MANAGEMENT OF COCONUT GARDENS

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE
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Cover:

Front : A well maintained coconut garden

Back : Polybag nursery
Co 3 Hybrid grass grown as intercrop

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MANAGEMENT OF COCONUT GARDENS

Coconut is primarily a small holders crop with a recorded history of cultivation going back to more than 3000 years. It is now cultivated through out the humid tropics. The coconut palm *Cocos nucifera* L. is one of the most beautiful and useful palms in the world. It provides a variety of useful products like food, fuel and timber. Every part of the tree is being utilized for some purpose or other. On account of this, it is called **"Kalpavriksha"**, the tree of heaven, the tree that provides all the necessities of life.

The average productivity of coconut in India is around 40 nuts per palm per year. However, there exists a wide gap between the average productivity (40 nuts) and the research station yield (175 nuts). The low national average is mainly due to inadequate irrigation, manuring, presence of senile and unproductive palms, low genetic potential of native palms, incidence of diseases, pests and cultivation in marginal and sub-marginal lands. Added to this, the price fluctuation in coconut, aggravates the conditions of the coconut farmer. Planting of high yielding varieties and adoption of modern production technologies can increase the productivity. To bring about sustainability in coconut farming, crop intensification, crop diversification and product utilization are important.

Area, production and productivity of coconut

In India, most of the area under coconut (90 per cent) lies in the four southern states i.e., Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. Kerala ranks first in area (53.76 per cent) and production (45 per cent) followed by Tamil Nadu, Karnataka and Andhra Pradesh. Compared with the states which are having fairly large area under coconut, Tamil Nadu has a high level of productivity. In the world scenario, India ranks third in area (1.91 million ha) and first in production with 14925 million nuts followed by Indonesia and Philippines.

Ecological requirements

Climate

The coconut is essentially a crop of the lowland humid tropics, with 90 per cent of production coming from the zone between 20^0 N and 20^0 S latitude. It has been successfully grown up to an elevation of 1000 m near the equator. The required average temperature is in the range 27^0 to 32^0C with a diurnal variation of not more than 7^0C. Temperature level of less than 15^0C results in abnormalities of the fruits. Annual rainfall requirements range between 1000 mm and 2500 mm and sunshine is required preferably in excess of 2000 hours, with 120 hours of sunshine per month. Ideal relative humidity is 80 to 90% and relative humidity below 60% results in stomatal closure that restricts transpiration. Humidity close to saturation predisposes the palm to a number of diseases.

Soil

Coconut is grown under diverse soil conditions ranging from littoral sand to

clayey soils, ill-drained low lying areas to well drained hill slopes, strongly acidic peaty soils to alkaline calcarious soils. The major coconut growing soils along the west coast are laterite, littoral sand and red sandy loam, while deltaic alluvium, red soil and littoral sand are important coconut soil along the east coast. Among these soil types, the best soil is deltaic alluvial followed by red sandy loam. Any soil with a depth of 1.0-1.5 metre, well drained, rich in organic matter that has good fertility and water holding capacity with a pH range of 5.0 to 8.5 is ideal (The favourable pH is 5.5-7.5), for growing coconut.

Nursery management

In coconut, seedling vigour is highly correlated with adult palm characters such as early flowering, nut yield and copra production. If the seed nut happens to be of poor quality, the new plantation will prove to be uneconomic, causing considerable loss of time and money to the grower. Coconut being a perennial plant, the performance of the new progeny can be judged only several years after planting, poor selection continues as a source of loss throughout its life period. Further, being a cross-fertilized palm, it does not breed true and makes the selection of seed nuts and seedlings more difficult and important. Through a series of selections made at different stages, it is possible to obtain quality seed nuts and seedlings.

Selection of seed gardens

Gardens should have palms with a high proportion of heavy bearers. Garden should be free from the incidence of diseases and from severe attack of pests.

Selection of mother palms

Palms should be regular bearers with an annual yield of greater than 80 nuts and copra content not less than 150 g/nut under rainfed conditions (under irrigated-120 nuts/year). Palms should have reached the full bearing stage and have been giving consistently high yields for at least four years. Avoid very old palms of above 60 years age. Palms which produce barren nuts or those shedding large number of immature nuts should be discarded.

Collection of seed nuts

- ❒ Collect seed nuts from January to April in the West Coast region.
- ❒ Only fully matured nuts i.e., about 12 months old should be harvested.
- ❒ Nuts should not be damaged while harvesting.
- ❒ Discard nuts having irregular shape and size.

Raising nursery

- ✱ Select well-drained, coarse-textured soil near dependable water source for irrigation.
- ✱ Prepare raised beds if water stagnation is a problem during rainy season.
- ✱ Soil may be treated with chlordane 5% dust @ 120 kg/ha, or drenched with

chlorpyriphos in places where nursery is being raised for the first time as a precaution against white grubs and termites.

- Nursery can be raised either in the open with artificial shade or in gardens where the palms are tall and the ground is not completely shaded.

- The seed nuts should be planted in long and narrow beds at a spacing of 40 x 30 cm during May-June, either vertically or horizontally in 20-25 cm deep trenches. Advantage in vertical planting is less damage during transit. However, in delayed planting when the nut water goes down considerably, it is better to go for horizontal planting.

Poly bag nursery

Germinated seeds are transplanted in poly bags of size 60 x 40 cm with 8-10 holes at the bottom. The potting mixture is prepared in the 2:1:1 ratio of top soil, sand and compost mixture. The advantage of poly bag seedlings is that there is no transplanting shock and the seedlings are with better vigour. But the disadvantage is that the expenditure on transportation and seedling cost would be more.

Maintenance

- Mulching and shading should be done immediately after the monsoon ends, when the nursery is raised in the open space.

- Keep nursery free of weeds.

- Regular surveillance for any incidence of pests and diseases.

- Remove those nuts that have not sprouted even after five months of sowing.

Irrigation

Nursery requires frequent irrigation (once in 3 or 4 days). About 10 mm of water should be applied at every irrigation.

Selection of seedlings in the nursery

- Every coconut nursery contains some plants which are deformed or whose development is stunted, which must be eliminated.

- Select seedlings, which have germinated early.

- From the one-year-old nursery, select vigorous seedlings having minimum of six leaves and girth of 10 cm at the collar.

- Early splitting of leaves is a good indicator of the rapid development and early bearing.

- The recovery of good seedlings will be 60 to 65 per cent of total seed nuts sown.

Varieties and hybrids

Systematic evaluation of indigenous cultivars at CPCRI and the Coordinating Centres resulted in the release of high yielding varieties and hybrids in coconut (Table 1).

Table 1 : Performance of released coconut varieties and hybrids

Hybrids/ Varieties	Nuts/ palm/ year	Copra weight/nut (g)	Copra yield/ha (t)	Oil content (%)	States for which recommended
Chandrakalpa (LCO)	98	185	1.9	72	Kerala, Tamil Nadu, Andhra Pradesh & Maharashtra
Pratap (BGR)	151	152	2.3	65	Maharashtra
Philippines Ordinary	110	198	4.9	66	West coast, Coastal Andhra Pradesh & West Bengal
Chandrasankara (COD x WCT)	116	215	4.4	68	Kerala, Karnataka & Tamil Nadu
Kerasankara (WCT x COD)	108	187	3.5	68	Kerala, Karnataka & Tamil Nadu
Kera Sowbhagya (WCT x SSG)	116	196	2.6	65	Kerala, Karnataka & Tamil Nadu
Lakshaganga (LCO x GBD)	108	195	3.7	69	Kerala
Kerashree (WCT x MYD)	112	216	2.7	66	Kerala
Chandralaksha (LCO x COD)	109	195	3.7	69	Kerala & Karnataka
Anandaganga (ADO x GBD)	95	216	3.6	68	Kerala
Keraganga (WCT x GBD)	100	201	3.5	69	Kerala
VHC-1 (ECT x CGD)	98	135	2.3	70	Tamil Nadu
VHC-2 (ECT x MYD)	107	152	2.9	69	Tamil Nadu
ECT x GBD	140	150	3.7	68	Andhra Pradesh
WCT	80	176	2.5	68	Coastal Kerala and Karnataka

In addition to these varieties and hybrids, Chowgat Orange Dwarf is recommended for tender nut purpose.

Planting systems

Most of the existing coconut plantations are planted in the square system at a spacing of 7.5 m x 7.5 m. Adoption of hedge (rectangular) system of planting coconut with wider row spacing (e.g., 9.0 m x 6.5 m with 170 palms/ha) and rows oriented in east-west direction would increase light

Field planting of seedling (Pit size 1x1x1 m)

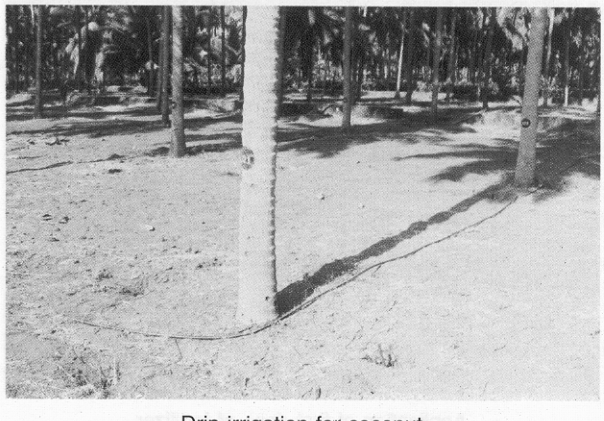
A vigorous one year old seedling

Under planting in a systematically planted garden

Application of first dose of fertilizer

Green leaf manure application along with 2nd dose of fertilizer

Basin irrigation



Drip irrigation for coconut

Perfo irrigation for mixed cropped garden

availability to intercrops. This would also facilitate growing annuals and perennials right from the time of planting onwards. Triangular system of planting (equilateral triangle) accommodates 30 palms more than square system of planting. However it interferes with the cultural operations and growing of intercrops.

The size of the pit for planting of seedlings is 1 m x 1m x 1m in normal soils. However in soils with rocky or hard substrate, larger pits (1.2 to 1.5 m^3) are preferred. After opening the pit, fill up the pit with top soil to a height of 60 cm below ground level and plant seedlings inside the pit. If Farm Yard Manure or any other compost is available, it can be mixed with top soil and the pit can be filled to a height of 60 cm. In water logged soil, mounds are made and seedlings are planted at the centre of the mound.

Time of planting

Planting is generally done during the beginning of monsoon season. This varies with states. In Tamil Nadu and Andhra Pradesh, it is done in October-November and for Kerala it is during June-September. In areas liable to water logging, planting is taken up towards the end of monsoon.

Replanting or under planting

Replanting or under planting becomes necessary when the yield become very low due to old age, long-term neglect and continuous exposure to adverse conditions. Generally under planting is practised where old palms are removed in stages over a period of three to four years.

- Peg mark the area to be under planted.
- Remove very poor yielders and those very close to the planting pits.
- Plant the seedlings in the usual way.
- The other trees are removed @ one-third each year during 2nd, 3rd and 4th year after planting.
- If the existing garden is irregularly spaced, remove old palms within 1 m radial distance in first year, 2 m distance in second year, 3 m distance in third year and the rest in fourth year.
- Generally, flowering is delayed in under planted palms.

Care of young plantations

- Mulching the base with coconut husk, dry leaves etc.
- Husk burial in planting pits.
- Irrigation during dry months @ 45 litres once in four days.
- Pitcher irrigation may be adopted in water scarcity areas.
- Providing shade during summer.
- Regular weed management.

Management of adult plantations

Nutrient Management

Coconut is a perennial crop that exports

nutrients to the above ground parts continuously from a limited volume of soil throughout its existence. Once the seedlings are planted in the main field, about one-tenth of the adult dosage should be applied after three months, one third after two years of growth, two third after three years and full dosage from fourth year onwards (Table 2). General requirement of fertilizer elements for palms yielding an average of 50 nuts per palm per year could be 500 g N, 320 g P_2O_5 and 1200 g K_2O/palm/year.

Table 2 : Fertilizer recommendation (g/palm)

Year	May-June			September-October		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
First year	-	-	-	50	40	135
Second year	50	40	135	110	80	270
Third year	110	80	270	220	160	540
Fourth year onwards	170	120	400	330	200	800

Fertilizer application is usually recommended in two splits a year, one third of the recommended dose must be spread around the palms within a radius of 1.8 m and forked in immediately after the pre monsoon showers. Remaining two third fertilizer dose should be applied in September when the monsoon rain recedes along with 30 kg of green matter or 25 kg of Farm Yard Manure. Boron deficiency causes characteristic malformation of leaves like hook leaves, nut cracking, drying of the female flowers etc. Soil application of Borax @ 50 g/palm twice at monthly intervals after appearance of the first symptom corrects the deficiency.

Irrigation methods for coconut

Irrigation methods commonly adopted in coconut gardens are flooding, basin irrigation, sprinkler or perfo-sprays and drip irrigation (Table 3). In certain areas of Tamil Nadu, East Godavari and West Godavari Districts of Andhra Pradesh where adequate supply of water is available, coconut gardens are flood irrigated. There is considerable wastage of water under flood irrigation. In basin irrigation, water is applied in the basins of 1.8 m which is the active root zone of coconut. Irrigation channels are provided in between two rows and each basin is connected with the channel. In this method, there will be some loss of water due to deep percolation, seepage and evaporation. However this loss is reduced when basins are irrigated through hose pipe. This is being advocated to reduce water loss in transit.

Still, there is loss due to deep percolation and surface evaporation. Application of 200 litres of water once in four days is recommended.

Sprinkler irrigation or perfo sprays are more suited to inter or mixed cropping systems where the entire surface requires wetting. The quantity of water applied should be at least 75 per cent of open pan Evaporation (Eo). Drip irrigation is ideally suited for widely spaced crops like coconut as it saves water, energy and labour and the Water Use Efficiency is high. Based on a study conducted at Kozhikode, it was concluded that yield of coconut with drip irrigation @ 30 litres per palm per day during January to May was comparable to basin irrigation @ 600 litres per palm per week. Thus, there is 67 per cent saving of water in drip irrigation. Drip irrigation demonstration for coconut with 50 litres per palm per day in various districts of Kerala by CWRDM during 1985-88 has shown that the yield of nuts improved significantly from 3rd year after starting of the irrigation. Experiment conducted at CPCRI revealed that irrigation at 66 per cent of open pan evaporation is sufficient to produce yield on par with irrigation at 100 per cent of open pan evaporation.

Table 3 : Methods of irrigation and its suitability to different types of soil

Sl No	Irrigation method	Suitable soil types	Remarks
1	Flood irrigation	Alluvial	In the present situation of water scarcity, this method should be discouraged
2	Sprinkler overhead, Perfo	Laterite sandy loam, sandy soil, soil of undulated terrain	Suitable for coconut with intercrops
3	Basin irrigation	Laterite and sandy loam	Best for homestead gardens with few trees
4	Drip irrigation	All soil types	Even saline water can be used. Avoid drippers and use micro tubes to reduce clogging

Effect of drought on coconut

1. Petiole breakage, leaf drooping, leaf fall, slower production of new leaves and reduction in leaf area index.
2. Fewer number of inflorescence, button shedding and nut drop.
3. Reduction in nut size and copra content.

Moisture conservation

Coconut is mainly grown under rainfed conditions in most coconut growing regions. For reducing surface evaporation and improving water retention under rainfed conditions and to reduce the erosion hazard, the following conservation methods are suggested.

- Mulching with coconut husk, coir dust, green leaves, dried coconut leaves etc. Mulching should be done immediately after rains when there is sufficient moisture in the soil. Providing thick mulch in the basin area with husk or leaves will sustain the palms for 2 to 3 months even if there is no irrigation. When husk is used, it should be applied during rainy season. It has the capacity to hold water 5 to 6 times of its weight. Generally a two layered husk mulch should be provided, the lower layer with concave side facing upward and the top layer with concave side facing downward.

- Addition of organic manures or green manure – This increases the capacity to retain more moisture in the soil.

- Husk burial- effect lasts for 7 years - Husk is buried in the trench opened in the inter space of coconut rows. A trench size of 1x1x3m is opened and filled with coconut husk with concave side facing upward and top single layer convex side facing upward.

- Inter cultivation - After rains when the soil is tilled or ploughed, the top soil forms mulch and the capillary movement of the water is broken down thus conserving the soil moisture.

- Bunding, terracing etc. - In slopy lands, the practices of bunding and terracing help in soil and water conservation.

Cultural practices

Next to manuring and irrigation, intercultivation is the most important operation. Intercultural operations increase the yield not only through weed control per se, but also by providing a soil rhizosphere environment favourable for mineralisation and soil moisture conservation. Cultivation alone, twice a year, one at pre monsoon and another at the post monsoon in the coconut gardens was found to increase the yield to 39 nuts/palm/year, compared to the neglected plots (10 nuts/palm/year).

The response studies on West Coast Tall palms to management practices viz., Cultivation + Organic + Inorganic manuring have shown an increase in yield by ten folds compared to the control palms under rainfed conditions (Table 4).

Green manuring/cover cropping

The nitrogen fixing potential of legumes - Rhizobium symbiosis can be exploited in the interspaces of coconut through intercropping with green manures, cover legumes and forage legumes. *Pureraria phaseoloides, Calapogonium muconoides* and *Mimosa invisa* can be grown as suitable green

Husk filled in trench and pineapple grown in the band as a soil and moisture conservation measure

Water harvesting structure to store 50 lakh litres of water

Husk burried in trench for moisture conservation

Basin preparation in coconut garden after 2nd ploughing at the end of the monsoon rains

Vermicompost pit / tank with coconut leaves for composting

Vermicompost from coconut leaves

High density multi species cropping system

Mixed farming system

Table 4 : Coconut yield under different management practices

Treatments	Nuts/palm/year
Cultivation + organic + inorganic	101.0
Cultivation + inorganic	75.4
Inorganic + forking the basin	77.8
Cultivation alone	39.2
Weed control using herbicide (Glyphosate @ 50 ml/ 10 litres of water)	29.2
Control	9.6

manure crops in coconut basin as well as in the interspaces. Cover cropping helps to prevent soil erosion and weed growth. It adds a large quantity of organic matter and forms a thick mulch that improves soil fertility and water holding capacity. Legume cover crops also fix atmospheric nitrogen. When these legumes are grown in coconut basin (1.8 m radius), they contribute 15-30 kg of green matter which adds 150-200 g of N per basin, when incorporated after four months of sowing. Green manuring results in enhanced microbial activity and fertility of coconut soils. From the interspaces, about 3-4 tonnes of green matter can be obtained, which will supply nutrients, equivalent to 20-111 kg N, 4-21 kg P_2O_5 and 15-67 kg K_2O per hectare.

Application of *Glyricidia* prunings from interspace of coconut garden can meet a major protion of requirements for nitrogen (90 per cent), part of phosphorus (25 per cent) and potassium (15 per cent). Growing *Glyricidia* in the interspaces of coconut does not affect the growth of coconut.

Vermicomposting of coconut palm wastes

The process of composting of organic matter using earthworms is vermi-composting and the end product is known as vermicompost. The commonly used earthworms for vermicomposting are *Eudrilus eugeniae, Eisenia foetida and Perionyx excavatus*. The steps involved in vermicomposting are: multiplication of earthworms, preparation of base materials for vermicomposting, introduction of earthworm, management of vermi-composting bed and separation of vermicompost from undecomposed materials. The management of vermi-composting requires regular watering to keep the bed moist. Direct sunlight is harmful for worms and the bed should be mulched with dry grasses or moist gunny bags. It takes nearly 60 days to compost most of the materials. Harvesting of vermicompost requires separation of worms (adult and juveniles) and cocoons by sieving the compost. The granular vermicastings thus obtained can be dried and stored.

Coconut palm wastes being very hard are decomposed rather slowly and vermicomposting has more relevance. Ligno-cellulosic waste materials from coconut plantation can be converted into brown, odourless, granular vermicastings using earthworms. At CPCRI, a local earthworm closely related to the African night crawler, *Eudrilus eugeniae* has been isolated and has been found to be effective in vermicomposting of coconut palm wastes. Organic wastes weathered in rains for 3-4 months can be directly used for vermicomposting. Composting can be done in pits of convenient size, with depth less than one metre dug in coconut plantation. Cow dung may be added to the wastes at the rate of 10 per cent by weight and the heap should be watered and allowed to undergo preliminary decomposition for 1-2 weeks. Then earthworms may be added at the rate of 1kg per tonne of organic wastes (50 no./ kg of organic waste). The bed should be mulched and watered regularly to maintain sufficient moisture and the composting will be completed in about 2-3 months. Watering should be avoided for one week before the removal of compost. Worms will move to deeper moist area and compost can be collected, sieved and dried. The recovery of compost could be as high as 70 per cent. From one ha coconut garden, we get 4000 kg of vermicompost from leaves alone. The final product contains 1.2-1.8% Nitrogen, 0.1-0.2% Phosphorous and 0.2-0.4% Potassium.

Crop intensification and diversification

Coconut based farming systems involving cultivation of compatible crops in the interspaces of coconut and its integration with other enterprises like dairy, poultry etc. lead to considerable increase in production and productivity per unit area, by more efficient utilization of precious resources like sunlight, soil, water and labour.

Scope for multiple cropping

A spacing of 7.5 m x 7.5 m in the square system is recommended for coconut (175 palms/ha). Experimental evidence has shown that a sole crop of coconut does not fully utilize the available resources like soil, air space and sunlight.

a. Soil and space

Coconut palm like all monocots, has a typical adventitious root system. Under favourable conditions, 4000 to 7000 roots are found in middle aged palms. About 80 per cent of the roots produced by a palm under good management do not go beyond 2 m lateral distance and 82 per cent of the roots are confined to the 30 to 120 cm depth of soil. Thus the active root zone of coconut is confined to about 22 per cent of the available land area and the remaining area could be profitably utilised for raising subsidiary crops.

b. Solar radiation

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 leaves in the crown are not randomly distributed, but clumped around a few widely spaced growing points. It is estimated that as much as 56 per cent of the sunlight was transmitted through the canopy during the peak hours (10 - 16 hours) in palms aged around 25 years. The diffused sunlight facilitates growing a number of shade tolerant crops in the interspaces. Age, spacing, soil fertility status, varietal characteristics, leaf area and time of the day influence the light penetration through the canopy. Based on the growth habit of the palm and the amount of light transmitted through its canopy, life span of coconut palm could be divided into three distinct phases, from the point of view intercropping.

- Planting till full development of canopy (below 8 years): Good light transmission initially, but decreasing with age - suitable for growing annuals/biennials.
- Young palms (8 to 25 yrs): Maximum ground coverage and low canopy - poor light availability - not suitable for multiple cropping.
- Mature palms (above 25 years): Increase in trunk height; reduction in crown size - light transmission increasing with age - ideal for raising annual and perennial crops.

Criteria for selection of subsidiary crops

- Crops should be selected according to their shade tolerance and amount of solar radiation available.
- Should not grow as tall as coconut.
- Should not be more susceptible than the main crop to diseases they have in common.
- Should not require harvesting or other operations, which would damage the main crop or induce soil erosion or damage soil structure.
- Should not have an economic life longer than the main crop.
- Its root system should be able to exploit different soil horizons/zones.
- Crops should be selected according to the soil type, rainfall pattern, irrigation facilities and climatic conditions.
- Availability of marketing/processing facilities and labour availability.
- It may not be necessary to fulfill all these exacting requirements to have successful crop combinations. But one must ensure that the correct crop is chosen. In most cases, failure of inter and mixed cropping is due to the wrong choice of the crops.

Intercropping systems

Intercropping refers to the practice of growing annuals/biennials in the interspaces of coconut. A large variety of crops have been found suitable for cultivation in coconut gardens under irrigated and rainfed conditions.

Tuber crops: Tropical tuber crops such as tapioca, elephant foot yam, colocasia, greater

yam and lesser yam have been found to be compatible intercrops in coconut gardens. The suitability of growing rhizome spice crops such as ginger and turmeric has also been demonstrated in coconut gardens.

Floriculture/medicinal and aromatic plants: The feasibility studies of intercropping coconut palm with ornamental, medicinal and aromatic crops in the interspace revealed that *Heliconia*, Anthurium, *Jasminum pubescence* and Marigold under ornamental crops and Long pepper, Kacholam, Arrowroot and Patchouli under medicinal crops were compatible as intercrops in coconut garden.

Vegetable crops: Experiments carried out at Kasaragod have indicated that vegetable crops like snake gourd, bottle gourd, amaranthus, coccinia, brinjal and bitter gourd are compatible with coconut. Intercropping with vegetables helps to generate additional employment to the tune of 215 to 365 mandays/ha/year. Among the different sequences tried, snake gourd - ridge gourd - amaranthus was found to be the most remunerative one (Rs. 22217/ha/year) followed by amaranthus - bottle gourd - brinjal (Rs. 20920/ha/year).

Mixed cropping

Growing of perennial crops in association with matured coconut palm is referred to as mixed cropping. A number of perennials like cocoa, clove, nutmeg, coffee, pepper, mulberry, jack, breadfruit, mango, sapota, papaya and timber yielding trees can be grown in association with coconut. Studies carried out at CPCRI, Kasaragod and elsewhere revealed that cocoa, pepper, clove and nutmeg are the most compatible crops with coconut and can be grown as mixed crops in the west coast region.

High-density multispecies cropping systems

High-density multispecies cropping systems (HDMSCS) involve growing a large number of crops at very high plant population per unit area to meet the diverse needs of the farmer such as food, fuel, timber, fodder and cash. They 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. The salient features of the system are as follows:

- HDMSCS model consists of a large number of crop species at very high plant density.
- It includes annuals, biennials and perennials.
- The crops selected include cash crops, food crops and fodder crops.
- It includes large, medium and small canopy crops arranged in a systematic way.
- The soil disturbance is kept at minimum - only slash weeding is done.

* The biomass (other than the economic part) is recycled within the system.

* The annual crops are removed as the canopy size of perennial crops increases.

A HDMSCS model was established at Kasaragod, during 1983 in 1.2 ha of an 18 year old coconut plantation spaced 8 m x 8 m by interplanting 17 additional crops. The crops included in the model are: tapioca, elephant foot yam, colocasia, banana, pineapple, mango, bread fruit, jack, nutmeg, clove, sapota, acid lime, guava, pepper, papaya, San Ramon coffee and subabul. 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, 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 the recommended levels of fertilisers was applied to each of the component crops including coconut. The mean yield of coconut and other crops during the past few years showed that the yield of most of the crops was comparable at the graded levels of manuring indicating the scope for reducing the fertiliser input.

Mixed farming in coconut garden

Mixed farming in coconut refers to the integration of other enterprises such as dairy, poultry and sericulture with coconut cultivation by raising fodder crops, mulberry etc. in the interspaces. Coconut based mixed farming system involves establishment of pastures in the interspaces of coconut, maintenance of milch animals on the fodder produced and recycling the cattle manure, urine etc. to the fodder crops and coconut. Studies have shown that some of the fodder grasses like hybrid Napier grass, Sudan grass, Guinea grass, Setaria, Rhodes grass and legumes like lucerne and berseem come up very well in the partially shaded conditions of coconut plantations in humid tropics.

Mixed farming provides additional employment to the tune of 900 man days and ensures good returns without any yield decline in coconut. In the mixed farming unit in 1.04 hectare coconut garden at Kasaragod, comprising coconut, grass, dairy, poultry, sericulture and pisciculture, coconut, milk yield and broiler birds accounted for 97 per cent of the revenue generated from the system. The total variable cost involved in maintaining the system was Rs. 183169. The net return obtained was Rs. 73142 per annum (Year 2000). About 64 tonnes of cow dung, 53.2 kg silkworm waste and 487 kg of poultry and quail manure obtained from the system were recycled in the coconut and grass plot, thereby improving the physico-chemical and biological properties of the soil. A total of 30 tonnes of fodder grass obtained from the grass plot was fed to the milch animals.

Harvest

Twelve months old nuts are harvested both for seed as well as copra preparation. However, for tender nut purposes 7 to 8 months old nuts are harvested. If the nuts are harvested for seed purpose, in case of talls, it can be stored for 2 to 3 months before sowing whereas in dwarfs and hybrids, the nuts should be sown within a period of 10 –15 days of harvest. On an average, we can go for eight harvests though the coconut palm produces inflorescence every month. For oil extraction, nuts are generally sun dried for copra making. As there is a chance of dirt accumulation followed by oil quality deterioration, nuts can be dried in various types of dryers available (Kiln, electric and solar dryers). The advantage of drying in these dryers is that good quality copra can be obtained in short time. Moisture content in copra for final use should be around 5-6%. The oil yield of WCT palms under rainfed conditions will be around 1.7 to 2 tonnes per hectare.

Product diversification

The coconut is a very versatile tree. It yields multi-products, perhaps more products of use to mankind than any other tree in the world. Product diversification not only enhances exports, attracts additional revenues but also reduces import of coconut products or substitutes. Diversification also can result in the maintenance of continuous momentum of activities in the coconut sector. Philippines lists about 40 non-traditional coconut products ranging from coconut oil-based fatty alcohol to handicrafts while India and Sri Lanka ship out a wide range of fibre products.

There are numerous opportunities within the coconut sector in which small-scale producers can add value to coconut through product diversification, technology improvements and enhanced market access. Charcoal making, handicrafts and many others are some of the traditional products that could be derived from coconut to increase farmers' income.

Thus the returns from coconut cultivation in this country could be improved considerably through crop intensification, crop diversification and product utilization.

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