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INTERCROPPING IN ARECANUT

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INTRODUCTION

Intercropping, one of the major forms of multiple cropping, is a potential system for increasing crop production especially under the subsistence level of farming. Apart from providing additional sources of food and other agricultural commodities, intercropping systems contribute large quantities of plant residues which improve soil fertility and productivity, if ploughed back. Intercropping, as applied to plantation crops, refers to growing annuals and biennials in the interspaces of the main crop (Nelliat and Iyer, 1977). But, according to Freyman and Venkateswaralu (1977) and Beets (1978) intercropping should also imply a definite planting pattern of the component crops in separate rows. In this review, the term intercropping will be used to mean growing any other crop, annual, biennial or perennial, in the interspaces of areca palms without any specifications to their planting geometry and population proportions. However, studies relating to cacao are not included in this review as the same form subject matter of another chapter in this volume.

In India, systematic field experimentation to study the implications of intercropping with different crop combinations in areca gardens began at different locations mostly under the initiative and inspiring leadership of late Dr. K. Shama Bhat. A comprehensive, but not exhaustive, review on the same is attempted here.

Preliminary Concepts

Intercroppng in areca gardens was practiced from early times. Bavappa (1951) reported that the arecanut farmer resorts to intercropping with crops like banana, betel vine, tapioca, pepper, colocasia, Dioscorea, pineapple and even coconut and jack to realise some income during juvenile phase of arecanut. Bavappa *et al.* (1958) again visualised the primitive nature of intercropping in many areca gardens. Shama Bhat and Abdul Khader (1970) reported that the long pre-bearing age of 5 to 8 years, the low income in the early period of bearing and the fluctuations in the market price of arecanut from year to year have forced the arecanut growers to take up intercropping in areca gardens. The choice of a crop depends mainly upon its ability to grow under the shade of areca palms and to withstand heavy drippings during the monsoons. The crops which can be successfully grown in areca gardens are seasonal crops like elephant foot yam, pineapple, guinea grass and banana and perennial crops like pepper, betelvine and cacao. Shama Bhat (1974) stressed the importance of intercropping as a source of additional income to the arecanut farmer during off-season and also

as a safeguard against the uncertainties of returns from monoculture gardens. He also suggested that the intercrops chosen should create only minimum problems of soil exhaustion and pest build up, while ensuring maximum production and returns per unit area per unit input to the farmer. For utilizing the interspaces for growing other crops in an areca garden, understanding of the rooting pattern and light interception of areca palm as well as the requirement of component crops is necessary.

Rooting Pattern

Shama Bhat and Leela (1969) made elaborate studies on the rooting behaviour of an actively growing, eight-year-old areca garden planted with different plant densities. The results (Table 1) revealed that 61.3 per cent of all roots and 51.3 per cent of fine roots were concentrated within a radius of 50 cm from the trunk of the palm planted at a spacing of 2.7 × 2.7m. Another 19.2 per cent of all roots and 23.2 per cent of fine roots were in the adjoining 51 to 75 cm radius. The horizontal zone of 51 to 100 cm had 27.6 per cent of all roots and 33.1 per cent of fine roots. Thus 80.5 per cent of all roots and 33.1 per cent of fine roots were within 75 cm radius, horizontally, of the stem. Roots did not extend beyond 100 cm when the spacing was 2.7 × 2.7m or more.

Table 1. *Distribution of Areca roots planted at different spacing.*

Distance from trunk (cm)	Per cent distribution of roots					
	All roots			Fine roots		
	3.6×3.6m	2.7×2.7m	1.8×1.8m	3.6×3.6m	2.7×2.7m	1.8×1.8m
(a) Horizontal						
26-50	66.9	61.3	60.9	55.6	51.3	54.3
51-75	15.7	19.2	21.2	17.2	23.2	23.3
76-100	7.0	8.4	17.9	10.3	9.9	22.4
101-125	4.5	6.1	-	7.1	8.4	-
126-150	3.2	5.0	-	5.4	7.2	-
151-175	5.7	-	-	4.4	-	-
Total	100.0	100.0	100.0	100.0	100.0	100.0
(b) Vertical						
0-20	39.6	36.2	22.0	43.7	44.7	27.5
21-50	39.4	30.1	42.5	32.2	27.5	48.8
51-80	14.3	15.4	16.6	15.0	10.6	11.1
81-120	4.9	8.8	9.4	6.3	5.4	6.5
121-160	1.3	4.6	2.1	1.9	4.0	2.5
161-200	0.5	3.5	1.7	0.8	5.0	2.4
201-260	-	1.4	0.7	-	2.8	1.2
Total	100.0	100.0	100.0	99.9	100.0	100.0

Studies on vertical distribution of roots revealed that 66 to 79 per cent of all roots and 70 to 76 per cent of fine roots were within the first 50 cm zone of the soil profile. The deeper zone of 51 to 100 cm below ground level contained 18.3 to 22.3 per cent of all roots and 13.6 to 20.0 per cent of fine roots. There were only 2.7 per cent of all roots and 4 per cent of fine roots below 100 cm. The deepest penetration of roots was up to 2.6 m. Closer spacings forced deeper root penetration than planting at wider spacings. It was also revealed that the quantity of roots per unit volume of soil within the feeding zone increased with increase in density of planting. A wider spacing should invariably facilitate better intercropping due to less root competition.

Table 2. *Average light interception by Sole crops and Combined Arecanut intercrop canopies (1978-79)*

Crops	Percent of total light intercepted					
	September		October		November	
	Sole crop	+Arecanut	Sole crop	+Arecanut	Sole crop	+Arecanut
Finger millet	82.6	78.8	89.9	84.2	73.4	73.2
Yam	60.9	79.2	72.7	84.4	81.8	86.4
Arrowroot	73.6	87.4	87.0	92.2	93.7	97.2
Dioscorea	61.1	85.0	75.9	89.1	86.2	90.0
Ginger	75.9	87.8	81.5	90.1	90.3	95.7
Turmeric	84.2	86.6	91.0	90.7	92.4	95.0
Colocasia	82.0	85.6	32.8	82.1	-	-
Fodder sorghum	67..7	70.9	80.7	75.0	-	-
Sweet potato	-	-	18.7	78.2	56.1	82.0
Hybrid napier	84.4	90.6	86.8	90.1	81.0	86.8
Banana	62.5	90.8	70.6	91.8	79.2	92.4
Arecanut	-	57.3	-	62.4	-	57.3
	February		March		April	
Ground nut	76.5	76.9	88.6	89.1	54.0	89.9
Sorghum	86.1	81.9	93.5	91.7	83.8	92.3
Beans	5.5	68.4	16.6	70.6	10.1	71.4
Maize	81.1	84.4	91.4	91.7	81.0	92.3
Chilli	73.5	85.5	77.9	86.5	68.3	90.1
Cowpea	88.9	87.7	82.3	90.6	-	-
Dolichos	88.2	88.2	89.5	92.0	82.6	90.7
Sweet potato	82.6	86.1	-	-	-	-
Hybrid napier	84.5	89.2	85.7	91.7	94.4	95.5
Banana	85.0	93.2	84.0	93.7	76.1	93.9
Arecanut (Cont.)	-	61.6	-	64.0	-	60.1

Light Interception

Muralidharan (1980) reported the relative interception of solar radiation by arecanut and intercrops during different months of the year. Light interception in a monocrop of 12 year old areca garden, planted at 2.7 × 2.7m spacing varied from 57 to 64 per cent (Table 2) of incident rays, while it went up to 97.2 per cent under an intercropping system consisting of arecanut and arrow root.

None of the respective sole crop systems exceeded this rate of light interception. Studies on the light interception by areca palms planted at six different spacings ranging from 1.8 × 1.8 to 3.6 × 3.6m carried out at CPCRI, Regional Station, Vittal revealed that 56.4 per cent of the incident sunlight was transmitted to the ground surface in the widest spacing of 3.6 × 3.6m. Only 37.2 per cent of the light penetrated to the ground under the close spacing of 1.8 × 1.8m. The amount of light fallen to the ground under the recommended spacing of 2.7 × 2.7m was 43 per cent (Muralidharan, 1980; Balasimha and Subramonian, 1987).

Productivity of Intercrops in Areca Garden

Abraham (1974) discussed the results of intercropping in arecanut gardens with pepper, tapioca, elephant foot yam, Dioscorea, sweet potato and pineapple (Table 3) and reported that the tuber crops, elephant foot yam and Dioscorea have given good yields.

He attributed the poor performance of sweet potato to the shade conditions and gravelly texture of the soil in the experimental plots. Shama Bhat (1974) stressed the importance of inter-cropping with high calorie crops for a country like India facing shortage of food grains. He estimated the calorie produced from few intercrops (Table 4) and reported that such systems can increase the productivity per unit area.

Muralidharan (1980) reported the biomass productivity of different crops when grown as intercrops under areca, as compared to respective monocrop situations in the open. The bio-productivity of all the intercrops was significantly lower than their respective sole crops (Table 5) except banana and beans. Cultivation of beans was a failure under both the systems in the location, where the studies were undertaken. The reduction in the productivity of intercrops varied from 20 to 88 per cent of the productivity when compared to respective sole crops.

Crops like banana, ginger, chilli, colocasia, paddy, turmeric, elephant foot yam and Dioscorea were more adapted for intercropping in areca gardens than the rest of the crops studied.

Six intercrops (ginger, turmeric, Dioscorea, elephant foot yam, chicory and sweet potato) were grown as intercrops in arecanut for four years at the CPCRI, Research Centre, Hirehalli (Karnataka) and the results have shown that Dioscorea and elephant foot yam continued to give satisfactory yield (Sannamarappa and Muralidharan, 1982). They also reported that the yield of ginger and turmeric declined under continuous intercropping (Table 6).

Table 3. *Yield of intercrops and net returns*

Intercrop	Yield kg/ha	Gross income Rs/ha	Cost of cultivation Rs/ha	Net returns Rs/ha
Pepper	555	2775	2520	255
Tapioca	4836	1209	618	591
Elephant foot yam	6496	3248	1548	1700
Dioscorea	6744	3372	1548	1824
Sweet Potato	712	536	417	61
Pineapple	3942	1577	736	847

Table 4. *Calorie production and additional income*

Intercrop	Yield (kg/ha)	Food value (Mil. cal/ha)	Additional income Rs/ha
Banana	4000	6.12	1500-1800
Pineapple	8000	4.00	700-1000
Elephant foot yam	12000	12.00	1400-1700
Arrow root	4000	14.20	1000-1200
Cacao	750	4.50	3000-3500

Table 5. *Biomass productivity of intercrops/sole crops*

Crops	Biomass (kg/ha) Intercrop(IC) x	Sole crop (Sc) y	Difference (y-x)	IC/SC %
Paddy	1425	3691	2266	38.6
Fingermillet	1075	6560	5885	16.3
Sorghum	2941	10633	8592	19.1
Maize	2704	10547	7842	25.6
Ground nut	1397	4776	3379	29.2
Beans	105	128	23	2.0
Cowpea	698	2403	1705	29.2
Dolichos	1072	3370	2298	31.8
Yam	5046	13570	8704	36.6
Arrow root	6580	9852	3272	66.7
Dioscorea	4078	12241	8163	33.3
Colocasia	2191	5647	3456	38.7
Sweet potato	1819	9904	8085	18.3
Ginger	2116	5498	2882	47.5
Chillies	1014	2291	1267	44.4
Turmeric	3287	8682	5395	37.8
Fodder sorghum	1183	9616	8433	12.3
Hybrid napier	9515	31360	21845	30.3
Banana	5956	10137	4181	58.7

Table 6. *Effect of continuous intercropping on yield*

Intercrop	Yield(kg/840m^2) over years 1979	1980	1981	1982
Ginger	208	208	161	9
Turmeric	1118	741	467	119
Dioscorea	782	792	863	569
Elephant foot yam	454	549	712	1077
Chicory	75	75	116	302
Sweet Potato	697	749	798	113

Table 7. *Yield of banana varieties intercropped with arecanut (wt. of bunch/kg/plant)*

Varieties	Plant crop	1975-78 period Ratoon I	II	Mean	Plant crop	1978-81 period ratoon I	II	Mean
Peyan*/Robusta*	10.4	9.9	9.8	10.0	14.2	13.5	8.4	12.0
Karpuravally	14.6	13.9	13.5	14.0	11.3	12.0	10.0	11.1
Dwarf Cavendish	8.8	8.3	7.9	8.3	10.7	9.0	7.0	8.9
Red Banana	9.0	9.3	9.4	9.2	11.8	10.5	8.0	10.1
Mysore Poovan	15.7	15.2	14.9	15.3	10.1	14.3	12.5	12.3
Kunnan*/Poovan*	4.3	4.1	4.2	4.2	7.0	6.0	6.3	6.1
Nendran	6.4	4.2	5.5	5.7	6.0	5.4	4.1	5.2

* Peyan, Kunnan - 1975 to 1978 only * Robusta, Poovan - 1978 to 1981 only

From a field experiment carried out to evaluate the performance of different varieties of banana in a 17 year old areca garden planted at 2.7 × 2.7m at CPCRI, Research Centre, Kannara (Kerala), Nayar *et al.* (1985) reported that the variety Mysore Poovan gave the highest yield of 15.3 kg per plant per year during the period 1975-78 and 12.3 kg per plant per year during the period 1978-81 (Table 7). The varieties 'Karpooravally' and 'Robusta' ranked next in yield of bunches.

The yield from the varieties 'Kunnan', 'Poovan', and 'Nendran' was very poor. The fruit of variety 'Peyan' was not acceptable to the market.

In many parts of Kerala and Karnataka, arecanut plants are used as ideal standards for training pepper. Nair (1984) reported that among four cultivars of pepper intercropped in areca garden at the CPCRI, Regional Station, Vittal, Panniyur-I gave the highest yield of 4685 kg green berries followed by Karimunda with 438 kg green berries per year (CPCRI, 1984). These two cultivars were significantly superior to the other cultivars 'Malligesara' (1250 kg/ha/year) and 'Uddadara' (771 kg/ha/year). However, in subsequent years 'Karimunda' gave higher yields than Panniyur-I. (Abdul Khader-Personal communication).

Effect of Intercropping on Productivity of Areca

Experiments conducted at various locations in India, in general, indicated that intercropping in areca has no significant deleterious effect on the productivity of areca (Muralidharan and Nayar, 1979). Abraham (1974) reported that no perceptible deleterious effect on the yield and condition of the palms could be observed due to intercropping with tubers and yams. Similar results were reported by Sadanandan (1974) on intercropping with elephant foot yam and ginger. From field experiments conducted at CPCRI research Centre, Hirehalli (Karnataka) with ginger, turmeric, Dioscorea, elephant foot yam, chicory and sweet potato as intercrops, no significant adverse effect either on the yield or yield attributes of areca palms was observed (CPCRI, 1984).

Singh *et al.* (1982) refuted the criticism prevailed in some of the arecanut growing areas of NE India, where the farmers believed that intercropping will adversely affect the yield of main crop by bringing out results of trials with eight intercropping systems on the yield of arecanut, at CPCRI, Research Centre, Mohitnagar, West Bengal (Table 8).

In these studies, it was observed that most of the systems benefited the main crop. The highest

Table 8. *Effect of intercropping on yield of arecanut*

Intercrops	Yield of arecanut	
	Nuts palm	Deviation from control (%)
Ginger	243	+ 10.2
Banana	224	− 2.8
Pineapple	219	− 6.0
Betelvine	255	+ 18.0
Pepper	270	+ 18.4
Elephant yam + Pepper	270	+ 18.4
Arrow root + Pepper	268	+ 17.5
Control (Arecanut only)	228	--

Table 9. *Long term effect of intercropping banana on yield of arecanut*

Treatment	Yield of arecanut	
	Number of nuts/ palm	Wt. of nuts per palm (kg)
Control (pure crop of arecanut planted at 2.7×2.7m)	144.7	5.24
Banana throughout the experimental period at full level, ie., 1:1	102.0	3.83
Banana at full level for three years and no banana thereafter	182.9	6.62
Banana at full level for three years and at reduced level for the rest of the period	134.5	4.83
Banana at full level for three years and at reduced level for next three years	130.2	4.57
Banana at full level for six years and no banana thereafter	136.4	5.14
Banana at full level for six years and at reduced level thereafter	143.2	5.32
Banana at full level for six years, reduced level for next four years and no banana thereafter	140.2	5.09
CV%	31.4	32.0

(NB: The three stages, viz., third, sixth, and tenth years corresponded to the three distinct phases of arecanut such as differentiation of internodes, flowering and full bearing stage).

increase (18.2%) on yield of arecanut over control (monocrop) was recorded when pepper or elephant foot yam + pepper was grown as intercrop(s). Though intercropping with banana or pineapple had a negative effect on the yield of arecanut, the decline was very meagre. Since banana is a very popular intercrop in many of the arecanut gardens (Sundaramurthy, 1950; Bavappa, 1951; Brahma, 1974; Shama Bhat, 1974) a detailed study to investigate the long term effects of intercropping with banana in areca gardens was undertaken at the CPCRI Regional Station, Vittal (Karnataka) since 1963, under the initiative of late Dr. K. Shama Bhat. The areca palms were planted at 2.7 × 2.7m. The details of planting of banana are given in Table 9. The mean yield of arecanut over a period of six years from the fifth year of planting showed a significant difference on yield of nuts due to intercropping with banana under different intensities of planting (CPCRI 1976).

Intercropping with banana at full level for first three years and no banana thereafter gave maximum number of nuts. Nayar *et al.* (1985) also reported that intercropping with different varieties of banana at CPCRI Research Centre, Kannara (Kerala) for five years during the period 1976 to 1980 did not show any adverse effect on the yield of arecanut (Table 10). Indeed, a general appraisal of the situation reveals that in many cases intercropping with banana stimulated the productivity of arecanut.

Bhandary (1974) also compared a set of biennial or perennial intercrops like banana, pineapple, cardamom, pepper and betelvine and reported that these intercrops did not affect the yield of arecanut to appreciable extent.

Nair (1982) reported from studies conducted at CPCRI, Regional Station, Vittal (Karnataka) that growing black pepper on areca did not affect the yield of arecanut. The advantages of training pepper on areca palms are not fully exploited by most of the farmers due to the fear that growing pepper on areca may depress the yield of arecanut or pepper or both (Nayar, 1982). Experimental data from a mixed crop of arecanut and pepper grown at the CPCRI Research Centre, Kannara (Kerala) over a period of 10 years revealed that

Table 10. *Effect of different varieties of banana on yield of arecanut*

Varieties	Yield of arecanut palm (Mean of 4 years)	
	No. of nuts per palm	Weight of fresh nuts-kg per palm
Control (arecanut only)	375	11.2
Peyan/Robusta	387	11.2
Karpuravally	403	12.7
Dwarf Cavendish	379	11.3
Red Banana	378	11.7
Mysore poovan	307	9.1
Kunnan/Poovan	317	9.6
Nendran	363	11.1
CD	NS	NS

NS Not significant

there was no significant detrimental effect on the yield of areca palms (Table 11). Abdul Khader (1987) also reported the feasibility of growing pepper using arecanut as a standard.

Muralidharan (1980) reported the effect of different intercropping systems on the yield of arecanut. In general these cropping systems had a net positive effect on the yield of arecanut (Table 12) ranging from 7.5 per cent to 37.3 per cent, except under two cropping systems involving arrow root + beans or hybrid napier where the yield of arecanut was lowered by 11.4 and 2.6 per cent respectively.

Instances of cardamom being intercropped in areca gardens have been reported by Abraham (1954) and Bhandary (1974). Cardamom is planted under the shade of areca in the valleys of some tea and cardamom plantations at a spacing of 1.5 to 2.0 m apart in between rows of arecanut. Though authentic data are not available

Table 11. *Long term effect of training pepper on arecanut*

Year	Yield of arecanut per palm			
	Arecanut alone		Areca + Pepper	
	No. of nuts	Fresh wt. (kg)	No. of nuts	Fresh weight (kg)
1969-70	225.7	7.5	267.0	6.9
1970-71	303.0	10.0	265.3	8.8
1971-72	370-0	12.0	366.3	12.2
1972-73	267.6	8.9	256.6	8.4
1973-74	280-0	9.3	278.8	9.0
1974-75	225.9	7.5	240.7	8.2
1975-76	275.4	9.1	280.8	9.6
1976-77	418.7	13.6	413.0	13,0
1977-78	362.5	12.8	376.9	12.1
1978-79	373.0	12.4	381.9	12.7
Mean	310.2	10.4	306.6	10.1

Table 12. *Effect of different intercropping systems on the yield of arecanut*

S.No.	Cropping systems	Yield of palms (mean of two years)			
		No.of nuts per palm	Dry wt. of nuts kg.palm	kg.ha.	±over control %
T_1	Areca+Paddy+Fingermillet+Groundnut	131	2.3	3957	37.3
T_2	Areca+Yam+Sorghum	136	2.1	3693	24.6
T_3	Areca+Arrow root+Henna	114	1.5	2554	11.4
T_4	Areca+Dioscorea+maize	129	2.0	3464	20.1
T_5	Areca+Ginger+Chilli	135	2.2	3895	35.1
T_6	Areca+Turmeric+Cowpea	129	1.8	3101	7.5
T_7	Areca+Colocacia+Dolichos	127	1.8	3133	8.7
T_8	Areca+fodder sorghum+sweet potato	133	2.0	3499	21.4
T_9	Areca+Hybrid napier	121	1.6	2809	− 2.6
T_{10}	Areca+Banana	132	2.2	3798	31.7
T_{11}	Arecanut only (control with additional tillage)	120	1.8	3154	9.4
T_{12}	Arecanut only (control)	112	1.7	2883	0.0
	CD (0.05)	—	0.24	157.5	--

on the yield and performance of cardamom under such conditions it is reported that intercropping with cardamom appeared to have no adverse effect on the yield of arecanut, provided both the crops are properly managed. Other perennial crops like cinnamom, clove and coffee are also being grown as intercrops to a limited extent, in areca gardens. In a field experiment conducted at CPCRI, Research Centre, Hirehalli, the yield of arecanut was found to be increased from 17,892 to 24,445 kg/ha over a period of three years due to intercropping with cinnamon (Sannamarappa and Muralidharan, 1982). In this experiment one year old cinnamon seedlings were planted at a spacing of 2.7 × 2.7m that is 1:1 proportion with arecanut. Intercropping with four varieties of coffee, viz., arabica S-6, arabica S-1936, SanRamon and robusta also shown similar effects on the yield of arecanut.

Studies on the effect of intercropping on Soil Biology and Fertility

Muralidharan (1980) reported increased root proliferation of arecanut palms due to intercropping. Bopaiah (1982) reported that intercropping arecanut with legumes enriched the soil nitrogen and several other plant nutrients. Intercropping with cowpea, hybrid napier and Guinea grass increased the nitrogen fixing *Beijerinkia*, *Azotobacter* and phosphate solubilizing microorganisms. The exploitation of asymbiotic nitrogen fixers, phosphate solubilizers and endogenic VA mycorrihizae, it is possible to increase the fertility of coconut soils. Mohapatra *et al.* (1982) reported that intercropping with leguminous green manure crops or cover crops have a number of advantages such as fixation of N, recycling of nutrients in the soil profile, prevention of soil erosion etc. all of which improve the fertility of the soil. They also reported that intercropping with green manure crops like *Pueraria javanica* and *Mimosa invisa* in arecanut gardens could add on an average 10 kg green manure per palm which could meet 69 to 89 per cent of the nutrient requirement of N, 28 to 43 per cent of P and 29 and 38 per cent of K. It was reported that fungal and bacterial population was relatively more in intercropped soil as compared to areca alone (CPCRI 1984). They ranged from 22 to 87 and 12 to 138 respectively in intercropped plots as compared

to 5 and 38 only in control plots. Highest fungal and bacterial population was noticed in Dioscorea plot. Actinomycetes population showed a reverse proportion. It was more (4 per g soil) in control plots than in intercropped plots (0-2 per g soil)

Socio-economic relationship of intercropping in arecanut

A major reason for intercropping in poorly developed agriculture is that it can give stability of income over different seasons. Indeed, the socio-economic benefits of intercropping are better realised than its biological or technical advantages. The long pre-bearing age, low returns during initial years of harvest, insecurity against pests, diseases and natural calamities, remoteness from the market and lack of transport are considered to be some of the reasons that induce the farmers to intercropping in areca gardens (Shama Bhat, 1974).

Economics of intercropping:

Additional and net profits ranging from Rs.128 to Rs.17,660 per ha per year have been reported by different workers due to intercropping in areca gardens (Abraham, 1974; CPCRI 1977; Roy, 1974; Sadanandan, 1974; Shama Bhat, 1974). The economics of inter- cropping arecanut with pepper, tapioca, elephant foot yam, Dioscorea and pineapple was studied. Pepper was most economical which brought an additional net return of Rs.17,666 per ha per year. However, these figures were based on the assumption that the intercrops did not affect the yield of arecanut.

Muralidharan (1980) reported the economics of different intercropping systems (Table 13) with arecanut. The highest net income was from the cropping system involving ginger and chilli followed by banana.

However, the benefit : cost ratio was inferior under all the intercropping systems except the one in which paddy, fingermillet and ground nut were grown as intercrops, as compared to the

Table 13. *Benefit:cost relationshship of different intercropping systems in areca*

Cropping system	Crops under the system	Cost (Rs/ha)			Receipts (Rs/ha)			Net return (Rs/ha)	Benefit: cost ratio	Net return cost(Rs)
		On arecanut	On inter crops	Total	From arecanut	From Intercrops	Total			
T_1	Arecanut+Paddy+Finger millet+Groundnut	5239	3050	8289	19198	3053	22251	13962	2.68	1.68
T_2	Arecanut+Yam+Sorghum	5239	6083	11322	17464	6830	24294	12971	2.15	1.15
T_3	Arecanut+Arrow root+Beans	5239	3439	8678	12381	3617	15998	7320	1.84	0.84
T_4	Arecanut+Dioscorea+maize	5239	4956	10196	16807	5759	22566	12370	2.21	1.21
T_5	Arecanut+Ginger+Chilli	5239	8385	13624	18924	12616	31540	17915	2.31	1.31
T_6	Arecanut+Turmeric+Cowpea	5239	4474	9713	15061	6503	21564	11850	2.22	1.22
T_7	Arecanut+Colocacia +Dolichos	5239	3446	8685	15182	3658	18840	10155	2.17	1.17
T_8	Arecanut+ fodder sorghum + sweet potato	5239	2127	7366	16964	1091	18055	10689	2.45	1.45
T_9	Areca+Hybrid napier	5239	2170	7409	13624	2813	16437	9028	2.22	1.22
T_{10}	Arecanut+Banana	5239	6788	12027	18445	11312	29757	17730	2.47	1.47
T_{11}	Arecanut+Frequent tillage only	5856	-	-	15310	-	15310	9454	2.60	1.61
T_{12}	Arecanut only (Control)	5517	-	5517	13960	-	13960	8443	2.55	1.53

Table 14. *Economics of intercropping in arecanut gardens (Rs/ha)*

Sl. No.	Crops	Cost of cultivation			Gross returns			Net profit			± % over control
		Areca-nut	Inter-crops	Total	Areca-nut	Inter-crops	Total	Areca-nut	Inter-crops	Total	
1.	Arecanut only (control)	7673	--	7673	22444	--	22444	14771	--	1477	
2.	Arecanut+Ginger	7673	4519	12192	23949	2486	26435	16276	2033	14243	- 3.6
3.	Arecanut+Banana	7673	3500	11113	22050	6350	28400	14377	2850	17287	17.0
4.	Arecanut+Pineapple	7673	2465	10138	21558	3202	24760	13885	737	14622	- 1.0
5.	Arecanut+ Betelvine	7673	3190	10863	25102	6484	31586	17429	3294	20723	40.3
6.	Arecanut+ Pepper	7673	2360	10003	21800	8864	30664	14127	6504	20631	39.7
7.	Arecanut+ Yam + pepper	7673	4400	12073	21540	13900	36540	13869	8600	24467	65.6
8.	Arecanut+Pepper+ Arrowroot	7673	4600	12273	21650	12500	34150	13977	7900	21877	48.7
9.	Arecanut+Pineapple +Pepper	7673	4797	12470	21559	11100	32650	13886	6303	20180	36.6

monocropping system of arecanut. Singh *et al.* (1982) studied the economics of eight intercropping systems in arecanut and found very encouraging results (Table 14).

It can be observed from the data that among various crop combinations with areca, elephant foot yam + black pepper registered highest net profit per ha per year followed by arrow root + pepper, betel vine, pineapple and banana. However, the intercropping system with pepper and ginger ran into loss. A perusal of the data further reveals that the gross return (Rs.2486) from ginger, grown as intercrop, was much less than its cost of cultivation (Rs.4512) indicating that the loss was not due to a lowering of the returns from arecanut, which indeed increased from Rs.22,444 to Rs.23,949 per ha, but due to the poor yield of the intercrop, ginger, itself. Nayar et al. (1985) reported the economics of intercropping with different varieties of banana (Table 15). Cultivation of any variety, except poovan is profitable.

The red banana variety though ranked only fourth in per ha yield gave maximum net profit per ha (Rs.590) due to its higher selling price in the market. Sannamarappa *et al.* (1984) reported that among six intercrops, maximum revenue was obtained from elephant foot yam followed by

Table 15. *Economics of intercropping with different varieties of banana in arecanut garden*

Variety	Cost of cultivation (Rs/ha)	Yield of bunches (kg/ha)	Sale price (Rs/kg)	Gross value (Rs/ha)	Net profit from intercrop (Rs/ha)
Robusta	3900	7200	1.00	7200	3300
Karpuravally	3828	6660	0.90	5994	2166
Dwarf cavendish	3900	5340	1.00	5340	1440
Red banana	3900	6060	1.50	9090	5190
Mysore poovan	3766	7380	0.90	6642	2876
Poovan	3828	3660	1.00	3660	– 168
Nendran	3900	3096	1.50	4644	744

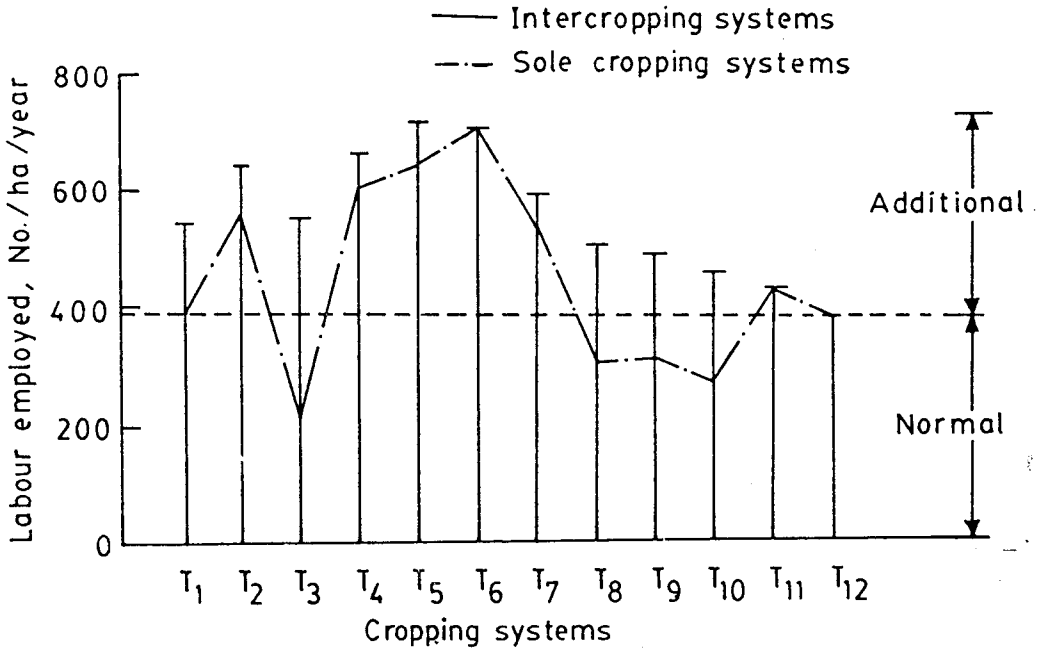

Fig. 1. Employment potential of different intercropping systems PPING

turmeric.

Nair (1982) reported that an additional net profit of Rs.18,100 per ha was possible by growing pepper as inter- crop in arecanut gardens. Abdul Khader (1982) also reported that a farmer can get a net additional income of Rs.8000-10,000 per ha per year by growing pepper as an intercrop in areca.

Employment potential:

Nair and Bavappa (1975) highlighted the tremendous potentialities of intercropping in arecanut and coconut plantations to generate additional employment opportunities for improving the quality of rural life. Muralidharan (1980) studied the employment potential of 12 different intercropping systems in arecanut (Fig.1) and reported that these systems (see table 13) tend to be labour-intensive since such systems often involve staggered planting and selective harvesting. The average labour requirement of a monocrop of arecanut was found to be 385.5 man days per ha per year. The additional requirement of labour (after making due adjustments for the lower number of man days of 12.3 per cent only required for the main crop under the intercropping systems) ranged from 19.7 per cent for intercropping with banana to 88 per cent for intercropping with ginger + chilli.

Research gaps

Areca being a perennial crop with an economic life span of over fifty years, there is necessity for long term field experimentation. An initial hike in the yield of main crop due to intercropping is

likely to diminish over the years in view of various interactive interferences between the component crops in such a system. A good deal of studies carried out so far are of short-term nature of less than five years. The author could come across only two experiments, one with banana and another with pepper, which had experimentation period longer than 10 years. In many of the studies no scientific explanation has been accorded to elucidate the causes of decrease or increase in yield of arecanut. Studies on estimation of capacity of each of the component crops to draw the requirement of water and nutrients from the common pool of resources and also its ability to withstand physical, mechanical and allelopathic stress from the neighbours are necessary for better understanding. In most of the experiments reviewed, the component crops were treated as individual units, which may not be valid as in a system they may respond differently to resource management under capital and input intensive monocrop habitats. It is yet to be studied whether the energy input in terms of fertilizers, water and pesticides can be lowered considering the relatively lower rate of growth of intercrops under shade and also by residue recycling and exploitation of beneficial microorganisms including VA-mycorrhizae. The pattern of nutrient build up or its release may be different in a mixed stand where absorbing surfaces of different species interpenetrate and compete for nutrients.

One largest research gap is on the availability of information regarding suitable varieties for low light intensity situations. By and large varieties recommended under normal light intensities are chosen for intercropping studies where they may not necessarily perform well. Crop varieties ideal to reduced light intensity and intercrop competition are to be identified from existing germplasm or exclusively evolved for the purpose. Another gap worth mentioning is the poor information on the innumerable changes that can be visualised below ground under the changing micro-environmental conditions. The activities of beneficial microorganisms, the use of trap crops for management of insect and nematode pests and alternate systems of moisture conservation are the other major areas of thrust in which additional information is to be collected.

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