. During the first and second years of planting, the fertilizers were applied at $\frac{1}{4}$ and $\frac{3}{4}$ the above dose respectively. After planting cacao, all the plots were sprinkler-irrigated at weekly intervals during the dry period from November to May @ 2.8 cm per irrigation.

The gross plot size was 30 m $\times$ 15 m with one row of coconut palms all around as the common border, thus giving a net experimental population of 3 coconut palms/plot. There were 18 cacao plants/plot in the single hedge and 32 in the double hedge.

The girth of cacao plants 10 cm above the ground level was measured every July. The date of first flowering and the yield performance (number of pods, weight of pods and weight of wet beans) of individual cacao plants were recorded. The yield of coconut palms in the experimental area was also recorded continuously.

There were many casualities of cacao plants in replications VI and VII, and they were replanted in subsequent seasons. Therefore, the average growth of cacao in these 2 replications was poorer than in the rest of experimental plants. The data of replications I to V were analysed statistically by 't' test to compare the performance of cacao under the systems of planting.

RESULTS AND DISCUSSION

Growth and yield of cacao plants

The girth of plants every July during the first 4 years is given in Table 1. There were no significant differences between the treatments, indicating that during the initial years, the growth of cacao plants was identical under both systems of planting. However, during 1974 the girth of plants was significantly more under single hedge than under double hedge.

The data on yield of cacao plants under the 2 systems of planting during 1973 and 1974 are presented in Table 2. In 1973, the yield/plant was slightly better under the double-hedge system than under the single-hedge system, but the difference was not significant. On the other hand, during 1974 the yield/plant under the single-hedge system was significantly more than that under the double-hedge system. This may be attributed to the increase in vegetative growth and the consequent closing of the canopies in the double-hedge system. The plants were pruned during August–September 1974 and the effect of pruning may manifest in the yield of the next season (1975). However, owing to nearly double the plant population under the double-hedge system, the yield/unit area was considerably higher (Table 4).

The pattern of yield of cacao in different months of the year is depicted in Fig. 1. Normally, cacao is reported to have only 2 peak seasons of yield (in

Table 1. Girth of cacao plants

Treatments	Girth of plants (cm)			
	1971	1972	1973	1974
Single hedge	10.3	15.4	22.4	26.5
Double hedge	10.3	15.1	21.9	26.0
't' test	NS	NS	NS	3.40**

**Significant at 1% level; NS, not significant.

Table 2. Yield of cacao plants

Treatment	1973				1974			
	Percentage of bearing plants	No. of pods/ plant	Weight of pods (kg)/ plant	Weight of fresh beans (kg)/ plant	Percentage of bearing plants	No. of pods/ plant	Weight of pods (kg)/ plant	Weight of fresh beans* (kg)/ plant
Single hedge	65.5	8.91	2.25	0.68	88.9	19.04	4.98	1.46
Double hedge	58.5	10.16	2.76	0.69	77.2	14.06	3.55	1.15
't' te	—	NS	NS	NS	—	3.01**	NS	2.65**

*The weight of pods and weight of fresh beans do not correspond to the total number of pods since a few pods were used for seed.
**Significant at 7% level; NS, not significant.

April–May and October–November). But in this experiment pods were available for harvest almost throughout the year, probably because the plants were grown under irrigated conditions. But 2 distinct peak seasons of harvest were observed under these conditions also (Fig. 1).

Yield of coconut

The yield of coconut palms in the experimental area is given in Fig. 2. The average yield during 1968 and 1969 was taken as the pre-experimental yield because that would indicate the yielding ability of the plants under higher levels of fertilizer application adopted since 1966. The period between 1970–71 and 1971–72 could be considered as the transition period. The period 1972–73 and 1973–74 was reckoned as the experimental period, and the average yield during this period was considered to be affected by the experimental treatment.

The difference in yield of nuts between the 3 treatments was not statistically significant, but the regression of experimental yield on the pre-experimental yield was linear and highly significant. However, analysis of covariance of the experimental yield as well as the response (increase in yield), taking the pre-experimental yield as the ancillary variable, also failed to reveal statistical significance.

Nevertheless the average increases in yield of nuts over the pre-experimental yield were quite substantial under the 3 treatments, the figures being 47.1 (73.3), 45.3 (66.5) and 58.5 (50.4) under the control, single hedge and double hedge respectively (the figures in parentheses are pre-experimental yields). Thus, there were 64.3, 68.1 and 115.9% increases, respectively, over the pre-experimental yield (Fig. 2). The rate of increase as well

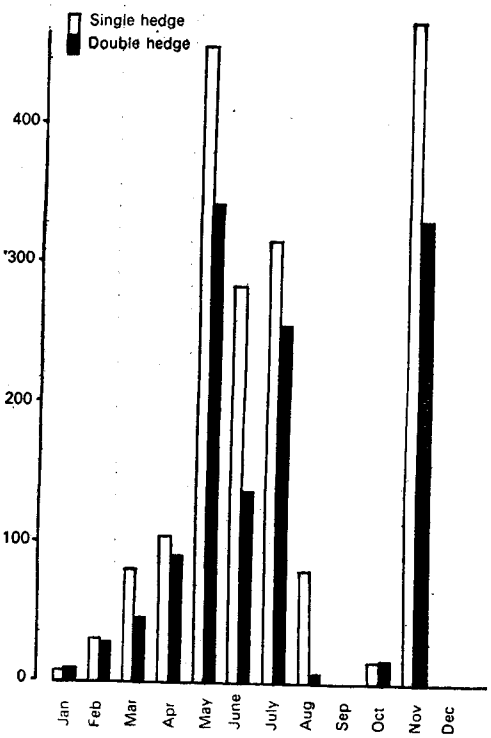

Fig. 1. No. of pods/100 plants under 'single-hedge' and 'double-hedge' systems of planting during different months of 1974.

Table 3. Response of palms of different yield groups

Yield group of palms (No. of nuts/palm/year)	Yield of nuts/palm/year											
	Control				Coconut + sing le hedge of cacao				Coconut + double hedge of cacao			
	No. of palms	Pre-experimental yield	Experimental yield	Response	No. of palms	Pre-experimental yield	Experimental yield	Response	No. of palms	Pre-experimental yield	Experimental yield	Response
30	4	19	57	38	5	22	74	52	7	15	85	69
30–60	7	50	125	75	7	42	141	95	4	53	118	68
60	6	88	178	90	6	83	170	87	3	78	190	111
Mean		73.3	120.4	47.1		66.5	112.0	45.5		50.4	109.0	58.5

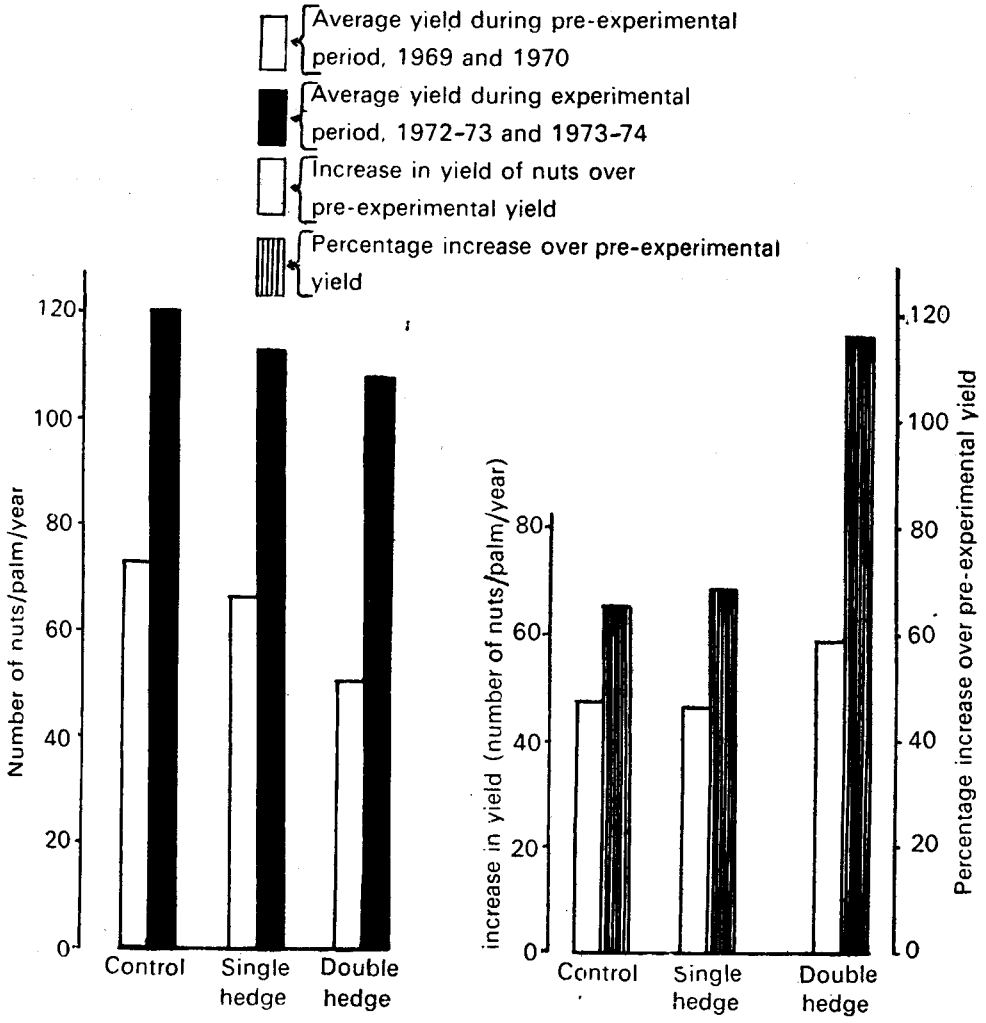

Fig. 2. Yield performance of coconut palms before and after planting cacao.

as absolute increase in yield of nuts was higher when the plant population of cacao grown as mixed crop was higher.

The pattern of yield response of palms of the 3 yield groups (less than 30, 30–60 and more than 60 nuts/palm/year) is given in Table 3. The quantum of response in terms of absolute number of nuts was almost directly proportional to the pre-experimental yield under all the 3 treatments (and more so under the double hedge), irrespective of the pre-experimental yield level of the palms. This is contrary to the previous reports on the response of palms to fertilizer application (Murray and Smith, 1952; CCRS, 1963; Muliyar and Nelliat, 1971), These reports indicated that the response was inversely proportional to the pre-experimental bearing level of the palms. The poor bearers showed greater response, and palms giving an annual yield of about 50 nuts did not show any further improvement in productivity due to fertilizer application

Table 4. Total productivity of coconut and cacao mixed cropping during 1974

Treatment	Plant population/ha		Annual increase in productivity/ha over the pre-experimental level	
	Coconut	Cacao	Number of coconuts	*Cacao (kg dry beans)
Coconut alone	175	—	8,249	—
Coconut + single-hedge cacao	175	350	7,932	200
Coconut + double-hedge cacao	175	650	10,237	275

*Calculated on the basis of an average yield of 3 kg processed beans per 100 pods.

(Muliyar and Nelliat, 1971). But these reports were based on experiments under rainfed conditions and single (annual) application of fertilizers. The present study indicates that palms of all yield groups respond well to proper management.

Synergistic effect of the crop combination

The analysis of growth and yield of cacao and coconut indicates that both the species were compatible as mixed crops. Apart from satisfactory performance, there was some synergistic effect of the crop combination. The increase in yield of coconut in the control plot reflected the influence of better management practices like irrigation and probably its interaction with higher dose of fertilizers. On the other hand, the rate of increase as well as the absolute increase in the yield of nuts in the 'double-hedge' treatment indicates the synergistic effect of the crop combination. The increase in the total productivity per unit area of the 3 systems of planting is given in Table 4.

Non-monetary inputs

The probable reasons for the synergistic effect of the crop combination are worth examining. Preliminary investigations on the rhizosphere micro-organisms of these plots have indicated that the crop mix favoured a higher incidence of micro-organisms in the rhizosphere of both coconut and cacao, the number being more when cacao was cultivated as a double hedge. Conspicuous among the micro-organisms were the nitrogen-fixing organisms (*Beijerinckia* sp.) phosphate-solubilizers (*Pseudomonas* sp. and *Aspergillus* sp.) and IAA-synthesizers (*Escherichia* sp., *Aspergillus flavus* and *A. fumigatus*). Several noticeable close associations between various fungi and host-root surface, similar to mycorrhizal associations, were also seen in the rhizosphere of the crop mix (Nair, 1974).

Similarly the microclimate of the irrigated coconut-cacao systems was reported to be milder than that of the pure stand of coconut palms (Balakrishnan *et al.*, 1975). The available nutrient status, especially the P of the top soil, was also found to be more favourable under this crop combination, particularly when cacao was cultivated as a double hedge (Nair, unpublished data), probably because of the enhanced activity of the phosphate-solubilizers. These beneficial aspects of the environment of the crop mix are some of the identified components of the non-monetary input of the crop combination. More elaborate studies on these and other aspects on this cropping system are warranted.

ACKNOWLEDGEMENTS

We are thankful to Mr P. Thomas Varghese for help in compilation of the data and to Mr Jacob Mathew and Mr M. P. Abdul Razak for statistical analysis.

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