11. ORGANIC FARMING IN COCONUT

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1. Introduction

Organic farming is getting much attention across the world as it minimizes the dependence on chemical inputs, thus safeguarding/improving quality of resources and food production. There is growing appreciation for organically grown food with the emerging health conscious population. Organic farming is expected to enhance and sustain production, soil health and system biodiversity. Organic method of cultivation by the use of natural and renewable resources is the best option to ensure soil, air and water around us unpolluted keeping the environment safe for the present and the future generations. Organic production systems are based on specific standards precisely formulated for food production using natural resources and aim at achieving agro ecosystem productivity, which are socially and ecologically sustainable.

2. The basic concepts of organic production on agricultural holdings

Organic agriculture follows the logic of a living organism in which all elements (soil, plant, farm animals, insects, the farmers etc.) are closely linked with one another. Organic farming, therefore, must be based on a thorough understanding and appropriate management of these interaction and processes. Organic farming relies heavily on soil management techniques (e.g. mulching), various cropping systems (e.g. inter cropping), agro forestry (where woody perennials are grown in association with crop/livestock) and recycling of on farm waste resources (e.g. manure, fodder, organic wastes etc). It is also concerned with correlating the number of animals kept on the farm and the available land area so that the farm can cover its feed and soil nutrient need within the system. Organic cultivation also relies upon adoption of various other means of pest and disease management practices including cultural, mechanical and biological measures than use of synthetic chemicals. Organic farming is often understood as a form of agriculture with use of only organic inputs for the supply of nutrients and management of pests and diseases. In fact, it is a specialized form of diversified agriculture, wherein problems of fanning are managed using local on farm resources to the extent possible. One of the basic principles of soil fertility management in organic systems is that plant nutrition depends on 'bio logically-derived nutrients' instead of using readily soluble forms of nutrients supplied through fertilizers and the idea should be to feed the soil to make it living rather than feeding the plants. The major mistake committed over the years was to consider and treat soil as non-living entity which in reality is a living one, harbouring highly diverse population of micro flora and micro fauna. These organisms mediate organic matter and nutrient transformations, making them available to plants in a sustained manner and are inevitable in maintaining healthy soil for healthy crops.

3. Coconut - a crop highly amenable to organic farming

Coconut exports nutrients to the above ground parts continuously from limited volume of soil throughout its existence. Unlike other field crops, there is no critical stage for nutrient requirement of coconut palm. Since the palms produce a spadix in the axil of each leaf, the yield depends on the number of leaves produced per year. Vegetative as well as reproductive growth goes on simultaneously and hence nutrition is important all the time. Coconut palms export nutrients to the above ground parts continuously from a limited volume of soil throughout its existence. Any deficiency of nutrients at any stage will adversely affect vegetative growth and will directly reflect on yield. It is, therefore, essential that a nutritionally rich environment is provided in the root zone of coconut all round the year to realise adequate yields. The growth habit and planting methods of coconut make it highly suitable for managing through organic fanning. About 74 percent of the roots produced do not go beyond 2 m from the bole and most of the roots also confine to the 30 to 120 cm depth thus utilizing only limited extent of land area for growth of palms. The orientation of leaves in the coconut crown helps penetration of sunlight into the soil and provides opportunities for exploitation of land and solar energy for inter/mixed cropping. Such an approach will also add large quantities of organic wastes to the system and their recycling within the system makes it productive even in the absence of external inputs.

3.1. Technologies in organic farming of coconut

3.1.1. Soil health management and crop nutrition

Organic manures are important in sustaining soil fertility and productivity especially with a perennial crop like coconut. Application of organic matters like green leaf manuring cattle manure etc are, practiced traditionally for coconut. However, due to the non-availability of land exclusively for cultivating green manure crops and also the limited supply of cattle manure for use as organic manure, organic , manuring is seldom practiced in coconut cultivation. Research efforts have resulted in development of technologies based on organic and bio-inputs for nutritious and soil health management.

3.1.2. Coconut basin management with nitrogen fixing legumes

Atmospheric nitrogen fixed symbiotically by legume-rhizobium association can form an important source of nutrients and organic manure for coconut palms. The basin area of 1.8 m radius around the bole of coconut palm generally is left unutilized by most of the fanners for any other purpose. Leguminous green manure crops such as *Pueraria phaseoloides, Mimosa invisa, Calopogonium mucunoides* and *Vigna unguiculata* can be successfully raised in coconut basins. The biomass production and nitrogen contribution by green manure legumes and their influence on soil fertility parameters vary with soil type, climatic factors and type of green manure raised. On an average they produce about 15-20 kg green matter/basin and their incorporation can contribute around 100-150g nitrogen/basin and other major nutrients as well as enhance the population of specific groups of beneficial micro organisms (bacteria and nitrogen-fixers) in the basin thereby improving the soil fertility. The significant increase in the population of micro organisms and the enzymatic activity modifies the soil environment for the benefit of palm growth. The method of cultivation of green manure in coconut basin is simple, inexpensive and can be adopted even by small farmers. With continuous cultivation of legumes, it is possible to augment soil organic matter resources for sustaining soil fertility and improving coconut yield. Sow the green manure seeds during May-June around the palm basins and uproot when one or two plants start to flower and incorporate the biomass. The nutrient level increases considerably as the biomass start decomposing.

3.1.3. Green manuring in coconut

Green leaf manuring was a common practice among the coconut growers since time immemorial. In this method green leaves from the adjoining forest areas/bulk areas were being collected and incorporated in the basins dug around the coconut palms in the month of August-September. But in view of the shortage of forest the practice has become difficult to follow year by year. Under such circumstances, green manuring, which is the practice of raising a legume and subsequently turning it down in soil after it reaches the maximum vegetative growth to increase the soil fertility, has great potential.

The selection of a green manuring crop is important for highest benefits. It should be high yielding, quick growing to compete with the weeds in the initial growth stages and adoptable to the climatic condition. Some of the green manuring crops viz., *Sesbania Calopogonium*, *Pueraria* , *Tephrosia*, *Crotalaria, Mimosa,* Horse gram and cowpea can be grown in the in the interspaces of coconut garden when coconut is grown as monocrop in the various parts of India

3.1.4. Glyricidia alley cropping in coconut for biomass generation

Generation of large quantities of nitrogen rich biomass is also possible through the cultivation of the fast growing perennial leguminous green leaf manure tree crop, *Glyricidia* in the coconut plantations. This can be very well grown along the borders of coconut plantation and can generate adequate amount of nitrogen rich green leaves. It can also be raised in littoral sandy soils where no other green manure can establish. The tree is propagated either through vegetative cuttings or seeds. One meter long stem cuttings or 3 to 4 month old seedlings raised in poly bags/raised beds can be used for planting. It is preferable that the planting season coincides with the monsoon (South West / North East monsoon) for better establishment. Spacing of 1m x 1m can be adopted. Two rows of glyricidia can be planted along the boundary of coconut garden in a zig zag manner. Plant stem cuttings or seedlings in an upright position in pits of 30 cm^3. For better establishment, a basal dose of 50 g of rock phosphate per pit may be applied. Height of the plants should always be maintained at 1m by pruning. Pest and disease of glyricidia is not a major problem and hence, no plant protection measures are required. Pruning can be started one year after planting and should be done at least thrice a year (February, June and October). Studies conducted at CPCRI has indicated that the best growth and biomass of leaves could be obtained with planting of three rows of Glyricidia (at 1 xl m spacing between two rows of coconut) and pruning of leaves during February, June and October. This could produce around 8t of biomass in one hectare of coconut garden. Application of Glyricidia prunings from the interspaces of one hectare of coconut garden to palms could supply around 90%, 25% and 15% of the requirement of N, P and K, respectively.

3.2 *Incorporation in the soil of organic materials composted (on farm) or not from the holdings (off farm)*

3.2.1. Availability of organic residues in coconut gardens

The availability of waste biomass from a well-managed coconut garden with 175 trees/ ha has been estimated as 14 to 16 tonnes per hectare per year in the form of leaves, stipules, spathe, bunch waste and husk. A considerable portion of husk is used for extraction of coir fibre. The by-product of coir processing factories, coir pith is usually dumped without any use. It has been estimated that 7.5 million tonnes of coir pith is available in the country from the various coir defibering units. The total availability of waste biomass from 1.94 million hectare of coconut plantation in the country has been estimated as 15.4 million tonnes annually. 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 waste in laterials. If they are recycled fully, this waste biomass can meet a major portion of nitrogen and a part of other nutrient requirement of crops. Recycling of coconut waste biomass is possible without affecting the prospects of husk or sheil based industries. It also helps to replenish the nutrients exhausted by the palms internally without depending on the external sources.

3.2.2. Vermicomposting of coconut palm wastes

Vermicomposting involves using native species of earthworm *(Eudrilus* sp.) for conversion of biomass into useful compost. Vermicomposting can be easily done *in situ* in coconut plantations using coconut leaves and other biomass including wastes from intercrops especially from banana. *In situ* recycling of coconut wastes by vermicomposting in trenches dug in interspaces of four coconut palms yield on an average recovery of 70% in a composting period of 90 days. The average nutrient composition of the vermicompost recovered will be around 1 .2- 1.8 % (N), 0.1-0.2 % (P) and O.2-0.4 % (K), organic carbon (17.84%), and *C/N* (9.95:1.00). Total microbial counts and beneficial microbial population will also be more in the coconut leaf compost compared to the base material. This enables disposal of coconut wastes in a less expensive way and eco-friendly manner with the benefit of producing high quality organic manure in the coconut plantation itself. Various methods such as cement tanks, trenches as well as composting in the coconut basin itself can be adopted for vermicomposting wherein composting in the basins itself reduces the cost of transportation of leaves and application of vermicompost. The leaf dry matter production by tall coconut palms is around 32 kg/palm/year and hence the availability of leaf from one hectare of coconut plantation can be estimated as 5.6 t per hectare per year. In this manner all the leaves produced from one coconut palm can be converted into very good organic manure. The , favourable weather conditions for effective vermicompostlng Kerala is found to be the monsoon and post monsoon periods (June to August and September to November).This technology can be adopted in plantations with very limited irrigation facilities as only less number of pits or trenches are to be irrigated. The coconut waste used for oyster mushroom production is also found suitable for vermicomposting 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 when compared to that of the untreated substrate. As vermicomposting can be carried out during most part of the year, it is in a position to provide employment opportunities for the farm families and self help groups as well as for income generation.

Apart from coconut leaves, other agro-wastes like pine apple waste, banana pseudo stem and leaves and glyricidia green manure can also be effectively used along with coconut leaves for vermicomposting. Hence, the agrowastes generated from coconut based cropping system can also be recycled efficiently in the production system. 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.

The water-soluble components from vermicomposting tanks may be collected as leachate by passing water slowly through the composting beds or by simple suspension of vermicompost in water. This vermiwash is honeybrown 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 treatment.

3.2.3. Vermicomposting of coir pith

Coir pith is yet another organic material available in huge quantities from coir processing units. Extraction of one kilo gram of coir fibre generates two kilo grams of coir pith. Approximately 180 grams of coir pith is obtained from the husk of one coconut. In India an estimated 7.5 million tonnes of coir pith is produced per annum. Coir pith hillocks are common in the neighbourhood of fibre extraction units. This spongy cork like material left as such is normally resistant to biodegradation and is a source of environmental pollution. 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 percent) and phytotoxic polyphenols and less of nitrogen. Hence, it is to be applied to soil only after composting. Technologies for large scale composting of coir pith has been standardized at Central Plantation Crops Research Institute, Kasaragod 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 micro organisms 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 the C: N ratio of 17-24: 1 within a short period of 40-45 days. *Pleurotlls* 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.

3.3. Soil and moisture conservation measures in coconut

3.3.1. Mulching coconut basins with leaves, coir pith etc.

Mulching the coconut basin helps to reduce soil temperature and evaporation from soil surface. Coconut leaves, husk and coir pith could be utilized as mulches to reduce the loss of soil moisture and create conditions for proper root growth and proliferation of soil flora and fauna. Decomposition of the mulches after a period of time results in enrichment of soil organic matter pool. Coconut husks can hold moisture to the tune of three to five times of its weight. Approximately 250 to 300 husks required for one coconut basin. Mulching is usually done upto a radius of 2 m. Two layers of husk may be buried in the coconut basin with the concave side facing upwards. These layers facilitate absorption of moisture. Above this another layer of coconut husk is placed with the convex side facing upwards to arrest evaporation. Effect of mulching lasts for about 5-7 years. 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 of material is 0.23% N, 0.04 % P_2O_5 0.78% K_2O, 0.08 % Ca and 0.05% MgO. On an average husk constitutes 45% of the weight of nut and on this basis, a nut weighing 1,000 g will have 450 g of husk with 20% moisture

3.3.2. Coconut husk burial in the interspaces of coconut garden

Husks, if buried in the soil act as a water reservoir and also supply palms with small amount of potash present in it. A fully soaked husk is able to retain about 5-6 times of its weight of water and is made available to the palms during summer season. Trenches of 50 cm width x 50 cm depth and convenient length would be made in between two rows of coconut palms. These trenches would then be filled with coconut husk. Coconut husks need to be filled in layers with the bottom layers facing up and top layer facing down. A bund of 20 cm height and suitable width (>50 cm) is made at the downstream using the excavated soil. Two layers of pineapple plants would be planted on the bund with a spacing of 20 cm plant to plant and 20 cm row to row. Pineapple plants would stabilize the bund and provide additional income to the farmer. The runoff water from the upper side would be collected in the trenches. Soil particles would also get collected in the trench along with the runoff water.

3.3.3. Half-moon bund around coconut basin reinforced with pineapple

This measure is to be taken up where there is mild slope (15-20%). Here a flat basin with a slight inward slope towards upstream is made 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 made at the downstream side of the coconut using the excavated soil. Two layers of pineapple plants would be planted with a spacing of 20 cm row to row and 20 cm plant to plant on the bund. 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.

3.3.4. Trench filled with coconut husk

This measure is to be taken up where the land slope is high. Trenches of 50 cm width x 50 cm depth and convenient length would be made in between two rows of coconut palms. These trenches would then be filled with coconut husk. Coconut husks need to be filled in layers with the bottom layers facing up and top layer facing down. A bund of 30 cm height and suitable width (>50 cm) is made at the downstream using the excavated soil. Two layers of pineapple plants would be planted on the bund with a spacing of 20 cm plant to plant and 20 cm row to tow. Pineapple plants would stabilize the bund and provide additional income to the farmer. The runoff water from the upper side would be collected in the trenches. Soil particles would also get collected in the trench along with the runoff water. Coconut husk retains the moisture and makes it available for plants during summer months.

3.3.5. Catch pits with pineapple border

Catch pits can be constructed at all slopes to conserve soil and water. Though there is no standard dimension for catch pits, we may go for catch pits of 1.5 m length x 0.5 m width x 0.5 m depth. 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. If it is without husk, periodic measurement of the dimension of the pit gives the amount of soil collected inside the pit, a direct measurement of soil erosion.

3.3.6. Cover crops as green manure and to reduce soil erosion

Crops like calopogonium, pueraria, cowpea etc., can be grown as cover crop in coconut gardens where mild to steep slopes are prevalent. Growing of cover crops protects the soil from beating effect of rain especially during high intensity of rainfall thus helping in the percolation of the rainwater. This also helps in preventing the soil as well as nutrient loss.

3.4. Recycling of by-products from livestock farming (manure)

Integration of crops and livestock can also be widely practiced in coconut gardens to generate not only additional income but also to provide relief against the fluctuating prices of nuts besides generating more employment. Mixed farming involves integrating animal enterprises such as dairy, poultry, duck rearing and aquaculture and cultivation of shade tolerant fodder crops in the interspaces of coconut as well as effectively recycling all the organic residues. The animals not only enhance the nutritional status of the household members but also help to augment the farm income by the sale of milk, eggs and other products. 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, They help to reduce dependence on inorganic chemical fertilizers and 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. Here the system is kept productive by maximizing the complementary and synergistic effects of the components involved, Fodder grasses such as hybrid Napier and Guinea grass can yield about 50 to 60 tonnes of fodder per hectare in a year under coconut shade. This will be sufficient to maintain five crossbred milch cows and provide enough farm yard manure that can be used as a component for meeting the on farm organic manure requirement of the system. This will also increase the labour opportunities in the farm. Biogas plant of suitable capacity can also be installed in the farm for production of biogas for use in the farm house and slurry for manuring coconut and other component crops.

3.5. Application of biofertilizers in organic farming

Micro organisms present in the soil play an important role in nutrient solubilization, mobilization, uptake and recycling. They have very wide potential as they increase nutrient availability, stimulate plant growth, control soil borne pathogens and accelerate decomposition of organic material, which help to increase crop production as well as maintain sound environments for crop production. The health of the soil is chiefly determined by its resident microbial flora. The group of microorganisms responsible for nitrogen fixation, phosphorus mobilization and production of plant growth promoting substances are used as biofertilizers in coconut based cropping systems. The coconut roots harbour association of 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 *Penicillum* sp. are predominant phosphate solubilizers in the coconut root region. These microscopic microorganisms are mass multiplied and formulated using locally available career materials and used as biofertilizers for sustainable organic coconut farming. Bioferilizer formulations of nitrogen fixing bacteria, *Azospirillum brasilense* and phosphate solubilising bacteria, *Bacillus subtilis* are used as inputs in organic farming trials in coconut as soil application at the rate of 100g per palm annually along with organic amendments. Plant Growth Promoting Rhizobacteria (PGPR) *Pseudomonas fluorescence* and *Bacillus subtitis* formulations have also been found to be 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. In mixed cropping, dominated nitrogen-fixing microbial group is the bacterium *Beijierinckia* and phosphate-solubilizers such as *Pseudomonas* sp., *Bacillus* sp., *Aspergillus* sp. and *Penicillium* sp. are present in higher numbers. Not only this, higher inhibition potential of resident soil bacteria to phytopathogens is seen in coconut based cropping systems when compared to coconut monocropping systems. When coconut is grown with cacao, rhizosphere activity increases and a better mobilization of phosphates take place 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 VA-mycorhizal colonization as well as the population of phosphate solubilizing bacteria in the root zone of coconut palms. Other organic amendments such as farm yard 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.

4. Crop diversity in coconut based cropping system

4.1. Mono cropping vs mixed cropping

In many coconut growing countries, coconut as a mono crop is only marginally productive and profitable and hence, a cropping system involving inclusion of compatible crops is necessary. The interplay of various factors like limited size of holding, number of trees, needs of the family, labour requirement for crop, year round returns, easiness of marketing are some of the considerations for the farmer to diversify his farm operations for higher returns by adopting intercropping, mixed cropping or introducing other enterprises like dairy, poultry etc. in the system. Under coconut based cropping system, the same land can be put to use to produce other crops so that the productivity of the land can be increased.

From the land utilization point of view, a pure stand of coconut utilizes only 22% of the area at a spacing of 7.5 × 7.5 m leaving nearly 78% of the area which is not effectively utilized. Thus the planting method and growth habit of coconut palms make them highly adaptable for crop diversification in the plantation (Table 2). 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.

Phases in growth of coconut palms and suitability for crop diversification

Life cycle of palms	Light/Shade availability	Crops suitable as companions
1st phase-up to 8th year	Good transmission of light, lowers with age of palms	Annuals/Biennials
2nd phase-8th –25th year	Maximum ground coverage and hence poor light availability	Not very deal. However shade tolerant crops can be grown
3rd phase-older than 25 years	Increase in plant height and crown. More light is available	Ideal for perennial mixed crops requiring more light

The following crops can be cultivated as inter/mixed crops.

Cereals: Rice, maize

Legumes and pulses: Groundnut, horse gram, cowpea, sun flower

Tubers: Tapioca, sweet potato, yams, colocasia, amorphophallus

Spices and condiments: Ginger, turmeric, chilly, vanilla, pepper, nutmeg, cinnamon, clove

Fruit plants: Banana, pineapple, papaya

Floriculture plants: Orchids, anthuriums, heliconia, jasmine, marigold

Medicinal and aromatic plants: vetiver, kacholam, arrowroot, chittadalodakam, thippali, aloe vera, chittaratha, neelayamari, sathavari,oorilia, moovila,patchouli etc.

Beverage crop: Cocoa

4.2. Cropping /farming system approach for sustaining soil productivity

Nutrient management in cropping/farming system is difficult as it is influenced by various factors like crop requirements, differential response of crops, crop residue additions, and management practices suiting to crop needs, water requirement of crops as well as soil environment. It is therefore imperative that the whole system should be considered as one unit and cultivation practices followed for the system as a whole.

Farming/ cropping systems designed based on local resources and needs consider the whole farm as a single unit and all components are given importance in the functioning of the system. These systems create conditions and microclimate suitable for the multiplication and activity of a variety of beneficial organisms. They protect soils from direct sunlight and rainfall and thus preserve soil organic matter reserves. As a number of component crops are involved, soil resources are utilized to the maximum extent, thus preventing the loss of nutrients from the system. As the biomass production per unit area will be very high, when the available organic wastes are recycled, soil health and coconut yields can be sustained even in the absence of external inputs. These systems can be adopted even by small scale farmers and coconut based homestead farming in Kerala is a typical example.

Coconut based farming system (CBFS) can be adopted by many small scale farmers as a self sustaining and risk minimizing strategy. The rationale is that the productivity of the coconut land can be increased. In large scale farm operations, CBFS is also adopted because it provides an efficient resource allocation strategy and minimizes input costs. The adoption of CBFS encourages improved husbandry practices, increases the productivity of coconut land, and enhances the viability of coconut ventures.

A multi-storey cropping system is a more complex CBFS, developed to accommodate two or more intercrops of different heights, canopy patterns and rooting systems, to maximize the use of available sunlight, nutrients, moisture and land area under coconut. The fundamental objective is to increase the productivity of coconut land. The coconut palm serves as the 'top floor', whereas, perennials such as cocoa, bananas, papaya etc., form the mid-storey crops, and short-growing crops such as spices, vegetables, pineapple, fodder etc., form the ground floor. As coconut palms do not have deep root system, the nutrients that are leached down are lost to the palms. When plants possessing deeper roots and greater root volume are included in the coconut based cropping system, the nutrients available below the root zone of the palms are captured and deposited on the soil surface via shed leaves, fallen twigs and other plant parts. These materials on decomposition release nutrients for the uptake by the palms.

The micro climate inside the multi-storeyed cropping system is characterised by lower maximum temperature, smaller diurnal variation and less evaporative demand compared to mono cropping system. Cultivation of different crops in a particular field results in the continuous addition of bio mass and higher level of nutrient supply which have a positive impact on the physico-chemical and biological properties of soil. The beneficial effects of such a system are evidenced by the enhancement of microbial population, improvement of soil fertility status and better utilization of natural resources for the benefit of plant growth and sustainable crop yields.

5. 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 bio control 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 the pest insect in the process), and pathogens (diseases that kill or decrease the growth rate of insect pests). Predatory insects on organic farms include lady beetles, lacewings and spiders. Parasitic insects include wasps and flies that lay their eggs *inion* 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 also can 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 rUl1cinetum and Eupatorium glandulosum* which are profusely growing in the plantations can be used for their anti feedant action against some leaf eating pests. Careful management in both time and space of planting of inter crops not only prevents pests, but also increases population of natural predators that have natural capability to control insects, diseases and weeds. Other methods that can be generally employed for the management of pests and diseases 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 micro organisms, parasites, predators and natural plant based pesticides from neem, tobacco and garlic are effective in managing pests of coconut and other intercrops. There are several examples of use of effective bio control 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 2. 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.

Management of pests and diseases under organic cultivation of coconut

a. Pests

Name of pest	Management practices
Rhinoceros beetle	1. Field sanitation 2. Hook out beetles from attacked palms 3. Fill three leaf axils around spindle with three Naphthalene balls covered with fine sand 4. Treat manure pits and other possible breeding sites with leaves and tender stems of *Clerodendron infortunatum* or *Metarzhizium anisopliae* (the green muscardine fungus) 5. Release *Baculovirus oryctes* infected adults @ 10-15 *I* ha
Red palm Weevil	1. Field sanitation 2. Leaf axil filling as in case of Rhinoceros beetle 3. Set coconut log traps with fermenting toddy or pineapple or sugarcane *activated* with yeast or molasses to attract weevil 4. Use of pheromone trap for attracting and killing adult weevils (this should be adopted as a coconut community level)
Leaf eating caterpillar	1. Cut and burn first affected leaves 2. Periodically release *larval I* pupal parasitoids such as *Goniozus nephantidis, Elasmus nephantidis* and *Brachymeria nosatoi.*
Coried bug	1. Apply neem based bio pesticide on the newly opened inflorescence *Coconut eriophyid mite* 1. Collect and destroy all the fallen buttons of the affected palm 2. Apply 2% neem oil + garlic emulsion or commercial neem formulation azadirachtin 0.004% (Neemazal *TIS* 1% @ 4 ml per litre of water) in the crown on young bunches.

Diseases

Name of disease	Management practices
Bud rot	1. Phytosanitation by *removing* severely affected palms. 2. Apply 10% Bordeaux paste on the cleaned crown. Spray 1% Bordeaux mixture on spindle leaves and crown of diseased palms 3. Provide adequate drainage in gardens and *avoid* overcrowding.
Root(wilt)	1. Follow strictly all prescribed prophylactic measures. 2. Grow green manure crops in basins and incorporate and supply adequate organic manures
Leaf rot	1. *Remove* the rotten portions from the spear and the two adjacent leaves. 2. Spray crowns and leaves with 1% Bordeaux mixture
Stem bleeding	1. *Remove* water stagnation and apply recommended doses of organic manure to make the palms healthy. 2. Apply neem cake @ 5 kg per palm in the basin along with other organics. 3 Use *Trichoderma hamatum* and *Trichoderma harzianum* for the management of the disease

6. Crop response to organic and bioinputs

A field experiment was initiated at the 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 x WCT). The age of palms was 35 years. Application of bio fertilizers (phosphobacteria and azospirillum @100 g /palm/year) and cover cropping of *Pueraria* in the interspace recorded higher nut yield of 120 nuts/palm/year and 94 nuts/palm/year) for D x T and WCT, respectively. In addition it was also observed that pest and disease incidence is very low in the organically maintained plots.

7. Gaps in current knowledge

Farmers who are applying heavy dose of chemical fertilizers will probably experience some loss in yields when converting their farms into organic production. There is a period of time between stopping the use of chemical inputs and sufficient biological activity being restored to the land (e.g. growth in beneficial insect populations, nitrogen fixation from legumes) during which pest suppression and fertility problems are typical. The degree of yield loss varies, however, and depends on factors such as the inherent biological attributes of the farm, farmer expertise, and the extent to which chemical inputs were used earlier. Where soil fertility is low and biological processes have been seriously disrupted, it may take years to restore the ecosystem to the point where organic production is possible. One approach to tide over the difficult transition period involves converting the farm to organic production over a period of time so that a smooth transition takes place and the entire operation is not at risk. Sufficient data on these aspects are lacking at present. Profitability of organic cultivation is influenced considerably by the ability to secure price premiums. The lack of adequate marketing channels can prevent an organic producer from securing the premium for some or all of his produce. Farmers are also unsure whether the premium will remain at least at the current level. Plantation crop farmers are also afraid that increasing the supply level might lead to a collapse in price premiums. But these apprehensions could be cleared by creating consumer awareness of the merits of organic products and production methods. Though producers are aware of the ill effects of chemical farming, they are to be educated on the potentialities of organic farming for large scale adoption.

8. Constraints in Adopting Organic Farming

There is general lack of awareness among the consumers about the quality aspects of organically produced coconut. Technology development through research and dissemination are also to be geared up. Hence, concerted efforts should be made in this direction to conduct more research on organic farming in view of its feasibility and viability.

For coconut palms, the most important nutrients required can be arranged as potassium, nitrogen, phosphorus, calcium and magnesium. Potassium is one of the key elements essential for palm health and is required in relatively large amounts. The organic manures, generally, contain less amount of potassium and at the same time, they contain more amount of nitrogen. Since coconut palms requires higher amount of potassium, application of large quantities of organic manures will be needed to meet the potassium requirement. Over a longer period of time, it may lead to imbalanced ratio of nutrients. Research in this direction is required to address such problem.

Research results indicated that 60-78 per cent of potassium is exhausted through coconut bunches, out of which 50-60 per cent is present in coconut husk. Effective utilization of husk in organic farming of coconut can to some extent mitigate potassium related problems. It also helps to replenish the nutrients exhausted by the palms internally without depending on the external sources.

In perennial tree, it is not advisable to wait for expression of deficiency symptoms of potassium and correct the same later. Instead, regular analysis of leaf tissues, and based on the results, timely application of sufficient quantities of organic manures can minimize the potassium deficiency.

9. Future thrust and development opportunities

As there is increasing demand and premium price for organically produced agro products including that from coconut, there is considerable potential for exploitation of organic farming technology in coconut based cropping system. The results from research studies and from farmers' own experiences point towards the ample opportunities available for organic cultivation by recycling residues available in coconut plantations not only from coconut and intercrops but also from the nitrogen fixing legumes that could be grown in the coconut basins and interspaces. The utilization of effective bio inoculants of beneficial microbes for improving the availability of nutrients and biological control of soil borne pathogens will promote biological interactions for the development of a sound ecosystem. So efforts should be made promotion of ultization biofertilizer, biopesticides and easy availbilty of these ecofriendly inputs at the farm level. On farm production of organic manure at the plant growing site itself will reduce transportation cost and enhance the economic viability of the production technology. Participatory technology development may be needed for spreading the benefits of organic cultivation among farmers. The recent introduction of cluster approach in the coconut based cropping system programme can be taken as a step towards the adoption of organic cultivation of coconut and other crops in a more meaningful way in the years to come. It is also important that direct and indirect benefits of organic farming on a long term basis needs to be quantified

Organic farming can be a reality in coconut cultivation provided all the steps are taken to create awareness and arrangements made for certification using the guidelines of organic production. Further strengthening of organic farming research system is also necessary to address various aspects of organic farming for improvement of technologies from time to time. To achieve the potential of organic farming in coconut, farmer participatory training is essential. The farmers also will require financial support to meet the initial yield reduction and other cost of cultivation. They also should be provided adequate market intelligence and marketing support for getting the maximum profit out of organic farming. As the diffusion of any technology will depend on the satisfaction of farmers with regard to the economics of cultivation, they should be assured encouraging price support for their organic produce and products. Elaborate market promotion for organic coconut products may be needed to catch up in the markets.