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PACKAGE OF PRACTICES FOR ORGANIC FARMING IN COCONUT

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1. Introduction

The coconut palm is referred to as 'Kalpavriksha' – the 'tree of heaven' is a multipurpose tree crop. Every part of the coconut palm finds uses in human life one way or the other. Millions of families in India depend on coconut for their livelihood either directly or indirectly. It is an important crop of economic importance in India especially for States viz., Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Goa, Maharashtra and to a some extent other states like Orissa and West Bengal. Worldwide there is ever increasing demand for organically grown agricultural produce and products. There is also growing demand for organic coconut products and spices (which are usually grown in coconut plantations as mixed crops) in the western world. This trend is likely to continue and farmers who produce organic tender nuts and mature nuts could be able to get a premium price. Research conducted at CPCRI has resulted in the development of a number of viable agro techniques suitable for organic cultivation of coconut which are described in the following sections.

2. Agro-Ecological Requirements

Coconut is essentially a tropical plant, growing mostly between 20^0 N and 20^0 S latitudes. The ideal mean annual temperature is 27^0 C with 5-7^0 C diurnal variation and humidity > 60 per cent. A well-distributed rainfall of 2000 mm per annum is preferred. Coconut is grown in different soil types such as laterite, coastal sandy, alluvial and also in reclaimed soils of the marshy lowlands. It tolerates salinity and a wide range of pH (from 5.0-8.0). Soil with a minimum depth of 1.2m and fairly good water holding capacity is preferred for coconut cultivation. Shallow soils with underlying hard rock, low lying areas subject to water stagnation and clayey soils are to be avoided as it will be difficult to raise successful coconut plantations under such conditions. Proper supply of moisture either through well distributed rainfall or irrigation and sufficient drainage in water logged soil are essential for coconut.

3. Aspects of cultivation

3.1. Planting material production

The need for seedlings would arise only in the case of raising a new plantation or replanting the existing old plantations. Under such situations, selection of seed nuts and seedlings is of utmost importance in coconut as the performance of the new progeny can be evaluated only several years after planting. Location specific varieties which are adapted to local soil and climatic conditions are to be preferred. The following varieties and hybrids have been found suitable for cultivation in different states:

Variety	States for which recommended
Chandra Kalpa	Kerala, Tamil Nadu, Andhra Pradesh, Maharashtra
Pratap	Goa, Coastal Maharashtra
Kera Chandra	West Coast, Coastal Andhra Pradesh, West Bengal
VPM 3	Tamil Nadu
ALR 1	Tamil Nadu
Kamrup	Assam
Kerasagara	Kerala
Kera Keralam	Kerala, Tamil Nadu, West Bengal
Kera Bastar	Chattisgarh, Andhra Pradesh, Maharashtra
Kalyani Coconut	West Bengal
Kalpa Dhenu	Kerala, Tamil Nadu, Andaman & Nicobar Islands
Kalpa Mitra	Kerala and West Bengal
Kalpatharu	Kerala, Karnataka, Tamil Nadu
*Kalpasree	Root (wilt) disease prevalent tracts
*Kalpa Pratibha	Kerala, Tamil Nadu, Andhra Pradesh, Maharashtra
*Kalparaksha	Root (wilt) disease prevalent tracts
*Gautami Ganga	Andhra Pradesh
#Chowghat Orange Dwarf	All coconut growing areas

* for copra and tender nut purpose; # for Tender nut purpose

Hybrid	States for which recommended
*Chandra Sankara (CODxWCT)	Kerala, Karnataka, Tamil Nadu
Laksha Ganga (LCTxGBGD)	Kerala
Chandra Laksha (LCTxCOD)	Kerala, Karnataka
Kera Ganga (WCTxGBGD)	Kerala
Ananda Ganga (ADOTxGBGD)	Kerala
Kera Sankara (WCTxCOD)	Kerala, Karnataka, Coastal Maharashtra, Coastal Andhra Pradesh
Kera Sree (WCTxMYD)	Kerala
Kera Sowbhagya (WCTxSSA)	Kerala
VHC-1 (ECTxMGD)	Tamil Nadu
VHC-2 (ECTxMYD)	Tamil Nadu
VHC-3 (ECTxMOD)	Tamil Nadu
Godavari Ganga (ECTxGBGD)	Andhra Pradesh
*Kalpa Samrudhi (MYDxWCT)	Kerala, Assam
Kalpa Sankara (CGDxWCT)	Root (wilt) disease prevalent tracts

* for copra and tender nut purpose

3.2. Mother palm selection

For raising new coconut plantations, seed nuts are to be collected from selected mother palms. Mother palms should be of 20 years old or more. Wherever possible, it is advisable to select middle-aged trees as they will be in their prime of life and it is easier to spot good yielder from mediocre/poor yielder. The important features are: a) straight stout trunk with even growth and closely spaced leaf scars, b) spherical or semi-spherical crown with short fronds, c) short and stout bunch stalks without tendency to drooping, d) more than 30 leaves and 12 inflorescences carried evenly on the crown, e) inflorescence with 25 or more female flowers, f) consistent yield of about 80 nuts under rainfed conditions and 120 nuts under irrigated conditions, g) 150 g copra per nut and h) absence of disease and pest incidence.

3.3. Collection of seed nuts and sowing

Collect seed nuts during April-May and sow during June in west coast region of India, whereas in the east coast region, sow nuts during October-November to coincide with the monsoon. However, when irrigation facilities are available seed nuts can be collected and sown at any period of time depending of the requirement. Only fully matured nuts i.e. about 12 months old should be harvested. Care should be taken not to damage the seed nuts while harvesting. Discard nuts which are too big or too small in the bunch and also the nuts of irregular shape and size. Sow the seed nuts of tall varieties one or two months after collection and that of dwarf varieties either immediately or within 10-15 days after harvest.

3.4. Raising nursery

Nursery site should be well-drained with coarse-textured soil near dependable irrigation water source. The seed nuts can be sown in flat beds if there is no drainage problem. The seeds are to be sown in raised beds if water stagnation is a problem. Nursery can be raised either in the open area 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 or September-October, 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 good to go for horizontal sowing for better germination.

3.5. Selection of seedlings

Remove seed nuts, which do not germinate within 6 months after sowing as well as those with dead sprouts. Select only good quality seedlings (9-12 months old) by a rigorous selection based on the following characteristics.

1. Early germination, rapid growth and seedling vigour.
2. Six to eight leaves for 10-12 month old seedlings.
3. Collar girth of 10 cm and above
4. Early splitting of leaves.

3.6. Poly bag nursery

Good quality seedlings can be raised using poly bags. Transplant germinated seeds in poly bags (500 gauge thickness) of 45 x 60 cm with 8-10 holes at the bottom. The commonly recommended potting media are top fertile soil mixed with sand (3:1) or top

Poly bag nursery

fertile soil, sand or coir dust and well rotten and powdered cattle manure (3:1:1). Potting mixture containing sand + vermicompost (3:1) is also ideal for raising poly bag seedlings. As the entire ball of earth with the root system can be placed in the pits, there won't be any transplanting shock for the seedlings. Care should be taken not to throw away the poly bags in the coconut plantation. Biofertiliser (*Azospirillum* spp. and Phosphobacterium *Bacillus* sp.) 25 g each can be applied to the poly bags. This will result in production of more vigorous and robust seedlings.

3.7. Preparation of land and planting

The depth of pits will depend upon the type of soil. In laterite soil with rocky substratum, deeper and wider pits (1.2 x 1.2 x 1.2 m) are to be dug and filled up with fertile

Control and biofertilised seedlings

top soil, powdered cow dung and ash up to a depth of 60 cm before planting. Addition of 2 kg of common salt will help in loosening the soil in such areas. Arrange two layers of coconut husk with concave surface facing up at the bottom of the pit before filling up the soil. This will help in conserving soil moisture. At the center of the pit, remove the soil mixture and plant the seedling. Press the soil well around the seedling and provide the seedling with shade by using coconut leaves or palmyrah leaves.

In loamy soils with low water table, planting in pits (1.0 x 1.0 x 1.0 m) filled up to 50 cm depth is generally recommended. However, when the water table is high, planting at the surface or even on mounds are

necessary. Even while planting at the surface or mounds, digging pits and filling has to be done. If planting is taken up in the littoral sandy soil, application of 0.15 m^3 of red earth is recommended. The pits should be cleared of weeds periodically.

3.8. Spacing

A spacing of 7.5 x 7.5 m is generally recommended for tall varieties of coconut. If triangular system is adopted, an additional 20 to 25 palms can be planted. Wider spacing provides ample opportunity to accommodate a number of annual and perennial crops in the interspaces.

3.9. Time of planting

Planting the seedlings during May/ October, with the onset of pre-monsoon rains is ideal. Under assured irrigation, planting can be done during April also. In low-lying areas, plant the seedlings in September after the cessation of heavy rains. Planting can also be taken up in Tamil Nadu with the onset of north-east monsoon.

Planting of seedlings

3.10. Care of young palms

Protect the seedlings from heavy sunlight by proper shading and irrigate during summer months. Irrigate once in four days with 45 litres of water in sandy soils. Provide proper drainage in areas subject to water logging. Care should be taken to avoid soils covering the collar region of coconut seedlings due to heavy rain. Remove soil washed down by the rains and covering the collar of the seedlings. Widen the pits every year before the application of manures. Gradually fill up the pits as the young plants grow. Inspect the plants at regular intervals for any insect or fungus attack and necessary remedial measures should be taken up as and when required.

4. Nutrient management for young palm up to three years

Any one of the green manure crops like *Pueraria*, cowpea, sunhemp, *Calapagonium* or daincha may be sown and ploughed *in situ* at the time of flowering as a substitute of compost to be applied. Sow any one of the green manure crops immediately after the receipt of first monsoon rains (May-June and September-October for the areas benefited by South-West monsoon and North-East monsoon, respectively) according to the soil

and climatic conditions @ 50 g/palm in the basin and incorporate before flowering. If there is no intercrops grown in the interspaces, green manures crops can be grown in the interspaces. Coir pith compost/ vermicompost made from coir pith/coconut leaves/other wastes from coconut grove can be applied @ 5 to 10 kg/per palm for the initial period depending upon the organic resources used.

5. Organic farming practices for adult plantation

The practices for organic farming includes adoption of nutrient management and biological plant protection measures along with regular practices like irrigation, mulching and cropping/farming system.

5.1. Nutrient management

For an adult plantation under conventional farming, a conversion period of three years is necessary for getting certification as organic garden. Organic and bio inputs such as vermicompost produced from coconut leaves, coir pith compost, vermiwash, cultivation and incorporation of green manure legumes, glyricidia loppings and biofertilizers are found to be ideal sources of nutrients for organic cultivation of coconut. The method of production and application of the nutrient sources are described below.

5.1.1. Vermicomposting

a. Vermicomposting in the basin

Open a basin with a radius of 2 m from the trunk with minimum soil disturbance. Fallen dried coconut leaves from individual palm should be collected and spread in the basin. Cut the leaves into two or three pieces and apply in basins in such way that the leaflets can hold water to hasten pre composting process. Initially vermicomposting can be started with the addition of five to six coconut leaves. Later, add fallen leaves in respective basins as and when available. Where palms are irrigated, maintenance of optimum moisture is easy. However, when

Vermicomposting in the basin

palms are grown under rainfed condition, vermicomposting is feasible only in the rainy period. Vermicomposting may be started at the beginning of monsoon season. After spreading leaves in the basin allow pre curing for three weeks. After completion of this process, apply cow dung @10% of leaf weight. Wherever possible, the cow dung should be obtained from the organically maintained dairy unit. Then release around fifty earthworms of *Eudrilus* sp. to each basin. Adequate care should be taken for the protection of the earthworms. The basin should be covered with suitable mulch material such as dried weed material etc. In case of continuous

rainfall, care should be taken to drain excess water in the basin to avoid water stagnation. When the monsoon recedes, make necessary arrangements for maintaining optimum moisture either by hose or micro irrigation. The vermicomposting system should be kept adequately moist 40 to 50% as deficit in soil moisture results in death of worms and it necessitates further application of earthworms. Vermicomposting in coconut basins not only provides major, secondary and micro nutrients, but also acts as mulch, improves soil physico chemical properties, suppresses weed growth and ensures higher microbial population build up thereby enhancing soil health. Incorporate newly dried fallen and partially decomposed leaves without any damage to earthworms and their activities. Care should be taken to provide adequate biomass materials in the basins for continuous vermicomposting. Advantage of this system is that all the coconut leaf and weed materials added in to the basin is completely composted. Through vermicomposting alone a quantity of 25 to 30 kg of vermicompost is added per palm per year.

b. Vermicomposting in trenches

Vermicomposting in trenches can also be done by opening trenches of 1.5 m width x 1 m depth in the interspaces of coconut garden. Collect and apply fallen dried leaves in such trenches, apply cow dung at a ratio of 1: 10 (Cow dung: coconut leaves) and release earthworms at the ratio of 1:1 (1 earthworm per kg of dried leaves). Other organic

Vermicomposting in the trenches

materials i.e., dry weeded materials can be also applied in the trenches. Proper stirring should be done for adequate aeration and to hasten vermicomposting process. Newly fallen dried leaves can also be incorporated as and when available. Once the vermicomposting is completed, remove the vermicompost and apply to coconut palms. New partially decomposed leaves can be added in such trenches along with old undecomposed materials. This method can be practiced even under limited irrigation or when palms are maintained under rainfed conditions. Through this 25 to 30 kg vermicompost per palm per year is added.

c. Vermicomposting in tanks

Vermicomposting of coconut wastes can be done in cement tanks. The weathered coconut leaves collected from the garden should be kept for two weeks after sprinkling with cowdung slurry. Cowdung should be used at the rate of one tenth of the weight of the leaves. Afterwards earthworms (*Eudrilus* sp.) are to be introduced at the rate of one kg for one tonne of the material. Care should be

taken to provide sufficient moisture for the decomposing material by frequent sprinkling of water. Adequate shade also should be provided to avoid direct sunlight. Vermicompost will be ready in about 75-90 days. Stop providing water one week before collecting the compost. On an average, 70 per cent recovery of vermicompost was obtained. Nucleus cultures of the local strain of *Eudrilus* sp. capable of composting coconut plantation wastes are being supplied from CPCRI at a nominal cost. These worms can be multiplied fast in a 1:1 mixture of cow dung and decayed leaves, mulched properly with grasses.

d. Vermiwash production and application

Another important product of vermicomposting technology is the vermiwash, which is rich in nutrients in readily available form, plant growth promoting hormones, beneficial microorganisms and can be used for improving the productivity of crops. All the physiologically active water soluble components of vermicompost such as humic acid, plant growth regulators, amino acids, vitamins, micro nutrients and microbial cells extracted in water is known as vermiwash. In order to prepare vermiwash, composting is to be done in tanks with provision made for vermiwash collection. The water soluble components from vermicompost can be collected by passing water slowly through the tank. Alternatively, vermiwash can be produced by allowing water to percolate through the drilosphere (tunnels) made by

Vermiwash collection from tank

Eudrilus sp. in coconut leaf + cow dung substrate kept in a 200 litre plastic barrel. Water is allowed to drip from a pot hung above the barrel in to the actively vermicomposting system. After 45 days, clear brown liquid is collected out through the tap fixed at the bottom of the barrel. The collection can be done for another two cycles from the same barrel. Then the content of the barrel should be removed and fresh substrate along with earthworms should be added. The vermiwash production can also be carried out in mud pots in a similar way. Fresh coconut leaf vermiwash is alkaline and contains major and minor nutrients in appreciable quantities. It also has sugars, amino acids and phenols along with the plant growth promoting hormones *viz.*, indole acetic acid, gibberlic acid and humic acid.

Fresh vermiwash harbours a large number of fluorescent pseudomonads that help in plant growth promotion and protection.

Vermiwash can be applied either through foliar spray or soil drenching. It should be applied @ 1: 5 dilution. Vermiwash has been found to be effective as foliar spray for growth promotion and bio suppression of pathogens in crop plants. Laboratory studies have shown that coconut leaf vermiwash improves the germination percentage and seedling vigour of cowpea and paddy. In green house experiments with nutmeg, clove, pepper and vanilla, application of vermiwash has resulted in better shoot growth, more leaf production and particularly higher root biomass that too with large amount of fine root hairs that improve the water and mineral absorption capacity of the plants. Field studies with soil application of coconut leaf vermiwash showed increased biomass production of green manure cowpea with increased nodule numbers. In maize, increase in cob yield with higher cob weight could be realized. Bhendi yield could also be enhanced. Vermiwash application stimulated the increase in numbers of microrganisms particularly the beneficial ones (free living nitrogen fixing bacteria, phosphate solubilizers, cellulose degraders and antibiotic producing actinomycetes) in the root region of the above crops along with increasing the soil dehydrogenase, phospahatase and urease enzyme activities. In bhendi, the population of the nematode *Meloidogyne incognita* and gall formation was greatly checked on application of vermiwash.

5.1.2. Growing of green manure crops

a. Basin management with legumes

When vermicomposting is practiced in the trenches, green manure crops can be grown in the basins. Sow 100 g seed of *Pueraria phaseolodies* or *Calapogonium muconoides* or cowpea *(Vigna unguiculata)* or sunhemp *(Crotalaria juncea)* in coconut basins with the onset of the monsoon in May. Among these leguminous crops, the former two species are

Pueraria cover crop in the basin

preferable because of shade tolerance, self seeding nature and higher biomass productivity. Sowing during heavy rainfall should be avoided. Lightly stir soil around the basin in 2 m radius area and broadcast the seeds uniformly and later on cover the seeds by slight raking. Allow the plants to grow in the basin and harvest the biomass as and when one or two plants start flowering and put back into the basin and cover with soil. While doing so, the soil should be disturbed to the bare

Cowpea as a cover crop in the basin

minimum. About 20-25 kg of biomass can be generated in the basin of coconut palm and it contributes 150 to 200 g nitrogen per palm. When irrigation is practiced sowing of green manures may be undertaken twice in a year.

b. Growing green manure crops in the interspaces

When vermicomposting is done in the basins, green manure crops can be grown in the interspaces leaving 2 m radius area from the stem. About 250 g of seed of *Pueraria phaseolodies* or *Calapogonium muconoides* or cowpea *(Vigna unguiculata)* is to be sown with the onset of monsoon. Harvest the biomass as and when one or two plants start flowering and put them into the basin and cover with soil. While doing so, the soil should be disturbed to the bare minimum. A quantity of 25 to 30 kg of biomass per palm is available which can be added in to the basin.

Pueraria in the interspace

c. Glyricidia as green manure crop

A fast growing, multi-purpose tropical leguminous tree, *Glyricidia sepium* with high nitrogen fixing potential is well adapted in coconut growing soils. Glyricidia cuttings can be planted in the border areas. Boundary of one hectare coconut garden can accommodate 450-500 cuttings. The tree is propagated either through vegetative cuttings or seeds. One metre 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 coincide with the monsoon (South West/North East monsoon) for better establishment. Spacing of 1 m x 1 m can be adopted. Two rows of glyricidia can be planted along the boundary

Glyricidia in the border area

of coconut garden in a zig zag manner. Plant stem cuttings or seedlings in an upright position in the 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 1 m 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). By this method, a quantity of 10 kg green manure/palm/year can be made available to the palm. The green manure should be applied in the basin of the coconut palm (2 m radius area).

Similarly when there is no intercops grown in the interspaces, two or three rows of glyricidia can be planted in between two rows of coconut. Three rows of glyricidia in between two rows of coconut with three prunings per year resulted in biomass yield of

Glyricidia as intercrop (Green manure)

7970 kg ha^{-1}. The loppings can be chopped and incorporated into the soil as green manure.

5.1.3. Application of organic manure from off farm source

a. Coir pith as a manure

Coir pith is a by product from coir processing factories can be converted to quality organic manure by vermicomposting/ composting with microbial inoculants and poultry manure amendment.

b. Vermicomposting of coir pith

Farmers can employ this vermicomposting technique using the local strain of *Eudrilus* sp. wherever they have easy accessibility for the raw material i.e., coir pith. As coir pith alone is not able to support the growth of earthworms, it is to be treated with lime and rock phosphate @ 0.5 per cent each and incubated for three weeks and later

Composting of coir pith

mixed with cowdung and fresh vermicompost each @10 per cent. This mixture has to be layered with uncut coconut leaves @ 20 per cent to facilitate aeration in the bed. The earthworm *Eudrilus* sp. has to be introduced

at the rate of 1000 numbers/tonne of organic materials and the bed should be mulched and protected from direct sunlight. Moisture has to be maintained at 50 per cent by regular watering. Earthworms form burrows in the bed and vermicastings appear as surface casts. A granular vermicompost with 1.2 per cent nitrogen and C: N ratio of 16.7:1 can be obtained in two months.

Co-composting coir pith with solid poultry manure with/without lime and rock phosphate amendment revealed that the composting process facilitated by poultry manure amendment brought about bioconversion of coir pith to a final product in 45 days and the final product possessed physico-chemical characteristics required for quality organic manure. C:N ratio, which is considered as a maturity index of composting process, got reduced during the composting process, to 21.42. The composted coir pith can be used as manure in coconut plantations and can increase the capability of soils to store moisture and nutrients. Composted coir pith @ 25 kg /palm can be applied in the basin of coconut palm during the month of August-September.

c. Composting of lignin rich biomass using microbial cultures

Technologies are available for bioconversion of coir pith having a high C:N ratio to acceptable organic manure with the help of biopolymer degrading micro-organisms. *Pleurotus sajor caju* and *Trichoderma* inoculations are effective in the production of quality compost from coir pith. Large scale composting has been standardized with the amendment of lime and rock phosphate at 0.5 per cent level each and glyricidia leaves (10 per cent) and fungal inoculation at 0.2 per cent level. The raw coir pith with a C:N ratio of 100:1 is converted to acceptable manure with a C:N ratio of 17:1 within a period of 40-45 days.

d. Application of biofertilizers

Biofertiliser formulations of nitrogen fixing *Azospirillum* spp. and phosphate solubilising *Bacillus* sp. can be prepared using sterilized vermicompost as carrier material. The cell count at the time of preparation is maintained at a minimum of 1×10^7 for *Azospirillum* spp. and 1×10^8 for *Bacillus* sp. as per Bureau of Indian Standards (BIS) specifications. Utilization of vermicompost produced from coconut leaves results in the production of high quality biofertilizers with more than 10^8 cfu bacteria per gram of the carrier material. The recommended dose of biofertilizer for coconut is 100 g of carrier based inoculants per palm. The biofertilizer is to be applied in the coconut basin, twice in a year (pre monsoon and post monsoon), by mixing with top soil followed by application of organic amendments. Organic amendments such as vermicompost, coir pith compost, farm yard manure, neem cake, green manures etc. can be combined with bioferilizers. While applying biofertilizers, organic amendments such as vermicompost are added @ 20 kg/ palm. Use only certified biofertilizer

inoculants. The biofertilizer should be mixed with one kg vermicompost and applied to soil and incorporated. Care should be taken to use only biofertilizer containing adequate number of living micro organism and before the expiry period mentioned in the packet. It has been observed that in many instances desired results are not obtained due to the use of preparation not containing the required number of metabolically active micro organisms. Optimum soil moisture is essential after biofertilizer application to ensure the survival of the introduced microbial inoculum in the soil. Hence, biofertilizer application should coincide with the onset of monsoon especially when the palms are maintained under rainfed condition. However, under irrigated conditions, it can be applied at any time, since maintaining optimum moisture is not a problem.

e. Other organic manure resources

Organic manures *viz.*, neem cake, ash etc can also be applied on nutrient equivalent basis. Experiments conducted at different centers of India under AICRP revealed that application of these manures on nutrient equivalent basis resulted in comparable coconut yield as compared to other nutrient management practices.

5.2. Irrigation

To reap the full benefits of organic farming, irrigating the coconut palms is highly essential. Coconut palms can be irrigated by drip irrigation or basin irrigation (hose irrigation). Drip irrigation is a micro irrigation system in which the water is applied to the root zone at the rate at which the palm can take up. It is ideal considering the advantage of water saving. Four pits with a size of 30 x 30 x 30 cm have to be dug one metre away from the bole of the palm at equidistance and the pits filled with raw coir pith. The water has to be delivered to the bottom of the pit through conduit tube placed in slanting position. Under northern Kerala conditions, 32 liters/palm/day is sufficient (66 % of the evaporation requirement) to achieve higher yield. Another advantage is that vermiwash and other organic solution also can be applied through drip irrigation i.e. fertigation. To supply 32 litres/day, four drippers at a discharge rate of 4 litres/hour will be required so that daily two hours of irrigation is sufficient. 200 liters water once in four days interval should be applied when basin irrigation is employed.

5.3. Weeding

Generally, weeding is carried out when the monsoon recedes preferably during September- October. Weeding can be done either by hand or with a sickle depending on the intensity of weed growth. The weeds can be removed by hand around the palm base and the weeds in the inter space need only be slashed with sickle. Clean weeding may be avoided. While weeding, dried shoots and other thrashed materials can be used as mulch around the base of palms, which will help to conserve moisture in the ensuing dry months and help in vermicomposting process in the basin as well as in the interspaces.

5.4. Coconut based cropping system

Crop diversification rather than mono cropping is to be adopted in an organic production system. Cropping/farming systems by raising compatible subsidiary crops and/or integrating with livestock enables to increase the productivity and net returns from unit area of coconut plantations. Farm resources like land, labour, sunlight, water and nutrients can be effectively utilized in such a system and higher productivity could be achieved as a result of synergistic interaction among the crop and crop-livestock components. Crop diversity involving a number of annual, biennial or perennial crops as inter/mixed crops in perennial stands of coconut also promote the productivity and sustainability of the system.

The growth habit and planting methods of coconut make it highly suitable for inter/mixed cropping. About 74 per cent 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.

Coconut offers scope for intercropping in the initial stage of the growth of palms and mixed cropping in the later part of life of palms. In an organic production system, it is essential that all the crops in the field are cultivated and maintained strictly following organic methods of production. In the case of short duration annual crops, a system of crop rotation involving a legume in the cycle would help to restore fertility levels.

Ginger as an intercrop

Crops belonging to the same family (e.g., ginger and turmeric) should be avoided as far as possible in the rotation.

Coconut based cropping systems involving annuals, perennials and combinations of both annuals and perennials have been developed to suit the availability of resources

Turmeric as an intercrop

Pinapple as an intercrop

like labour, rainfall and irrigation facilities, finance, soil characteristics and the farmers' needs and market demands. The crops *viz.*, cowpea, pumpkin, ash gourd, amaranthus, bhendi, turmeric, ginger, pepper, pineapple etc are found to be suitable intercrops which can be grown organically in the interspaces of coconut garden.

Amaranthus as an intercrop

Mixed farming system integrating crop husbandry and livestock is an integral part of the organic production system. It involves cultivation of shade tolerant fodder crops in the interspaces of coconut and integrating animal enterprises like dairy, poultry, fisheries etc. and recycling the by-products. Care should be taken that the maintenance of livestock and other components as well as production of fodder (feed) needed for them are based on organic standards. Such a system enables the use of by-products in the farm itself without depending on external sources. The suitable grasses for rainfed condition are guinea grass, Congo signal and for irrigated condition, hybrid bajra Napier. Experimental results from CPCRI revealed that intercropping of hybrid bajra Napier Co 3 in coconut and

Coconut based mixed farming

maintained organically resulted in 106 tonnes green fodder/ha/year and this fodder could be sufficient to manage 10 milch animals. Based on the results obtained from coconut based integrated mixed farming system for one hectare involving eight milch animals, 4 to 6 batches of broiler birds (100 birds/batch), 100 quails and 625 m^2 area of fish pond, the out put from different components for average of five years is as follows; the average nut yield from one ha was 20,189 nuts, the average milk

yield from the system was 11,785 litres per annum. Broiler birds are reared up to 50 days and then disposed off. On an average, six batches of 100 birds each are maintained per annum. Each bird gained a weight of 1.5-2.0 kg in 7 weeks. Quails started laying eggs after 40 days and continued up to 200 days. The average body weight of females was 150-180 g and that of males 120-150 g. From pisiculture on an average 400 kg of fish was harvested. In addition about 35 tonnes of FYM is thus collected from the dairy unit and 2 tonnes of poultry manure from poultry unit. This accounted for about 250 kg N, 156 kg P_2O_5 and 230 kg K_2O. Hence part of the nutrient requirement of the coconut palms, grass and subsidiary crops was met from recycling the cow dung, poultry manure and shed washings. From 3 m^3 biogas plant, gas generated was used for cooking by the farm family and for emergency lighting in the cowshed.

5.5. Soil and water conservation under rainfed situations

Proper soil and moisture conservation practices are essential for ensuring sustainable production especially when coconut is grown under rainfed condition with undulating terrain and sloppy conditions.

a. Mulching

In order to conserve soil moisture in the coconut plantation, mulching with various types of organic materials can be practiced. The best time for mulching is before the end of the monsoon and before the top soil dries up. For mulching, cut coconut leaves into two or three pieces. To cover 2 m radius of coconut basin, 15 to 25 fallen coconut leaves are required to spread in 2-3 layers.

Mulching with composted coir pith to 10 cm thickness (approximately 50 kg/palm) around coconut basin is also ideal method to conserve moisture. Coir pith can hold moisture five times of its weight. Due to its fibrous and loose texture, incorporation of coir pith considerably improves the physical properties and water holding capacity of soil and thereby increases the coconut productivity. The applied material may last for about 4 to 5 years. The weeded materials also can be used for mulching and should be properly dried before applying as mulch in the basins.

b. Husk burial

Burial of husk in trenches in between the rows of palms is also effective for moisture conservation in coconut gardens. Husk burial is to be done at the beginning of the monsoon in linear trenches of 1.5 to 2 m wide and about 0.3 to 0.5 m deep between rows of palms with concave side of husk facing upwards and each layer is to be covered with soil.

c. Catch pit filled with coconut husk

Catch pits can be constructed at all slopes to conserve soil and water. Though there are no standard dimensions for catch pits, catch pits of 1.5 m length x 0.5 m width x 0.5 m depth can be constructed. A bund is

to be made at the downside using the excavated soil and pineapple suckers planted on it. This pit is also filled with coconut husk.

d. Contour 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 are to 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 are to be planted on the bund with a spacing of 20 cm x 20 cm. 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.

5.6. Pests and their management

The organic production should aim at minimizing losses from pests, diseases etc. As organic system of cultivation does not permit use of chemical pesticides for the management of pests, other measures such as use of cultural, mechanical, biological and use of botanical and bio pesticide are to be adopted.

Being a perennial crop, coconut is subjected to attack by an array of pests round the year. Even though there are over 750 insect species (including the ones that directly feed and those which are only associated) recorded on coconut palm, only a few are considered to be of economic importance. All parts of the palm *viz.*, leaves, stem, root, inflorescence and the nuts are subjected to attack by pests. Damage when caused to the leaves, leads to reduction in photosynthetic efficiency and decrease in value for thatching purpose, but when done to inflorescence and nuts leads to direct economic loss. The major insect pests of coconut are rhinoceros beetle (*Oryctes rhinoceros*), red palm weevil (*Rhynchophorus ferrugineus*), leaf eating caterpillar (*Opisina arenosella*), root eating white grub (*Leucopholis coneophora*), coried bug (*Paradasynus rostratus* Dist.) and coconut eriophyid mite (*Aceria guerreronis* Keifer).

a. Rhinoceros beetle (*Oryctes rhinoceros*)

Symptoms

The adult beetle bores through into the unopened fronds and spathes. The affected frond when fully opened shows the characteristic geometric cuts. Infestation on spathes often destroys the inflorescence and thus prevents production of nuts. The beetle breeds in a variety of materials such as decaying organic debris, farmyard manure, dead coconut logs, compost pit etc.

Coconut palm damaged by rhinoceros beetles

Clerodendron infortunatum

Metarzhizium anisopliae infested grubs

Management

- Field sanitation by proper disposal of decaying organic debris.
- Mechanically extract beetles with hooks without causing any further injury to the growing point of the palm.
- Crown cleaning should be done annually.
- Apply powdered neem cake or "Marotti cake" (*Hydnocarpus wightiana Blume*) @ 250 g mixed with equal quantity of sand in top most three leaf axils three times a year or fill the innermost two leaf axils with 12 g naphthalene balls covered with sand at 45 days interval.
- Treat manure pits and other possible breeding sites with leaves and tender stems of *Clerodendron infortunatum* or with the culture of *Metarzhizium anisopliae* (green muscardine fungus). Spray 250 mg fungal culture diluted with 750 ml water/m^2 of breeding site. The fungus can be mass multiplied on local materials such as coconut water and cassava chips.
- Release *Oryctes* rhinocerous virus (ORV) infected adult beetles @ 10-15 / ha of coconut plantation.
- Apply mixture of either neem seed powder + sand (1:2) @150 g/palm or neem seed kernel powder + sand (1:2) @150 g per palm in the base of the threee inner most leaves in the crown.

- Set up PVC trap using the Oryctalure pheromone @ 1 to 2 per ha to trap and kill the beetles.

b. Red palm weevil (*Rhynchophorus ferrugineus*)

Symptoms

Young palms below 20 years succumb to severe damage by this pest. Bud rot and leaf rot disease and rhinoceros beetle attack are predisposing factors for red palm weevil infestation. Being an internal feeder, it is very difficult to detect the damage caused by the pest at an early stage. Wilting of the central spindle, presence of chewed fibers and cocoons in the trunk, presence of holes in the trunk with brown fluid oozing out are the important symptoms. The symptom of infestation becomes clear in advanced stages when the crown of the affected palm topples. The weevil multiplies enormously in young coconut plantations causing loss to an extent of 5 to 10 per cent.

Red palm weevil infestation on coconut

Management

- Avoid injury to the palms, as they would attract the weevil to lay eggs. Injuries caused by rhinoceros beetle, mechanical injury during cutting of leaves or steps cut on the trunk for climbing give a favourable condition for egg laying.

Pheromone trap for red palm weevil

- Mechanical injury caused, if any, should be treated with coal tar.
- While cutting of fronds, leave petiole to a length of 120 cm from the trunk to prevent the entry of weevils through the cut end.
- Periodically clean the crown to avoid decaying of debris in leaf axils.
- Remove palm in the advanced stage of infestation, split open the stem and burn

- Adopt prophylactic leaf axil filling as suggested for rhinoceros beetle.
- Set longitudinally split coconut log traps (50 cm length) after smearing the cut surfaces with fermenting toddy or pineapple or sugarcane activated with yeast or molasses to attract weevil. Coconut petiole pieces smeared with fermented toddy kept in pots @ 10 pots/ ha also serve as weevil traps. The traps should be placed at dusk and the weevils trapped destroyed, the next morning.
- Install traps with aggregation pheromone @ 1 trap/ha on coconut trunk at a height of 2 m from ground to mass trap and destroy the weevils. This technology should be taken up on community basis.

c. Leaf eating caterpillar (*Opisinia arenosella*)

Symptoms

Leaf eating caterpillar commonly occurs in the coastal and backwater tracts. In recent years, it has assumed severe proportions in interior tracts as well. The caterpillars live on the under surface of leaflets inside silken galleries and feed voraciously on the chlorophyll containing functional tissues. This affects the health of the palm adversely by reducing the photosynthetic area and results in reduction of yield. The severity of infestation by this pest will be marked during the summer months from February to June. With the onset of SouthWest monsoon, the

Leaf eating caterpillar infested coconut garden

pest population begins to decline. In severe outbreaks of leaf eating caterpillar, the older leaves of the palms are reduced to dead brown

Leaf damaged by *Opisinia*

tissue and only three or four youngest leaves at the centre of the crown remain green. In case of severe infestation, the whole plantation presents a scorched appearance.

Management

- Cut and burn the heavily affected and dried outer most 2 to 3 leaves.
- Adopt biological control by periodical release of larval parasitoids such as *Goniozus nephantidis* @ 20 parasitoid /

Larval parasitoid (*Goniozus nephatidis*)

palm, *Bracon brevicornis* @ 30 parasitoid / palm.

- The release of pre pupal parasitioid *Elasmus nephantidis* @ 49 per cent and pupal parasitioid @ 32 per cent *Brachymeria nosatoi*, respectively, for every

Parasitioids

100 pre-pupae, pupae estimated to be present on the palm. Combined release of the parasitoids is required in multistage condition of the pest.

d. White grub (*Leucopholis coneophora*)

Symptoms

The soil inhabiting white grubs cause damage to the roots of coconut. Besides coconut, it infests tuber crops like tapioca, colocasia, and sweet potato etc., grown as intercrops in coconut gardens. In coconut nursery, the grubs feed on the tender roots and tunnel into the bole of the collar region resulting in drying up of the spindle followed by yellowing of the outer leaves and gradual death of the seedling. In older coconut plantations continuous infestation by the grub results in yellowing of leaves, tapering of crown, premature nut fall, delayed flowering, retardation in growth and reduction in yield.

Management

- Collect and destroy adult beetles during peak period of emergence in May–June to reduce the population.
- Setting up of light traps in the infested field helps to collect and destroy the beetles during peak period of emergence.

e. Coried bug (*Paradasynus rostratus*)

Symptoms

The adults and nymphs feed by desapping the contents on buttons and developing nuts below the perianth region. The feeding points develop to brownish necrotic lesions, which later turn to furrows or cracks. The symptoms are easily identified by cracks and gummosis. Severe damage leads to nut fall and malformation of mature nuts.

Management

- Apply neem based bio pesticide on the newly opened inflorescence.

- The red ant , *Oceophylla smaradigna* has been found to have antagonistic effect on the pest

f. Eriophyid mite (*Aceria guerreonis*)

Symptoms

Mite feeds on the upper portion of the developing nut that is covered by perianth. Feeding by mites in this zone causes physical damage to cells. The feeding sites that grow downward from the perianth appear as longitudinal patches and later develop into triangular yellow patches, turn brown, develop longitudinal fissures and finally appear as warts and develop into longitudinal splits on the surface of nuts. The liquid oozing from these patches dries and as a result dried decayed matter is noticed. The damage affects the quality of husk and dehusking becomes difficult.

Management

- Adopt phytosanitary measures in coconut plantations like crown cleaning.
- Collect and destroy all the fallen buttons of the affected palm.
- Spray neem oil-garlic-soap emulsion @ 2 % concentration (200 ml neem oil, 50 g soap and 200 g garlic mixed in 10 litres of water) or commercial neem formulation azadirachtin 0.004 % (Neemazal T/S 1% @ 4 ml per litre of water) during April-May, October-November and January-February. Apply the spray solution as fine droplets on the perianth region and general surface of developing nuts of 1-6 months old bunches with hand sprayer or rocker sprayer.

Mite damage symptom

5.7. Diseases and their management

The coconut palm is affected by a number of diseases, some of which are lethal while others gradually reduce the vigour of palms causing severe loss in yield. As in the case of management of pests, no chemicals are allowed for the control of diseases in organic cultivation.

a. Bud rot

Causal organism: *Phytophthora palmivora*

Symptoms

The first visible symptom is withering of the spindle leaf marked by pale colour. The spindle turns brown and droops down. The tender leaf base and soft tissues of the crown rot into a slimy mass of decayed material emitting a foul smell. The disease may spread to adjacent leaves, producing a dead centre with a fringe of living leaves. The disease kills the palm if not controlled at the early stages. Palms of all age are liable to be affected but normally young palms are more susceptible.

The disease is more prevalent during monsoon when the temperature is low and humidity is high.

Management

- Cut the palms which are in the advanced stage of disease or dead palms and burn the infected crown.
- As a prophylactic measure spray 1% Bordeaux mixture to all the palms in the garden in the disease endemic areas.
- In early stages of the disease, when the spindle leaf starts withering, cut and remove all affected tissues of the crown and apply Bordeaux paste and protect it from rain by providing polythene covering till normal shoot emerges. Later remove the cover as the shoot grows.
- Destroy infected tissues removed from the affected palm by burning.
- Spray 1% Bordeaux mixture on spindle leaves and crown of palms around the infected area to prevent the disease spread.

Bud rot affected palm

- Provide adequate drainage in gardens and avoid overcrowding.

b. Root (wilt) disease

Causal organism: Phytoplasma. The disease is transmitted by lace bug *Stephanitis typica* and the plant hopper *Proutista moesta*.

Symptoms

The important visual diagnostic symptoms are abnormal bending or ribbing of the leaflets (flaccidity), general yellowing and marginal necrosis of the leaflets and unopened inflorescences. The nuts are smaller and the kernel is thin. The oil content of copra is also reduced.

Management

This disease is not lethal but only debilitating. As no curative measure is known at present, the approach will be to manage the disease in the already infected gardens. To reduce the loss due to the disease, the strategy would be to contain the disease by improving the health of affected palms and increasing the yield through proper manuring and other agronomic practices.

- Cut and remove all the affected palms in mildly disease affected areas.
- In the heavily disease affected tracts, remove severely affected uneconomic adult palms (those yielding less than 10 nuts per palm per year) and all diseased palms in the pre-bearing age.
- Adopt improved management practices in the affected gardens to enhance the yield of palms.
- Organic recycling by following mixed farming system - Raising fodder crops in the interspace and maintaining milch cows and application of farm yard manure to palms.

- Growing suitable inter and mixed crops.
- Basin management with green manure crops.
- Irrigation during summer months.

Root (wilt) affected palm

- Leaf rot disease which is usually noticed in root (wilt) affected palms can be controlled by applying *Pseudomonas fluroscens* or *Bacillus subtilis* either alone or in combination @50 g in 500 ml water to the axil of spindle leaf.
- Replanting with progenies of disease free elite palms located in hot spot areas.

c. Leaf rot

Causal organism: *Exserohilum rostratum* and *Colletotrichum gloesporioides*

Symptoms

Symptoms appear as minute water soaked angular spots on spindle leaves. They enlarge, coalesce and cause spindle rot.

Management

- Cut and remove rotten portion of the spindle and two adjacent leaves.
- Since leaf rot affected palms are prone to pest attack, filling the youngest three leaf axils with a mixture of powdered neem/ marotti cake with equal quantity of sand and covering with sand three times a year may be adopted.
- Apply *Pseudomonas fluroscens* or *Bacillus subtilis* either alone or in combination as explained above.

d. Stem bleeding

Causal organism: *Thielaviopsis paradoxa*

Symptoms

The disease is characterized by the exudation of dark reddish brown liquid from the longitudinal cracks in the bark, generally at the base of the trunk. The bleeding patches spread throughout as the disease advances. The liquid oozing out dries up and turns black. The tissues below the lesions rot and turn yellow first and later black. Leaves in the outer whorl prematurely turn yellow, droop and dry. Production of bunches is affected and nut fall also is noticed. The trunk gradually tapers at the apex and crown size becomes reduced.

Management

- Remove water stagnation (if it is a problem) and apply 5 kg neem cake fortified with *Trichoderma* per palm along with other organics during September-October.

e. Thanjavur wilt/Ganoderma disease

Causal organism: *Ganoderma lucidum* and *Ganoderma applanatum*

Symptoms

Decay of root system, flaccidity of spindle leaves, browning of outer leaves, arrested fruit set and appearance of bleeding patches on the basal region on the stem are the symptoms observed. Ultimately the palm dies off. In advanced stages, brackets of fungus causing the disease are seen on stumps.

Management

- Apply 50 kg organic manure and 5 kg neem cake fortified with *Trichoderma* per palm and provide irrigation.
- Provide drainage channels between rows of palms.
- Isolate the affected palm from the healthy ones by digging a trench around the affected palm
- Adopt phytosanitary measures (remove dead palms, bury the affected roots and bole in a pit).
- Intercropping of banana is desirable as the root exudates of banana are found to inhibit the growth of pathogens.

f. Leaf blight or Grey Leaf spot

Causal organism: *Pestalotia palmarum*

Palms treated with *Trichoderma* swapping for stem bleeding

Symptoms

In the mature leaves of the outer whorl, yellow specks encircled by a greying band appear which later turn to greyish white. The spots coalesce into irregular necrotic patches causing extensive leaf blight. When the infection is severe the leaf blade completely dries and shrivels off.

Management

- Cut and remove older affected leaves and spray the foliage with 1% Bordeaux mixture.
- Combined application of talc-based powder formulation of *P. fluorescens* to soil (50 g/palm/year) along with neem cake (5 kg/palm/year).

g. Mahali or fruit rot and nut fall

Causal organism: *Phytophthora palmivora*

Symptoms

Shedding of buttons and immature nuts are noticed. Water soaked lesions appear on buttons near the stalk which later develop and result in the decay of the underlying tissues. The disease caused by the fungus appears as whitish webby growth on the surface of the affected part.

Management

- Collect and burn the affected shed nuts.
- Spray 1 % bordeaux mixture to the bunches just before the onset of monsoon.

6. Harvest

Twelve month old coconuts are to be harvested both for seed as well as copra preparation. However, for tender nut purposes 7 to 8 months old nuts can be harvested. On an average six to eight harvests can be made in an year depending on the yield of palms.