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Technologies for organic cultivation in Coconut

Agriculture has been practised traditionally in an organic way from time immemorial in India. To be commensurate with the demand of the increasing human population, improved and scientific agricultural technologies are being adopted to increase production and productivity. With the advent of the green revolution, the intense use of high-yielding varieties, inputs like fertilisers, chemicals and mechanisation came into practice. Over the years, though the production increased, the soil health and sustainability deteriorated. This situation has compelled scientists and farmers to look back and turn to organic farming without compromising the yield. Thus, in recent years with the global climate change, emerging health consciousness, and environmental awareness among consumers, organic farming has been gaining momentum worldwide. The core concept of organic farming relies mainly on the recycling of on-farm biomass resources for sustained nutrition (e.g. manure, fodder, organic materials, etc.), soil management techniques (soil moisture conservation measures), selection of location-specific cropping systems, agroforestry (where woody perennials are grown in association with crop/livestock) and adoption of eco-friendly pest and disease management (by excluding the use of chemical pesticides). This article discusses the practice of organic cultivation in coconut.

COCONUT being a perennial crop, requires congenial growth conditions throughout its life cycle to achieve sustained yield. Once the palm starts bearing, it produces one leaf and one inflorescence each month; thus, about 12-15 inflorescences are produced in a year. This implies that the palms do not have any critical period for water and nutrient requirements, unlike field crops. Maintaining optimum soil moisture and nutrient availability throughout the year is essential for higher coconut productivity and palm survival. Organic farming, which helps conserve soil moisture and releases nutrients for a longer period due to the slower decomposition of organic materials applied, helps in a continuous supply of moisture and nutrient to the crop. Hence the system of farming is highly suitable for coconut.

The unique canopy architecture and fibrous root system of coconut provides opportunities for exploitation of land and solar energy for inter/mixed cropping, an essential component in organic farming. This approach adds large quantities of recyclable organic biomass, and their recycling within the system makes it productive even without the inclusion of external inputs for nutrition. Thus, the growth habit and wider spacing for planting coconut makes it highly suitable for managing the production system through organic farming

Organic farming practices for coconut cultivation

Green manuring: Growing of leguminous green manure crops helps in fixation of atmospheric N, thereby recycling of this biomass helps in addition of a considerable quantity of essential nutrients; besides it also improves soil physical and biological properties thereby improving soil health. Green manuring can be practiced as a cover crop in the basin (1.8 m radius area from the trunk) and in the interspaces available in the coconut garden. The green manure crops suitable for different soil

Cowpea | Daincha | *Calapogonium* | Sunhemp | Wild Indigo

Green manure crops in coconut

Table 1. Green manure crops suitable for coconut growing regions

Sl. No.	Common name	Scientific name	pH range	Characteristics
1	Berseem/ Egyptian clover	*Trifolium alexandrinium*	6.4-7.1	Annual cover, suitable for all soils except very light sandy soils
2	Buffalo bean	*Macuna aterrima*	5.5-7.5	Tropical legume crop
3	Calapogonium	*Calopogonium mucunoides*	4.5-5.0	Vigorous, annual, short-lived perennial legume, suitable for warm humid tropic, withstands water stagnation
4	Centro	*Centrosema pubescens*	6.1-6.4	Annual or perennial legume, suitable for sandy loam
5	Cluster bean	*Cyamopsis tetragonoloba*	7.0-8.5	Annual herb legume, suitable for medium to light textured soils
6	Cowpea	*Vigna ungiculata*	5.0-6.5	Annual herbaceous legume
7	Daincha	*Sesbania aculeata*	4.5-7.5	Suitable to a variety of soil conditions, from waterlogged to saline and from sandy to clay soils
8	Desmanthus	*Desmanthus virgatus*	>6.5 (neutral to alkaline)	Perennial shrub, suitable for clay or loamy soil
9	Field beans	*Vicia faba*	6.5-9.0	Suitable for clay and silt soils in addition to sandy soils
10	Indigo	*Indigofera tinctoria*	6.0-7.0	Resistance to drought, suitable for light sandy, medium loamy and heavy clay soils with proper drainage
11	Lucerne/ alfalfa	*Medicago sativa*	6.2-7.8	Perennial pasture legume, suitable for well-drained, soils of sand to moderately heavy clays with a slightly acid to alkaline *p*H
12	Manila Agathi	*Sesbania rostrata*	5.5- slightly alkaline	Erect, robust, annual or short-lived perennial, can tolerate waterlogging
13	Mimosa	*Mimosa invisia*	6.0-7.0	Non-thorny, profuse vegetative growth with single or cluster nodules on its roots, suitable even for unfertile land and interspaces of orchard crops
14	Pillipesara	*Phaseolus trilobus*	7.0-8.5	Annual, spreading, and herbaceous runner, suitable for variety of soils including black cotton soils, red lateritic soils and sandy loam soils
15	Pueraria	*Pueraria phaseoloides*	3.5 to 5.56	Vigorous twining and climbing perennial legume, suitable for wide range of soils from sandy loam to clay but not for clay soil
16	Sithagathi	*Sesbania speciosa*	5.5-8.0	Annual to biennial herb
17	Sun hemp	*Crotalaria juncea*	5.0-7.5	Annual leguminous herb suitable for loamy sand
18	White clover	*Trifolium pratense*	5.6-7.0	Herbaceous perennial plant, well adapted to clay, silt and sandy soils
19	Wild Indigo	*Tephrosia purpurea*	7.0 -9.0	Erect or spreading annual or short-lived perennial herb, suitable for dry, gravelly or rocky and sandy soils and saline and sodic soil

and climatic conditions in coconut growing region across India have been tabulated here.

***Gliricidia* alley cropping:** *Gliricidia* is a fast-growing perennial leguminous green manure/green leaf manure tree crop which generates a large quantity of nitrogen-rich biomass and can be grown on border as well in the interspace in coconut gardens. An ICAR-CPCRI study recommends growing *Gliricidia* in two rows along the boundary of the coconut garden in a zig-zag manner which can produce 2 t/ha green manure. Similarly, planting *Gliricidia* in three rows at 1 m × 1 m spacing between two rows of coconut can produce around 8 tons of biomass, which on incorporation and decomposition meet around 90%, 25% and 15% of the requirement of N, P and K, respectively. It can be grown in soils with *p*H ranging from 5.0 to 8.5.

Gliricidia as a border crop

Organic biomass recycling in coconut gardens: From a well-managed one hectare coconut garden (175 palms), 14 to 16 tonnes/year of organic biomass is generated in the from of leaves, spathe, bunch waste and husk which can be recycled in the form of mulching and composting. Though a considerable quantity of husk is used for extraction of coir fibre in coir processing factories, it is always advisable to use raw/unprocessed husk to reap more benefits, viz. improving the water holding capacity of the soil (husk water holding capacity is 5 to 6 times of its weight) and addition of a considerable quantity of potassium to the soil.

The conversion of biomass into useful compost using native *Eudrilus* sp. of earthworm (vermicomposting) can be easily done using coconut leaves and other crop biomass by various methods such as cement tanks, trenches, and composting in the coconut basin itself. Composting in the basins will reduce the cost of transporting leaves and the application of vermicompost. Vermicomposting in trenches dug in interspaces of four coconut palms yield an average recovery of 70% in a composting period of 90 days. However, care should be taken to cover the trenches with nylon mesh to trap the entry of rhinoceros beetle. The water-soluble components from vermicomposting tanks can be collected as leachate by passing water slowly through the composting beds or by simple suspension of vermicompost in water. This vermiwash is honey brown with a *p*H of 8.5 and contains both major and minor nutrients in appreciable quantity along with growth-promoting hormones (IAA and GA). It is ideal for foliar applications after sufficient dilution.

Composting of coir pith have been standardised at ICAR-CPCRI with amendments like poultry manure, lime and rock phosphate @ 10 kg, 0.5 kg and 0.5 kg, respectively, for every 100 kg of coir pith as well as inoculation of biopolymer degrading microorganisms at 0.2% level, *Pleurotus* spp. can degrade part of the cellulose and lignin present in coir pith by the production of enzymes, viz. cellulases and lactases.

Use of biofertilisers: Biofertilizer formulations of nitrogen-fixing bacteria, *Azospirillum brasilense* and phosphate solubilising bacteria, *Bacillus subtilis* are used as soil application @ 100 g/palm/year along with organic amendments in organic coconut cultivation. 'KeraProbio', a talc formulation of *Bacillus megaterium*, effective for raising robust coconut seedlings, has been developed at ICAR-CPCRI. Similarly, an Arbuscular Mycorrhiza Fungal (AMF) bioinoculant, 'KerAM', has been developed for coconut seedlings. It is always advisable to use location-specific consortia.

Soil and moisture conservation measures in coconut: In organic farming approach of crop cultivation, it is advisable to use *in situ* moisture conservation measures by collection, conservation and judicious utilisation of water resources, which helps to reduce soil erosion and improve nutrient availability. To conserve soil moisture in the coconut plantation, mulching with various types of organic materials, viz. coconut leaves (in two to three layers), husk (in two to three layers-250 to 300 husks/basin) and coir pith (10 cm thickness-approx. 50 kg/palm) can be practised which helps to reduce soil temperature and evaporation from the soil surface and create conditions for proper root growth and proliferation of soil flora and fauna. The best time for mulching is before the end of the monsoon and before the top soil dries up.

Half moon bund

Trenches filled with husk and bunds stabilised with pineapple

Trenches filled with husk in the coconut interspaces

Table 2. Coconut plant health management practices

Pests	
Name of pest	**Management practices**
Rhinoceros beetle (*Oryctes rhinoceros*)	• Field sanitation • Hook out beetles from attacked palms • Three naphthalene balls placing in leaf axil and covering with fine sand • Leaf axil filling with botanical cakes (Pongamia cake/neem cake/admixed with sand) • Manure pits and other possible breeding sites to be treated with *Clerodendron infortunatum* or *Metarhizium majus* (the green muscardine fungus) • Release *Baculovirus Oryctes* @ 10-15 per ha
Red palm Weevil	• Field sanitation • Leaf axil filling as in case of rhinoceros beetle • Coconut log traps with fermenting toddy/pineapple/sugarcane activated with yeast/molasses • Use of pheromone trap at the community level
Leaf eating caterpillar (*Opisina arenosella*)	• Removal and burning of heavily infested 2-3 outer fronds • Periodically release larval/pupal parasitoids - *Goniozus nephantidis, Elasmus nephantidis, Bracon brevicornis,* and *Brachy merianosatoi*.
Coried bug	• Neem-based biopesticide application on the newly opened inflorescence • Collect and destroy all the fallen buttons of the affected palm
Coconut eriophyid mite	• 2% neem oil + garlic emulsion or commercial neem formulation azadirachtin 0.004% (Neemazal *TIS* 1% @ 4 ml per litre of water) application in the crown. • Spraying acaropathogenic fungus, *Hirsutella thompsonii*, on the bunches immediately after pollination • Predatory mites, *Neoseiulus baraki* and *Amblyseius* sp.
Rugose spiralling whitefly (RSW) (*Aleurodicus rugioperculatus*)	• Use aphelinid parasitoid, *Encarsia guadeloupae* and the chrysopid predator, *Apertochrysa* sp., lady beetles *Jauravia pallidula, Serangium parcesetosum* and *Menochilus sexmaculatus, cybocepahlid* predator, *Cybocephalus* sp. as well as *in situ* preservation of the sooty mould scavenger beetle, *Leiochrinus nilgirianus* Kaszab. • Use of yellow sticky traps @ 5 per acre. • Coconut leaflets can be dislodged by forced water spray, targeting the lower surface of the leaflets.
Root grub	• Use of entomopathogenic nematode, *Steinernema carpocapsae* @ 1.5 billion IJ/ha.
Coconut scale, *Aspidiotus destructor*	• Use of aphelinid parasitoid, *Aphytis* sp. • Lady beetles, *Chilocorus nigritus, Sasajiscymnus dwipakalpa* and *Pharoscym nushorni* (Coccinellidae) used as predators.

Diseases	
Name of disease	**Management practices**
Bud rot	• Phytosanitation by removing severely affected palms. • Apply 10% Bordeaux paste on the cleaned crown. Spray 1% Bordeaux mixture on spindle leaves and crown of diseased palms. • Provide adequate drainage and avoid overcrowding.
Root (wilt)	• Follow strictly all prescribed prophylactic measures. • Grow green manure crops in basins and incorporate and supply adequate organic manures.
Leaf rot	• Remove the rotten portions from the spear and the two adjacent leaves. • Spray crowns and leaves with 1% Bordeaux mixture. • Talc-based formulation of *Pseudomonas fluorescens/ Bacillus subtilis* application singly or in consortium @ 50 g in 500 ml/palm.
Stem bleeding	• Remove water stagnation and apply recommended doses of organic manure to make the palms healthy. • Neem cake application @ 5 kg/palm in the basin along with other organics. • Use *Trichoderma hamatum* and *Trichoderma harzianum*.

Coconut husk burial in layers with the bottom layers facing up and top layer facing down, in the trenches (50 cm width × 50 cm depth and convenient length) dug out in the interspace of coconut will also help in soil moisture conservation. Half-moon bund around coconut basin reinforced with two rows of pineapple can also be taken up wherever there is a mild slope (15-20%) of land. Here the bund prevents run-off, and water gets collected within the basin and percolates down. Pineapple would help protect the bund and stabilise the same, giving fruit yield. If the land is highly sloped, then trenches of 50 cm width × 50 cm depth and convenient length would be made between two rows of coconut palms and filled with coconut husk, and bunds should be stabilised with crops like pineapple. Catch pits of 1.5 m length × 0.5 m width × 0.5 m depth with a bund at the downstream can also be created. This pit also may or may not be filled with coconut husk.

In levelled coconut gardens, trenches of convenient length (1 m × 0.6 m dimension) can be opened in the interspace. The excavated top soil can be put into the

basin of the coconut palms. The trenches should be filled with husk/coconut leaves, which helps improve the water infiltration, water holding capacity, and proper aeration.

Growing crops like *Calopogonium, Pueraria*, cowpea, etc. in coconut gardens with mild to steep slopes not only acts as green manure crop but also help as cover crops to protect the soil from the beating effect of rain, especially during the high intensity of rainfall, thus, enabling rainwater to percolate down. This also helps in preventing soil as well as nutrient loss.

Crop diversity: Organic farming should be system-oriented, involving the accommodation of agriculture and allied enterprises in a closed system approach. This involves intercropping (preferably leguminous crops), mixed cropping, high-density multi-species cropping, and integrated farming systems. It was found that inclusion of cocoa in the cropping system will help in generating 13 tons of recyclable cocoa biomass, which includes pruned material (8.5 t), litter-fall (3.0 t) and pod husk (1.5 t).

In a coconut-based farming system, the integration of crops and livestock (animal enterprises such as dairy, poultry, duck rearing, aquaculture and cultivation of shade tolerant fodder crops in the interspaces) in coconut gardens ensures the diversity needed for organic cultivation. It generates additional income and more employment, besides providing relief against the fluctuating price of nuts. While the crop residues and fodder provide animal feed, the manure and litter of the livestock provide renewable sources of organic matter and plant nutrients. Recycling crop and livestock waste helps to maintain soil health, resulting in a high degree of organic recycling. Such integration will also maximise the beneficial impact of species diversity on soil fertility.

Studies on coconut based high density multi-species cropping system model at CPCRI comprising of coconut (planted at a spacing of 8.0 m × 8.0 m), pepper (trailed on each coconut trunk), banana cv. Kadali, Robusta, cinnamon (inter-row space of palm) and nutmeg (between four coconut palms) with recycling biomass (as vermicompost @ 30 kg/palm)+ biofertiliser application (*Azospirillum* and Phosphobacterium @ 200 g/plant) + green manuring (*in situ*) + vermiwash application (10 L/palm) + husk burial + mulching with coconut leaves revealed that the efficient recycling of available organic materials could sustain the coconut productivity over a longer period (136 to 155 nuts/palm). However, soil potassium levels should be maintained over a longer period of time with the restricted application of sulphate of potash.

Similarly, a 10-year-long trial on organic farming conducted at CPCRI, Kasaragod in laterite soil recorded an increase of 149-162% in nut yield (90 to 100 nuts/palm) through organic cultivation compared to the pre-experimental period in WCT, while in D × T (120 to 130 nuts/palm), the yield increase was 144-159%. Among the organic cultivation practices, vermicomposting in the trenches; application of biofertilisers; and cover cropping in the basin and vermicomposting in trenches and application of biofertilisers recorded higher nut and copra yield in both genotypes. There is a clear improvement in soil biological and chemical properties of soil through organic cultivation.

Plant health management: The basis of pest and disease management in organic farming systems is the reliance on the inherent equilibrium in nature. The use of bio-control agents, use of pest and disease resistant varieties, use of Neem-based pesticides, diluted cow urine, aerial parts extract of *Artemisia vulgaris, Urtica dioica, Polygonum* and *Eupatorium glandulosum,* employing clean cultivation, crop rotation, using physical barriers and using semi-chemicals such as pheromone attractants and pests trap are important practices. The important pests and diseases, as well as their management practices to be followed under an organic system of cultivation, are given in Table 2.

CONCLUSION

Organic farming in coconut is possible for sustainable coconut production. However, potassium is one of the key elements essential for palm health and is required in relatively large quantity and organic manures generally contain less amount of potassium. Hence, proper recycling of husk as K- source and judicious utilization of organic source of potassium as per organic farming certification requirements is imperative for successful organic farming in coconut.

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