

Exploring potential of organic coconut

In coconut, about 74% of the roots produced are confined to 2 m from the bole and most of the roots grow to a depth of 30-120 cm, thus, utilizing only limited extent of land area for their growth. The orientation of leaves in crown helps penetration of sunlight into soil and provides opportunities for exploitation of land and solar energy for inter/mixed cropping ensuring crop diversity, an essential component in organic farming. Such an approach will also add large quantities of organic wastes and their recycling within the system makes it productive even in the absence of external inputs for nutrition. Thus, growth habit and wider spacing for planting in coconut make it highly suitable for managing the production system through organic farming.

COCONUT is a perennial crop, which can live for decades together and hence, is essential to provide congenial growth conditions to maintain the growth and give sustained yield of palm. Once the palms start bearing, on an average, it produces one leaf and one inflorescence during each month and, thus, about 12-15 inflorescences are produced in a year. It takes 44 months for an inflorescence bud to grow and develop into to produce mature nuts. Since, a palm produces an inflorescence every month, its crown has inflorescences at different stages of development throughout the year. As there is continuous production of leaves and inflorescence throughout the year, coconut palms do not have any critical period for water and nutrient requirement as in the case of other field crops. Coconut export nutrients to the above ground parts continuously from limited volume of soil throughout its growth. Any deficiency of nutrients at any stage will adversely affect vegetative growth and thus, directly reflect on yield. It necessitates maintaining optimum soil moisture and adequate nutrient availability throughout the year for higher coconut productivity as well as palm survival.

ORGANIC COCONUT FARMING

Soil Health Management

Application of organic matters through green leaf manuring, cattle manure etc. was practiced traditionally for coconut, which helped to sustain soil fertility and productivity. However, due to the non-availability of land exclusively for cultivating green manure crops and also the limited supply of other organic manures, large scale use of organic manures became difficult. The technologies based on organic and bio-inputs for nutrition and soil health management, have been developed.

Coconut Basin Management

Growing any one of the leguminous green manure crops, viz. *Pueraria phaseoloides*, *Mimosa invisa*, *Calopogonium mucunoides*, and *Vigna unguiculata* helps in fixation of atmospheric N and can contribute on an average about 15-20 kg green matter/basin and their incorporation provides N (around 100-150 g palm) and other major nutrients as well as enhances the population of beneficial microorganisms and enzymatic activity, thereby improving the soil fertility.



Pueraria



Cowpea



Horse gram

Basin management



Cowpea



Sunhemp

This practice is inexpensive and can be adopted even by small farmers. During May-June, green manure seeds can be sown around the palm basins and when one or two plants start to flowering, the biomass can be incorporated in the basin. By providing irrigation, green manure crops can be grown in the basins for two or three times a year. Sesbania, sun hemp, dhaincha, pillipesara, and cluster beans are some of the other efficient and economically viable green manure crops. Green manure crops can be raised in the interspaces as well in gardens where land is available after growing inter crops. From the interspaces of 1 ha coconut garden, 15-20 tonnes of fresh biomass can be incorporated in soil.

Glyricidia Alley Cropping

By cultivating *Glyricidia*, a fast growing perennial leguminous green leaf manure tree crop in coconut plantations along the borders, it is possible to generate large quantity of nitrogen rich biomass. It



Glyricidia as alley crop in coconut

can also be raised in littoral sandy soils where no other green manure establishes. The tree is propagated either through vegetative cuttings or seeds. One meter long stem cuttings or 3 to 4 months old seedlings raised in polybags/ raised beds can be used for planting.

Organic Biomass Recycling

From a well-managed coconut garden of one hectare with 175 trees, the availability of organic biomass has been estimated as 14-16 tonnes/year in the form of leaves, spathe, bunch waste and husk.

Planting

Plant them during the south west or north east monsoon season at spacing of 1 x 1 m. Two rows of glyricidia can also be planted along the boundary of coconut garden in a zig-zag manner. Plant stem cuttings or seedlings in an upright position in pit size of 30 x 30 x 30 cm. For better establishment, a basal dose of 50 g of rock phosphate per pit may be applied. Prune the plants regularly to keep the height of the plants at 1 m. Pruning can commence one year after planting and taken up at least thrice a year. Studies conducted at ICAR-CPCRI indicated that planting three rows of glyricidia in one hectare coconut garden at 1 x 1 m spacing between two rows of coconut and pruning leaves during February, June and October could produce around 8 tonnes of biomass, which on incorporation and decomposition meet around 90, 25 and 15% of the requirement of N, P and K, respectively.

Though a considerable quantity of husk is used for extraction of coir fibre, coir pith, which is the by-product of coir processing factories, is usually dumped without any use and caused environmental pollution up on burning. The natural decomposition of these wastes and the nutrient release are very slow due to the high lignin content and the nature of lignocellulose complex of the coconut wastes. By proper recycling, this waste biomass can meet a major portion of nitrogen and a



Daincha



Mimosa

Green manure in interspaces of coconut

part of other nutrient requirement of palms. It also helps to replenish the nutrients exhausted by the palms internally without depending on the external sources.

Vermicomposting

Vermicomposting, the conversion of biomass into useful compost using native species of earthworm (*Eudrilus* sp.), can be easily done *in situ* in coconut plantations using coconut leaves and other biomass including wastes from intercrops, pineapple waste, banana pseudo stem and leaves and glyricidia green manure etc. Vermicomposting coconut leaves will also enhance the total microbial as well as beneficial microbial population.

Various methods such as cement tanks, trenches as well as composting in the coconut basin itself can be

adopted for vermicomposting. For large scale composting, permanent cement or brick tanks can be constructed to provide an opportunity to maintain appropriate quantity of food substrate, optimum moisture, temperature and other factors which are very essential for production of efficient and quality vermicompost. This will also give proper protection for the worms from predators like rodents, ants, birds and wild boars.

Vermicomposting in trenches dug in interspaces of four coconut palms yield on an average recovery of 70% in a composting period of 90 days. Composting in the basins itself will reduce cost of transportation of leaves and application of vermicompost. The favourable weather conditions for effective vermicomposting in Kerala are found to be the monsoon

Water-soluble Fertilizers

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 in colour with a pH of 8.5 and contains both major and minor nutrients in appreciable quantity. Growth promoting hormones like IAA and GA are also present in vermiwash. It is ideal for foliar applications after sufficiently diluting, based on the need. Vegetables and ornamental plants have been reported to respond very well to this vermiwash application. Thus, vermicomposting enables safe disposal of coconut wastes in a less expensive, eco-friendly manner with the benefit of producing high quality organic manure in the coconut plantation itself. As it can be carried out during most parts of the year, it also provides employment opportunities for the farm families and self help groups as well as for income generation.



Trench method



Earthworms
Vermicomposting



Vermicompost

and post-monsoon periods (June-August and September-November).

The average nutrient composition of the vermicompost is 1.2-1.8% (N), 0.1-0.2% (P) and 0.2-0.4% (K), with organic carbon (17.84%), and C/N (9.95:1.00). The coconut waste used for oyster mushroom production is also found suitable and it will have higher content of nutrients (1.0 to 1.3% N and 0.08 to 0.13% P) and low C:N ratio. The composted spent substrate also contains higher levels of micronutrients such as Fe, Zn, Cu and Mn.

Composting of Coir Pith

Coir pith is an organic material available in huge quantities from coir processing units. Extraction of 1 kg of coir fibre generates 2 kg of coir pith. Approximately, 180 g of coir pith is obtained from the husk of one coconut. Though coir pith has a number of beneficial properties like improving soil physical properties and moisture holding capacity to a great extent, its direct utilization as manure is not advisable as it contains large amounts of lignin (75%) and phytotoxic polyphenols and less of nitrogen. Hence, it has to be applied to soil only after composting. Technologies for large scale composting of coir pith has been standardized at

ICAR-CPCRI with amendments like poultry manure, lime and rock phosphate @ 10, 0.5 and 0.5 kg, respectively, for every 100 kg of coir pith as well as inoculation of biopolymer degrading microorganisms at 0.2% level. The raw coir pith with a C:N ratio of 100-112:1 can be converted to an excellent organic manure with C:N ratio of 17-24:1 within a short period of 40-45 days. *Pleurotus* spp. has the capacity to degrade part of the cellulose and lignin present in coir pith by production of enzymes, viz. cellulases and lactases. The lignin content also reduces considerably.

Use of Biofertilizers

The coconut roots harbour nitrogen fixing bacteria such as *Azospilillum lipoferum*, *Azospirillum brasilense*, *Herbaspirillum frisingense*, *Bacillus* sp., *Burkholderia* sp., *Azoarells* sp., *Arthrobacter* sp. and *Beijerinckia indica*. Bacteria such as *Pseudomonas* sp. and *Bacillus* sp. and fungi including *Aspergillus* sp. and *Penicillium* sp. are predominant phosphate solubilizers in the coconut root region. These microorganisms can be mass multiplied, formulated using locally available carrier materials, and used as biofertilizers for sustainable organic coconut farming. Biofertilizer formulations of nitrogen fixing bacteria,



Coconut leaf



Coconut husk



Coir pith



Weeds and crop residues

Mulching

Azospirillum brasilense and phosphate solubilising bacteria, *Bacillus subtilis* are used as inputs in organic coconut cultivation as soil application @ 100 g/palm/year along with organic amendments. Plant Growth Promoting Rhizobacteria (PGPR) *Pseudomonas fluorescences* and *Bacillus subtieis* formulations are important as biopriming agents to enhance the growth and vigour of coconut seedlings. The beneficial nature of biofertilizers becomes even more important in coconut based mixed cropping/ farming systems as the component crops continually add plant residues to the soil which undergo organic recycling. This leads to alterations in the composition of the rhizosphere, which promotes the growth and population of beneficial microorganisms. Inclusion of livestock enterprises also creates a favourable environment for proliferation of beneficial microflora. Moreover, higher inhibition potential of resident soil bacteria to phytopathogens are also seen in coconut based cropping systems when compared to coconut monocropping systems. When coconut is grown with cocoa, rhizosphere activity increases and a better mobilization of phosphates take place which is coupled with fixation of nitrogen and production of growth substances such as auxins and gibberellins in rhizosphere, which is observed to enhance yield.

Soil amendments as well as farming practices also bring about a protracted change in rhizosphere microflora, which favour the growth of specific microorganisms, thus leading to better plant growth and crop yield. For example, organic amendments like cow dung increase Vascular Arbuscular Mycorrhizal (VAM) colonization as well as the population of phosphate solubilizing bacteria in the root zone of coconut palms. Other organic amendments such as farmyard manure, coir pith, neem cake and green manures can be combined with microbial inoculants like *Beijerinckia indica* for improving the nitrogen fixation by indigenous diazotrophs in coconut soils.

SOIL AND MOISTURE CONSERVATION

Mulching Coconut Basins

In order to conserve soil moisture in the coconut plantation, mulching with various types of organic materials, viz. coconut leaves, husk and coir pith can be practiced which helps to reduce soil temperature and evaporation from soil surface and create conditions for proper root growth and proliferation of soil flora and fauna. Mulching is to be done before the end of the monsoon and before the top soil dries up.

For mulching, cut coconut leaves into two or three pieces and spread in two to three layers in the basin. To cover 1.8 m radius of coconut basin, 15 to 25 fallen coconut leaves are required. Mulching with composted coir pith to 10 cm thickness (approximately 50 kg/palm) in basin is also ideal method to conserve moisture. Due to its fibrous and loose nature, incorporation of coir pith considerably

improves the physical properties and water holding capacity of soil and thereby increases the coconut productivity.

Coconut husks can also be used for mulching and around 250-300 husks will be required for one coconut basin. Mulching is usually done up to a radius of 2 m. Besides conserving soil moisture, coconut husk is an important organic material and a good source of plant nutrients. On dry weight basis, the average composition is 0.23% N, 0.04% P₂O₅, 0.78% K₂O, 0.08% Ca and 0.05% MgO.

Coconut Husk Burial in Interspaces

Trenches of 100 cm width × 50 cm depth and convenient length are to be made in between two rows of coconut palms and filled with coconut husks in layers with the bottom layers facing up and top layer facing down.

Half-moon Bund Around Coconut Basin

In mild slopy areas (15-20%), this measure is to be taken up by making flat basin with a slight inward slope towards upstream by excavating soil from the upstream side and filling the excavated soil at the downstream side. After making the basin, a bund of 30 cm height and >50 cm width is to be made at the downstream side of the coconut palm using the



Husk burial in trenches



Half-moon bunds around coconut palm



Trench filled with coconut husk besides pineapple intercrop

excavated soil and plant two rows of pineapple plants on the bund with a spacing of 20 cm row to row and 20 cm plant to plant. The bund prevents runoff and water gets collected within the basin and percolates down. Pineapple would help to protect the bund and stabilize the same in addition to giving fruit yield and additional income.

Trench Filled with Coconut Husk

In areas where the land slope is high, take trenches of 50 cm width \times 50 cm depth and convenient length in between two rows of coconut palms and fill with coconut husk in layers with the bottom layers facing up and top layer facing down. A bund stabilized with pineapple can also be made at the downstream as in the case of half moon bund.

Catch Pits with Pineapple Border

Construct catch pits (1.5 m length \times 0.5 m width \times 0.5 m depth) in all slopes to conserve soil and water. A bund is to be made at the downstream using the excavated soil and pineapple plants planted

on it. This pit also may or may not be filled with coconut husk.

Cover Crops to Reduce Soil Erosion

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

Plant Health Management

The basis of pest and disease management in organic farming systems is the reliance on the inherent equilibrium in nature. Use of biocontrol agents plays a crucial role in this aspect. The natural enemies are insect predators (insects that consume part or all of pest insects), parasites (insects that use other insects to produce their offspring, thereby killing pest in the process), and pathogens (diseases that kill or decrease the growth rate of insect pests). Predatory insects on



Catch pits with pineapple border

organic farms include lady bird beetles, lacewings and spiders. Parasitic insects include wasps and flies which lay their eggs in/on pest insects, such as larvae or caterpillars. The emphasis on organic plantations should ideally be on the use of varieties resistant to pest and diseases. Neem-based pesticides produced from neem kernel extracts can also be used to repel pests. Spraying of diluted cow urine can be frequently practiced. The extracts derived from the aerial parts (leaves and stem) of *Artimisia vulgaris*, *Urtica dioica*, *Polygonum* and *Eupatorium glandulosum* which are profusely growing in the plantations can be used for their anti-feedant action against some leaf eating

Table 1. Management of pests and diseases under organic cultivation of coconut

Pests management	
Rhinoceros beetle	<ul style="list-style-type: none"> • Field sanitation • Hook out beetles from attacked palms • Fill three leaf axils around spindle with three Naphthalene balls covered with fine sand. • Treat manure pits and other possible breeding sites with leaves and tender stems of <i>Clerodendron infortunatum</i> or <i>Metarhizium anisopliae</i> (the green muscardine fungus) • Release <i>Baculovirus oryctes</i> infected adults @ 10-15/ha
Red palm weevil	<ul style="list-style-type: none"> • Field sanitation. • Leaf axil filling as in case of Rhinoceros beetle. • Set coconut log traps with fermenting toddy or pineapple or sugarcane activated with yeast or molasses to attract weevil. • Use of pheromone trap for attracting and killing adult weevils (this should be adopted at community level)
Leaf eating caterpillar	<ul style="list-style-type: none"> • Cut and burn first affected leaves. • Periodically release larval/pupal parasitoids such as <i>Goniozus nephantidis</i>, <i>Elasmus nephantidis</i> and <i>Brachymeria nosatoi</i>.
Coried bug	<ul style="list-style-type: none"> • Apply neem based bio pesticide on the newly opened inflorescence. • Collect and destroy all the fallen buttons of the affected palm
Coconut eriophyid mite	<ul style="list-style-type: none"> • Collect and destroy all the fallen buttons of the affected palm • Apply 2% neem oil + garlic emulsion or commercial neem formulation azadirachtin 0.004% (Neemazal TIS 1% @ 4 ml/litre of water) in the crown on young bunches.
Diseases management	
Bud rot	<ul style="list-style-type: none"> • 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 in gardens and avoid overcrowding.
Root (wilt)	<ul style="list-style-type: none"> • Follow strictly all prescribed prophylactic measures. • Grow green manure crops in basins and incorporate and supply adequate organic manures
Leaf rot	<ul style="list-style-type: none"> • Remove the rotten portions from the spear and the two adjacent leaves. • Spray crowns and leaves with 1% Bordeaux mixture. • Apply talc based formulation of <i>Pseudomonas fluorescens</i> or <i>Bacillus subtilis</i> singly or in consortium @ 50 g in 500 ml/palm
Stem bleeding	<ul style="list-style-type: none"> • Provide proper drainage and apply recommended doses of organic manure to make the palms healthy.. • Apply neem cake @ 5 kg/palm in the basin along with other organics. • Use <i>Trichoderma hamatum</i> and <i>Trichoderma harzianum</i> for the management of the disease

pests. Careful management in both time and space of planting of inter crops not only prevents pests, but also enhances population of natural predators that have natural capability to control insects, diseases and weeds. Other methods that can be generally employed are clean cultivation, improving soil health to resist soil pathogens and promote plant growth; crop rotation; encouraging natural biological agents for control of diseases, insects and weeds; using physical barriers for protection from insects, birds and animals; modifying habitat to encourage pollinators and natural enemies of pests; and using semi-chemicals such as pheromone attractants and trap pests.

Biopesticides including

Mixed Farming in Coconut Gardens

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 diversity needed for organic cultivation, generates not only additional income but also 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 wastes helps to maintain soil health, resulting in a high degree of organic recycling. Such integration will also maximize the beneficial impact of species diversity on soil fertility. Fodder grasses such as hybrid Napier and Guinea grass can yield about 80-120 tonnes of fodder per hectare in a year under coconut shade. This will be sufficient to maintain 8 to 12 crossbred milch cows and provide enough farmyard manure that can be used as a component for meeting the on farm organic manure requirement of the system. Biogas plant of suitable capacity can also be installed in the farm for biogas production for use in the farm house and slurry for manuring coconut and other component crops.

microorganisms, parasites, predators and natural plant based pesticides from neem and garlic are effective in managing pests of coconut and other intercrops. There are several examples of use of effective biocontrol agents for suppression of pest and diseases of coconut and other component crops. The important pests and diseases as well as their management practices that are to be followed under organic system of cultivation are given in Table 1. It will be most ideal if a community approach is adopted in the management of various pests and diseases of coconut.

Many plants are suitable as botanical pesticides and can be incorporated in the cropping system.



High-density multi-species cropping system

Organic Farming

A long term field experiment was initiated at ICAR-Central Plantation Crops Research Institute, Kasaragod during 2002-03 to evaluate the performance of coconut palms under different organic cultivation practices as well as to understand the effect of such treatments on soil chemical and biological properties.

The experiment was conducted on West Coast Tall, the popular coconut variety and Chandra Sankara, a hybrid (COD × WCT). The age of palms was 35 years. Analysis of 10 years yield data of coconut revealed significantly higher nut yield with all the organic cultivation treatments compared to control in both the genotypes. There was increase of 149-162% in nut yield through organic cultivation compared to pre-experimental period in WCT, while in D × T, the increase in yield was to the tune of 144-159%. Among organic cultivation practices,

Crop Diversity in Coconut Cropping System

Crop diversity through inter/mixed cropping should be adopted while organic farming in coconut is taken up. The interplay of various factors like size of holding, number and nature of existing trees, family needs, labour requirement for crop, year round returns, easiness of marketing etc. are some of the considerations for the farmer to diversify his farming system. Under coconut based cropping system, the same land can be put to use to produce various crops so that the productivity of the land can be increased. A well-spaced coconut garden provides adequate inter-row and intra-row spaces where it is possible to grow a variety of useful seasonal and perennial crops. Crop rotation should be followed while growing intercrops year after year. Inclusion of leguminous crops will improve soil fertility status.

solubilizers and *Azospirillum*) under organic treatments compared to control.

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