R. P. F. III

(90)

FINAL REPORT

1. Institute Code No. Agr.IV(131)

2. I. C. A. R. Code No. Pl-63/2-ICI-F26/2710

3. Name and Address of Research Institute/Centre: Central Plantation Crops Research Institute, Regional Station Vittal 574 243, D.K., Karnataka

4. Project Title: Inter and mixed cropping trials

(a) Arecanut and Cocoa

5. Name and Designation of Project Leader: Dr.K.Shama Bhat,Jt.Director (from June 1970 to Oct.,1987)

6. Name(s) and Designation(s) of Project Associates including Project Leader and work to be done:

Sl. No.	Name and Designation	Time spent	Work done
1.	Dr.K.B.Abdul Khader,Scientist S.G.	April 1987 to April,'90	(Project Associate)
1.	Dr.K.Shama Bhat,Jt.Director(PL)	4 manmonths 1970 to 1987	Layout, planting,maintenance of the experiment,manurial & cultural operations,recording observation on experimental data,statistical analysis, preparation of reports and final recommendation
2.	Dr.K.Venugopal,Jt.Director (PL)	4 manmonths 1988 to 1990	Maintenance of the experiment
3.	Dr.K.B.Abdul Khader,SG(Agronomy)	2 manmonths 1987 to 1990	Recording observations,statistical analysis of the data and writing of final reports.

7. Location of Research Project with complete address (Division/Section/Sub-Centre)

Central Plantation Crops Research Institute, Regional Station, Vittal 574 243, Dakshina Kannada, Karnataka under Agronomy section.

8. Date of start : 1970

9. Date of termination : 1990

10. (a) Objectives (Not more than 150 words)

1) To study the optimum spacing for mixed cropping of cocoa in arecanut garden.
2) To study the manurial requirements of both cocoa and arecanut.
3) To study the rooting pattern of cocoa and arecanut when raised together.
4) To study the economic viability of raising of cocoa in arecanut garden.

(b) Practical Utility including background information (Not more than 150 words)

Given in separate sheet

10 (b) **Practical utility including background information:**

Into India Cacao (Theobroma cacao L.) is believed to have been introduced about 200 years ago. According to Watt (1983), cacao was grown in a limited extent in the 19th century by the Roman Catholic Missionaries in Malabar. Rathnam(1961) reported that eight cacao seedlings (Criolla)seedlings were first introduced in 1798 from the Amboyna Islands of East Indies by the East Indian Company into the valleys of Courtollam in Madras Presidency (now mostly comprised of Tamil Nadu). Later in 1842 the Board of Revenue introduced cocoa seedlings to Kolli hills of Salem and later into Nilgiris. But no serious attempts have been made to establish it as a commercial plantation crop until India attained Independence in 1947. Since areas with environmental conditions of rainfall, shade etc. required for large scale cultivation of cocoa as monocrop were limited the progress of planting was not encouraging. Arecanut (Areca catechu L.) to a considerable extent raised as an irrigated crop in southern part of India. The shade, soil, moisture and microclimate conditions in these plantations are same to satisfy the requirement of cocoa. Trials were therefore begun at the Central Plantation Crops Research Institute, Regional Station,Vittal (CPCRI) to explore the feasibility of raising the crop in mixed cropping with arecanut. Initial success of these attempts were reported by Bhat and Leela (1968) and Bhat and Bavappa (1972).

In arecanut, as a sole crop does not utilise fully the natural resources of crop production viz., the soil, space and the sunlight and these features facilitate inter and mixed cropping by introducing parallel or simultaneous combinations of compatible crops. Cocoa is one of the such crops which can be successfully grown as a mixed crop in arecanut garden for increasing the income per unit area.

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11. Technical Programme: Date of Start: 1970

The studies were undertaken at the Central Plantation Crops Research Institute, Regional Station, Vittal, situated at 57 m. above MSL and at 12.57°N latitude in a typical tropical climate. The soil is of literitic in origin, texturally classified as sandy loam. The experiment with mixed crop of arecanut with cocoa was planted in 1970 in a 6x2x4 confounded asymmetrical factorial design having six different spacings as detailed below:

Treatments:

a) Spacing:-

Treatment	Areca (m)	Cocoa(m)
S_1	2.7 x 2.7	2.7 x 2.7
S_2	2.7 x 2.7	2.7 x 5.4
S_3	2.7 x 2.7	5.4 x 5.4
S_4	3.9 x 3.9	3.9 x 3.9
S_5	3.3 x 3.3	3.3 x 3.3
S_6	1.6 x 5.4	3.6 x 5.4

b) Manurial levels

M_1 : 100:40:140 g of NPK per palm or tree/year for both arecanut and cocoa.

M_2 : 100:40:140 g of NPK per palm/year for arecanut and 200:80:280 g of NPK per tree/year for cocoa.

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12. Final Report: 1970 —1990 Date of Start· 1970

Cocoa seedlings were 12 months old and arecanut seedlings 18 months old at the time of planting. Both the crops were provided with partial shade with palm leaves during the first two years. They were irrigated uniformely during the dry weather period (November to April) each year. Growth character of the trees recorded annually. Harvesting of ripenuts from cocoa and ripe arecanut from areca were recorded periodically and the yield recorded for both the crops from the first bearing. Data on the wet weight of pods, number of beans per pod, wet and dry weight of beans were collected taking samples of pods from each plot during different months of harvest. Representative samples of arecanut from different seasons were taken, dried and the dry weight of kernel (chali) recorded.

Growth habits

Cacao trees: From the data (Table 1) on growth parameters, it is seen that at the time of planting the differences in the heights and girths of plants are not significant. At the fifth year there is significant difference in height, the trees in closest spacing are tallest and those with the widest spacing shortest. In the tenth year also the height of trees under the closest spacing (S_1) is maximum and under the widest spacing minimum and the east-west spread is significantly lowest in closest spacing. The cacao plants which recorded mean height of 85 cm at the time of planting attained a mean height of 482 cm i.e., about 5.7 times the original height in ten years. The difference in the girth of plants planted under different densities is not significant.

The rate of horizontal spread and area covered by the canopy of trees are fairly uniform at different ages irrespective of the densities up to eighth year from planting (Table 2). At the end of tenth year the trees under closest spacing S_1 have comparatively lesser spread than trees with wider spacing. In so far as the space available per tree is concerned, the percentage of area covered increases with the density of planting. Under the closest spacing S_1, 51.9% of the available space is covered within two years and by tenth year the canopy occupies 306.0% of the available space, i.e., only about one-third of the canopy is within its zone and two-thirds of the branches spread far beyond into the adjoining rows. The situation in the widest spacing S_3 is that about 45.2 per cent of the available space is covered only after six years and not fully covered even at the end of ten years.

Arecanut palms: The data (Table 3) on growth (height and girth of stem) parameters of palms show no significant differences in the height and girth of palms at the time of planting. The different densities of planting also have no significant influence on the height of palms at later stages of growth.

The relative heights of arecanut palms and cacao trees at different ages when compared show that the height of arecanut palm is slightly less than or almost on par with cacao plants in the first two years. Thereafter the arecanut palms take a lead. The ratios in the heights remain almost constant (1.0:0.6) till the end of the seventh year. Later the arecanut palms grow faster. It is also seen that though the total height of arecanut palms is more than that of cacao trees, even in the early years, it is only after five or six years that the entire crown of arecanut palm gets lifted up above the level of cacao canopy (Table 4).

Yield:

Cacao: The cacao trees commenced to yield fruits from the second year of planting and assumed to near full capacity from six years. The data (Table 5) on mean yield of pods per year for the period from seventh

to eleventh year after planting show that spacing has significant influence on the yield of pods, the widest spacing S_1 giving the maximum and the closest spacing S_1 giving the minimum yield per tree. On hectare basis S_5 recorded maximum yield which is significantly more than all other spacings except S_1. The lowest yield per hectare is under S_3 which is significantly lower than all other spacings.

Regarding seasons of harvests, the crop is available almost throughout the year. On an average 55.1% of the pods is harvested during the south-west monsoon period (from June to September), 16.2% between October and January and the remaining 28.7% between February and May.

The season of harvest and density of plants influenced one or more characters of pods and beans (Table 6). The mean wet weight of a pod harvested in February-March is significantly more than that harvested either in May-June or July. The weight is minimum for May pods. February-March harvests give significantly more number of beans per pod than pods harvested during May, June or July. The wet weight of 100 beans is significantly more for June, July crop, followed by February, March crop and minimum for May harvest. The dry weight of beans is significantly more for May crop than June,July crop. The mean dry weights of beans of February, March harvests and May do not differ significanlty. The pod value(number of pods required to produce one kg of dry beans) is significantly more (34) for June, July crop, followed by May crop (29) and minimum for February, March harvests (26). The influence of density of plants is significant on weight of pod and pod value.

Arecanut: The arecanut palms commenced to yield fruits from the fourth year after planting. The yield per palm differs under different densities. The yield per hectare also differs under different densities. The plots under S_3 spacing recorded significantly more yield than plots under all other spacings except those under S_2 spacing (Table 5).

The two perennial crops involved in the study have contrasting above ground morphological characters. Arecanut palm, an important economic garden land crop in India, having tall slender single stem with a raised crown made up of a tuft of leaves has been chosen as a shade tree for the cacao tree with a comparatively short stem but with a much wider branching canopy. The studies made have revealed the much differing architectural and growth pattern of the species involved. Because of the differnt growth habits of the two species, the distance in the vertical gap between the crown of arecanut palm and the canopy of cacao trees widens as the trees grow. There is thus

a possibility of more and more slant rays of sun falling on the canopy of cacao as the age of palms advances. The unfurled umbrella like crown of arecanut palm with its tall slender stem casts uniform shade to the canopy of cacao trees growing underneath.

When the economic yield of cacao is considered, S_5 has the highest yield per hectare. The estimated dry bean yield per hectare is 2,107 kg. The yield compares well with the yield reported ffom other important cacao growing countries. Alvim (1977) reported that in most producing areas where traditional methods are used the mean yield varies from 300 to 500 kg of dry beans per hectare per year, though with high yielding cultivars and improved cultural practices it is possible to harvest 2,000 to 3,000 kg per hectare per year. Under a situation like this it is the combined yield of component crops that is important than the individual crop yields. The spacing S_5 has recorded the highest combined yield closely followed by S_1 though they are not significantly better than S_2 spacing (Table 5). The arecanut palms are yet to reach the full bearing stage and hence the order of ranking is likely to change in another four or five years.

In assessing the efficiency of multiple cropping Hildebrand(1976) emphasized that the only way to realistically compare the system is by the market value of the produce. Similar approach has been adopted here in assessing the impact of introduction of cacao in arecanut gardens. Since the price of the two commodities are changing often a sliding price scale method has been attempted. The total revenue from different spacing combinations of the component crops under different price situations for cacao (dry beans) and arecanut (dry kernel estimated (Table 7) show that maximum gross revenue per hectare can be expected from S_5 combination until the price of cacao is almost equal to that of arecanut. At 1:1 price ratio, the gross revenue from S_1 spacing also equals to that of S_5. When the ratio of cacao and arecanut prices reaches to 1.0:1.25, the gross revenue is maximum under S_2 spacing. With further increase in price of arecanut and with the price ratio reaching 1.0:1.5 and above the gross revenue is maximum at S_3. Thus it is indicated that it is necessary to have some flexibility in selecting a combination in view of the fluctuating prices of the component crops. The normal spacing for arecanut is 2.7m x 2.7m Considering this, as well as the combined yield of the two crops and the revenue expected, it is safe to select either S_1 or S_2 combination, but since the yield difference between these two is not appreciable and in view of the operational advantages combination S_2 is preferable over S_1.

Rooting Pattern of Crops

One of the under the ground studies made was on the root spread of the component crops under the sole crop condition as well as under the mixed crop situation when the trees were 10 years old (Fig.2). When arecanut was planted as a monocrop 61 per cent of total roots. 70 per cent of thick roots and 51 per cent of fine roots were radially spread within 50 cm distance from the centre of the palms. In the second zone lying between 51 to 100 cm radius, the concentration of total, thick and fine roots were 28, 23 and 33 arecanut were found to traverse up to 2.6m though 66 per cent of total roots, 61 per cent of thick roots and 73 per cent of fine roots were within 50 cm depth. The second horizon between 51 to 100 cm contained 21 per cent of all roots, 28 per cent of thick roots and 13 per cent of fine roots. The zone lying beyond 100 cm had only 13 per cent of all roots, 12 per cent of thick and 14 per cent of fine roots.

In cacao trees under the monocropping condition, the maximum concentration was within 25 cm radius from the tree. The lateral spread of all roots, thick and fine roots within 50 cm radius were 81, 86 and 69 per cent of total respectively. There was a sharp decrease in the dry weight of all categories of roots beyond 150 cm radius from the tree. The vertical penetration of cacao roots was up to 350 cm, though 68 per cent of all roots and 60 per cent of the fine roots were within the first horizon of 50 cm depth. The zone up to 100 cm contained 87 per cent of total and 74 per cent of fine roots.

Under the mixed cropping condition, 65 per cent of all roots and 51 per cent of fine roots of arecanut were within 50 cm radius. The zone within 75 cm radius wasoccupied by 91 per cent of total roots and 86 per cent of fine roots. On the whole 99 per cent of total roots were within 100 cm from the palm. Depth-wise, 55 per cent of total roots and 57 per cent of fine roots were within 50 cm from the ground. The second layer of 51 to 100 cm contained 41 per cent of total roots and 37 per cent of fine roots. The magnitude of roots traversing beyond 100 cm was low, though they could be seen up to 300 cm. In cacao under the mixed cropping situation, 42 per cent of total roots and 24 per cent of fine roots were confined to 25 cm radius. The sector between 26 and 50 cm radius contained 14 per cent of total roots and 16 per cent of fine roots. In the third strata lying between 51 and 75 cm there was 11 per cent of total and 15 per cent of fine roots. There was a rapid decrease in the spread of roots beyond 75 cm radius. The first 50 cm layer was occupied by 40 per cent of total and 30 per cent of fine roots. The second horizon between 51 and 100 cm depth was occupied by 32 per cent of total and 13 per cent of fine roots. The ramification of all roots rapidly decreased beyond 100 cm depth, though they could be traced up to 480 cm below ground level.

A comparison of the rooting system of arecanut palm under the two systems of planting revealed certain interesting features. The sphere of spread of total roots though were confined to more or less to same distance both radially and vertically under the two systems, there was some difference in the percentages of distribution of different types of roots in different zones within the sphere of spread. Under the mixed cropping system, more than 96 per cent of thick roots were within 100 cm depth, whereas under monocrop condition only about 88 per cent were within the same depth. Interestingly, the quantity of fine roots in the top 50 cm layer was only 57 per cent under the mixed crop condition as against 73 per cent of similar roots in the top layer when planted as monocrop. There was a better exploitation of the second layer between 51 to 100 cm by the fine roots under the mixed cropping condition than under the sole cropping system, the percentages of fine roots in the second layer under the two systems being 37 and 13 respectively. The roots of cacao traversed as deep as 480 cm under mixed cropping situation while the penetration was confined to 350 cm depth in a monocrop situation. The percentage of all roots was only 40 in the first 50 cm depth under the mixed cropping whereas it was 68 per cent under the sole cropping. In the same zone only 30 per cent of fine roots were traces in the mixed cropping whereas it was 60 per cent under the sole cropping. The overall situation was that when 90 per cent of the fine roots were within 200 cm below ground level under the sole cropping, it was spread over to 350 cm depth under the mixed cropping, indicating a deeper exploitation of soil by cacao roots under the latter condition.

Data on yield of arecanut and cocoa for the crop year 1988-89 is presented in Table 1. There were no significant differences in the yield of arecanut due to spacing treatments. However, in closer spacing of 2.7 x 2.7m for arecanut and with less competition from cocoa with 5.4 x 5.4m spacing the yield of arecanut was highest (6.66 t/ha). The yield of cocoa pods was significantly high(19.86/ha) at closer spacing (2.7 x 2.7m) and the yield of cocoa decreases proportionately as the population per unit area decreases(Table 8).

The data on mean yield of arecanut and cocoa for 11 years period from 8th to 18th year of cropping is presented in Table 9 and the data on economics of 'Arecanut + Cocoa' mixed cropping based on the 11 year mean yield is presented in Table 10. The yield of arecanut (chali) was higher (2.09 t/ha) at S_3(2.7 x 2.7 : 5.4 x 5.4) spacing where the competition from cocoa was the least. The yield of cocoa pods was highest (16.36 t/ha) at a closer spacing (2.7x2.7m) and the yield of pods proportionately decreases with increased spacings. In all the years manurial treatments did not show significant yield differences.

The economics of 'Arecanut + Cocoa' mixed cropping (Table 10) revealed that the spacing treatment S_2(2.7x2.7m for arecanut and 2.7x5.4m for cocoa) is more appropriate spacing combination which gave the highest net return of Rs.54,390/- per hectare per year.

Table 1. Growth of cacao trees (cm)

Treatment spacing	First year		Fifth year				Tenth year			
	Girth	Height	Girth	Height	Spread(SN)	Spread (EW)	Girth	Height	Spread(SN)	Spread(EW)
S_1	5.0	87	32.4	443	413	426	43.4	514	535	531
S_2	4.6	83	33.0	391	434	457	45.7	485	547	647
S_3	5.2	84	33.0	359	407	412	47.9	462	597	602
S_4	4.7	83	33.4	384	419	418	46.7	477	565	589
S_5	4.9	85	33.9	376	415	418	45.9	473	579	576
S_6	4.8	87	34.6	365	426	438	47.2	478	569	625
Mean	4.8	85	33.3	386	419	428	46.1	482	565	595
CD(P =0.05)				42.5						44.6

Table 2. Area covered by the canopy of cacao

Spacing	Area available/ plant (m^2)	Area covered (m^2)				
		2nd year	4th year	6th year	8th year	10th year
S_1	7.29	3.78 (51.9)	8.29 (113.7)	13.82 (113.6)	21.03 (288.5)	22.31 (306.0)
S_2	14.58	3.20 (21.9)	8.27 (56.7)	15.58 (106.9)	22.95 (157.4)	27.75 (190.3)
S_3	29.16	3.27 (11.2)	6.66 (22.8)	13.17 (45.2)	22.48 (77.1)	28.18 (96.6)
S_4	15.21	3.12 (20.5)	6.95 (45.7)	13.76 (90.5)	20.38 (134.0)	26.14 (171.9)
S_5	10.89	3.31 (30.4)	7.31 (67.1)	13.62 (125.1)	22.26 (204.41)	26.19 (240.5)
S_6	19.44	3.53 (18.2)	8.12 (41.8)	14.65 (75.4)	21.40 (110.1)	27.93 (143.7)
Mean		3.36	7.60	14.1	21.8	26.4

Figures in parentheses give the percentage of available space covered

Table 3. Growth of arecanut palms (cm)

Spacing	First year		Fifth year		Tenth year	
	Girth	Height(total)	Girth	Height of stem	Girth	Height of stem
S_1	10.5	165	44.0	231	45.3	626
S_2	10.3	155	45.1	235	45.5	636
S_3	10.4	158	46.0	218	46.7	620
S_4	10.4	160	46.7	237	46.7	618
S_5	10.5	168	45.1	214	45.6	603
S_6	10.6	166	44.8	233	45.1	636
Mean	10.4	162	45.3	228	45.8	623

Table 4. Relative heights of arecanut and cacao at different ages

Age of tree (year)	Height of tree*(cm)		Ratio
	Arecanut	Cacao	
1	152	200	1.0 : 1.32
2	265	250	1.0 : 0.94
3	388	286	1.0 : 0.74
4	511	323	1.0 : 0.63
5	635	364	1.0 : 0.57
6	686	416	1.0 : 0.61
7	778	446	1.0 : 0.57
8	870	475	1.0 : 0.55
9	954	496	1.0 : 0.52
10	1039	517	1.0 : 0.50

*From ground level to top of canopy

Table 5. Average yield of cacao and arecanut/year (7th to 11th year)

Treatment	Cacao				Arecanut				Combined yield of cacao + Areca/ha ('000 kg)
	No.of pods/tree	Wet wt.of pods/tree (kg)	No.of pods/ha ('000)	Wt.of pods/ha ('000 kg)	No.of nuts/palm	Wt.of nuts/palm (kg)	No.of nuts/ha ('000)	Wt.of nuts/ha ('000 kg)	
S_1	38.2	12.9	52.5	17.7	146.4	4.8	200.9	6.6	24.3
S_2	65.0	21.9	44.6	15.0	178.4	5.7	244.8	7.8	22.8
S_3	83.3	26.7	28.6	9.2	222.1	7.0	304.7	9.6	18.8
S_4	61.2	20.7	40.2	13.6	210.2	6.8	138.1	4.5	18.1
S_5	62.5	20.9	57.4	19.2	192.0	6.3	130.6	5.9	25.1
S_6	72.6	25.2	37.3	13.0	188.9	6.0	194.4	6.2	19.2
Mean	63.8	21.4	43.4	14.6	189.7	6.1	210.6	6.8	21.4
CD (P =0.05)	15.98	5.37	8.34	3.14	45.49		57.52	1.89	3.9

Table 6. Influence of Season and density on pod and bean characters

Treatment	Feb.-March		May		June-July		Mean	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
S_1	373	40	298	37	332	36	334	38
S_2	372	38	294	37	338	36	335	37
S_3	346	42	282	35	299	35	309	37
S_4	385	42	305	37	341	36	344	37
S_5	394	41	288	36	335	35	339	38
S_6	390	40	305	38	329	36	341	38
Mean	377	41	295	37	329	36	334	38
CD(P=0.05) for seasons							14.8	1.4
for spacing								-

(i) Weight of a pod(g); (ii) Number of beans/pod

Table 6 contd..

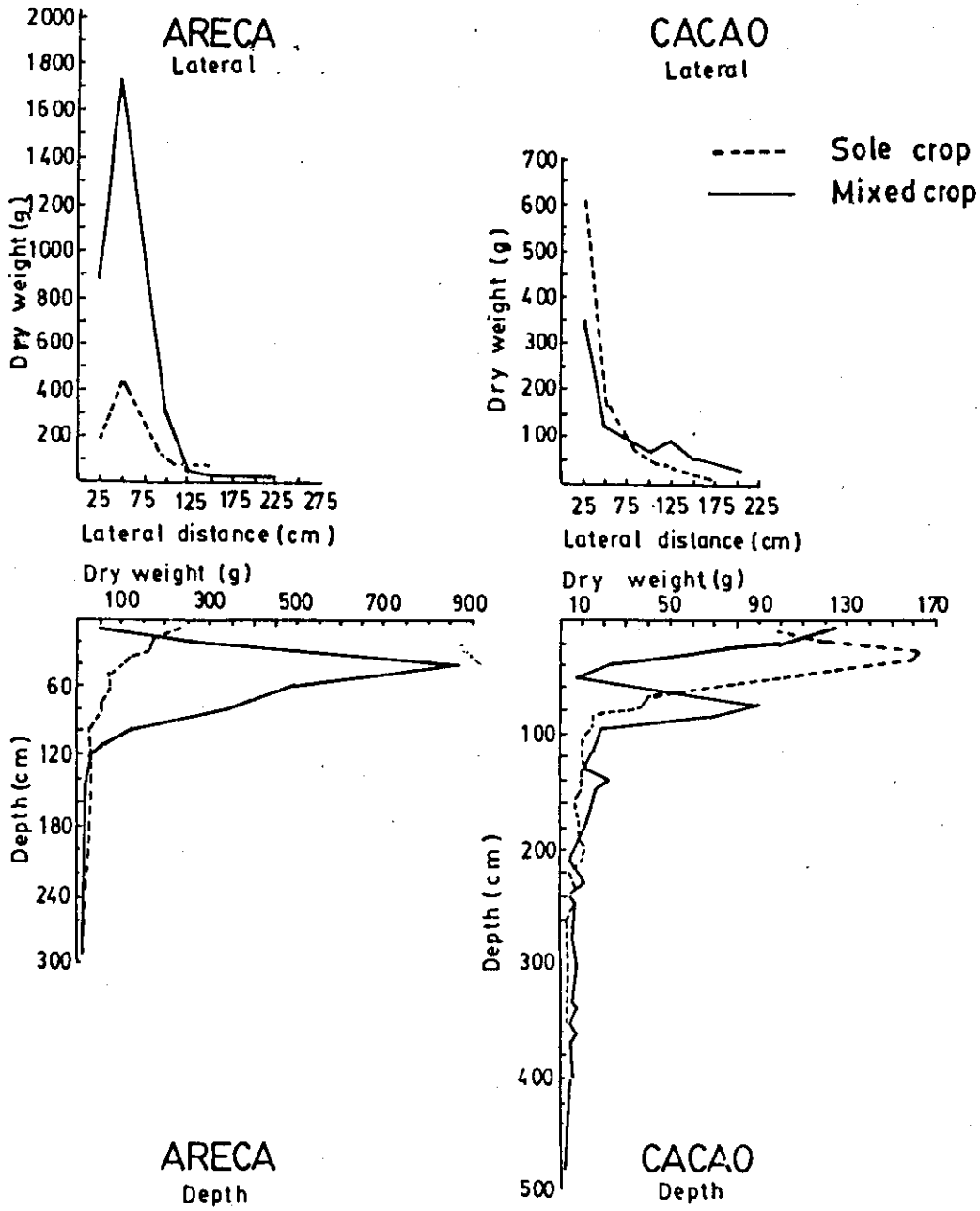
Treatment	February-March			May			June-July			Mean		
	(iii)	(iv)	(v)	(iii)	(iv)	(v)	(iii)	(iv)	(v)	(iii)	(iv)	(v)
S_1	221	96	26	208	95	29	248	87	32	226	93	29
S_2	235	96	28	209	95	29	245	82	35	229	91	31
S_3	228	94	26	218	99	30	227	78	38	224	90	31
S_4	218	91	26	215	99	28	253	86	33	229	92	29
S_5	227	97	25	215	95	30	257	86	33	233	93	30
S_6	245	102	25	229	102	26	252	84	33	242	96	28
Mean	229	96	26	216	97	29	247	84	34	231	92	30
CD(P=0.05) for seasons										9.7	3.6	1.4
for spacing										-	-	2.0

(iii) Wet wt. of 100 beans(g); (v)Dry weight of 100 beans(g); (v) Pod value

Table 7. Total revenue (Rs./ha) from treatment combination under different price situation (on dry weight basis) for cacao and arecanut
cacao:arecanut

Price ratio	S_1	S_2	S_3	S_4	S_5	S_6
1 : 0.25	2.34	2.11	1.58	1.75	2.46	1.79
1 : 0.50	2.73	2.57	2.14	2.02	2.80	2.15
1 : 1.00	3.50	3.49	3.27	2.54	3.50	2.88
1 : 1.25	3.89	3.95	3.84	2.81	3.85	3.24
1 : 1.50	4.28	4.40	4.41	3.07	4.20	3.60
1 : 2.00	5.06	5.32	5.54	3.59	4.90	4.32
1 : 2.50	5.84	6.24	6.67	4.12	5.59	5.05
1 : 3.00	6.62	7.16	7.81	4.64	6.29	5.77
1 : 4.00	8.18	8.99	10.07	5.69	7.69	7.22

Value inside the table has to be multiplied by a "K".
Where K = Value in Rupees for 1,000 kg of cacao (dry beans)



Rooting pattern of crops.

Table 8. Yield of arecanut and cocoa in "Areca + Cocoa" mixed cropping(1988-89)

	Spacing(m)		Arecanut yield(ripe nuts, tonnes/ha)			Cocoa yield(pods, tonnes/ha)		
	Areca	Cocoa	M1	M2	Mean	M1	M2	Mean
S_1	2.7 x 2.7	2.7 x 2.7	1.83	7.42	4.62	19.89	19.84	19.86
S_2	2.7 x 2.7	2.7 x 5.4	5.24	7.46	6.35	12.47	17.24	14.86
S_3	2.7 x 2.7	5.4 x 5.4	7.53	5.79	6.66	10.68	10.61	10.64
S_4	3.9 x 3.9	3.9 x 3.9	4.15	3.72	3.93	14.66	14.85	14.75
S_5	3.3 x 3.3	3.3 x 3.3	3.86	4.02	3.94	17.35	16.11	16.73
S_6	1.8 x 5.4	3.6 x 5.4	3.50	3.00	3.25	11.94	11.85	11.90
	Mean		4.35	5.24		14.50	15.08	

C.D. for spacing ..... N.S. 4.58

C.D. for manure(M) ..... N.S. ..... N.S.

TABLE 9: Mean yield of Cocoa and Arecanut/year for 11 years (8th to 18th year)

	Spacings(m)		Cocoa Weight of pods		Arecanut Weight of Chali	
	Areca	Cocoa	Kg/ tree	Tones/ ha	Kg/ tree	Tones/ ha
S_1	2.7 x 2.7	2.7 x 2.7	11.94	16.36	1.24	1.71
S_2	2.7 x 2.7	2.7 x 5.4	18.45	12.55	1.39	1.91
S_3	2.7 x 2.7	5.4 x 5.4	22.14	7.53	1.52	2.09
S_4	3.9 x 3.9	3.9 x 3.9	17.87	11.62	1.60	1.04
S_5	3.3 x 3.3	3.3 x 3.3	18.64	17.12	1.37	1.26
S_6	1.8 x 5.4	3.6 x 5.4	20.36	10.47	1.40	1.43
Mean				16.61		1.57

Table 10. Economics of mixed cropping of cocoa in arecanut garden under different spacings (Rs./ha) based on mean yield of 11 years (8th to 18th year).

	Spacings (m)		Gross income/ha		Total income/ha	Cost of cultivation		Net income/ha	Addl. income from Cocoa/ha
	Areca	Cocoa	Areca	Cocoa		Areca	Cocoa		
S_1	2.7×2.7	2.7×2.7	42750	32720	75470	13700	9590	52210	23130
S_2	2.7×2.7	2.7×5.4	47750	25100	72850	13700	4760	54390	20340
S_3	2.7×2.7	5.4×504	52250	15060	67310	13700	2380	47630	12680
S_4	3.9×3.9	3.9×3.9	26000	23240	49240	6500	4550	38190	18690
S_5	3.3×3.3	3.3×3.3	31500	34240	65740	9180	6426	50134	27814
S_6	1.8×5.4	3.6×5.4	35750	20940	56690	10200	35980	42892	17342

Rate of arecanut = Rs. 25/- per kg of Chali
Rate of cocoa = Rs. 2/- per kg of pods
Cost of cultivation of arecanut = Rs. 10/- per tree
Cost of cultivation of cocoa = Rs. 7/- per tree

13. Approximate expenditure incurred in the Project: (Give reasons for variation, if any, from original estimated cost)

Rs.80,000/- per year

14. Publications and material (one copy each to be supplied with this proforma)

a) Research papers - Four (enclosed)

b) Popular articles - Six

c) Reports - 25

Thesis - One (Plant Interactions in a Mixed Crop Community of Arecanut and Cocoa - Khandige Shama Bhat (1983). Thesis submitted to the* Mysore University for th award of Ph.D.

d) Seminars and workshops (Relevant to the Project) in which the Scientists have participated:

77th Session of Indian Science Congree held in Cochin from 4th to 9th February, 1990 - Arecanut based cropping system - K.B.Abdul Khader and K.Venugopal

e) Material developed (such as new varieties of crops or breeds of farm animals, implements, products, etc.)

Cocoa was recommended as a profitable mixed crop in arecanut garden. The spacing recommended was 2.7m x 5.4m in alternate rows when arecanut was planted at 2.7m x 2.7m.

15. Details (Nos. etc.) of Field/Laboratory Note books and final material and their location

Experimental Log Book, and Project file

16. Comments/suggestions of Project Leader regarding possible future line of work that may be taken up arising of this project:

i) Detailed studies on water and nutrient requirements both arecanut and coc in a mixed cropping system.
ii) Effect of cocoa on the performance of arecanut in a long run
iii) Possibilities of thinning out/drastic pruning of cocoa after 10-15 years since interplanting and gap filling of arecanut is a problem in the cocoa arecanut mixed gardens.
iv) Standardization of pruning of cocoa for optimum yield.
v) An indepth study on inter and intra competition between arecanut and coco if any for nutrients, moisture, shade, light etc. and similarly a detaile study on alliloplyltic effect of cocoa and arecanut mixed cropping system.

17. Signatures with name of Project Leader and Associates:

(Dr.K.B.Abdul Khader)
Joint Director i/c
Central Plantation Crops Research Institute
Regional Station, VITTAL-574 243
Karnataka State. INDIA

18. Signature (with comments, if any) of Head of Division/Section/Station:

19. Signature (with comments, if any) of Director:

Director
Central Plantation Crops Research Institute
KASARAGOD - 670 124