III. INTERCROPPING IN COCONUT

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Growing one or more annuals in the interspace of coconut is an age-old practice in the coconut growing tracts in India. Krishna Marar (1964) estimated the extent of inter/mixed cropping in coconut gardens in Kerala at 78% and that tapioca was grown in 20% of the stands. In Andhra Pradesh 34.7% of the gardens had inter/mixed crops, viz., banana, mango, citrus, and turmeric. The area under intercrops or mixed crops in Tamil Nadu was 65% and the popular intercrops were rice, sugarcane, sorghum, tapioca and vegetables. He also added that in Philippines ginger, groundnut, colocasia and pineapple were widely grown.

The small size of the holdings makes it uneconomical to the owners to invest large amounts on irrigation and land development. As a result most of the coconut holdings are rainfed. Krishnaji et al. (1976) have stated that in the major coconut growing state of Kerala, except in the Alleppey District, where 27.8% of the area under coconut was irrigated, only a very small percentage of the area under coconut got summer irrigation. Kerala receives an annual precipitation ranging from 2500-3600 mm. The data on the mean rainfall received in different centres of CPCRI is presented in Table 1.

The rainfall pattern clearly shows that in northern parts of Kerala (Kasaragod), there is a prolonged dry period from December to April. As many of the small and marginal farmers cannot afford to set up

Table 1. *Rainfall received at different Research Centres of CPCRI in Kerala*

Month	Mean rainfall received (mm)			
	Kasaragod (1957–76)	Kannara (1972–76)	Kayamkulam (1971–76)	Palode (1972–75)
January	0.8	—	15.7	8.0
February	—	1.6	25.8	25.4
March	3.8	4.9	34.9	46.8
April	42.6	100.7	182.2	297.8
May	266.1	299.8	308.5	239.3
June	976.1	1861.8	464.0	289.9
July	1098.2	701.4	427.6	351.0
August	663.8	513.8	273.6	262.6
September	324.0	239.6	289.4	196.8
October	187.5	206.0	325.0	523.8
November	77.6	91.0	89.2	309.6
December	19.3	64.7	59.9	77.1
Total	3659.8	2385.3	2495.8	2628.1

Source: Central Plantation Crops Research Institute 1977. Annual Report for the year 1976, pp. 273–283

Table 2. *Management practices for intercrops*

Intercrops grown	Scientific name	Variety	Population per ha gross area	Method of planting and spacing	Fertiliser dose (kg/ha) N: P_2O_5: K_2O	F.Y.M. t/ha	Time of planting
Elephant foot yam	*Amorphophallus companulatus*	Local	1295	Pits 1×1m	52: 26:52	6.5	March-April
Tapioca	*Manihot utilissima*	M4	2590	Mounds 0.9×0.9m	26: 20:43	2.6	April-May
Yam	*Dioscorea* spp.	Local	1295	Pits 1×1m	52: 26:52	6.5	March-April
Sweet potato	*Ipomoea batatas*	Local	10360	Ridges 50 cm apart	15: 10:15	2.0	May
Banana	*Musa* spp.	Poovan	666	5.4×2.7m	160:160:320	6.6	Sept.-Oct.
Pineapple	*Ananas sativa*	Kew	2590	Trenches 0.9×0.9m	26: 13:52	7.5	May-June
Ginger	*Zingiber officinale*	Maran		Beds 25 cm apart	60: 60:150	6.5	April-May

irrigation facilities, the possibility of successfully growing crops round the year is very much restricted. The only choice is growing annuals, taking advantage of the monsoon rains, in the interspace of coconut for enhancing the income from the land and employment. Hence, intercropping in coconut stands is of paramount importance to the small and marginal farmers, who form the largest group among the coconut growers.

Studies on intercropping in coconut stands were initiated in the thirties at the Coconut Research Stations (CRS), Kasaragod and Pilicode. Work on this aspect was, however, intensified during the past two decades. Field trials were conducted with different species and varieties of pulses, oilseeds, and tubers with the main objective of identifying compatible and remunerative crops and their varieties for intercropping, and to find out the optimum time of sowing/planting. The salient points of the work done and results obtained from the various field experiments are presented in the following paragraphs.

Willey (1979) had identified three different situations under intercropping. They are: 1. intercropping must give the full yield of the main crop and some yield of the second crop, 2. combined yield of intercrops must exceed the higher sole crop yield, and 3. combined intercrop yield must exceed the combined sole crop yield.

In all the intercropping studies with coconut, only the first situation was considered. The emphasis was that the yield of the main crop of coconut should not decrease due to the growing of intercrops.

Intercrops were sown/planted taking advantage of the summer showers in April-May or in the first week of June when the south-west monsoon commenced on the west coast of India. Crops like pulses, which cannot withstand heavy rains, were sown after the heavy rains were over in August-September. All these crops are planted/sown leaving a circular area of 2 m radius around the base of the palm (effective root zone of the coconut) to facilitate the application of inputs like fertilisers for coconut. The package of practices adopted for these crops is described in Table 2.

Input requirements

Varghese et al. (1978) reported the results of a field experiment conducted at CPCRI, Kasaragod, during 1967–70 in which tapioca and elephant foot yam were raised as intercrops in coconut stands with the following treatments: t_1—no intercrop—coconut manured, t_2—intercrops grown—only intercrop manured, and t_3—intercrops grown—coconut and intercrops manured.

Table 3. *Effect of raising intercrop in coconut gardens (Yield data for main crop and intercrop) (Varghese et al., 1978)*

Intercrop	Treatment	Mean annual yield of coconut Pre-treatment 1964–67 per palm	Treatment 1968–70 per palm	Response per palm	Mean yield of intercrop (1967–70) t/ha
Elephant yam	T_1—No intercrop-coconut manured	47.0	38.4	– 8.6	—
	T_2—Intercrop alone manured	49.2	33.1	–16.1	8.41
	T_3—Both crops manured	31.9	36.2	4.3	9.18
Tapioca	T_1—No intercrop-coconut manured	46.5	35.8	–10.7	—
	T_2—Intercrop alone manured	50.1	34.0	–16.1	2.85
	T_3—Both crops manured	33.0	33.4	0.4	5.08

The effect of the treatments on the performance of coconut and intercrops is presented in Table 3.

There was a general reduction in the yield of coconut, which had passed the prime bearing age. But there was no such reduction when both the intercrop and coconut were manured as per the recommended package of practices. The greater reduction in the yield of coconuts (16 nuts/palm/year) when the intercrop alone was manured (t_2) compared to that of 9.7 nuts in the plots where there was no intercrop but coconut was manured (t_1) was due to the competition for nutrients between the main crop and intercrop. This was overcome by fertilising both the crops as evidenced by the yield of coconut in t_3.

Besides, the yield of tubers was also poor when the intercrop alone was manured compared to that in the plots where both the intercrop and the main crop received fertilisers.

This study revealed that when intercrops are grown, both the main and subsidiary crops should be given the recommended management practices, as if they were grown as sole crops so as to ensure satisfactory yields and profitability of the practice.

Tubers as intercrop

Among the intercrops, tropical tubers like tapioca and elephant yam are the most popular ones. One of the main reasons for their popularity is that while the coconut gives the farmer cash income, the tubers grown as intercrops partially meet the food requirements of the farmer's family. Experiments at CPCRI, Kasaragod and Coconut Research Station (CRS), Pilicode have shown that tapioca and elephant yam are the most profitable among the intercrops.

Kannan and Nambiar (1976) reported the result of experiments on intercropping conducted at the CRS, Pilicode in coconut stands aged about 50 years during 1967–75, with tapioca, colocasia, rice, ragi and groundnut. They observed increased production of nuts and enhanced overall returns from the coconut garden due to intercropping. The increase in nut yield ranged from 2.7% in groundnut intercropped plot to 30.3% in colocasia intercropped plots. The results of their experiments are presented in Table 4.

Among the various intercrops tried tapioca gave the highest net return of Rs 1503/ha. The coconut-colocasia/ragi

Table 4. *Yield and returns from different intercropping systems (Kannan and Nambiar, 1976)*

Intercrop	Yield of coconuts nuts/palm/year		Yield of intercrop (kg/ha)	Addl. returns from coconut (Rs/ha)	Profit from intercrop (Rs/ha)	Total additional net profit Rs/ha
	Pre-treatment 1960–66	Treatmental period 1968–74				
Rice	59.9	70.8	850	1164	885	2019
Tapioca	55.9	61.0	15452	544	1503	2047
Colocasia	45.1	58.8	6250	1463	715	2178
Groundnut	58.9	60.5	965	150	455	605

Table 5. *Yield of coconut palm during pre-experimental and experimental periods under different treatments (Varghese et al., 1978)*

S.No.	Treatment	Mean yield of nuts/palm/year		Response nuts/palm	Percentage increase (+) or decrease(–)
		Pre-Expt.*	Expt.**		
1.	Control (no intercrop)	48.2	45.2	–3.0	–6.2
2.	Tapioca (every year-no rotation)	54.8	51.2	–3.6	–6.6
3.	Elephant yam (every year-no rotation)	68.3	59.3	–9.0	–13.2
4.	Tapioca and elephant yam in alternate years	73.0	68.2	–4.8	–6.6
5.	Elephant yam and tapioca in alternate years	66.6	62.4	–4.2	–6.3
6.	Mean of items 4 and 5	69.8	65.3	–4.5	–6.5
7.	Tapioca, elephant yam, sweet potato, ginger, and turmeric in 5 year rotation	49.7	52.1	2.4	+4.8
8.	Yam, lesser yam, colocasia and coleus in rotation	60.8	69.8	9.0	+14.8

*For items 1 to 6 mean yield of years from 1970 to 72 and for items 7 and 8 from 1971–73

**For items 1 to 6 mean yield of years from 1974 to 1977 and for items 7 and 8 from 1975–77.

combination also resulted in substantial increase in net additional returns.

Need for intercrop rotation

A field trial was conducted at CPCRI, Kasaragod from 1972 to '77 to study the effect of growing tapioca and elephant yam in the same plots year after year and growing these by rotation.

Another experiment was also in progress from 1973 to '78 in which five tuber crops, viz., tapioca, sweet potato, ginger, elephant yam and turmeric were grown as intercrops in coconut in different five yearly rotations. The results of these experiments were reported by Varghese et al (1978).

The data on the effect of growing tuber crops on the yield of the main crop of coconut are presented in Table 5. In the first experiment, the palms were more than 65 years old. The reduction in the yield of coconut in the plot, where no intercrop was grown, was 3 nuts/palm/year (6.2%). The yield reduction in other treatments, except the one in which elephant yam was grown continuously was of the same magnitude. But, where elephant yam was grown every year, the coconut yield was lowered by 13.2% (9.0 nuts/palm/year). This showed that it is preferable not to grow the same tuber as an intercrop in the same coconut stand year after year, as it affects the yield of coconut.

In the second experiment, where five year-five crop rotations were tried, the coconut palms showed an increased yield of 2.4 nuts/palm over the pre-experimental yield. It is, therefore, evident that the main crop of coconut was not adversely affected when intercropping was taken up with tubers, provided rotation of intercrops and proper management practices were adopted.

Yield of intercrops

The yield of intercrops in the above two experiments is presented in Table 6.

Table 6. *Yield of tubers as intercrops in coconut garden (Varghese et al., 1978)*

Intercrops grown	Yield in t/gross ha of coconut plantation				
	1973–74	1974–75	1975–76	1976–77	Mean
Tapioca (every year-no rotation)	5.8	2.6	6.2	3.2	4.5
Tapioca alternated with elephant yam	7.1	6.7	8.3	3.2	6.3
Elephant yam (every year no rotation)	5.6	7.6	9.5	3.0	6.4
Elephant yam alternated with tapioca	16.2	8.9	13.8	8.1	11.8
Rotation experiment					
(*a*) Tapioca	7.7	7.4	14.2	8.3	7.6**
(*b*) Elephant yam	12.9	9.2	15.2	11.6	12.2
(*c*) Sweet potato	9.5	6.5	7.2	5.2	7.1
(*d*) Ginger	11.6	3.9	NA*	NA*	7.8
(*e*) Turmeric	10.9	NA	8.2	5.2	8.1
Greater yam	12.7	5.4	12.8	10.3	10.3
Lesser yam	9.0	8.5	7.4	5.3	7.5
Colocasia	NA	NA	11.8	6.6	9.2
Chinese potato	6.0	6.6	6.7	3.0	5.6

*Ginger crop was destroyed by soft-rot disease
**Mean yield for 1973–74 and 1974–75 only.
NA: Not available

Table 7. *Net returns and additional employment generated per year from one hectare of coconut garden intercropped with tuber crops*
(Varghese et al., 1978)

Intercrop	Yield of intercrop (t/ha)	Value of intercrop (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns from intercrop alone (Rs/ha)	Input: output ratio for intercrop	Total net income including coconut	Additional employment	
							Man days	Woman days
Coconut alone	—	—	2900	8400	—	5500	—	—
Tapioca	11.2	4480	2122	2358	2.11	7858	93	12
Elephant yam	12.2	9760	3246	6514	3.01	12014	123	8
Sweet potato	7.1	2840	2055	785	1.38	6285	56	26
Ginger	7.8	9750	4730	5020	2.06	10520	108	24
Turmeric	8.1	3248	4568	1808	0.71	3692	108	24
Chinese potato	5.6	4480	2035	2445	2.20	7945	92	23
Greater yam	10.3	5150	2827	2323	1.82	7823	64	12
Lesser yam	7.5	4500	2827	1673	1.59	7173	64	12

Value of intercrops in Rs/t: Tapioca-400, Elephant yam-800, Sweet potato-350, Ginger-1250, Turmeric-400, Coleus-800, Greater yam-500, Lesser yam-500, Coconut Re 0.80/nut.

When tapioca was grown every year, it gave a mean yield of 4.5 t/ha (range 2.6-6.2 t/ha). But when rotated with elephant yam, its mean yield was 6.3 t/ha (range 3.2-8.3 t/ha). Elephant yam also showed a similar trend. Rotation with tapioca on alternate years, increased the yield of elephant yam to 11.8 t/ha from 6.4 t/ha when it was grown every year in the same field. In the second trial where five year rotation was adopted, these tubers gave still higher yields. Tapioca variety M4 yielded 7.6 t/ha in 5 year rotation, whereas variety H 165 gave the highest yield of 11.3 t/ha. Similarly elephant yam in 5 year rotation yielded 12.2 t/ha.

These results further emphasise the need to adopt intercrop rotations rather than growing the same intercrop year after year.

Feasibility studies were also conducted with tubers like greater yam (*Dioscorea alata*), lesser yam (*Dioscorea esculenta*), Chinese potato (*Coleus parviflorus*), and Colocasia (*Xanthosoma sagitifolium*). These crops gave yields ranging from 5.6 to 10.3 t/ha and were also found compatible with coconut.

Profitability and additional employment

The additional income and employment opportunities that can be generated by tropical tuber crops as intercrops in coconut garden is presented in Table 7.

Even under rainfed conditions, a net income of Rs 7,000 – 8,000 per ha could be obtained by growing tuber crops in coconut gardens. Elephant yam followed by ginger gave the highest total net return per hectare. However, ginger is highly susceptible to *soft rot* disease, which can completely wipe out the crop. Hence, adequate precautions should be taken against this disease. Besides the additional returns, these crops provide additional employment for the agricultural labour. Crops like elephant yam and ginger are more labour intensive than tapioca and sweet potato. Elephant yam doubles the employment potential per unit area of land compared to sole crop of coconut.

An intercropping experiment with six tubers was carried out in the laterite gravelly soil at CRS, Pilicode. Maximum profit was realised from elephant yam (Anonymous, 1979 *b*). The mean yield of intercrops were: ginger 5.2 t, turmeric 7.2 t, sweet potato 1.0 t, elephant yam, 1.0 t, colocasia 0.7 t and tapioca 7.0 t/ha.

Table 8. *Effect of intercropping on the yield of coconut palms in a root (wilt) affected garden (Menon and Nayar, 1978)*

Treatment	Yield of nuts/palm/year		Percentage increase/ decrease	Estimated net response %
	Pre-exptl. period	Exptl. period		
Control (no intercrop)	41.0	38.6	-5.8	—
Tapioca	49.8	48.9	-1.8	4.96
Elephant yam	52.5	58.7	11.8	17.57
Yam	57.0	58.3	2.3	2.04

Root (wilt) affected area

Experiments conducted at CPCRI Regional Station, Kayangulam—an area where coconut is affected by root (wilt) disease—have revealed that tuber crops like tapioca, elephant yam and yam can be grown profitably as intercrops under disease affected conditions (Menon and Nayar, 1978). This experiment was conducted in a 16 year old coconut garden spaced 7.5×7.5m apart. They were raised for three years from 1975. The yield of the coconut palms during the pre-experimental period and experimental period are presented in Table 8.

Considering the overall response of palms, there was no reduction in yield due to intercropping. A slight increase in the mean yield of palms was noticed in the plot where elephant yam was cultivated(11.8%) followed by the plot where yam was cultivated (2.2%).

The effect of intercropping on the number of palms in different disease intensity groups was also studied (Table 9). In the control plot, during the course of three years, all the apparently healthy palms had developed disease symptoms. But in the intercropped plots, some of the palms continued to be free from disease symptoms. The mean disease index for the control plot increased from 34.2 to 36.1, indicating advancement of the disease. Palms intercropped with tapioca also exhibited a similar trend, but slightly larger increase in disease intensity (32.1 to 37.3). However, palms intercropped with elephant yam showed a marginal reduction in disease intensity from 37.0 to 33.3.

Yield and net profit

Tapioca variety H 165 gave the highest tuber yield of 15.93 t/ha/year (Table 10). Raising all the three intercrops was profitable. Tapioca gave the highest net profit. From the cost benefit analysis, it was found that coconut+tapioca combination gave the highest net return per rupee invested (1:1.47).

All these experimental results establish that tubercrops, especially, tapioca and elephant yam can be profitably grown as intercrops in coconut gardens.

Rice

Rice being the staple food of the local population, efforts were made from time to time to find out the possibility of growing upland rice varieties as an intercrop in coconut gardens. One of the earliest reports on raising rice as an intercrop in coconut gardens from Nileshwar (Anonymous, 1934) was not very encouraging as the grain yield

Table 9. *Effect of intercropping on number of palms under different disease intensity groups (Menon and Nayar, 1978)*

Group	(% of total)							
	Control		Tapioca		Elephant yam		Yam	
	1975	1977	1975	1977	1975	1977	1975	1977
Apparently healthy	13.33	—	18.36	10.22	12.00	13.00	5.26	16.66
Diseased early	26.67	26.66	20.40	18.36	20.80	22.00	21.05	22.23
Diseased middle	40.00	40.82	40.82	51.02	42.38	33.00	60.52	41.66
Diseased advanced	20.00	33.33	20.40	20.40	23.82	35.00	13.17	19.45

Table 10. *Yield and cost benefit analysis of intercropping (Menon and Nayar, 1978)*

Crop(s)	Yield of intercrops (t/ha)	Value of* intercrops (Rs/ha)	Value of* coconut (Rs/ha)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Net return per rupee invested (Rs)
Control (coconut)	—	—	5320	5320	2800	2520	0.90
Coconut + tapioca H 165	15.93	5575	6860	12435	5020	7415	1.47
Coconut + elephant yam	5.36	2680	8260	10940	5050	5890	1.16
Coconut + yam	5.45	2725	8120	10845	5105	5650	1.08

*The values were calculated @ Rs 800/1,000 coconuts, Rs 350/t of tapioca and Rs 550/t of elephant yam and yam.

was only 160 kg/ha. However, upland rice variety Kattamodan was successfully grown as an intercrop in coconut garden at CRS, Pilicode and among the various grain crops tried, rice sown in June was found to be the best (Anonymous, 1942). It gave a grain yield ranging from 423 to 749 kg/ha under coconut compared with 755 to 1208 kg/ha in the open.

Although these trials showed that upland varieties can be grown successfully as intercrops in coconut gardens, the unsatisfactory early growth due to inadequate summer showers resulted in low yields of rice varieties PTB 29 and PTB 30 (Anonymous, 1960). Experiments were conducted at CPCRI, Kasaragod from 1976 to '78 to spot out suitable variety or varieties of upland rice for intercropping in coconut gardens. Three varieties of rice of about 110 days duration, viz., Rohini, Chennellu and Culture 12814 were tried. The yield data are given in Table 11.

Table 11. *Yield of three upland rice varieties as intercrops in coconut garden*

Variety	Yield (kg/ha)			
	1976	1977	1978	Mean
Rohini	1926	1586	1427	1646
Chennellu	1840	1005	849	1231
Culture 12814	1703	1036	1170	1303

Variety Rohini which gave the highest mean yield of 1646 kg/ha of coconut plantation was found to be the most suitable and remunerative. The sowing was done immediately after the onset of the monsoon rains.

Banana

Krishna Marar (1964) reported that banana was popular as an intercrop in Andhra Pradesh, Tamil Nadu and Kerala. In Andhra Pradesh, banana was the most common intercrop in areas where irrigation facilities were adequate. It gave an yield of 1200 to 1300 bunches per ha/with an average net profit of Rs 500-750/ha (Anonymous, 1964). Narayanan and Louis (1965) found that in parts of Tamil Nadu, banana was always grown as a mixed crop in young coconut plantations. Kuttappan (1971) conducted a small survey among the coconut growers having less than one hectare and growing banana as an intercrop, and concluded that up to 1000 banana plants could be raised in one ha of coconut garden, if the density of coconut was restricted to 125 palms/ha. Banana gave a net additional income of Rs 1,000 on an average at the 1971 rates.

Experiments were conducted at CPCRI, Kasaragod to screen and find out the banana varieties best suited for intercropping. Four varieties, viz., Dwarf Cavendish, Grosmichel, Peda Pacha and Nendran were tried. The yield data are presented in Table 12.

The data showed that Grosmichel and Peda Pacha were the highest yielders during 1976, whereas Dwarf Cavendish gave higher yield during 1977. But all the varieties gave very poor yields during the third year, indicating that to get satisfactory yields,

Table 12. *Yield of banana raised as intercrop in coconut garden*

Variety	Weight of fruits per bunch (kg)		
	Plant crop	Ratoon	
	1976	1977	1978
Dwarf Cavendish	5.5	7.1	2.
Grosmichel	10.0	4.7	2.5
Peda Pacha	7.5	6.8	2.0
Nendran	5.2	4.7	—

banana should be replanted after the first ratoon crop.

At Veppankulam, Tamil Nadu, banana varieties Kanchi and Karpooravalli performed well in coconut garden, giving an yield of 11.4 kg of fruits/bunch. But the variety Dwarf Cavendish failed to establish (Anonymous, 1978*b*). Krishnaji et al. (1976) have reported that banana grown as an intercrop in coconut gave a net profit of Rs 2905 per ha and provided an additional employment of 132 man days and 6 woman days per ha per year.

At CRS, Pilicode, banana varieties Robusta, Nendran, Njalipoovan and Palayankodan were grown as a rainfed crop on the laterite gravelly soil (Anonymous, 1979*b*). A randomised block design with five replications was adopted. The yield data are given in Table 13.

Table 13. *Yield of banana varieties as rainfed intercrop*

Banana variety	Mean weight per bunch (kg)	No. of hands per bunch	No. of fingers per bunch
Robusta	6.57	6.9	78.2
Nendran	5.77	5.1	50.0
Njalipoovan	5.31	6.7	90.1
Palayankodan	6.50	9.2	118.7

Source: Kerala Agricultural University, 1979. Research Report for 1977, Vellanikkara, Trichur, India

The yield was low because of the moisture stress experienced during the flowering and fruit maturing stages. It appears that banana as a rainfed intercrop in laterite gravelly soil may not be successful.

Millets

A lot of interest was evinced on the possibilities of raising millets as intercrop in coconut gardens during the thirties. However, in subsequent years, with more and more emphasis on tuber crops and perennials like cacao, nutmeg, pepper, and cinnamon, the interest in millets diminished.

The initial studies at Kasaragod during 1930–31 and 1931–32 showed that ragi was not a profitable intercrop. It gave an yield of only 292 and 236 kg grain per ha respectively, during the above years (Anonymous, 1932).

Elaborate experiments were conducted at the CRS, Pilicode, on the intercropping of millets in coconut gardens. During 1939–40 to 1941–42, intercropping trials were carried out with various millets like *tenai*, *samai*, *ragi*, *cholam*, *kudiravali*, *panivaragu*, *cumbu*, and *varagu* (Anonymous, 1941, 1942 and 1943). These millets were also grown in the open to study their comparative performances. Different dates of sowings were also tried. However, one lacuna in the above studies was that no published information is available regarding the yield of coconut under the different intercrops. The yield data of these crops are summarised in Table 14.

The data presented in the table show that sowing of the various millets at the beginning of the monsoon was more advantageous than sowing late. During 1941–42, sowing in early May and at the beginning of south-west monsoon (last week of May) were successful, but sowing in August first week was a complete failure. Among the millets varagu (*Paspalum scrobiculatum*) seemed to be the best suited for the west coast of India. However, due to the poor market demand from the local population which did not relish this millet, there was little scope for popularising this millet. One interesting point to be noted is that most of these millets gave equal or better yields under coconut compared to their yields in the open. Besides, in most of the cases, the yield of straw was very high

Table 14. *Yield of millets as intercrops in coconut garden and in the open—Pilicode* 1939–40, 1940–41 *and* 1941–42

S.No.	Common name	Scientific name	Cultivar	Time of sowing	Yield of grain kg/ha		Yield of straw kg/ha	
					Under coconut	Open	Under coconut	Open
1.	Ragi	*Eleusine coracana*	EC 593	June 39	750	1275	—	—
				June 40	352	738	1566	2494
				Aug. 40	207	154	557	454
				2 May 41	755	484		
				28 May 41	483	815		
2.	Cumbu	*Pennisetum typhoides*	PT 17	June 39	1148	1102	4727	4909
				June 40	1010	352	5721	4039
				Aug. 40	137	23	1593	1171
				2 May 41	831	161	5724	6025
				28 May 41	438	106	4529	3495
3.	Varagu	*Paspalum scrobiculatum*	PS 1	June 39	1364	2250	3455	5090
				June 40	874	1352	2654	1976
				Aug. 40	716	465	2048	2687
				2 May 41	2220	1389	5121	3309
				28 May 41	906	2094	3204	3615
4.	Samai	*Panicum miliare*	PM 2	June 39	63	800	6727	6909
				June 40	57	148	8122	6852
				Aug. 40	250	397	2184	1957
				2 May 41	412	720	4579	5893
				28 May 41	45	513	3374	5000
5.	Kudiravali	*Echinochloa frumentacea*	PC 29	June 39	108	57	—	—
			PC 49	June 40	102	31	408	77
				Aug. 40	20	20	—	—

ndicating excessive vegetative growth due o the continuous rains received during the nonsoon.

Recently efforts were made to grow ragi as an intercrop in coconut at Thanjavur (Tamil Nadu). However, the two varieties tried EC 4847 and EC 4849 gave very poor yields of 175 and 570 kg of grains/ha (Anonymous, 1978*b*).

Pulses

Since growing pulses have the added advantage of fixing atmospheric nitrogen, trials were conducted from earlier days to grow pulses as intercrops in coconut stands. Experiments carried out at Kasaragod during 1930–31 showed that horse gram, grown as a grain crop, gave a poor yield of 85 kg/ha (Anonymous, 1932). During 1932–33 red gram gave a green matter yield of 1480 kg/ha and was found to be the better green manure crop among the various intercrops tried, viz., red gram, soybean, sunflower and *Crotalaria paniculata* (Anonymous, 1934).

Trials were conducted at CRS, Pilicode with seven pulse crops, viz., black gram, dew gram, green gram, red gram, pillipesara, horse gram and cowpea during 1939–40. Among these, except red gram, all others failed completely. Red gram gave an yield ranging from 133-454 kg/ha (Anonymous, 1941). Its yield in 1940–41 was very poor, i.e. 19-57 kg/ha (Anonymous, 1942).

During 1976–77, experiments were conducted at Regional Coconut Research Station, Arsikere with different pulses, viz., cowpea, horse gram, red gram and green gram. Among these cowpea (Var. C 152 and C 448) and red gram (Hybrid 3C) gave satisfactory yields (Anonymous, 1978*a*). At Veppankulam also the performance of cowpea var. C 152 was encouraging, whereas the other pulses like cowpea var. PLS 370, red gram, black gram, green gram, and soybean (EC 39821) gave very poor yields (Anonymous, 1978*a*).

Experiments were conducted at CPCRI, Kasaragod during the last few years to screen the different pulses and their varieties as intercrops. During 1974 horse gram gave an encouraging yield of 355 kg grain/ha whereas the yield of black gram was poor (72 kg/ha) (Anonymous, 1975).

During 1975 a trial was conducted to find out the proper time of sowing and to evaluate the varieties for intercropping. The results showed that cowpea, var. 779 could be sown during the last week of September as a rainfed crop under normal conditions of rainfall. Soybean var. Davis sown in September second week alone came to harvest. The subsequent sowings dried up before harvest (Anonymous, 1976).

Similar studies were conducted during 1976 also. Trials were conducted with three varieties of cowpea, two varieties of black gram and three varieties of green gram, sown at fortnightly intervals from mid-August. The yield of these crops is presented in Table 15 (Anonymous, 1977).

Another trial was also conducted with seven varieties of red gram sown at fort-

Table 15. *Grain yield of pulses grown as intercrops during* 1976

Crop/variety	Yield at different dates of sowing (kg/ha)	
	16–8–1976	1–9–1976
Cowpea		
779	75	83
New Era	300	267
Kunnamkulam	500	467
Green gram		
Philippines	—	—
PS 7	117	67
PS 16	300	250
Black gram		
S1	58	58
T9	317	233

nightly intervals at CPCRI, Kasaragod during 1976. Late August or early September sowing appeared to be the best.

The results of the various experiments presented so far indicated that pulse crops were best sown immediately after the heavy rains i.e. second fortnight of August. Some of the pulses like cowpea appear to be promising intercrops. However, further trials are required before any final conclusion is drawn and valid recommendations are made. Though the legumes are known to enrich the soil by fixing atmospheric nitrogen, information on the influence of intercropping with pulses on soil fertility status is scanty.

Oilseeds

Though India has achieved a spectacular increase in the production and productivity of cereals, the production of oilseed crops is unable to keep pace with the increasing demand for vegetable oil. Intercropping with oilseed crops like groundnut in coconut gardens offer excellent possibilities in this regard.

Trials were conducted at Kasaragod and Pilicode during the thirties and early forties for finding out the suitable oilseed crops and their varieties for intercropping in coconut plantations. These trials were confined to three popular annual oilseed crops, viz., groundnut, gingelly and castor.

Among these, efforts to grow castor proved unsuccessful both at Kasaragod and Pilicode probably because the crop varieties were not tolerant to shade (Anonymous, 1934; and 1941).

Gingelly proved only partially successful. The crop grew fairly well and gave moderate yields. It yielded 97 kg/ha in August sowing and 278 kg/ha in June sowing during 1940–41.

Successful growing of groundnut as an intercrop in coconut gardens was reported by Sahasranaman (1964) and Kannan and Nambiar (1976). The studies carried out on intercropping with groundnut in coconut garden reveal some interesting information.

During 1930–31 groundnut, raised as an intercrop in coconut at Kasaragod grew up well. However, it was ploughed in during October, because it was thought that the crop will deplete the soil moisture and will have an adverse effect on coconut palms if kept longer (Anonymous, 1932). Groundnut was raised as intercrop at Pilicode during 1939–42 and gave yields ranging from very low yields to very good yield of 1364 kg/ha. These results established that groundnut can be successfully grown, if sown during the first fortnight of May and then adequately managed.

Sahasranaman (1964) reported that groundnut var. TMV 2 when grown as an intercrop in coconut garden at CPCRI Regional Station, Kayangulam yielded 600 kg/ha and gave an additional net profit of Rs 183/ha (at 1964 prices). Besides it helped to suppress the weed growth and kept the soil in good tilth for a major part of the year.

Kannan and Nambiar (1976) reported that groundnut, grown as an intercrop, increased the yield of main crop of coconut from 59 nuts/palm/year in the pre-treatment period to 60.5 nuts/palm/year during the treatment period. It gave an yield of 965 kg pods/ha resulting in an additional net profit of Rs 455/ha. Besides, it provided employment to the tune of 75 man days and 90 woman days per season.

Leela and Bhaskaran (1978) reported the results of intercropping studies with groundnut in coconut gardens. Groundnut variety TMV 2 was grown in a garden of middle aged palms in the red sandy loam soil of CRS, Nileshwar during May-September for two years ,viz., 1972 and 1973. The recommended package of practices were followed.

Groundnut gave an yield of 1326 kg of pods and 1448 kg of haulms per ha of

coconut garden. Projecting this yield on the basis of effective land occupation of 72%, the sole crop yield worked out to 1842 kg/ha. This was as good as the yield of a good sole crop of groundnut in the open under rainfed condition.

Besides, intercropping with groundnut helped to skip certain operations for the main crop of coconut like two ploughings during May and September, and liming. When the cost of these operations are added to the returns from groundnut, the net additional returns work out to Rs 2773 per ha.

In addition, weed growth was suppressed by 61% in the intercropped area. It was more pronounced on monocot weeds (85.2%) than on dicot weeds (33.0%).

Leela and Bhaskaran (1978) have also carried out studies on the nutritional status of the soil in plots with and without intercrop (Table 16).

Table 16. *Post-treatment nutritional status of soil and weed growth in plots with and without intercropping (Leela and Bhaskaran, 1978)*

Nutrient element	With intercrop (ppm)	Without intercrop (ppm)
N	815	645
P	571	419
K	378	318
Ca	601	518
Type of weed	Weed growth Dry matter (kg/ha)	
Dicot	485	724
Monocot	125	845
Total	610	1569

The data clearly showed that intercropping with groundnut resulted in the higher availability of the nutrients in soil. This could be attributed to the fixation of atmospheric nitrogen by groundnut and addition of organic matter to the soil which facilitate greater microbial activity.

Thus, growing groundnut as an intercrop in coconut stand was not only highly remunerative but also had beneficial effects on the productivity of coconut and fertility of soil.

During 1973 sunflower was grown as intercrop in coconut at CPCRI, Kasaragod. Though the early growth was satisfactory, rain water dripping from coconut leaves affected their performance (Anonymous, 1974).

Other crops

In an observational trial to find out the comparative performance of pineapple (Kew) as an intercrop with and without summer irrigation at CPCRI, Kasaragod, the number of fruits harvested per unit area and the weight of fruits was considerably higher in the irrigated crop. In the irrigated plot, 33% of the plants gave fruits, with a mean weight of 1.54 kg. The fruiting was less than 1% and the mean fruit weight was 0.71 kg in the rainfed crop (Anonymous, 1979*a*).

In experiments conducted at Regional Coconut Research Station, Arsikere, raising potato (Chandramuki) during the monsoon season, followed by chilli gave the highest net income of Rs 5,300/ha even though the yield of potato was lower than the normal yield. Hybrid maize followed by bengal gram gave a net income of Rs 3,855/ha. In another experiment at the same place, soybean+wheat and groundnut+wheat sequences gave high net incomes of Rs 2,600 and Rs 2,450 per ha, respectively (Anonymous, 1978*b*).

Sahasranaman (1961) reported that chilli was a profitable intercrop in coconut gardens.

A net income of Rs 100 per ha at the then prevailing price was obtained.

Sethi (1963) suggested that Andrews variety of sea island cotton could be grown as an intercrop in coconut gardens.

Sen (1956) reported that arrow root often grew wild in coconut gardens of West Bengal. He opined that with little more care, it could be made a source of profit to coconut growers.

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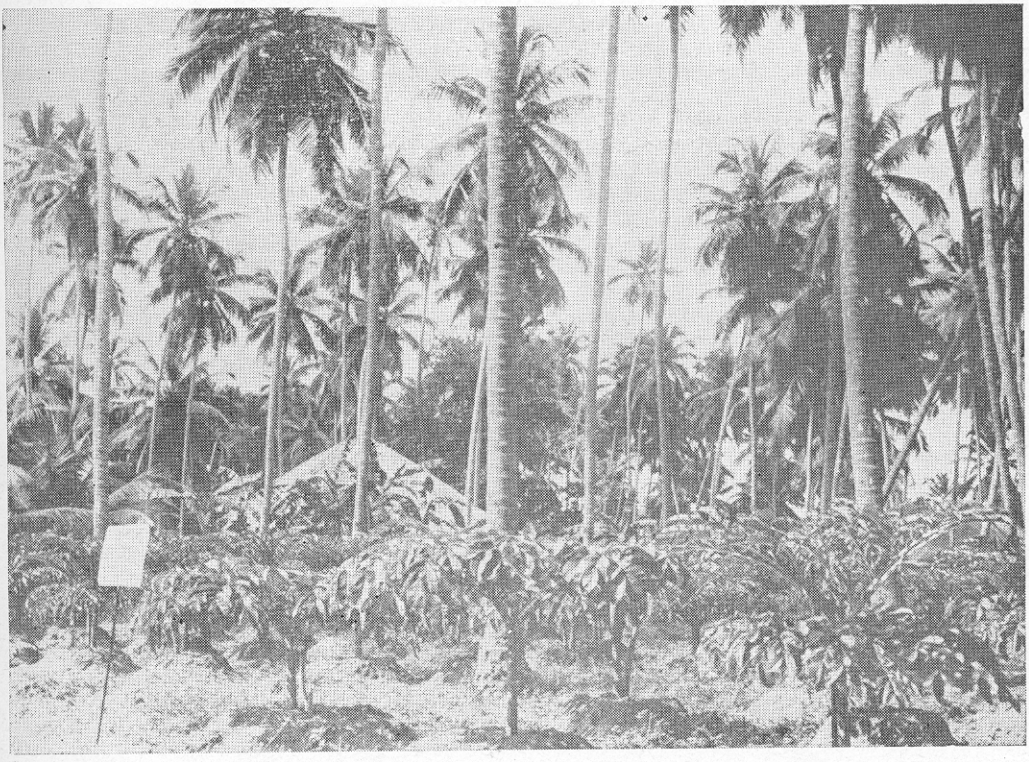
Tapioca intercropped in coconut garden



Elephant yam intercropped in coconut garden