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EXPERIENCES IN COCONUT BASED FARMING SYSTEMS IN INDIA

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ABSTRACT

A sole crop of coconut, at the recommended spacing of 7.5 × 7.5 m does not fully utilise the available soil and air space and incident solar radiation. Crops identified as compatible ones with coconut include many tuber crops (cassava, elephant foot yam, yams, colocasia), rhizome-spices (ginger, turmeric), pulses (cowpea), oilseeds (groundnut, soybean), upland rice, fruit crops (banana, pineapple) and vegetables among the annuals and cocoa, black pepper, clove and nutmeg among perennials. Many intensive crop combinations which involve different annuals and perennials over a period of time such as multistoreyed cropping system and high density multispecies crop models have also been developed. Mixed farming systems, which integrate other enterprises like dairying and sericulture provide higher employment generation and enhanced net income. Among the annual crops, elephant foot yam and ginger are the most profitable. The additional employment generated ranged from 76 to 900 mandays/ha/year in different systems.

INTRODUCTION

Coconut is mostly a crop of small farmers in India, the average size of a holding being 0.22 ha. More than 90 per cent of the five million coconut holdings in the country are less than one ha in size (Thampan, 1988). These small holdings neither provide gainful employment opportunities for the family labour throughout the year nor generate sufficient income to meet the family requirements. The possibilities of increasing the productivity and net returns from coconut stands by introducing compatible subsidiary crops and integrating livestock are discussed in this paper.

Scope for Multiple Cropping in Coconut

A spacing of 7.5 × 7.5 m is recommended for field planting of coconut (175 palms/ha) but in the homestead gardens of Kerala, the density is much higher (200 to 250 palms/ha) whereas in the *malnad* region of Karnataka state much wider spacings are adopted with densities as low as 120 palms/ha. Experimental evidences have shown that a sole crop of coconut, at the recommended spacing of 7.5 × 7.5 m does not fully utilise the available resources.

Coconut palm like all monocots has a typical adventitious root system. Under favourable conditions, as many as 4000 to 7000 roots are found in middle-aged palms. Kushwah *et al.* (1973) reported that about 74 per cent of the roots produced by a palm under good management did not go beyond 2 m lateral distance and 82 per cent of the roots were confined to the 31 to 120 cm depth of soil. Recent studies have confirmed that more than 80 per cent of the root activity was confined to a lateral distance of 2 m from the trunk (Anil Kumar and Wahid, 1988). Thus the active root zone of coconut utilises only 25 per cent of the available land area and the remaining area could be profitably exploited by raising subsidiary crops.

The venetian structure of the coconut crown and the orientation of leaves allow part of the incident solar radiation to pass through the canopy and fall on the ground. The apparent coverage of ground and shade cast by the canopy, and the magnitude of radiation transmitted through the canopy vary according to the age of palms as shown in Fig. 48.1 (Nelliat *et al.*, 1974). Besides age, spacing, soil fertility, varietal characteristics and time of the day also influence the light penetration. The life span of coconut palms may be divided into three phases, namely, pre-bearing trees up to eight years (good light transmission,

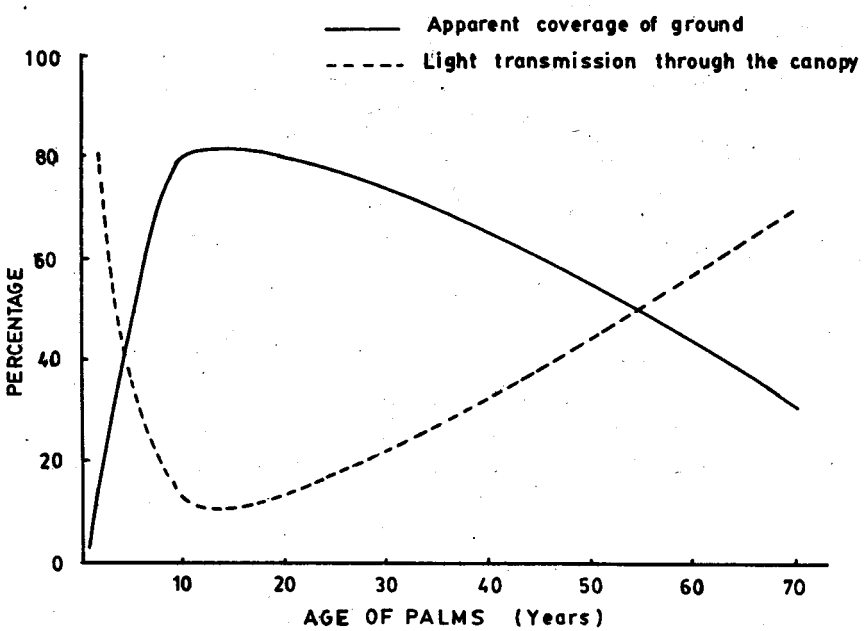

Fig.48.1: Light transmission through coconut canopies of various age groups (Nelliat *et al.*, 1974).

but decreasing with age), young palms of eight to 25 years (poor light transmission) and mature trees aged over 25 years (light transmission increasing with age) (Nair, 1979). Nair and Balakrishnan (1976) estimated that as much as 56 per cent of the sunlight was transmitted through the canopy during the peak hours (10 to 16 hours) in palms aged around 25 years. The diffused sunlight facilitates growing a number of shade tolerant crops in the interspaces.

Coconut Based Cropping Systems Research in India

Research on intercropping in coconut gardens was initiated during the thirties, and was intensified in the seventies with the establishment of the Central Plantation Crops Research Institute at Kasaragod. It received further impetus with the launching of the All India Coordinated Coconut and Arecanut Improvement Project in 1972 and establishment of centres in different coconut growing states. At present, research is in progress at Kayangulam, Pilicode, Kasaragod (all in Kerala), Goa and Ratnagiri (Maharashtra) along the West Coast, Veppankulam (Tamil Nadu) and Ambajipeta (Andhra Pradesh) in the East Coast and Arsikere (interior Karnataka) besides Sipighat in the Andaman Islands.

Cropping Systems

Coconut based cropping systems involving annuals, perennials and combinations of both annuals and perennials have been developed to suit the availability of resources like labour, rainfall and irrigation facilities, finance, soil characteristics and the farmers' needs and market demands. The crops found suitable for raising as subsidiary crops in coconut gardens include tuber crops (cassava, elephant foot yam, yams, colocasia, Chinese potato), rhizome spices (ginger and turmeric), cereals (upland rice), pulses (cowpea), oilseeds (groundnut and soybean), fruit crops (banana and pineapple) and vegetables (snake gourd, bottlegourd, amaranthus and brinjal) among the annuals and beverage crops (cocoa) and spices (clove, nutmeg and black pepper) among the perennials.

ANNUALS

a) Tubers and Rhizomatous Spices

Tropical tubers like cassava and elephant foot yam and rhizomatous spices like turmeric and ginger are the most popular intercrops raised in coconut gardens. The tuber crops partially meet the food requirements of a farm family and almost always find a place in the homestead gardens of Kerala. The productivity of tuber crops and rhizomatous spices raised as intercrops in coconut in different centres in Kerala is summarised in Table 48.1.

b) Millets and Cereals

Experiments conducted at Pilicode (Kerala) during the late thirties and early forties have shown that millets like *varagu* (*Paspalam scrobiculatum*), pearl millet (*Pennisetum typhoides*) and finger millet (*Eleusine coracana*) performed well as intercrops in coconut garden, when sowing was taken up at the

beginning of the south-west monsoon season. However, due to lack of demand, these crops are not grown at present (Gopalasundaram and Nelliat, 1979). Among the three varieties of upland rice (Rohini, Chennellu and Culture 12814) tried, Rohini recorded the highest yield of 1946 kg/ha at Kasaragod.

Table 48.1: Productivity (t/ha) of tubers and rhizomatous spices raised as intercrops

Crops	*Locations*		
	Kasaragod	*Kayangulam*	*Pilicode*
Cassava (*Manihot esculenta*)	14.8	15.9	13.8
Elephant foot yam (*Amorphophallus companulatus*)	13.5	5.4	5.2
Greater yam (*Dioscorea alata*)	13.6	5.5	–
Lesser yam (*D. esculenta*)	9.3	–	–
Sweet potato (*Ipomea batatas*)	8.4	–	–
Colocasia (*Colocasia esculenta*)	9.2	–	–
Ginger (*Zingiber officinale*)	8.6	–	2.4
Turmeric (*Curcuma longa*)	10.9	–	4.4

Source: Menon and Nayar, 1978; Nambiar *et al.*, 1988; CPCRI unpublished data.

c) Pulses

Many pulses like green gram, black gram, red gram, horse gram and cowpea have been tried as intercrops at different areas and among them, cowpea performed better as a rainfed crop yielding 300 to 500 kg/ha (Gopalasundaram and Nelliat, 1979). Further studies are necessary to identify suitable varieties and standardise the agro-techniques.

d) Oilseeds

Groundnut and soybean have been reported to be compatible intercrops with coconut. At Pilicode the groundnut variety TMV-2, yielded as much as 1326 kg pods and 1448 kg haulms/ha and was highly profitable (Leela and Bhaskaran, 1978). Recent studies at Kasaragod have shown that soybean can be successfully grown as an intercrop during the post-rainy period under irrigated conditions. The variety PK-472 had recorded the highest yield of 980 kg/ha (Hegde and Yusuf, 1992).

e) Vegetables

Only limited work has been done on intercropping vegetables in coconut gardens. Raising of chillies, potato and french beans was found to be a profitable practice in *maidan* areas of Karnataka (Rethinam, 1989). Recent experiments at Kasaragod have indicated the suitability of vegetables like snake gourd, bottle gourd, amaranthus, coccinia and bitter gourd as compatible crops with coconut.

f) Fruit Crops

Banana is a highly profitable intercrop in coconut gardens, which is very popular in areas with good irrigation facilities. Reddy *et al.* (1980) reported

that in Godavari delta of Andhra Pradesh, banana was the best intercrop with complementary effect on coconut yield. At Veppankulam (Tamil Nadu), banana as an intercrop recorded a mean yield of 6 kg/bunch and the additional net profit obtained was Rs. 5,748/ha (Ramanathan, 1985). In Kerala, Palayamkodan, Robusta, BB Batheesa, Karpooravally and Poovan were identified as suitable varieties for intercropping (Nambiar *et al.*, 1988; Suma *et al.*, 1989) and gave mean yields ranging from 8 to 12.8 kg/bunch.

Pineapple also performs well in the partially shaded conditions of coconut gardens. At Kasaragod, a mean yield of 1.54 kg/fruit was recorded. However, pineapple requires irrigation during the dry period for its successful cultivation.

Perennials

A number of perennials like cocoa, clove, nutmeg, pepper, jack, breadfruit, mango and timber yielding trees are often raised as mixed crops in coconut plantation (Nelliat *et al.*, 1979). However, productivity of such a system is low due to improper selection of companion crops and adoption of unscientific management practices.

Cocoa has been identified as an ideal mixed crop with coconut. Experiments conducted at Kasaragod and Pilicode since 1970 have proved beyond doubt the profitability of growing cocoa as a mixed crop in coconut. Comparison of the performance of cocoa raised in single hedge and double hedge systems in a coconut garden, planted at the recommended spacing of 7.5 × 7.5 m has shown that even though the productivity of cocoa per ha was slightly high in the double hedge system, single hedge system was more desirable. The productivity of coconut was also improved when cocoa was grown as a mixed crop (Table 48.2).

Table 48.2: Productivity of coconut and cocoa in the coconut-cocoa mixed cropping experiment at Kasaragod

Cropping system	*Coconut (nuts/palm/year)*		*Cocoa (pods/year) (1974–'88)*	
	Pre-experimental (1966–'70)	*Experimental period (1972–'87)*	*Per plant*	*Per ha*
Coconut-sole crop	68.0	106.6	–	–
Coconut + cocoa single hedge	56.7	108.3	32.3	11,270
Coconut + cocoa double hedge	39.1	88.5	19.3	12,545

The experiment conducted at Pilicode in a 50-year old WCT coconut plantation spaced at 9 × 9 m from 1970 to 1983 has shown that the productivity of coconut was not affected by mixed cropping with cocoa. Under this wider spacing 9 × 9 m for coconut, the double hedge system of raising cocoa was found to be superior, yielding 378 kg dry beans/ha/year (1976 to 1983) as against 165 kg in the single hedge system (Nambiar *et al.*, 1988). The net returns

from cocoa were estimated to be Rs. 2,542 and Rs. 5,880/ha under the single and double hedge systems, respectively.

Perennial spice crops like clove, nutmeg and pepper (trained on coconut and on live standards) are also popular mixed crops. Potty *et al.* (1979b) evaluated the performance of six varieties of pepper in the multistoreyed cropping system and suggested that Karimunda and Panniyur-I perform better under mixed cropping situations.

Multistoreyed Cropping Systems

This is an intensive four crop combination which includes coconut, black pepper (trained on coconut trunk), cocoa and pineapple. The system requires irrigation during the summer months and ensures efficient foraging of soil without undue competition between component crops and intercepts solar radiation at different heights. Pineapple performs well in such a system in the initial five or six years and will have to be removed once cocoa develops its full canopy. The productivity of crops in the multistoreyed cropping system at Kasaragod is given in Table 48.3.

Table 48.3: Yield of crops in the multistoreyed cropping system

Crops	*Coconut + cocoa SH* + pepper + pineapple*	*Coconut + cocoa DH* + pepper + pineapple*
Coconut (nuts/palm/year)		
(i) Pre-experimental period	45.2	38.3
(ii) Experimental period	104.5	88.8
Cocoa (pods/plant/year)	32.3	25.6
Pepper (kg/vine/year)	0.64	0.42

* SH—single hedge; DH— double hedge.

High Density Multi-species Cropping Systems

High density multi-species cropping systems, involve growing a large number of crops to meet the diverse needs of the farmer such as food, fuel, timber, fodder and cash, and are ideally suited for smaller units of land and aim at maximum production per unit area of land, time and inputs with minimum or no deterioration of land (Bavappa and Jacob, 1982). Such a system was established at Kasaragod in 1.2 ha of an 18-year-old coconut plantation spaced 8 × 8 m during 1983. The system included 17 crops (mango, bread fruit, jack, nutmeg, clove, *sapota*, acid lime, guava, pepper, *ipil-ipil*, banana, papaya, coffee (San Ramon), elephant foot yam, colocasia and cassava) in addition to coconut and the population was increased to 13,030 plants/ha.

The annual crops (except banana) were withdrawn from the system in stages as the perennials grew and utilised more and more space and sunlight. Some perennials like lime, *sapota*, mango, guava, pepper, *ipil-ipil*, papaya and coffee were also withdrawn from the system as their performance was not satisfactory.

The experimental area was divided into three plots and one-third, two-third and full dose of recommended levels of fertilisers are being applied for

each crop. The mean yield of coconut and other crops during the past few years were comparable (Table 48.4) under different levels of manuring indicating scope for reducing the fertiliser input.

Table 48.4: Mean yield of crops in coconut based high density multi-species cropping system at Kasaragod (1985–86 to 1989–90)

Crops	*Produce and unit*	*Fertiliser levels*		
		One-third	*Two-third*	*Full*
Coconut	nuts/ha/year	23634	23166	23010
Pineapple	fruits (kg/ha/year)	2676	2509	2765
Banana	bunches (kg/ha/year)	1194	1425	1465

Coconut Based Mixed Farming Systems

Coconut offers considerable scope for raising shade tolerant forage crops in the interspaces and integrating animal enterprises. Fodder grasses like hybrid napier (Pusa Giant and NB 21), Guinea grass and Guatemala grass yield about 50 to 60 t green fodder/ha/year under coconut shade (Jacob Mathew and Shaffee, 1977), which is sufficient to maintain five cross-bred milch cows. Among the legumes, Brazilean lucerne and cowpea perform well yielding about 30 t/ha (Sahasranaman and Pillai, 1976).

A family model mixed farming unit was maintained at CPCRI, Kasaragod from 1972 to 1988. Fodder crops were raised in 1.04 ha of a 60-year old coconut garden, pepper was trained on coconut trunk and intercrops like banana, cassava and vegetables were raised along the borders and field bunds. Five cross-bred Jersey cows were given to the family and a biogas plant was also erected. The cow dung slurry from the gas plant and urine were recycled within the experimental area. The output from one ha of the model is furnished in Table 48.5. This system generated maximum employment opportunities.

Table 48.5: Mean annual output from one ha of mixed farming unit

Items	*Output*	
Coconut	11,270	Nos.
Milk	7,089	l
Pepper	80	kg
Banana	250	kg
Beef (estimated)	350	kg
Biogas	2.8–3.5	m^3/day
* Dung	14.6	t
* Urine	3600	l

* Recycled within the system.

Coconut Based Sericulture

In *maidan* areas of Karnataka state, where coconuts are generally grown at a wider spacing of 9 × 9 m or more, growing of mulberry as a mixed crop and

silk worm rearing is very popular. Shanthamallaiah *et al.* (1985) reported that sericulture yielded about 420 kg of silk worm cocoons/ha of coconut garden/ year. In addition, the yield of sole crop of coconut was also increased to 85 nuts from 76 nuts/palm/year. The net income was more than trebled and employment potential doubled.

Complementary Interactions in Coconut Based Cropping Systems

Experiments conducted during the last two decades have indicated many complementary interactions between component crops in the systems. The beneficial effects include improvement in soil fertility status, enhanced microbial activity, higher interception of light, better micro-climate and reduced weed growth which helped to achieve higher productivity.

Cocoa raised as mixed crop in coconut adds considerable quantity of organic matter to the soil. A five-year-old cocoa crop in the system through its shed leaves and prunings, was estimated to add 818 and 1985 kg dry matter (oven dry weight)/ha/year, respectively in single and double hedge systems. This helps in recycling of plant nutrients, besides improving soil organic carbon status (Varghese *et al.*, 1978b). Nair and Rao (1977a) reported that activity of nitrogen fixers like *Beijerinckia*, phosphate solubilisers like *Pseudomonas* sp. and *Aspergillus niger*, and *Escherichia* sp., *A. flavus* and *A. fumigatus* which produce growth promoting substances was much higher in coconut-cocoa mixed stands compared to coconut monocrop stands. The available phosphorus content of rhizosphere soil was found to be 65 ppm in coconut + cocoa double hedge, 41 ppm when cocoa was grown in single hedge, compared to 20 ppm in coconut sole crop (Nair and Rao, 1977b). Leela and Bhaskaran (1978) also observed improvement in soil available N, P, K and Ca status of coconut intercropped with groundnut.

The micro-climate inside a mixed crop system was characterised by lower maximum temperature, smaller diurnal variation and less evaporative demand compared to pure crop stands (Nair and Balakrishnan, 1977). Raising groundnut as an intercrop, suppressed weed growth in coconut plantations and maintained good tilth for the major part of the year (Sahasranaman, 1964; Leela and Bhaskaran, 1978).

Management of the Systems

The success or failure of a coconut based farming system is often decided by the choice of the system components, based on the availability of light, age of coconut palms and their spacing, soil type, climatic conditions, moisture availability, irrigation facilities, canopy architecture and light requirements of subsidiary crops and market demand. Lalitha Bai and Nair (1982) studied the shade response of different intercrops and classified sweet potato as shade sensitive, coleus and colocasia as shade tolerant and ginger and turmeric as shade loving. Attempts have also been made to identify varieties suitable for multiple cropping situations in crops like banana, citrus, pepper and turmeric (Valsamma *et al.*, 1987; Potty *et al.*, 1979a; Suma *et al.*, 1989). Varghese *et al.*

(1978a) indicated the need for crop rotation among the annual intercrops and application of adequate fertilizers for both the main crop of coconut and the intercrops to maintain the productivity of the system. It is also necessary to maintain the population of companion crops at optimum levels by proper placement of the subsidiary crops, especially perennials besides canopy management by pruning etc.

Economics

Adoption of any system by the farming community will ultimately be decided by its economic advantages. The monocrop of coconut provides employment opportunities for only around 150 mandays/ha/year and gives a net income of Rs. 10,400/ha. The various systems that have been developed and discussed in this paper generate additional employment to the tune of 130 to 606 mandays/ha/year and the estimated net returns range from Rs. 18,670 in the case of coconut + cassava system to Rs. 50,000/ha in coconut based mixed farming (Table 48.6).

Table 48.6: Economics and employment potential of coconut based farming systems

Systems	*Net returns (Rs/ha/year)*	*Additional employment (mandays/ha/year)*
Coconut – sole crop	10,400	–
Coconut + cassava	18,670	130
Coconut + elephant foot yam	20,940	131
Coconut + ginger	36,590	500
Coconut + banana*	25,675	NA
Coconut + cocoa*	24,600	NA
Coconut + clove*	38,500	NA
Multistoreyed cropping system*	30,300	191
Coconut based mixed farming*	50,000	600

NA = Not available.
* = under irrigated conditions.

FUTURE THRUST

Based on the results of research conducted during the past few decades, many new cropping and farming systems have been developed and management practices also formulated. Future research activities will mainly concentrate on the following aspects:

i) Work on the screening of new crops and crop varieties needs to be continued for developing new models. In addition, research on breeding of crop varieties specially suited for inter/mixed cropping situations should be initiated.

ii) Many new crop models have been planted in suitable agroclimatic regions of the country based on the experience gained so far. Evaluation of these models and newer ones will continue to select the best ones.

iii) Systematic studies on rooting pattern, canopy architecture, light profile, nutrient enrichment and depletion processes, microbial activity, soil moisture utilisation pattern and microclimate will be taken up.

iv) Attempts will be made to develop suitable computerised system analysis models by integrating the information collected on different aspects with a view to developing appropriate management practices for the system as a whole rather than for the individual components of the system.

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