COCONUT
CULTIVATION PRACTICES

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COCONUT CULTIVATION PRACTICES

Introduction

The coconut palm is referred to as 'Kalpavriksha' – the '*tree of heaven*' as each and every part of the palm is useful to mankind in one way or other. It provides food, drink, fuel and timber. Millions of families in India depend on coconut for their livelihood either directly or indirectly. India ranks third in area and production of coconut in the world. As per 2004-05 statistics, the annual coconut production in India is 12.83 billion nuts from an area of 1.93 million ha with an average productivity of 6632 nuts/ha. The four southern states viz., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh are the major coconut producing states in India accounting for more than 90 per cent of area and production. It has been demonstrated that a four fold increase in yield can be achieved by adopting scientific technologies in coconut cultivation as compared to the unscientific practices. Thus, there is a great scope for enhancing the productivity of coconut through adoption of scientific cultivation technologies, which are described here under.

Climate and soil

The coconut palm is found to grow under varying climatic and soil conditions. It is essentially a tropical plant, growing mostly between 20° N and 20° S latitudes. The ideal temperature for coconut growth and yield is 27 $\pm$ 5°C and humidity >60 per cent. The coconut palm grows well upto an elevation of 600 m above MSL. However, near the equator, productive coconut plantations can be established up to an elevation of about 1000 m above MSL. The palms tolerate wide range in intensity and distribution of rainfall. However, a well distributed rainfall of about 200 cm per year is the best for proper growth and higher yield. In areas of inadequate rainfall with uneven distribution, irrigation is required.

Cultivars and hybrids

Basically, coconut cultivars are classified into two groups viz., tall and dwarf.

Tall cultivars

Tall varieties are the common type that occurs through out the world. The life span of talls extends from 60 to 80 years. They grow to a height 15 to 18 m. They produce copra of good quantity and quality, and have fairly high oil content as compared to dwarf cultivars. The different cultivars of the Talls are generally named after the place where they are largely cultivated. The tall cultivars are most commonly cultivated for commercial production in all coconut growing regions of the world. The Tall cultivars commonly grown in India are the West Coast Tall (WCT), Tiptur Tall (TPT) and East Coast Tall (ECT). The tall cultivars including high yielding types are given below.

Variety	Average yield (nuts/palm/year)	Suitable region for cultivation
West Coast Tall	80	Kerala, Karnataka, Gujarat, Bihar, Madhya Pradesh, Lakshadweep, Orissa, Tamil Nadu and Tripura
Chandrakalpa (Laccadive Ordinary)	100	For all the states
VPM-3 (Andaman Ordinary)	94	Andamans, Andhra Pradesh, Bihar, Assam, Orissa, Madhya Pradesh, Kerala, Pondicherry, Tamil Nadu, Tripura and West Bengal
East Coast Tall	70	Tamil Nadu, Andhra Pradesh, Bihar, Pondicherry, Madhya Pradesh, Orissa, Andamans and West Bengal
Aliyar Nagar-1 (ALR-1) (Arasampatti Tall)	126	Tamil Nadu, Pondicherry
Tiptur Tall	86	Karnataka
Benaulim Green Round (Pratap)	150	Maharashtra and Goa
Kamrupa (Assam Green Tall)	101	Assam and North Eastern States
Kera Chandra (Philippines Ordinary)	110	For all the states
Kerasagara (Seychelles)	100	Kerala

Dwarf cultivars

Dwarf varieties are shorter in stature and life span. They grow to a height of 5-7 m with an average life span of 40-50 years. They start bearing from 3-4 years after planting. The nuts are smaller and the copra soft, leathery and low in oil content. The dwarf cultivars are generally grown for tender nuts and also used for hybrid production. The common Dwarfs available in India are Chowghat Orange Dwarf (COD), Chowghat Green Dwarf (CGD), Kenthalli (KTOD) and Gangabondam (GBGD).

Among the Dwarfs, Chowghat Orange Dwarf has very good quality of tender nut water and has been released as a tendernut variety suitable for cultivation in all states.

Hybrids

Hybrids are the intervarietal crosses of two morphological forms of coconut. They show earliness in flowering, and give increased yield, higher quantity and better quality of copra and oil when compared to the parents. When the tall is used as female and dwarf as male, they are called T x D hybrid while the reciprocal is known as D x T hybrid. Hybrids perform well under good management conditions including nutrient management and irrigation.

Released coconut hybrids

Hybrid	Average yield (nuts/palm/year)	Released by
Kerasankara (WCT x COD)	106	CPCRI
Chandrasankara (COD x WCT)	116	CPCRI
Chandralaksha (LCT x COD)	109	CPCRI
Keraganga (WCT x GBGD)	100	KAU
Lakshaganga (LCT x GBGD)	108	KAU
Anandaganga (ADOT x GBGD)	95	KAU
Kerasree (WCT x MYD)	140	KAU
Kerasoubhagya (WCT x SSAT)	130	KAU
VHC-1 (ECT x MGD)	98	TNAU
VHC-2 (ECT x MYD)	107	TNAU
VHC-3 (ECT x MOD)	156	TNAU
Godavari Ganga (ECT x GBGD)	140	APAU

Planting materials

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. If the seed nuts and seedlings happen to be of poor quality, the new plantation will prove to be uneconomic, causing considerable loss of time and money to the grower. The fact that the coconut is a cross-fertilized palm and that it does not breed true, makes the selection of seed nuts and then of seedlings in the nursery all the more difficult and important. By means of a series of selections made at different stages, it is possible to eliminate poor quality seed nuts and seedlings.

Mother palm selection

Seed nuts should be collected from mother palms which should have attained an age of 20 years, yielding constantly more than 80 nuts per palm per year and free of any disease. Further, it should have a minimum of 30 leaves with nut weight more than 600 g and copra weight 150 g and above. The trees should have short and strong petioles with wide leaf base firmly attached to the stem. The bunch stalk should be short, stout strong and should not show any tendency to droop down or buckle. Palms which produce barren nuts or those shedding large number of immature nuts should be discarded. Avoid palms of very old age i.e., above 60 years. Also avoid palms growing in very favourable conditions e.g. trees near manure pits. Palms showing alternate bearing tendency also should be avoided.

Collection of seed nuts

Generally the seed nuts are collected in the months of April-May and is planted in June in west coast region, whereas in the east coast region, nuts are sown in the months of October-November. Tall varieties are sown one or two months after collection whereas dwarfs should be sown immediately after harvest (within 10-15 days). Seed nuts grown in the pot mixture (soil: sand: FYM) filled in poly bag produce healthy and vigorous seedlings.

Selection of seedlings

Only good quality seedlings are to be selected from the nursery for field planting. The vigorous seedlings which are one year old, having minimum of six leaves and girth of 10 cm at the collar should be selected for planting. Early splitting of leaves is another character preferred for selecting good seedlings. Generally one-year-old seedlings are preferred for planting. However, for planting in waterlogged areas, 1½ to 2 year old seedlings are preferred.

Poly bag nursery

Germinated seeds are transplanted in poly bags of size 60 x 40 cm with 8-10 holes at the bottom. The potting mixture is in the 2:1:1 ratio of topsoil, sand and FYM. The advantage of poly bag seedlings is that there is no transplanting shock and the seedlings are more vigorous. But the disadvantages include difficulty for transportation and higher cost of seedling production.

Establishment of a plantation

Selection of the site

Soil with a minimum depth of 1.2 metres 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. However, in lands, reclaimed by heaping alternate layers of sand and clay, coconut thrives well. Proper supply of moisture either through well distributed rainfall or irrigation and sufficient drainage are essential for coconut.

Preparation of land and planting

Preparation of land for planting coconut depends to a large extent on soil type and environmental factors. If the land is uneven and full of shrubs, the shrubs have to be cleared and land leveled before taking pits. 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, may be dug and filled up with loose soil, powdered cow dung and ash up to a depth of 60 cm before planting. In loamy soils with low water table, planting in pit size of 1 x 1 x 1 m filled with top soil to height of 50 cm is generally recommended. However, when the water table is high, planting at the surface or even on mounds may be necessary. Even while planting at the surface or mounds, digging pits and filling has to be

done. While filling the pits with soil, it is advisable to use the top soil. Two layers of coconut husk can be arranged at the bottom of the pit before filling up the soil (with concave surface facing up). This will help in conserving the moisture. In laterite soil, addition of 2 kg of common salt will help in loosening the soil.

Replanting/Underplanting

Generally underplanting is done in plantations where the palms become unproductive and uneconomic to the farmer. Old palms are removed in stages over a period of 3 to 4 years. First peg mark the area to be underplanted. Remove the very poor yielders (less than 10 nuts per year) and those close to the planting pits and plant the seedlings in the usual way. The other trees are removed at the rate of one third each year during 2nd, 3rd and 4th year after planting. If the existing garden is irregularly spaced remove old palms within 1 m radial distance from the newly planted seedlings in the first year, 2 m distance in second year, 3 m distance in third year and the rest in 4th year.

Spacing

For realizing better yield from coconut, optimum plant density must be maintained in the field. A spacing of 7.5 x 7.5 m is generally recommended for coconut. This will accommodate 177 palms per ha under the square system of planting. If the triangular system is adopted, an additional 20 to 25 palms can be planted. Also a hegde system can be adopted giving a spacing of 5.0 to 5.5 m along the rows and 9 to 10 m between rows. Wider spacing of 10 m x 10 m provides ample opportunity to accommodate a number of perennial and annual crops in the interspaces.

Time of planting

In well drained soils where water stagnation is not a problem, seedlings can be transplanted with the beginning of southwest monsoon. If irrigation facilities are available, it is advisable to take up planting at least a month before the monsoon sets in so that the seedlings get well established before the onset of heavy rains. Planting can also be taken up before the north-east monsoon. In low lying areas subject to inundation during monsoon periods, it is preferable to plant the seedlings after the cessation of the monsoon.

Care of young palms

Sufficient attention will have to be paid to the young palms in the early years of growth. The field planted seedlings should be shaded and irrigated properly during the summer months. Irrigation with 45 litres of water once in 4 days has been found to be satisfactory in all soil types. Provision of proper drainage is also equally important in areas subject to water logging. If planting is taken up in littoral sandy soil, application of 0.15 m^3 of red earth is recommended.

The pits should be cleared of weeds periodically. Soil washed down by the rains and covering the collar of the seedlings should also be removed. The pits should be widened every

year before the application of manure. The pits should be gradually filled up as the seedlings grow. The palms should be frequently examined for any insect or fungal attack and necessary remedial measures should be taken up promptly.

Manuring

Regular manuring right from the first year of planting is essential for good vegetative growth, early flowering and bearing and high yield of coconut palms.

Application of chemical fertilizers

The first application of chemical fertilizers should be done three months after planting. The quantity of fertilizer to be applied is approximately one tenth of the recommend dose of fertilizer for adult palms. During the second year, one third of the dosage recommended for adult palms may be applied in two split doses in May-June and September-October. This dosage may be doubled during the third year. From the fourth year onwards, fertilizers may be applied at the rate recommended for adult palms.

An application of 500 g N, 320 g P_2O_5 and 1200 g K_2O per palm per year is generally recommended for adult plantations. To supply the above quantity of nutrients for an adult palm, it is necessary to apply about 1 kg urea, 1.5 kg Mussorie phos/rock phosphate in acidic soil or 2 kg super phosphate in other soils and 2 kg of muriate of potash in two split doses. If coconut mixture (10:5:20) is used, 5 kg of the same is to be applied in two split doses. Rock phosphate is recommended as an ideal and cheaper carrier of phosphorus in laterite and acidic soils.

Fertilizers may be applied in two split doses for the rainfed palms. After the receipt of summer showers, one-third of the recommended dose of fertilizers may be spread around the palms within a radius of 1.8 m and forked in. Circular basins of 1.8 m radius and 25 cm depth may be dug during August-September and green leaf or compost at the rate 30 kg per palm may be spread in the pits. The remaining two-third of the recommended dose of fertilizers may be spread over the green leaf or compost and covered.

Fertilizer recommendation for coconut (g/tree)

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

If the palms are irrigated, the fertilizers can be applied in 4 or more equal splits avoiding the heavy rainfall period of the area. If there is drip irrigation facility, then the water soluble fertilizers like Urea, DAP, phosphoric acid (commercial grade) and muriate of potash can be applied along with drip irrigation in 6 equal splits. Through fertigation, it is recommended to provide 91 g urea, 33 ml phosphoric acid and 170 g muriate of potash per palm per application. When DAP is used it is recommended to provide 70 g urea, 60 g DAP and 170 g muriate of potash for a single dose per palm.

When the recommended dose of phosphatic fertilizers are applied continuously, the available phosphorus in the soil goes up. When it is more than 20 ppm, application of phosphatic fertilizers can be skipped off for a few years until the level goes below 20 ppm. If the level is 10 to 20 ppm, half of the recommended P_2O_5 can be applied.

In sandy soils with acidic nature, in addition to the recommended levels of fertilizers, 1 kg of dolomite may be applied per palm per year. Dolomite may be broadcast during April-May in the basins and incorporated into the soil by forking. It should not be applied with other fertilizers.

For coconut palms showing yellowing of leaves due to Magnesium deficiency, 0.5 kg of magnesium sulphate can be applied in the basins along with other fertilizers during September-October.

Application of organic manures

Application of sufficient quantity of organic manure improves the soil characteristics and provides nutrients to coconut palms. Organic matter addition enhances moisture retention capacity of soil and the bulk density of soils is reduced thereby increasing aeration, drainage and water intake. Organic manuring also helps in enhancing soil microbial activity and recycling of minerals. Organic manures such as farmyard manure, compost, green leaf manure or vermicompost can be applied to coconut. Circular basins of 1.8 m radius and 25 cm depth may be dug during August-September and green leaf or compost @ 30 kg per palm may be spread in the basin.

Basin management with legume cover crops

An agrotechnique has been developed at CPCRI to generate significant quantities of organic manure and nitrogen in coconut gardens utilizing the leguminous cover crops. It involves cultivation of leguminous creepers having symbiotic association with efficient *Rhizobium* strains in coconut basins and interspaces during the monsoon period and incorporation of biomass generated to the palms at the maximum vegetative growth of legumes. The field experiments on basin management with legumes in adult coconut plantations revealed the effectiveness of this technique to substitute fertilizer nitrogen for coconut upto 30 per cent. The effectiveness of

the legume treatment as a component in the management programme for root (wilt) disease of coconut has also been demonstrated. *Pueraria phaseoloides*, *Mimosa invisa* and *Calopogonium mucunoides* are the species of legumes superior in biomass and nitrogen contribution in coconut basins. They contribute about 15-25 kg of biomass and 100-200 g of nitrogen in coconut basins during a growth period of 140-150 days in monsoon season. Pelleting of inoculated seeds with neutral or inert materials enhances nodulation by introduced rhizobia in acidic soils.

Growing Glyricidia as green manure crop

Generation of large quantities of nitrogen rich biomass is also possible through the cultivation of the fast growing leguminous tree crop, Glyricidia in the coconut plantations. It can also be grown in littoral sandy soils where no other green manure can establish. Application of glyricidia prunings from the interspace of one hectare of coconut garden to the coconut plantation in littoral sandy soil could meet a major portion of nitrogen (90%), part of phosphorous (25%) and potassium (15%) of the recommended dose of fertilizer. It acts as a source of slow release fertilizer in addition to improving the water holding capacity. However, if adequate quantity of glyricidia is not available, 50 per cent of N can be met by inorganic + 50 per cent through glyricidia. This resulted in 44 per cent increase in coconut yield in comparison to the application of inorganic fertilizer alone to coconut palms in sandy soil.

Vermicompost

Fallen coconut leaves in the coconut garden can be effectively converted into rich vermicompost using the earth worm *Eudrilus* spp. Vermicompost preparation can be done in cement tanks or in trenches made in the coconut garden. 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 earth worms (*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 2 ½ - 3 months. Watering should be stopped one week before collecting the compost. On an average, 70 per cent recovery of vermicompost is obtained. Nucleus cultures of the local strain of *Eudrilus* spp. 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 cowdung and decayed leaves, mulched properly with grasses.

Composting of coir pith

Coir pith, which accumulates as a problematic waste in coir defibering units can be converted to organic manure by composting. Large scale composting of coir pith can be done either in cement tanks or by the heap method in a shaded place. Coir pith obtained from coir processing units are treated with lime (0.5%), urea (0.5%), rock phosphate (0.5%) and legume biomass (*Glyricidia* leaves) or cowdung or compost from previous batch (10%) and moistened. The treated coir pith is sprayed with 1 per cent jaggery solution and mixed with fungal inoculum *Marasmiellus troyanus* and *Trichoderma sp.* at 0.2 per cent level, 15 days after the amendment. Regular watering is done to keep the heap moist. The raw coir pith with a C:N ratio of 108:1 would turn into compost having a C:N ratio of 15:1 and high microbial population within a period of 40-50 days.

Composting of coir pith can also be done using poultry manure (10%) and by this method, we can get compost within a period of 50-60 days.

Irrigation and soil moisture conservation

The coconut palm responds well to summer irrigation. Under west coast conditions, 2 cm irrigation through perfo-sprays once in 5 days during December-February and once in 4 days during March-May has been found to be beneficial in increasing yields in sandy loam soil. Where basin irrigation is practised, 200 l/palm once in 4 days will be beneficial. In areas where water is scarce, soil is sandy and labour is costly, drip system of irrigation can be adopted. The quantity of water recommended for drip irrigation is 66 per cent of the open pan evaporation which comes to 30-32 l/palm/day for Kasaragod conditions during summer months (for a basin area of 1.8 m radius). In the drip irrigation system, microtubes are better than emitters in areas where the clogging problem is acute.

Fertigation

Fertigation is an efficient method of fertilizer application through drip or any other system of irrigation. Drip fertigation helps to increase the fertilizer use efficiency, make savings in fertilizer costs, reduce labour requirement, enables uniform, precise and direct application to root zone and correction of micronutrient deficiencies etc. Soluble fertilizers viz., urea (for nitrogen), DAP (for phosphorus and nitrogen) and Muriate of potash (for potassium) can be combined and supplied through drip irrigation, after filtering the solutions before adding to the fertilizer tank. The other possibility is to use liquid fertilizers, which are highly soluble and hence there is no clogging problem. But these are costly. Fertigation can be done using a fertigation tank or venturi system. The fertilizer should be applied in the active absorption zone for which the emitter should be placed 1 m away from the bole of the palm. Compared to conventional method, we can save fertilizers up to 50 per cent because of the higher fertilizer use efficiency.

Soil and moisture conservation in coconut garden

Proper soil and moisture conservation practices are vital for better performance of coconut palms; especially in slopy and undulating terrains.

- Regular ploughing or digging of the interspaces of coconut palms twice in a year, first at the beginning of the monsoon and second at the fag end of the monsoon helps in moisture conservation.
- Mulching is an important practice for moisture conservation. The coconut basins can be mulched with coir dust, coconut husks, green leaves, dried leaves, organic wastes, and dried coconut leaves. Mulching should be done before the end of monsoon and before the top soil dries up.
- Application of sufficient quantity of organic manure by way of cattle manure, farmyard manure, compost or green leaves improves the soil characteristics and provide nutrients to coconut palms. Organic matter addition enhances moisture retention capacity of sandy soil and the heavy soils are made loose and porous thereby increasing aeration, drainage and water intake. Organic manure also helps in enhancing soil microbial activity and recycling of minerals.
- Husk burial helps to absorb and retain large quantities of water for use by the coconut palms. Husk burial can be done in coconut basins or in the interspace. The beneficial effect of husk burial lasts for seven years. The husk can be buried either in linear trenches taken 3 m away from the trunk. between rows of palms or in circular trenches taken around the palm at a distance of 2 m from the trunk. The trenches may be dug with 50 cm width and 50 cm depth. The husks are to be arranged in layers with concave surface facing upwards and covered with soil.
- Measures such as contour bunding, terracing etc. can be taken up in slopy lands for soil and moisture conservation.
- Half moon bund with pineapple on the bund is one of the best way of *in situ* harvesting of rain water in the basin area of coconut palms.

Intercultivation

Tillage operations like digging the garden with "mammatty" (spade), ploughing, forming small mounds in August-September and spreading them in December-January and making shallow basins with a radius of about 2 m at the beginning of monsoon and filling up at the close of monsoon are beneficial to the trees. In sandy soils, which are generally of

low fertility and do not have a luxuriant growth of weeds, regular intercultivation may not be necessary; but in other soils which permit quick growth of weeds, intercultivation will be necessary to keep weeds under control. Method of intercultivation will depend upon local conditions, availability of labour, size of holding, soil type, topography and distribution of rainfall.

Cover cropping

Cover cropping is recommended where inter and mixed cropping is not followed to prevent soil erosion in coconut gardens. This will also add organic matter to the soil. Leguminous crops such as *Mimosa invisa*, *Pueraria phaseoloides*, *Centrocema pubiscens*, *Stylosanthes gracilis* and *Calopogonium mucunoides* are suitable for growing as cover crops in coconut garden. Green manure crops like sunhemp (*Crotolaria juncea*) and kolinji (*Tephrosia purpurea*) can also be raised and ploughed in, at the end of the monsoon. These crops can be sown in April-May when pre-monsoon showers are received.

Coconut based cropping systems

Coconut as a monocrop does not fully utilize the basic resources such as soil and sunlight available in the garden. Adoption of multiple cropping practices in coconut garden ensures better utilization of basic resources, enhances income and employment opportunities. Inter/ mixed crops are to be selected based on the age of the palms, size of the crown and availability of sunlight in the garden.

A variety of inter crops like pineapple, banana, elephant foot yam, groundnut, chillies, sweet potato and tapioca can be raised in coconut gardens upto 8-10 years.

During the second growth phase of palms, i.e., 10 to 22 years of age, growing of other crops in the interspace may be difficult due to poor sunlight availability. However, crops like colocasia, some varieties of banana like palayamkodan etc. which can tolerate shade can be cultivated in this phase.

After the palms attain a height of 5 to 6 metres (above 22 years) i.e., in older plantations, perennials like cocoa, pepper, cinnamon, clove and nutmeg can be grown as mixed crops along with the inter crops. In places where rainfall is not well distributed, irrigation is necessary during summer months. However, these crops are to be adequately and separately manured in addition to the manures applied to the coconut palms.

Cultural requirements of crops for mixed cropping in coconut garden

Crops	Propagation	Planting pits	Spacing	No. of plants per ha	Fertilizer dose (g/plant/year)		
					N	P_2O_5	K_2O
Cocoa	Grafts	75 x 75 x 75 cm	3m x 3m (Single hedge)	450	100	40	140
Pepper	Rooted cuttings	50 x 50 x 50 cm	7.5m x 7.5m (At the base of the palm)	175	100	40	140
Clove	Seedlings	60 x 60 x 60 cm	7.5m x 7.5m (At the centre of four palms)	148	300	250	750
Nutmeg	Grafts	60 x 60 x 60 cm	7.5m x 7.5m (Centre of four palms)	148	500	250	1000

High Density Multispecies Cropping System

High density multispecies cropping system (HDMSCS) involves growing a large number of crops to meet the diverse needs of the farmer such as food, fuel, timber, fodder and cash. This is ideally suited for smaller units of land and aims at maximum production per unit area of land, time and simultaneously ensuring sustainability. This system includes annuals, biennials and perennials. The crops selected include cash crops, food crops and fodder crops. The biomass other than the economic part is recycled within the system. From the experimental plot on HDMSCS maintained at CPCRI Kasaragod, which involves coconut and other crops like banana, pineapple, pepper, clove and nutmeg, it is observed that an average annual net income of Rupees 80,000 can be obtained per ha. Besides, 25 tonnes of organic wastes are also made available per ha which can be recycled and applied to the crops as vermicompost. In HDMSCS if organic recycling is effectively carried out we can reduce the chemical fertilizer input for coconut to two third of the recommended dose.

Coconut based mixed farming

Milk is scarce in areas where coconut is extensively grown mainly because of non availability of fodder. Mixed farming by raising fodder grasses such as hybrid napier or guinea grass along with leguminous fodder crops such as *Stylosanthes gracilis* in coconut gardens has been found to be profitable. Raising the above crops in one hectare of coconut garden can support four to five dairy animals. However if hybrid bajra napier (Co3) is grown as inter crop in coconut garden 8 to 10 animals can be maintained. In addition to the cattle, poultry, pisiculture and apiculture may be integrated depending upon the farmers' interest. The cattle and poultry manure generated from the

Chandrasankara - a DxT hybrid variety

Coconut poly bag nursery

Planting of cocount

Basin management with
Pueraria phaseloides

Drip irrigation in coconut

Coconut based mixed cropping

Inter cropping of fodder grass

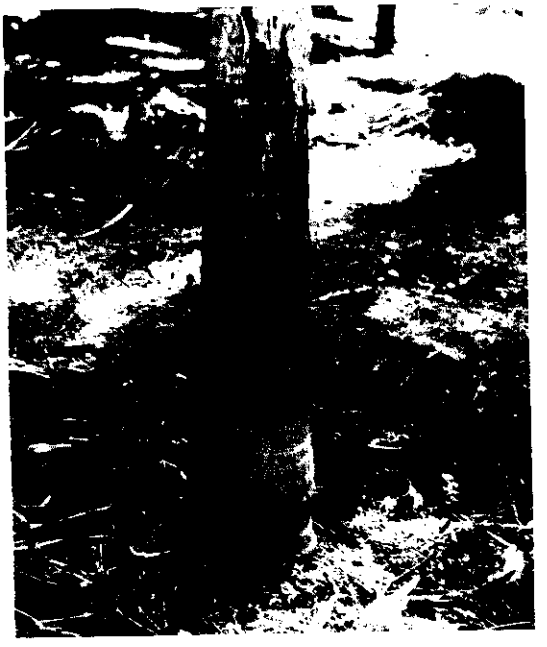
Half moon basin with pineapple planting

Trench filled with coconut husk

Symptom of Rhinoceros beetle attack

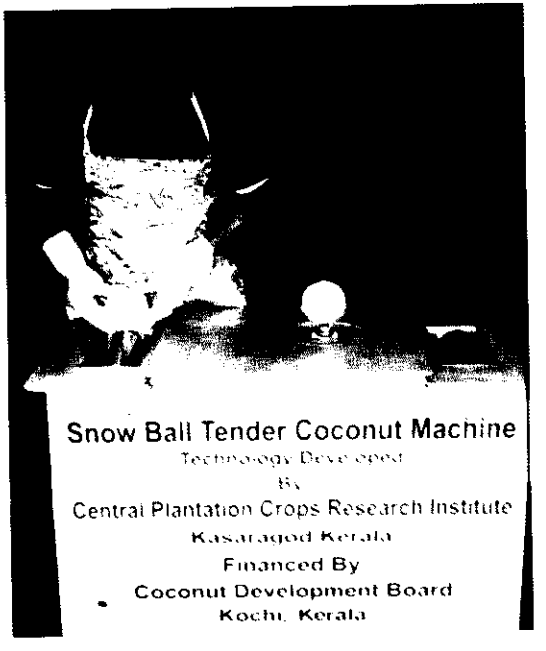
Symptom of mite infestation

Bud rot disease

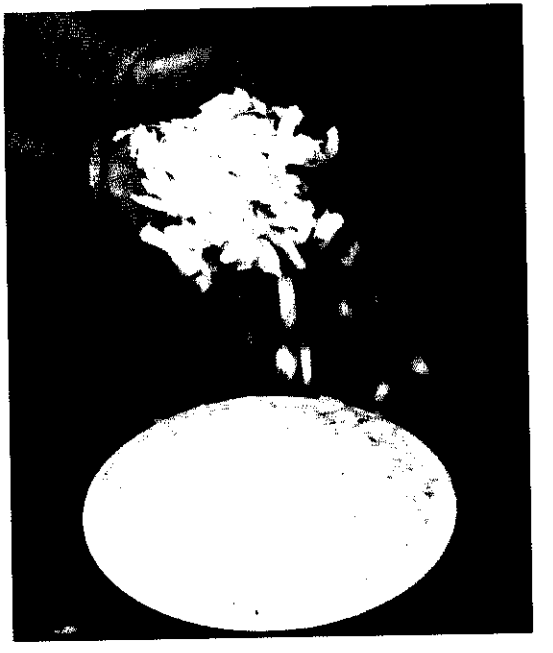


Stem bleeding disease

Vermicomposting of coconut leaves



Preparation of snow ball tender nut



Coconut chips

system when applied to coconut garden improves the soil fertility considerably. Maintaining milch cows and other components in coconut garden helps the farmer to enhance his income and provide additional employment to the family.

A net income of 1.2 lakh rupees per year can be obtained from a one ha coconut based mixed farming unit comprising of components such as 10 milch cows, 3 batches of poultry birds of 100 per batch and CO-3 Hybrid bajra Napier fodder grass. Employment generated from such a unit is about 900 mandays per year.

Crop protection

Pests

The major insect pests of the coconut palm are eriophyid mite (*Aceria guerreronis*), rhinoceros beetle (*Oryctes rhinoceros*), red weevil (*Rhyndhophorus ferrugineus*), leaf eating caterpillar (*Opisina arenosella*), and root eating white grub (*Leucopholis coneophora*).

Coconut eriophyid mite, *Aceria guerreronis* Keifer.

Coconut gardens in India are seriously affected by this non insect pest. These mites infest by sucking sap from the soft tissues beneath the tepals in buttons. In the initial stages, symptoms are seen as triangular patches close to perianth. Later because of the continuous desapping by various stages of mites present beneath the inner bracts of perianth, brown coloured patches are formed. As the nuts grow in size, the injured patches become warts and then develop into longitudinal splits on the surface of nuts. The damage thus caused affects the quality of husk and dehusking becomes difficult.

Management

Currently the IPM package recommended for mite management consists of the following measures.

- Phytosanitary measures in coconut plantations like crown cleaning.
- Root feeding of commercial neem formulations containing 5 per cent azadirachtin @ 7.5 ml + 7.5 ml water.
- Spraying with neem oil-garlic-soap mixture @ 2 per cent concentration (neem oil 200 ml, soap 50 g and garlic 200 g mixed in 10 litres of water) is effective.
- Spray neem formulations containing 1 per cent azadirachtin @ 4 ml/l of water during April-May, October-November and January-February.

Rhinoceros beetle, *Oryctes rhinoceros* Linn.

This pest has an ubiquitous distribution. 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 stumps, logs and compost. The total duration of life cycle of this pest is about six months.

Management

- Maintenance of sanitation in coconut gardens by proper disposal of decaying organic debris is an important step in the management of rhinoceros beetle.
- Mechanical method of control is possible by extracting beetles with hooks, without causing any further injury to the growing point of the palm.
- The innermost 2nd and 3rd leaf axils may be filled with powdered neem cake/marotti cake *Hydnocarpus sp.* @ 250 g/palm + fine sand (250g) per palm during pre and post monsoon months (April-May and September – October) as a prophylactic measure.
- Filling the innermost two leaf axils with 12 g of naphthalene balls covered with sand at 45 days interval is also effective.
- The breeding sites of beetle such as cattle dung, compost and other decaying organic debris may be treated with carbaryl 50 per cent WP at 0.01 per cent. Three applications in April, September and December are adequate to give sufficient protection to palms in heavily infested tracts.
- Incorporation of the weed plant *Clerodendron infortunatum* Linn. @ 10 per cent W/W in the compost pit is also effective.
- The *Oryctes* Baculovirus can be used for the biological control of rhinoceros beetle. Release of virus inoculated beetles @ 10-15 per ha brings down the pest population.
- The breeding sites may be treated with green muscardine fungus, *Metarhizium anisopliae*. The fungus can be mass multiplied on local materials such as coconut water and cassava chips. Spraying of 250 mg fungal culture diluted with 750 ml water per sq. m of breeding site helps to reduce the pest population.

Red weevil, *Rhyndophorus ferrugineus* Oliv.

Red weevil is a fatal enemy of coconut palm. Young palms < 20 years succumb to severe damage when infested by this pest. Palms infested by bud rot, leaf rot and rhinoceros beetle are predisposing factors, for red weevil infestation. Being an internal feeder, it is very difficult to detect the damage caused by red weevil 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 of red weevil attack. The symptom of their infestation becomes clear in advanced stages, the time at which the crown of the affected palm topples. The weevil multiplies enormously in young coconut plantations causing loss to an extent of 5 - 10 per cent.

Management

- Avoid causing 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. Infection by fungal disease is also a predisposing factor. Mechanical injury if any caused should be treated with coal tar and carbaryl.
- Periodical crown cleaning is to be done to avoid decaying of debris in leaf axils.
- While cutting of fronds, petiole to a length of 120 cm is to be left on the trunk to prevent the entry of weevils into the trunk.
- Removal and burning of palm with advanced stage of infestation would aid in destruction of various stages of the pest harbored in the trunk.
- Prophylactic leaf axil filling suggested for rhinoceros beetle may be attempted.
- Palms showing early stage of infestation may be subjected to curative treatment with 1 per cent carbaryl (20 g carbaryl per litre of water). If damage occurs in the crown, the damaged tissue has to be removed and insecticide suspension may be poured in. In case of entry of weevil through the trunk, the hole in trunk may be plugged with cement/tar. A slanting hole is made with the aid of an auger and the insecticide solution is poured with funnel.
- Log trap with toddy-Fresh coconut logs of 50 cm length are split longitudinally and the cut surfaces smeared with toddy fermented with yeast or acetic acid. The traps are set up by placing the toddy treated splits logs one above the other with the cut surfaces facing each other. The log so kept is effective in attracting the weevils.
- Coconut petiole pieces smeared with fermented toddy kept in pots @ 10 pots/ ha. serve as weevil traps. The traps should be placed at dusk and the weevils trapped are destroyed the next morning. Mud pot trapping with molasses can be done by placing sugarcane molasses 2.5 kg or toddy 2.5 l + Acetic acid 5 ml + yeast 5 g + longitudinally split tender coconut stem @ 75 Nos./ha.
- Installing traps with aggregation pheromone helps to mass trap and destroy the weevils. The weevils are trapped using a plastic bucket of 5 litre, with four windows (5x1.5 cm) made below the rim of the bucket. Coconut fiber/jute sack is wound over the bucket to provide grip to the alighting beetles. The commercially available pheromone lure (Ferrolure +) is hung inside on the lid of the bucket. The bucket is filled with 150 g banana, 2 g yeast and 2 g carbaryl in 1 litre of water. Instead of banana, pineapple can also be used. The traps are tied on the palm trunk at about 1.5 m above the ground level. Placing a single trap per hectare was found ideal. This technology would be successful if taken up on community basis.

Leaf eating caterpillar, *Opisina arenosella* Wlk.

Leaf eating caterpillar, another serious pest of coconut, commonly occurs in the coastal and backwater tracts. In recent years, they have 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 adversely affects the health of the palm 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 pest population begins to decline. In severe outbreaks of leaf eating caterpillar, the older leaves of the palms are reduced to dead brown tissue and only three or four youngest leaves at the center of the crown remain green. In the year following the outbreak, the crop may be reduced to half. In case of severe infestation, the whole plantation presents a scorched appearance.

Management

The pest is best managed if integrated management practices are followed.

- Cutting and burning the heavily affected and dried outer most 2 - 3 leaves helps to prevent the spread of the pest.
- During sporadic outbreaks, the pest can be kept under check by spraying dichlorvos 0.02 per cent (1 ml of dichlorvos 100 EC in 5 litre of water). The treatment may be done at quarterly intervals during March, June, September ad December depending on the abundance of the pest in the field.
- As this pest is subject to parasitisation by a good number of indigenous larval and pupal parasites, its biological suppression is feasible. Release bethylid, *Goniozus nephantidis* for third larval stage or above; Elasmid, *Elasmus nephantidis* for pre pupal stage and Chalcid, *Bradrymeria nosatoi* for early pupal stage. Larval parasitoid, *Bracon brevicornis* and pupal parasitoid *Xanthopimpla punctata* are also promising parasitoids. Combined release of the parasitoids is required in multistage condition of the pest. When an insecticide treatment is given, the release of parasitoids is to be done only after three weeks of spraying.

White grub, *Leucopholis coneophora* Burm.

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, premature nut fall, delayed flowering, retardation in growth and reduction in yield.

Management:

- Repeated ploughing once a week, 4 - 5 times after first rains in summer reduce the pest population by exposing the pest to predation by birds and other animals.
- Collection and destruction of adult beetles during peak period of emergence during May – June helps to reduce the population availability for the next season.
- Applying phorate 10 G @ 100 g/Palm during May – June and September – October, i.e., pre and post monsoon periods. In places where the copious rainfall is during September to November, the application may coincide with rainfall. The pesticide applied should be mixed and raked in the top 15 cm soil, so as to give effective control of the pest.

Coried bug, *Paradasynus rostratus* Dist.

Coried bug occurs in coastal areas and in high ranges of Kerala. The incidence is at a higher side in Trivandrum, Wynad and Kasaragod districts of Kerala. Apart from coconut it feeds on tamarind, cashew, cocoa, and guava. The peak population occurs during post monsoon period. The adults and nymphs feed by desapping the contents on button and developing nuts below the perianth region. The feeding points later 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 nutfall and malformation of mature nuts.

Management:

- Spraying carbaryl 0.1 per cent on the unopened spathes and bunches (except the newly opened inflorescence) at 45 days interval will control the pest.

Other pests

- **Slug caterpillars,** *Contheyla rotunda, Parasa lepida* etc., feed on coconut leaves. During the outbreaks they can be managed by spraying carbaryl 0.1 per cent.
- **Mealy bugs,** *Palmicalator palmarum*, during summer months colonize on tender plant parts like bases of spear leaf, spadix, and inflorescence and beneath the perianth of the nut. Colonization by the mealy bug on the spindle leaves results in failure of heart leaf development and eventually results in death of the seedling. In case of severe infestation the spadix remains stunted coupled with immature nut fall. Spraying 0.1 per cent fenthion helps to manage the pest.
- During summer months **scale insects** *Aspidiotus destructor* infest the leaves, button and rachilla. The infested leaves show chlorotic symptom and eventually dry up. Button shedding is noticed in palms with severe infestation. Spraying 0.1 per cent dimethoate helps to manage the pest.
- **Termite,** *Odontotermes obesus,* cause damage to both the seedlings and adult palms. The coconut seedlings are attacked either through the base of the seed nut or at the

collar region resulting in wilting and death of the seedling. Seedlings raised in lateritic soils are more prone to infestation by termites. In adult palms the infestation is confined to bark and crown region. Drenching the nursery with 0.05 per cent chlorpyriphos twice at 20 – 25 days interval or swabbing the affected portion of the trunk in adult palms with 0.05 per cent chlorpyriphos solution is effective.

Mammalian pests

- Rats damage tender nuts and cause severe crop loss in many places. Shed tender nuts with characteristic holes can be located at the base of the affected palms.
- Rats can be controlled by providing mechanical barriers (bands), poison baits and traps. G.I sheet bands, 40 cm wide, fixed around the trunk of palms at a height of 2 m from the ground serve as mechanical barriers for rats.
- The rats can be killed by poison baiting using either single dose acute poisons like zinc phosphide or multiple dose anti blood coagulants like bromadiolone.
- Rat burrows in the field can be fumigated with aluminum phosphide tablets. Poison baiting with 0.005 per cent bromadiolone in coconut crown at 3-4 days intervals at the rate of 30 palms (bait points)/ha reduces the rat population and damage by 94 per cent and 100 per cent, respectively.
- Poison baiting at the ground level does not have much effect in controlling the rats since they seldom come to the ground. If there are residential buildings within the plantations, rat control should be undertaken in both the places to check reinfestation. The best period to adopt the field operation to control the rat is late summer.
- Coconut bunches can be protected from the ravages of frugivorous bats (*Pteropus edwardsii*) by covering the bunches with thorny twigs of the wild plants like *Ziziphus* sp.

DISEASES

The coconut palm is affected by a number of diseases, some of which are lethal while others gradually reduce the vigour of the palm causing severe loss in yield. A brief account of the important diseases of coconut in our country is as follows.

Bud rot

Causal organism : *Phytophthora palmivora*

Symptom

The earliest symptom is the yellowing of one or two younger leaves surrounding the spindle. The spindle withers 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 kills the palm if not controlled at the early stages. Palms of all ages 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

- 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 a polythene covering till normal shoot emerges.
- Burn all disease affected tissues removed from the palm.
- As a prophylactic measure, spray 1 per cent Bordeaux mixture on spindle leaves and crown of affected palms as well as neighbouring palms before the onset of monsoon.
- Leaf axil filling with sevidol 8G, 25 g mixed with 200 g sand is recommended to prevent red palm weevil infestation of affected palms.

Dwarf varieties of coconut are sensitive to copper injury. Hence, Bordeaux mixture spraying should not be done. Instead, place small perforated sachets containing 2-3 g of Indofil M-45 in the top two or three leaf axils to control bud rot disease.

Preparation of 1 per cent Bordeaux mixture

Dissolve 1 kg of powdered copper sulphate crystals in 50 litres of water. In another 50 litres of water, prepare milk of lime with 1 kg of quick lime. Pour the copper sulphate solution into the milk of lime, slowly stirring the mixture all the while. Test the mixture before use for the presence of free copper which is harmful to the palms by dipping a polished knife in it. If the blade shows a reddish colour, add more lime till the blade is not stained on dipping. Always use wooden, earthen or copper vessels for the preparation of Bordeaux mixture.

Preparation of Bordeaux paste

Dissolve 100 g of copper sulphate and 100 g of quick lime each in 500 ml water separately. Mix together to make one litre of Bordeaux paste 10 per cent.

Root (wilt) disease

Root (wilt) disease has been prevalent in the state of Kerala for nearly 100 years and is believed to have made its appearance after the great floods of 1882. It has now established itself almost contiguously in eight south districts of Kerala *viz*. Thiruvananthapuram, Alappuzha, Kollam, Kottayam, Pathanamthitta, Idukki, Ernakulam and Thrissur. It has also made its sporadic appearance in the districts of Malapuram, Palakkad, Kozhikode, Wayanad, Kannur and in some groves in the neighbouring state of Tamil Nadu, Karnataka and Goa.

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

Symptom

The important visual diagnostic symptoms of the disease are abnormal bending or ribbing

of the leaflets, termed as 'flaccidity', a general yellowing and marginal necrosis of the leaflets and unopened inflorescence. The nuts are smaller and the kernel is thin. The oil content of copra is also reduced. Since the disease is not lethal but debilitating and 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 in the eight southern districts of Kerala for which the following measures are recommended.

Management

The strategy is to contain the disease in its present geographical limits and managing the disease by improving the condition of affected palms and increasing the yield through proper manuring and other agronomic practices.

- Eradication of the disease in mildly affected areas by cutting and removal of affected palms.
- In the heavily disease affected tracts, remove all the severely affected uneconomic adult palms (those yielding less than 10 nuts per palm per year) and all diseased palms in the prebearing age.

Adopt improved management practices in the affected gardens to enhance the yield of palms.

- Apply the recommended dose of NPK, 3 kg magnesium sulphate and 50 kg organic manure per palm.
- Organic recycling by following mixed farming system - Raising fodder crops in the interspace and maintaining milch cows and application of farmyard manure to palms.
- Growing suitable inter and mixed crops.
- Basin management with green manure crops.
- Irrigation during summer months.
- Control of leaf rot disease which is usually noticed in root (wilt) affected palms.
- Replanting with progenies of disease free palms located in hot spot areas.

Leaf rot

Leaf rot disease commonly occurs on coconut palms already affected by root (wilt) disease. Infection by this disease is the major reason for the low productivity of root (wilt) affected palms.

Causal organism: *Colletotrichum gloeosporioides*, *Exserohilum rostratum* and *Fusarium solani* are the fungal organisms causing leaf rot.

Symptoms

The first visible symptom of the disease is blackening and shriveling up of the distal ends of the leaflets in the central spindle and in some of the younger leaves. Later the affected portion breaks off in bits giving the infected leaves a fan like appearance. If no protective measures are taken, each new leaf of the diseased tree gets infected with the result that a stage is soon reached when all leaves of the tree show disease symptoms.

Management

- ☐ Cut and remove the rotten portion of the spindle and two successive leaves.
- ☐ Pour 300 ml of fungicidal solution containing 2 ml of hexaconasol (Contaf 5EC) or 3 g mancozeb (Indofil M-45) in the cavity around the base of the spindle.
- ☐ Apply 20 g phorate 10 G mixed with 200 g fine river sand around the base of the spindle to ward off insect pests.
- ☐ Treat the palms twice in a year ie., during April-May and October-November.

Palms in the early stages of disease will recover totally with two or three applications. Palms in the advanced stages (with an index of more than 50%) would take three years to recover fully. To prevent the recurrence of the disease, the treatment needs to be continued.

Stem bleeding disease

Stem bleeding disease is prevalent in all the major coconut growing states in India.

Causal organism: The fungus, *Thielaviopsis paradoxa*, is the primary causative agent. Growth cracks on the trunk, severe summer followed by sudden wetting, imbalanced nutrition, excess salinity etc. are the predisposing factors.

Symptom

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 turns yellow rather prematurely, droop and dry. Production of bunches is affected. Nut fall also is noticed. The trunk gradually tapers at the apex and crown size becomes reduced. In advanced stages, infestation with *Diocalandra* weevil can be seen which quickens the deterioration of the palms.

Management

- ☐ Remove completely the affected tissues using a chisel and dress the wound with calixin 5 per cent and apply coal tar after 1-2 days.
- ☐ Root feeding of 100 ml calixin 5 per cent thrice a year during June, October and January prevents further spread of lesions.
- ☐ Applyrecommended dose of fertilizers and provide irrigation during summer.
- ☐ Apply 5 kg neem cake per palm during September-October.

Thanjavur wilt/Ganoderma disease/Basal Stem Rot disease

Basal Stem Rot or Thanjavur wilt first appeared in the coastal areas of Thanjavur district of Tamil Nadu after cyclones of 1952 and 1955 and hence the name Thanjavur wilt. Now it is present in all the coconut growing areas in Tamil Nadu and in some parts of Kerala, Karnataka and Andhra Pradesh.

Causal organism: Fungi *Ganodermalucidum* and *Ganoderma applanatum* are the causative agents of the disease.

Symptom

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, the bracket of fungus causing the disease are seen on stumps.

Management

- ☐ Apply 50 kg organic manures and 5 kg neem cake fortified with antagonistic fungi 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 – removal of dead palms, burial of 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.
- ☐ Apply calixin @ 2 ml per 100 ml water through root feeding at quarterly intervals for one year.
- ☐ Drench soil with 0.1 per cent calixin @ 25 l per palm.

Crown choking

Crown choking disorder is commonly observed in Assam and West Bengal. A recent survey shows that 10 per cent of the palms are affected by the disease in Assam. The disease is characterized by emergence of shorter leaves with fasciated and crinkled leaves. The leaflets show severe tip necrosis and fail to unfurl. In many cases, it gives a choked appearance to the frond. Ultimately the affected palm dies.

Management

- ➢ Apply 50 g of borax at bi-monthly intervals till the symtom vanishes

Leaf blight or Grey Leaf spot

Causal organism: Fungus *Pestalotia palmarum*

Symptom

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 per cent Bordeaux mixture.

Mahali or fruit rot and nut fall

Causal organism: Fungus *Phytophthora palmivora*. The pathogen is more active during the rainy season when the atmospheric conditions are favourable for its growth.

Symptom

Shedding of female flowers (buttons) and immature nuts are the symptoms of the disease. Water soaked lesions appear on the young fruits or 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

- A pre-monsoon spraying followed by one or two sprayings at intervals of 40 days is generally advisable. Spraying the crown with 1 per cent Bordeaux mixture or mancozeb (0.3%) will control the disease.
- The affected shed nuts should be collected and burnt.

Harvesting

Usually 11-12 month old nuts are harvested. Coconuts are harvested at varying intervals in a year. The frequency varies depending upon the yield of palms. Usually, the nuts are harvested 6 to 10 times in a year. In well maintained and high yielding gardens, bunches are produced regularly and harvesting is done once in a month. Nuts which are 11 months old give fibre of good quality and can be harvested in the tracts where husk is utilized for manufacture of coir fibre. Skilled personnel are traditionally employed for climbing palms for harvesting nuts. Nowadays, lack of availability of skilled climbers for harvesting operations is a serious problem experienced by coconut farmers. A simple palm climbing device invented by a farmer from Kannur district of Kerala is gaining popularity.

Post harvest processing

Traditionally the post harvest processing of coconut is confined to the production of edible and milling quality copra, coconut oil and coir and coir based products. Technological research has been successful in evolving appropriate processing technologies for the profitable utilization of some of the products and by-products of the coconut palm. To cope with the market fluctuations, there is a need for product diversification and by product utilization.

Production of quality copra using copra dryers

The conventional system of copra drying is by spreading the cups on any open surface for sun drying. It takes about 5-8 days for getting copra and the quality deterioration due to deposition of dirt and dust on wet meat is unavoidable. To overcome the disadvantages of conventional system of copra drying CPCRI has developed a series of copra dryers with various sizes and capacities. The drying method of copra has been standardized through the principle of indirect hot air drying using these dryers. Of these dryers, the small holder's copra dryer and shell fired copra dryer are popular among the coconut farmers.

Small holders copra dryer

It is simple in design and safe to operate. Its capacity is 400 nuts per batch. Coconut shell, husk and any dried agricultural waste can be used as fuel. Time required for drying is 34-36 hours. This dryer is useful during the monsoon season when sun drying is not possible. Small-holders dryer is available with the Kerala Agro-Industries Corporation @ Rs.8,000 per dryer.

Shell fired Copra Dryer

Shell fired copra dryer developed by CPCRI is a natural convection dryer with a unique furnace. Coconut shell is used as fuel. Its capacity is 1000 nuts per batch. It requires less fuel. Time required for drying copra is 24 hours. Once ignited, the shell produces heat for about six hours. The labour requirement is less. Shell fired copra dryer will be made available through the Agricultural Technology Information Centre, CPCRI, Kasaragod. Shell fired copra dryer with a capacity of 500 nuts per batch has been also developed by CPCRI.

Copra moisture meter

To estimate the moisture content accurately, CPCRI has developed a moisture meter which works on the principle of electrical conductivity. It is calibrated to read the moisture content upto 40 per cent so that the moisture level at the different stages of drying can be found out.

Snow Ball Tender Nut (SBTN)

Snow ball tender nut is a tender coconut without husk, shell and testa which is ball shaped and white in colour. Coconuts of 7-8 months age is more suitable for making SBTN, as there is no decrease in quantity of tender nut water and the kernel is sufficiently soft. The main steps involved in the making of Snow Ball Tender Coconut are: removal of husk of 7 - 8 month old tender coconut in which the tender kernel thickness should be about 2 - 3 mm, making groove in the shell without breaking the kernel and scooping out the shell. For making the groove easily, a machine has been developed. Snow ball tender nut is sterile, nutritive and is a drink and a snack at the same time. Since there is no refuse after the consumption, there is no scope for littering of the premises. Since the snow ball tender nut can be individually packaged and refrigerated under hygienic conditions, the shelf-life of this product can be prolonged up to 15 days. In ambient condition it can be stored for about 8 hours.

Coconut chips

The dehydrated coconut chips is in ready-to-eat form and can be used as snacks. It can also be used at any time just like fresh kernel after rehydration of the chips. Fresh kernel of matured coconut containing reasonable amount of water are to be used for the production of the sweet coconut chips. Important steps involved in the production of the sweet coconut chips are: dehusking, removal of shell, removal of testa, slicing of kernel, blanching of slices, osmotic dehydration of slices, drying of

osmotically dehydrated slices in hot air dryer and then packaging in aluminium foil. The time of osmotic dehydration will be 40 minutes only. The drying time in hot air dryer is six hours.

In a plastic basin, mix one kg of sugar and one table spoon full of salt in one litre water. In a stainless steel vessel take three litre of water and heat upto boiling point.Take a dehusked coconut and scoop out the fresh kernel by using knife. By using the testa remover, remove the testa. Slice the white kernel pieces by using slicer. Wash the coconut slices in a clean water (two times). Transfer the slices to muslin cloth and then dip it in hot water for 2 minutes. Transfer the slices to the sugar solution (already prepared) and keep for one hour. Spread the soaked slices on the water absorbing paper for about 15 minutes. Dry the slices in the dryer for six hours. Pack the chips in the aluminium foil. For every coconut, add 75 g of sugar to the sugar solution and reuse it.

The quantity of chips obtained is about 50 per cent of the weight of the fresh kernel. On an average about 150 gram of chips can be obtained from one coconut.

Tender coconut water - pineapple beverage

Tender coconut water blended with pineapple juice has been found to be beneficial in the development of a new product. Pineapple is available in plenty in Kerala and its flavour and taste is acceptable to the consumer. Pineapple is a rich source of vitamins, thiamine and sugars whereas tender coconut water is rich in potassium, sodium and B- Complex vitamins. Tender coconut water and pineapple juice are separately collected, filtered and pasteurized. The two preparations are then blended and acidulants are added. Carbonation of the product enhances the taste and shelf life.

Preserve from tender coconut kernel

The fresh kernel left after the use of tender nut water can be developed into new products such as Tuity fruity, Peda and Candy. Processed young tender coconut kernel could be in the form of sweetened dehydrated or dried buko or young tender coconut kernel in syrup or dried buko chips. These young coconut kernel products are ideal for desserts or as snack food. It can also be used as a filling for the pies. Freshly made preserves are wholesome and attractive. The fruits mixed with cane sugar and subsequently drained and dried are called Candied fruits. Candied fruits covered with thin transparent coating of sugar is called Glazed fruit. When candied fruit is coated with sugar or sugar crystals are allowed to deposit on it, it is called crystallized fruit.

Mushroom cultivation using coconut byproducts

Methods to cultivate mushroom using by products of coconut as substrate have been developed at CPCRI, Kasaragod. Among the cultivated mushroom, Oyster mushroom

belonging to *Pleurotus* spp. is the ideal one for cultivation on coconut by products because of their ability to utilize lignin rich materials and the favourable climatic conditions in the coconut growing areas. Coconut bunch waste, leaf stalk, mixtures of leaf stalk + coir pith in 1:1 ratio and bunch waste + coir pith in 1:1 ratio were found to be better substrates for mushroom cultivation. On an average, mushroom yields of 590 and 570 g can be obtained per kg dry weight of leaf stalk and bunch waste in a cropping period of 73 and 60 days, respectively. Polybag method of cultivation could be followed using 3 per cent spawn applied by multilayering technique. Spawn run and cropping can be done in a low cost mushroom shed built exclusively with coconut materials such as plaited coconut leaves and coconut wood inside an adult coconut garden. Spraying of 1 per cent urea and 1 per cent super phosphate helps to reduce the interval between flushes. *Pleurotus eous, Pleurotus flabellatus, Pleurotus florida* and *Pleurotus sajor caju* are the suitable mushroom species for cultivation using coconut by products.

For further details on coconut cultivation and for technical guidance you may please visit CPCRI or write to:

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