



Integrated Cropping in Coconut Involving Spice Crops

The world looks upon India as the source of spices for their consistent supply. Spices like nutmeg, clove, cinnamon, all spices, garcinia, cardamom, black pepper, ginger, turmeric and vanilla are the ideal crops for cultivating in the interspaces in coconut garden. To reduce the cost of production and to increase the productivity, raising of compatible spice crops as subsidiary crops is essential in coconut garden. The scientists of KAU explain the viability and profitability of spice crops as inter crops in coconut garden.

Introduction

In India, coconut is cultivated in about 19,10,000 ha mainly in southern states of Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. In Kerala, average size of holding is as low as 0.22 ha (Thampan, 1998). Coconut based cropping systems are practiced in India, particularly in Kerala and Karnataka from time immemorial. However, the traditional models practiced by the farmers are not systematic and scientific in selection and arrangement of crops (Rethinam, 1990). Research on coconut based cropping system was initiated during thirties and intensified in the seventies with the establishment of CPCRI at Kasaragod and All India Co-ordinated Research Programme on Palms with centres in different coconut growing states.

A spacing of 7.5 m in the square system is recommended for coconut for optimum production. 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 31-120 cm depth of soil. Subsequent studies further confirmed that more than 80 per cent of



Vanilla

Resource use in coconut

Coconut which occupies the land continuously for several decades, utilizes the natural resources only to a very limited extent producing less than 10 per cent of the potential for dry matter production in the tropics (Nelliath *et al.*, 1974).

the root activity is confined to a lateral distance of 2 m from the trunk (Kumar and Wahid, 1988). The active root zone of coconut is confined to 25 per cent of the available land area and the remaining area could be profitably exploited for raising subsidiary crops.

The venation and structure of coconut crown and orientation of leaves allow part of the incident solar radiation to pass through the canopy and fall on the ground. The non-random distribution of leaves lead to low extension coefficient of around 0.65 for Photosynthetic Active Radiation (PAR). Age, spacing, soil fertility, varietal characterization, leaf area and time of the day influence light penetration through the canopy. Nair and Balakrishnan (1976) estimated that as much as 56 per cent of sun light is transmitted through the canopy during peak hours (10-16 h) in palms aged around 25 years. The diffused sunlight facilitates growing of a number of shade tolerant crops in the interspace.

Based on growth habit of the palm and the amount of light transmitted through its canopy, the life span of coconut palm could be divided into three distinct phases from the point of view of intercropping (Nair, 1979).

1. Planting till full development of canopy (about 8 years) : Good transmission initially, but decreasing with age; suitable for growing annuals/biennials; intercrops have minimal competition with coconut palm for ecological factors.
2. Young palms (8-25 years) : Maximum ground coverage (80 %) and low canopy due to shorter trunk; poor light availability; not suitable for growing any other crops in the interspace.
3. Adult palms (above 25 years) : Gradual increase in the magnitude of light penetration to the ground, decrease in apparent ground coverage of canopy; taller trunk; ideal for raising annual or perennial crops.

Factors influencing cropping systems

On a regional basis, intercropping patterns, their intensity and species



combination in non-irrigated areas are determined by the duration and amount of rainfall. Sandy loam soil, all along the coastal belt of East and West Coast of the Peninsular India offers good scope for multistoreyed cropping. Depending on the cropping system viz. intercropping, mixed cropping, multistoreyed cropping, high density multispecies cropping system (HDMCS) and mixed farming, crops are selected.

Suitability of intercrops for coconut garden

Intercropping experiments conducted in India proved that cereals, pulses, oilseeds, root crops, pasture legume grass, vegetables, beverage crops like cocoa, spice crops like clove, nutmeg, cinnamon, pepper, cardamom, vanilla, ginger and turmeric and fruit crops like banana, pineapple, papaya, lime, jack, mango, sapota and guava are suitable subsidiary crops.

Spices as intercrops

Spices like black pepper, cardamom, vanilla, ginger and turmeric and tree spices like nutmeg, clove, cinnamon, allspice and garcinia are ideal crops for growing in the coconut garden.

Black pepper

Black pepper is an ideal mixed crop in the third phase of growth of coconut palm i.e. 20-25 years onwards. By this time, coconut palm attains a height of about 6 m when 55 per cent of light is available below the palm canopy.

The improved varieties emerging from breeding programmes are to be tested as mixed crop in coconut gardens from time to time to find out the best variety suitable for growing under coconut shade. Potty *et al.* (1979) evaluated the performance of six varieties of pepper in the multistoreyed cropping system and suggested that Karimunda and Panniyur 1 perform better. CPCRI has initiated field screening trials of the latest pepper varieties/hybrids as mixed crops in coconut garden.

Black pepper requires a warm humid climate and a light porous, well drained soil, rich in organic matter. Cultivate only varieties/cultivars which are proven to be highly productive. Planting of standards is to be taken up in April - May with the onset of pre-monsoon showers. Murukku (*Erythrina indica*), Karayam or Killingil (*Garuga pinnata*), Matti (*Ailanthus* sp.) etc. are suitable standards for growing pepper. In high altitude areas, Dadap (*Erythrina lithosperma*) and Silver oak (*Grevelia robusta*) are ideal standards. Pits are prepared on the northern side of standards/coconuts. The pit size should be 50x50x50 cm. Fill the pits with a mixture of top soil and compost or well rotten cattle manure @ 5 kg/pit. With the onset of southwest monsoon in June-July, plant 2-3 rooted cuttings at a distance of 30 cm or 1 m away from the standard or coconut respectively. Growing portions of the cuttings are to be trailed and tied to the tree trunk. In the initial years, vines are to be covered with dry leaves and mulched during summer months. Both crops are to be adequately manured to prevent competition for nutrients between crops. Pepper has 10-12 adventitious roots, which grow to a length of 3-4 m and penetrate to a depth of 1-2 m with an extensive mat of surface feeding roots. Care should be taken not to damage these surface roots while doing cultural operations for coconut and fertilizer application. Manuring is done in basins taken around the plant 10-15 cm deep and 50-75 cm radius depending upon the growth of plants. Apply cattle manure/compost/green leaves at the rate of 10 kg/plant/year just at the onset of monsoon and cover lightly with soil. It is desirable to apply lime at the rate of 500g/vine in April-May with receipt of pre-monsoon showers in alternate years. The general recommendation for nutrients of pepper (3 years above) is NPK 50:50:150g/vine/year. Apply 1/3rd dose for one year old plants. The fertilizers may be applied in two split doses first in May-June and the second in August-September.

Pepper is a climbing vine and usually grows as tall as coconut. But the height of pepper vine is to be restricted to 6 m by pruning. This helps in harvesting of coconuts without damaging pepper vines on the trunk.

Pepper begins to yield in the 3rd year and comes to full bearing by 7th or 8th year. The yield declines after 15 years but gives satisfactorily yield even upto 60 years under good management practices (Reddy *et al.*, 2002).

In an experiment conducted at Coconut Research Station, Bhatye, Ratnagiri, during 1979 to 1998, where pepper vines trained on glyricidia were grown as intercrop, the yield of coconut was increased by 23.59 per cent (Nagawekar *et al.*, 2002). Average net profit/ha for four years was Rs. 39,398 whereas the monocrop of coconut gave a net profit of Rs. 30475.

Venkitaswamy (2002) in his studies on mixed cropping of black pepper in coconut in Pollachi tract of Tamil Nadu, reported that varieties Panniyur 1, 2 and 5 established well as mixed crops.

Black pepper is a successful component of multistoreyed cropping system in which crops having canopies of varying heights are chosen. The most profitable multistoreyed system with coconut as main crop established at CPCRI, Kasaragod had black pepper, cocoa and pineapple as component crops.

Cardamom

Shade loving crops like cardamom is found as the most suitable intercrop in coconut plantations in high ranges (500 m above MSL) (Korikanthimath *et al.*, 1998). It offers great scope as a mixed crop in coconut plantations which provide an overhead shade most essential for survival and better productivity. Field experiments conducted at Sirsi, Karnataka (600 m above MSL) by introducing cardamom as a mixed crop in 10 years old coconut garden spaced at 7.5 m x 7.5 m wherein



cardamom was introduced at spacing of 1.5 m x 1.5 m had a total plant density of 175/ha coconut and 4266/ha cardamom.

In areas with 'Katte' disease, seedlings are recommended for planting and in other areas, single shoot suckers are the ideal planting material. Pits are dug at the recommended spacing (1.5 - 2.0 m or cv. Malabar and 2 m for cv. Mysore and Vashukka) The recommended size of pit is 60 x 60 x 35 cm. The pits are filled with rich top soil at least two months in advance of planting the seedlings. Application of well decomposed FYM or compost or leaf mould and 100 g of rock phosphate with the top soil in the pit will help in better establishment of plants. Planting should be done with the commencement of southwest monsoon, before the heavy rains. A small mound may be formed inside the pit for planting the seedling/sucker. Only shallow planting should be done and the suckers

Sufficient mulch should be applied at the base of the plant during December to tide over summer. Trashing (removal of old and dried shoots, leaves and dried panicles) should be taken up once in a year during the month of June-July, with the onset of monsoon. The present recommendation of nutrients for cardamom is NPK @ 75:75:150 kg/ ha. The fertilizers may be applied in two splits before and after the southwest monsoon, in a circular band 20 cm wide at 30-40 cm away the base of the clump and incorporated with the soil.

Since the introduction of cardamom, coconut yield showed an increasing trend (Table 1). Cardamom started bearing in 1992-93 with 12.5 kg/ha, thereafter it increased to 525 kg/ha.

The low yield during 1995-96 (150 kg/ha) was due to natural phenomenon seen in cardamom i.e. bumper yield succeeds lower yield in the next season. It is clear from the data furnished in

Vanilla

In recent times, vanilla cultivation is gaining importance as one of the intercropping components under HDMCS in coconut plantations. Most of the spice growers are interested to grow vanilla as intercrop in coconut plantations. Being a shade loving crop, vanilla can be successfully introduced as an intercropping component in coconut plantations in the southern states like Tamil Nadu, Kerala and Karnataka.

Coconut plantations of age between 8-40 years old offer favourable shade requirement of 50-60 per cent whereas introduction of vanilla to coconut gardens below eight years and above 40 years can cause localised scorching on stem and leaves. In areas with optimum physiological conditions such as high elevation (450-725 m above MSL), high humidity and uniform rainfall, vanilla could be a successful intercrop in coconut gardens (Subbiah *et al.*, 2002). Two rows of vanilla are possible in between two rows of coconut. Being a creeper, the plant requires support to a certain height, Cuttings of *Plumeria alba*, *Erythrina lithosperma*, *Jatropha curcas* and *Glyricidia* are suitable as live supports. The support plants are planted well in advance and the vertical growth of the support plants is restricted to a height of 1.5 m to make them branch which will facilitate trailing of vanilla vines. Rooted or unrooted cuttings are used for planting vanilla. Plant cuttings of 60 cm length. Longer cuttings bear earlier than shorter ones. Set out the cuttings at a spacing of 2.7 m between plants in pits of size 40 x 40 x 40 cm. Trail the vines on the live supports and when they attain a height of 1.5 m, take the shoots to hang-down which will facilitate production of new shoot from the bend portion and induce flowering in the lower portion during Jan-Feb. Nipping of the tip portion of the hung shoots will have to be resorted to induce flowering. Provide heavy and frequent mulching to the vines. The crop cannot withstand even

Table 1. Yield pattern of coconut and cardamom in the mixed cropping system

Year	Coconut (nuts/ha)	Cardamom dry (kg/ha)
1990-91	1745	-
1991-92	3030	-
1992-93	4130	12.5
1993-94	8780	175.0
1994-95	11310	525.0
1995-96	13050	150.0
1996-97	17455	275.0

are to be staked and shaded. A regular schedule of cultural practices consisting of weeding, mulching, trashing, shade regulation, fertilizer application, irrigation etc. have to be undertaken.

Table 2 that except during the pre-bearing stage of cardamom, the mixed cropping of cardamom with coconut enabled to increase the return per unit area by many fold.

Table 2. Cost and return statement of mixed cropping system of coconut with cardamom (Rs./ha)

Year	Gross return	Cost of cultivation	Net return
1990-91	4362	39443	-38050
91-92	9090	18898	-9808
92-93	18205	30854	-12614
93-94	87620	48046	39574
94-95	333990	42230	291760
95-96	104700	39771	64928
96-97	152320	44397	107902



Table 3. Average net profit/ha of coconut based high density multispecies cropping system for four years

Treatment	Average net profit/ha over 4 yrs.	% increase over control
Coconut + nutmeg	69,573.00	177
Coconut + cinnamon	50,807.00	103
Coconut + clove	36,308.00	45
Coconut alone	22,081.00	-

Maximum net profit was obtained in coconut + nutmeg followed by coconut + cinnamon.

the slightest root disturbance. Organic manures are ideal for vanilla. Withhold irrigation by November last to facilitate flower initiation. Artificial pollination is to be done for fruit set. Irrigation is to be restarted with flowering. Studies conducted at Chikmangalur in Karnataka to investigate the economic feasibility of vanilla cultivation in coconut gardens revealed the viability of mixed cropping of vanilla in the coconut gardens in plains and low rainfall areas under irrigation. An average gross return of Rs. 94,219/ha and net return of Rs. 36247/ha were realized in a mixed cropping experiment with vanilla carried out at vanilla planters farm at Kadur, Karnataka (Table 4) (Korikanthimath *et al.*, 1999).

With the ban of synthetic vanilla in western countries, the demand for natural vanillin has shot up in global market. Efforts to propagate and popularise vanilla cultivation in India have resulted in large number of coconut farmers taking up vanilla cultivation particularly in Karnataka and Kerala.

The current import of synthetic vanillin to India is 404 tonnes valued

Rs. 1650 lakhs. For replacing even 10 per cent of this import by natural vanillin, India needs to produce a minimum of 2020 tonnes of cured beans which demand cultivation in a minimum area of 6733 ha. At present vanilla is cultivated in an area of only 1800 ha.

Ginger

Among annual spice crops, ginger and turmeric are ideal for intercropping in coconut gardens. Investigations conducted at Kerala Agricultural University to study the shade response of ginger revealed that maximum yield (22.22 t/ha) and dry matter production were recorded at low shade conditions of 25 per cent. As the performance of the crop is considered as shade loving, it is highly suited as intercrop in coconut gardens (Babu, 1993). In a 6 year old plantation, the cultivar Rio-de-Janeiro recorded maximum dry matter production. Quality of ginger rhizomes was also found improved when grown under shade. Cultivars 'Nedumangad', 'Himachal', 'Maran' and 'Kuruppampady' performed better under 25 per cent shade (George, 1992). Economic feasibility of raising annual crop including ginger and turmeric as intercrops was investigated in several

experiments and the data are presented in Table 5. Maximum profit of Rs. 2597/ha was received from turmeric (Rethinam *et al.*, 2001).

The best time for planting ginger is during the first fortnight of April, after receipt of pre-monsoon showers. For irrigated ginger, the best time for planting is middle of February. Prepare beds of convenient length, one metre width and 25 cm height. Plant rhizome bits of 15 g weight in small pits at a spacing of 20-25 cm and at a depth of 4-5 cm with at least one viable healthy bud facing upward. Apply manures and fertilizers @ 30 t/ha of FYM and NPK @ 75:75:50 kg/ha/yr. Fulldose of P and 50 per cent of K are to be applied as basal dose. Half the quantity of N may be applied 60 days after planting. Remaining quantity of N and K may be applied 120 days after planting. Immediately after planting, mulch the beds thickly with green leaves at the rate of 15t/ha. Repeat mulching with green leaves twice @ 7.5t/ha first 40-60 days and second 90-120 days after planting. Earth up the crop during the first mulch and avoid water stagnation.

In HDMCS models established at the AICRP Co-ordinating Centre at Assam, combination involving coconut + banana + Assam lemon + pineapple + ginger + turmeric + colocasia resulted in a net yield increase in coconut by 83 per cent over pre-experimental yield (Choudhary and Deka, 1997).

Turmeric

Turmeric is classified as a shade loving plant which can be successfully intercropped in coconut garden. Varietal adaptability to shade levels was found the prime factor governing the yield of turmeric as intercrop. Under rainfed condition, cultivars Sugandham, Wynad Local and T. Sunder were suitable for cultivation in coconut garden (Paul, 1992). A few varieties perform better both under shade and in the open. BSR-1 showed best performance as intercrop in coconut garden.

Table 4. Cost and return structure of mixed cropping of vanilla with coconut

Year	Gross return	Cost of cultivation	Net return
1994-95	24999	132489	-107490
1995-96	40000	27538	12462
1996-97	84375	30687	53688
1997-98	227500	41171	186329
Total	376874	231885	144989
Average (4 yrs)	94219	57971	36247

BCR = 1.34



Economics of an intercropping experiment at Erode in Tamil Nadu (Kumar *et al.*, 2002) revealed that coconut + turmeric gave a net profit of Rs. 24,071/ha whereas the sole crop gave a net profit of Rs. 22,075/ha. High curcumin varieties of turmeric from Kerala Agricultural University viz. Kanthi, Shobha, Sona and Varna perform well in coconut plantations when grown as intercrops.

On receipt of pre-monsoon showers in April, prepare beds of size 3 x 1.2 m x 0.25 m. Take small pits in the rows with spacing of 25 x 25 cm. Plant finger rhizomes flat with buds facing upwards and cover with soil or dry powdered cattle manure. Apply cattle manure or compost as basal dose @ 40 t/ha at the time of land preparation or by spreading over the beds after planting. Apply NPK @ 30:30:60 kg/ha. Full dose of P and half dose of K are to be applied as basal, 2/3rd N 30 days after planting and 1/3rd N and remaining K 60 days after planting. Mulch the crop immediately after planting with green leaves @ 15 t/ha. Repeat mulching after 80 days with the same quantity of green leaves.

Tree spices

The practice of growing tree spices in the interspace of coconut (mixed cropping) was in vogue for a long time particularly in the homesteads of Kerala for increasing the productivity over unit area. As components of mixed and multistoreyed cropping with coconut, cinnamon, clove, nutmeg, all spice and garcinia were tried in many locations.

At Ratnagiri, coconut mixed cropping with spice crops such as cinnamon, clove, nutmeg, garcinia and all spices increased the coconut yield considerably compared to coconut as

monocrop (AICRP, 1998). The net profit from coconut monocrop was Rs. 30,475/ha. Coconut mixed with nutmeg and cinnamon gave a net return of Rs. 82,355/ha and Rs. 62,475/ha respectively.

Average net profit/ha of coconut based high density multispecies cropping system at Ratnagiri for four years (Nagawekar *et al.*, 2002) is presented in Table 3.

In the square or rectangular system



Nutmeg

of planting, one seedling of the tree spice could be planted at the centre in the case of coconut plantations above the age of 20-25 years. Because of the shade effect, the yield of clove may be reduced by upto 30-40 per cent of pure stand yield. Even then a coconut small holder will gain substantial profit (Reddy *et al.*, 1998).

When nutmeg is grown as mixed crop, seedlings of twelve month old

grafts would be planted at the centre of four coconut palms.

Cinnamon

Plant 1-2 years old seedlings with the commencement of southwest monsoon in pits of 60 x 60 x 60 cm at a spacing of 2 m between plants. Apply cattle manure or compost @ 20 kg/plant/year and NPK @ 20:20:25 g/seedling in the first year and double the dose in the second year. Increase the dose of NPK to 200:180:200 g/tree/year for grown up plants of 10 years and above. Prune the plants when they are 2-3 years old at a height of 15 cm above ground level.

Clove

Select 18 months old seedlings for planting. Prepare pits of 60 x 60 x 60 cm at a spacing of 6 m between plants and plant the seedlings during May-June. Provide shade and irrigation. Apply cattle manure or compost @ 15 kg/tree/year during May-June. The recommended fertilizer dose is NPK @ 20:18:50 g/plant during first year, 40:36:100 g/plant during second year and 300:250:750 g/plant/year for a grown up tree of 15 years and above.

Nutmeg

Pits of 90 cm are dug at a spacing of 8 m and filled with top soil and compost or FYM and seedlings are planted. Nutmeg, being a dioecious plant, *in situ* budding is recommended for obtaining the desired number of female plants. For a well grown tree of 15 years and above, 50 kg of organic manure/year and NPK @ 500:200:1000 g/plant/year is recommended.

High Density Multispecies Cropping System (HDMCS)

An HDMCS model was established at CPCRI, Kasaragod in 1983 with 17 species of annuals/perennials planted at a high plant density of 14,976 planting points per hectare of coconut plantation (Bavappa *et al.*, 1986). As the perennials grew and utilized more space, the annual crops except banana were withdrawn from the system. The system

Table 5. Economics of intercropping ginger and turmeric in coconut garden

Intercrop	Rhizome yield (kg/ha)	Expenditure (Rs/ha)	Gross income (Rs/ha)	Net profit (+) or loss (-) Rs/ha
Ginger	2426	6679	7290	+ 611
Turmeric	4441	6285	8882	+ 2597



now consists of clove, nutmeg, banana and pineapple in coconut stand.

The coconut yield increased by 176 per cent as compared to the pre-experimental yield as a response to the adoption of high density cropping and irrigation. The cash flow analysis of the system was done for 1983 to 1997 involving banana, clove and pineapple (Sairam, 1999). A gross margin of Rs. 92,230/ha could be realized in 1996-97 compared to Rs. 1750/ha during 1983-84.

Besides this, many HDMCS models involving spices are being evaluated in different AICRP Co-ordinating Centres in India (AICRP, 1998).

Prospects of spice based cropping system in coconut garden

In view of the economic liberalization and being a member of the World Trade Organization, certain macro and micro level changes are expected to take place in Indian Agriculture. In the case of coconut and its products, India is in a disadvantageous position since the domestic prices of these commodities are higher than the international prices. In a free trade regime after 2000 AD, Indian entrepreneurs related to coconut industry may import these products from other competing countries which could drastically alter the domestic prices of coconut and its products. This in turn would reduce the profitability of coconut cultivation in the country. Hence, to sustain coconut cultivation as a profitable enterprise, the policies should focus more on competitiveness through higher productivity.

One way to achieve this goal is through reduction in cost of production. There are possibilities of reducing cost of production and increasing the productivity and net return from coconut gardens by raising compatible subsidiary crops. In Kerala, where most of the homesteads are coconut based, integrated cropping systems offer great scope. By this, farm resources like land,

labour, sunlight, water and nutrients are effectively utilized and there by the net return increases.

In the present global scenario, demand is more for organic spices. Organic farming technologies always prefer multiple crops than monocrop. The beneficial effects of integrated farming system are reflected on enhanced soil fertility status, enhanced microbial activity and better utilization of natural resources for the benefit of plant growth and sustainable crop productivity. Cultivation of different crops in a unit area result in the continuous addition of biomass and higher level of nutrient cycling which have a positive influence on the physico-chemical and biological properties of soil. All these increase the productivity of the system and also the quality of the produce.

To face the challenges of liberalization and to meet the increasing demand for organically produced products in coconut and spices, a combination of integrated cropping system and organic farming practices would be the better option.

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