Chapter 3

Organic Farming in Arecanut

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1. Introduction

The arecanut palm is the source of a widely used masticatory nut, popularly known as arecanut, betel nut, or *supari*. It is mostly chewed along with the betel leaf, or in the form of value-added products like *gutka, pan masala* and scented *supari*. Arecanut is an important commercial crop of India and its industry forms the economic backbone of nearly six million people and for many of them it is the sole means of livelihood. Although the cultivation and production of arecanut is focused only in a few states of India, the commercial products are widely distributed across the country and are being consumed by all classes of people. Area expansion of arecanut in India is discouraged; however, the area increased by 70 per cent during the last two decades and the production increase was mainly due to this phenomenon.

2. Production Scenario

2.1. Global Scenario

The current production of arecanut in the world is about 1275 thousand tonnes from an area of 926 thousand hectare (Table 3.1). India ranks first in both area and production (49 per cent) of arecanut. The other major arecanut producing countries are Indonesia (16 per cent area and 15 per cent production), China (5 per cent area and 11 per cent production) and Bangladesh (20 per cent area and 8 per cent production).

Table 3.1: Country-wise Area, Production and Productivity of Arecanut (Figures in brackets are percentage share)

Country	*Area ('000 ha)*	*Production ('000 t)*	*Productivity (kg/ha)*
India	453.6 (49)	632.6 (49)	1395
Indonesia	149.9(16)	187.0 (15)	1247
China	46.0 (5)	135.0 (11)	2935
Bangladesh	184.0 (20)	108.0 (8)	587
Myanmar	56.5 (6)	122.0 (9)	2159
Thailand	18.0 (2)	35.0 (3)	1944
Sri Lanka	15.9 (2)	37.7 (3)	2370
Others	2.0	17.5 (2)	—
World	925.9	1274.8	1377

Source: FAOSTAT.

2.2. Indian Scenario

In India, arecanut is cultivated in an area of about 4.54 lakh hectares with an annual production of 6.32 lakh tonnes (Table 3.2). The states of Karnataka, Kerala, Assam, West Bengal and Meghalaya are the major producers and account for more than 94 per cent of the area and production.

Table 3.2: State-wise Statistics of Arecanut in India

Country	*Area ('000 ha)*	*Production ('000 t)*	*Productivity (kg/ha)*
Karnataka	221.4 (49)	358.6 (57)	1620
Kerala	101.7 (22)	118.2 (19)	1162
Assam	75.1 (17)	72.6 (11)	967
West Bengal	11.4 (2)	21.2 (3)	1857
Meghalaya	16.0 (4)	23.0 (3)	1626
Others	28.0 (6)	39.0 (6)	—
India	453.6	632.6	1395

Source: NHB, 2012-13, Figures in brackets are percentage share.

3. Climatic Requirements

3.1. Geographical Position

Sub humid tropical climate suits the crop best, and therefore, arecanut thrives very well in the regions of 28° north and 28° south of the equator. Though arecanut is grown under different agro-climatic conditions, it is very sensitive to extreme climatic conditions. Although arecanut palms grow at altitude up to 1000m above MSL, at higher levels, the quality of the fruits will be adversely affected. In the high altitude areas like Wynad (Kerala) and Coorg (Karnataka), the endosperm

will not develop sufficient hardness. Moreover, high altitudes will also affect the germination of seeds and quality of chali (dry kernel).

3.2. Temperature

Arecanut palms grow well in a range of temperature between 14°C and 36°C. However, the crop is being cultivated in regions with extremes of temperatures as low as 5°C (Mohitnagar, West Bengal) to high as 40°C (Vittal in Karnataka and Kannara in Kerala). Extremes of temperature and wide diurnal variations are not conducive for the healthy growth of the palms.

3.3. Rainfall

Arecanut palms require very high rainfall ranging from 300 to 450 cm per annum. However, it is grown in. areas with wide variations in rainfall such as Malnad of Karnataka where the annual rainfall may go more than 450 cm as well as in low rainfall areas like Maidan parts of Karnataka or parts of Coimbatore district in Tamil Nadu where the annual rainfall is about 75 cm. In areas of prolonged dry spell, the palms are to be irrigated.

3.4. Relative Humidity

Relative humidity directly influences the water relations of palm and indirectly affects leaf growth, photosynthesis, pollen dispersal, occurrence of diseases and finally economic yield. Therefore, very high or low relative humidity is not conducive for growth and development of arecanut. High humid conditions provide congenial conditions for the rapid spread of diseases like fruit rot, bud rot *etc.*

4. Soil Requirements

Arecanut is cultivated in a wide variety of soils; however, sandy, alluvial, brackish, or calcareous and sticky clay soils are not ideal. The largest area under the crop, however, is in regions with the gravelly laterite soils of red clay. Deep black fertile clay loam soils supports luxuriant palm growth. Under well-drained deep soil conditions, the roots of arecanut palm traverse down to about three meters and the roots confine to only about 1.40 meters under shallow soil condition and, hence the palms require deep soil, preferably not less than two meters for development of proper root system. In Malaysia and Fiji, arecanut is cultivated in the hot, moist, rich alluvial areas of the coastal belt.

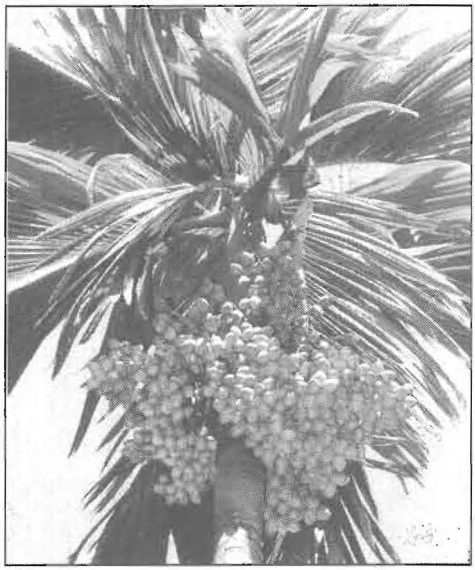
5. Varieties

The areca palms could be broadly classified into tall, semi tall and dwarf types. There is wide range of variations in fruit characters, stem height, inter node length and leaf size and shape. There are also wide variations in yield, earliness in bearing, fruit number/bunch, quality, and dwarfness. Variation in plant morphology, fruit colour, shape and size could also be observed in different accessions. The varieties suited for tender nut processing may not be suitable for mature fruit drying and vice versa. Many varieties have been released by different agencies like ICAR institutes and State Agricultural Universities (Table 3.3).

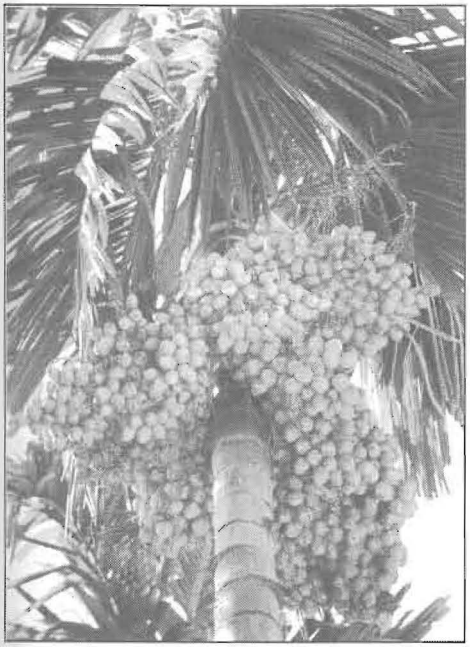
Table 3.3: Characteristics and Yield Performance of Arecanut Varieties/Hybrids Released in India

Variety	*Growth Habit and other Characteristics*	*Shape and Size of Nut*	*Chali Yield (kg/palm)*	*Areas Recommended for Cultivation*	*Year of Release*	*Agency responsible for Release*
Mangala	Semi-tall, early and heavy bearer	Round, medium	3.00	Coastal Karnataka, Kerala	1972	CPCRI
Sumangala	Tall, heavy bearer	Oval to round, medium	3.28	Karnataka,Kerala	1985	CPCRI
Sreemangala	Tall, long internodes	Round, oval, bold, deep yellow	3.18	Karnataka,Kerala	1985	CPCRI
Mohitnagar	Tall, uniform nuts, sturdy stem	Oval to round, medium, deep yellow	3.67	West Bengal, Karnataka and Kerala	1991	CPCRI
South Kanara	Tall	Round, bold	2.00	Coastal Karnataka and Kerala		
CAL17(Sumrudhi)			4.37	Andaman and Nicobar Islands		
SAS-1			4.60	Valleys of Sirsi, Karnataka	1995	RARS, UAS, Dharawad
Swarnamangala	Semi tall, regular bearer	Oblong to round, bold,	3.78	Karnataka, Kerala	2006	CPCRI
Madhuramangala	Medium tall, high yielding, suitable for ripe and tender nut	Orange	3.54	Konkan region of Maharashtra, Karnataka		
Kahikuchi Tall	Tall, shorter internodes	Round, big, orange	3.70	Assam, North east hills	2010	CPCRI
Nalbari	High yielding, good processing quality for ripe nuts		4.15	Karnataka,N. Bengal and NE region		
Arecanut hybrids						
Hirehalli Dwarf x Sumangala (VTLAH 1)	Dwarf with reduced canopy, very sturdy stem, early yield stabilization	Oval, medium, yellow to orange nuts	2.55	Karnataka, Kerala	2006	CPCRI
Hirehalli Dwarf x Mohitnagar (VTLAH 2)	Dwarf with reduced canopy, very sturdy stem, early yield stabilization	Oval, medium, yellow to orange nuts	2.64	Karnataka, Kerala	2006	CPCRI

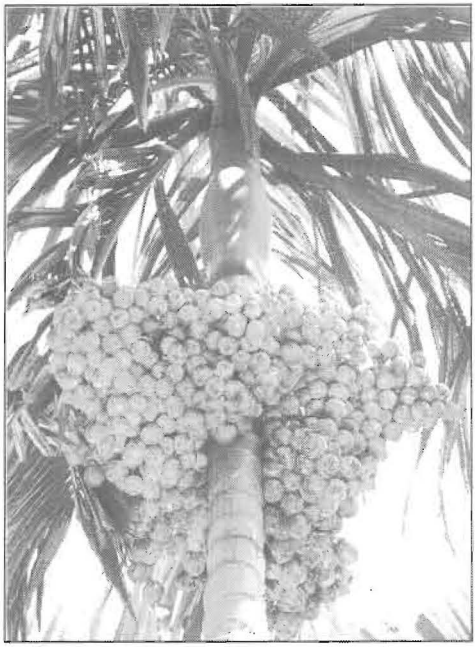
Madhuramangala



Mangala

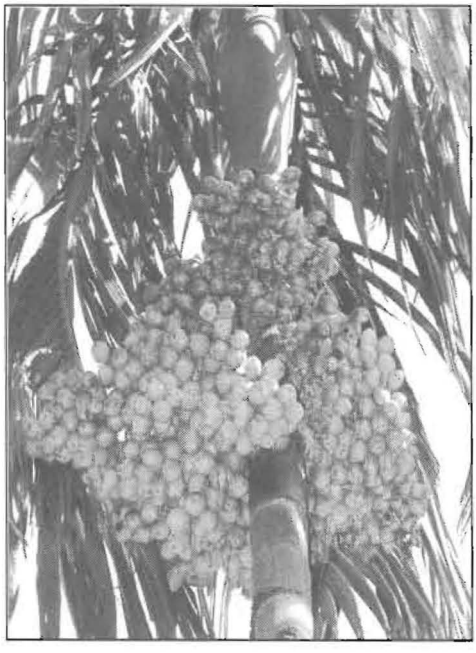


Mohitnagar



Nalbari

Figure 3.1a: Varieties of Arecanut.



Sreemangala

Sumangala

Swarnamangala

Figure 3.1b: Varieties of Arecanut.

VTLAH 1 VTLAH 2

Figure 3.2: Hybrids of Arecanut.

Characterisitcs of Local Varieties of Arecanut

a) **South Kanara:** It is largely grown in South Kanara district of Karnataka and Kasaragod district of Kerala. It is characterised by large nuts and uniform bearing. The average yield is 1.5 chali/palm/year (7 kg ripe nuts).

b) **Thirthahali:** It is grown extensively in Maland area of Karnataka. It is preferred for tender nut processing and not as dry nut.

c) **Sree Vardhan or Rotha:** It is predominantly grow in coastal Maharashtra. The nuts are oval, in shape and the yield is 1.5 kg chali (7kg ripe nuts) per palm per year. The kernel colour when cut is marble white. Its endosperm is tastier than other varieties. It starts bearing after 6-7 years of planting.

d) **Mettupalayam:** It is grown widely in Mettupalayam area of Tamil Nadu, the nut size is very small.

6. Production of Planting Materials and Nursery Management

6.1. Selection of Mother Palms

The areca palm is a seed-propagated plant and, in general, seedlings are used as planting material. Presently, tissue culture derived plants are also available

as planting material. The age at first bearing and regular bearing habit are two important characters to be considered for selection of mother palm. While selecting seeds, it must be ensured that they are obtained from trees that are already stabilized in their yielding pattern, and at least more than 10 years in maturity. More number of leaves on the crown (>10), shorter internodes, 350 to 400 fresh nuts/palm/year and high fruit set (>55 per cent) are some of the other characters to be considered while selecting mother palms. Mother palms should be selected based on the processing requirement also as all cultivars are not suitable for preparing either chali or tender processed nuts.

6.2. Selection of Seed Nut

Fully ripe nuts weighing > 35g are to be selected. Heavier nuts and those float vertically in water with calyx end pointing upwards produce more vigorous seedlings. Nuts with nine or ten months of maturity can be used for seed nut purpose. As the viability will be lost quickly, the nuts could be stored only for 3-6 days.

6.3. Raising of Seedlings

In order to produce quality seedlings, they are to be raised with adequate care. There are two steps to raise arecanut seedlings.

6.3.1. Primary Nursery

Whole fruits are to be used as seed nuts and sown immediately after harvest in soil/sand and water once in two days for early and good germination. The nuts are to be sown vertically with calyx end just covered at a distance of about 5 cm. Thick mulching using straw or arecanut leaves is to be done. The nuts commence germination by around 45-50 days and complete by about 90-95 days. The number of days required for germination increases with altitude.

6.3.2. Secondary Nursery

Seedlings are raised in secondary nursery by preparing beds of about 1.5 m width and 15 cm height. Plant three months old sprouts at 30 cm to 45 cm. Apply a basal dose of decomposed farm yard manure@ 5 t/ha in the secondary nursery. Areca sprouts and seedlings are highly susceptible to exposure to direct sun, and hence needs shading. The shade may be either of coconut or arecanut leaves spread over a pandal or by planting some fast growing green manures or banana. The commercially available shade nets can also be used for this purpose. *Sesbania aegyptica* has been found to be one of the best live shades in areca nurseries especially in Maidan parts of Karnataka, India.The concept of primary and secondary nursery can be avoided and the seed nuts can be directly sown in raised beds (15cm) of 130 cm width at a spacing of 30cm x 30cm in the sub-Himalayan region of West Bengal where the harvesting and sowing seed nuts coincide with rainy season. Seedlings can also be raised in PVC (polyvinyl chloride) bags of 25 cm x 15 cm, 150 gauge with a mixture of top soil, cattle manure, and sand used in the ratio of 7:3:2, respectively. Solarization of soil by covering with black polythene sheet and sun drying potting

Figure 3.3: Arecanut Nursery Seedlings.

mixture helps to avoid soil borne disease. Three months old sprouts can be planted in polybags. Apply water on each day during non rainy periods.

6.4. Selection of Seedlings

Arecanut, being a perennial crop committed to the land for many decades, adequate attention is to be bestowed for adoption of scientific cultivation practices right from the beginning. Disease and pest free seedlings with five or more leaves (early splitting) and minimum 90 cm height and 26 cm collar girth are to be selected from the secondary nursery for field planting. One or two years old seedlings when used for planting produce more vigorous palms with early flowering. They should have well established root system. Uproot the seedlings with a ball of earth adhering to roots for field planting. Covering the base with ball of earth with plastic sheet/ bag will help in keeping the seedlings in good condition for long distance transport.

In Assam, where soil is heavy and water stagnation could be problem, planting of 18-30 months old seedlings is ideal.

7. Planting and after Care

7.1. Site Selection and Layout

Exposure of arecanut palms to direct sunlight causes scorching effect on stems and they become weak and susceptible to wind fall, and therefore, site selected should have protection against hot sun from both southern and western side by tall growing trees. Planting methods like square, triangle and quincunx may be followed. Aligning the rows in north-south direction and planting on quincunx system with angling 35° towards west lowers the incidence of sun-scorching. The palms cannot withstand both drought and water stagnation. Thus, the site selected should have facility for irrigation during dry weather and sufficient drainage to drain away excess water during heavy rains.

7.2. Spacing

The spacing followed in different areca growing regions varies from 1.25 m x 1.25 m to 3.6 m x 3.6 m. Arecanut plants require sufficient sunlight for better growth and yield, and hence, proper spacing should be adopted. The root distribution studies in relation to individual palm yield and unit area yield indicated that 2.7 m x 2.7 m spacing is optimum for arecanut and this spacing is generally adopted by the farmers. In areas where wider spacing is adopted, the resource utilization will not be complete, and if closer spacing is followed, there will be heavy concentration of roots in the lower layers of soil resulting in reduction in yield. However, wider spacing provides ample opportunity to accommodate a number of perennial and annual crops in the interspaces.

7.3. Depth of Planting

Depth of planting is mainly decided by the soil type and the water table. In laterite soil with good drainage, the seedlings can be planted at 90 cm depth. However, in areas where natural drainage can be provided (particularly during the heavy rainfall period), deeper planting of seedlings up to 90 cm depth is preferred, as it provides firm anchorage to the roots and provides large volume of space for spread of roots. If shallow planting is practiced, the roots get exposed and the palm needs earthing up. The seedlings are to be planted with a ball of earth in the pits after filling half portion with top soil and compost mixture. The base of the seedling should be pressed properly and the pit mulched with green leaves.

7.4. Season of Planting

In areas of heavy rainfall due to south-west monsoon and in river banks, where inundation is likely, planting of arecanut seedlings can be done in September-October. In other areas planting can be done during May-June.

7.5. Drainage

Proper drainage ensures better growth and development of the plants, since arecanut cannot withstand water stagnation. The soil type will decide the number of drainage channels to be made in the plantation. In light soils, it could be less, whereas, in heavy soils, the channels should be dug in each row to drain out excess water. Prepare channels which are at least 15 - 30 cm deeper than the depth at which the seedlings are planted. The channels are to be cleaned every year for easy flow of water. The planted pits also should be provided with outlets to drain away the water.

7.6. Shading

The arecanut plants are highly susceptible for sun scorching, and hence, the seedlings should be given adequate protection against the direct exposure to sun. This can be done either by covering the plants with coconut or arecanut leaves or by planting banana in between two rows of arecanut. Such banana plants give additional income to the farmers. Sun scorching is usually noticed during October - January. The stems of young palms have to be protected during this period, as the part once lost or got damaged cannot recover. Planting quick growing shade

trees on southern and western sides of the garden also helps to protect the arecanut plants from sun scorching. The palms are to be irrigated in such cases.

7.7. Irrigation Water Management

Arecanut cannot withstand drought for a long time, and being a perennial crop, once affected by water stress, it may require two-three years to regain the normal vigour and yield. Therefore, in places where such situations are likely to occur, irrigating the palms becomes essential. However, in places with high sub-soil moisture and in areas where the rainfall is well distributed, throughout the year, no irrigation is necessary. Irrigate the palms once in a week during November to February, once in 4 days during March to May. Drip irrigation @16 – 20 lit/tree/day will be economical. The water use efficiency can be enhanced through a good combination of irrigation and mulching. Mulching is very important in arecanut plantation because the highly porous soils in which the crop is planted can lead to water loss through seepage. Different types of organic mulches could be used for this purpose.

8. Arecanut Based Cropping/Farming System

Arecanut being essentially a crop of small and marginal holders, often with less than one hectare, the insufficient income will not be able to sustain dependent families. The growth habit and long pre-bearing period (5–6 years) of arecanut provide ample opportunities for increasing land and other resource use efficiency by way of adoption of multiple cropping practices. Such system ensures better utilization of basic resources, enhances income and employment opportunities. The palm with its compact crown, raised well above the ground (10–15 m), allows more sunlight to transmit to ground and maintains high humidity. Studies

Figure 3.4: Cocoa as Mixed Crop in Arecanut Field.

indicated availability of congenial microclimate and less utilization of resources for intercropping in arecanut plantations. 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. The initial pre-bearing phase is the ideal time to grow intercrops, especially short duration ones, whereas, in later years of growth of palms, as the canopy enlarges in height, mixed cropping with other shade tolerant perennial crops can be practiced. From the perspective of biodiversity management within the arecanut plantation, the general practice by the farmers has been that fruit crops such as papaya, citrus and banana are intercropped with arecanut without loss of soil fertility and productivity. In fact, these fruit trees provide shade and enhance the moisture retention capacity of the soil. The fruit trees also attract insects which in turn act as pollinators for the arecanut palm.

A number of annual crops, such as rice, sorghum, beans, corn, groundnut, and sweet potato, vegetables, yams, banana, and pineapple can be grown in arecanut plantation. When these crops are cultivated, all of them are also to be rasied following organic cultivation practices. Banana is the most preferred intercrop in all the arecanut gardens as it also provides good shade during early growth of arecanut palms. Black pepper can also be grown using arecanut stems as live standards. Cocoa is another important intercrop as the microclimate, especially shade, soil moisture, and temperature, in the arecanut gardens is ideal for cocoa growth. A spacing of 2.7 m x 2.7 m or a spacing of 2.7 m x 5.4 m combination could be adopted, although operational advantages are better in the latter spacing. High-density multispecies cropping in arecanut can be adopted with combination of crops such as black pepper, cocoa, coffee, or banana occupying different vertical air space levels. Population of general and function specific microorganisms will also be higher under such a system. Cropping models for heavy rainfall zone are arecanut + cocoa; arecanut-based high density multispecies cropping system with cocoa, banana and pepper; arecanut + pepper + cocoa + banana, arecanut + medicinal and aromatic plants and arecanut + vanilla.

9. Nutritional Management

Majority of the arecanut growing areas, being lateritic in nature, have low soil fertility status and exhibit wide spread micronutrient deficiency. Incidence of disorders like crown choking, crown bending, shortened internodes and oblique nodes are increasingly being noticed due to nutritional disorders. Unless these problems are taken care of, arecanut will not be a profitable crop in future. While raising nursery, apply basal dose of well decomposed FYM or vermicompost @ 2 t/acre treated with *Trichoderma* 2-3 weeks before planting seed nuts in sand bed nursery. Organic manures such as cattle manure, compost, or green leaves (*Glyricidia maculata*, which can be grown on the boundaries of arecanut gardens) are to be used to supply nutrients at the time of planting @ 12 kg/plant.

9.1. Green Manure Crops

Growing of green manure crops with the onset of monsoon will help suppress weed growth, prevent soil erosion and add large quantities of organic matter to

the soil. *Pueraria javanica, Calopogonium mucunoides, Stylosanthes gracilis* and *Mimosa invisa* are good leguminous cover crops in arecanut gardens to supply green manure and nutrients. The cover crops may be sown in the months of April and May and the green matter may be cut and applied to the arecanut palms. Sesbania can be grown wherever water logging and drought are likely to occur. It can be grown in valleys of Assam, Karnataka and Kerala receiving high rainfall.

9.2. Organic Matter Recycling

Despite less canopy and leaf area, arecanut produces waste biomass comparable to other palms such as coconut (12–18 t/ha) and oil palm (14–15 t/ha) due to a high population density per unit area. The recyclable organic biomass production from sole crop of arecanut would be around 9-10 t/ha/year. This includes arecanut leaf with leaf sheath, husk and rachis (bunch wastes) *etc.* Arecanut is intercropped with annual and biennial crops during the initial years and perennials such as cocoa, banana, clove, pepper and acid lime *etc.* in high-density multi-species cropping system (HDMSCS) during the bearing stage and therefore, the availability could be further increased to 14 t/ha by such cropping system. The husk biomass accounts for 16.5–17 per cent of the total weight of the dry nuts of arecanut, but it is largely being wasted as fuel. Taking into account the current area under arecanut cultivation, the annual recyclable biomass production could be about 9 to 11 million tonnes in the world, 50 per cent of which (4.5–5.5 million tonnes) will be contribution from India. Direct application of these wastes in the garden will result in immobilization of available nutrients due to high C:N ratio, and as it takes considerable time for decomposition, will not meet the nutrient demand of the crop immediately. The nutrient composition in these arecanut wastes is reported in the range of 0.62–1.59

Figure 3.5: Arecanaut Leaves for Recycling.

per cent nitrogen (N), 0.07–0.16 per cent phosphorus (P) and 0.75–1.25 per cent potassium (K). Recyclable biomass in arecanut supplies approximately 95 g N, 10 g P_2O_5 and 110 g K_2O per palm per year. As husk contains higher potassium content, it can be used as a potential source of K in organic farming due to heavy K feeding nature of arecanut. Efficient recycling of these wastes supplies a substantial quantity of nutrients and meets crop nutrient demand to a great extent.

9.3. Utilization of Organic Wastes as Vermicompost

Though plantation wastes supply considerable nutrients, their direct recycling does not meet the immediate nutrient demand of the crop. Nitrogen immobilization, which occurs when plantation wastes with a high C: N ratio of 37:62, lignin and polyphenol are directly incorporated in the soil, should be avoided. The normal composting methods for management of plantation wastes is not efficient in terms of nutrient quality and time. These organic wastes could be converted into vermicompost using *Eudrilus eugeniae* earthworms, which gives a recovery of 75-88 per cent in a period of 90 days. To prepare vermicompost, areca wastes are to be chopped into small pieces of 5-10 cm and filled in tanks or pits. As the earthworms cannot eat fresh organic materials, the wastes should be in a stage of partially decomposition. Therefore the organic waste heap is to be mixed with cow dung slurry @ 10 kg/100 kg of waste and kept for two weeks with sprinkling water daily. This mixed organic waste may be watered regularly to maintain sufficient moisture (30-40 per cent) and incubated for 2-3 weeks to initiate microbial action. One or two turnings may be given to reduce the heat generated. A layer of 10-15 cm waste material is alternated with 2 cm layer of cow dung over which earthworms can be released @ 1000 numbers per square meter. The wastes are converted into fine granular, odourless vermicompost within 90 days. Application of vermicompost improves the soil organic carbon and available nutrient contents as well as helps to meet the nutrient demand to some extent.

On-farm recycling of waste biomass of arecanut-based cropping system as vermicompost produces good-quality compost and results in reduced production cost. The arecanut wastes recycled in the form of vermicompost have potential to meet about 50 per cent N, 32.5 per cent P and 26 per cent K requirement of arecanut. Under organic farming with application of vermicompost to supply 100 per cent of recommended N in arecanut the yield obtained was 1.70 kg dry nut (chali)/palm/year which indicated that arecanut crop can be cultivated with organic inputs to realize economic yield. Leachates derived from vermicomposting are beneficial and can be used as liquid fertilizer due to high concentration of plant nutrients. Vermicompost extract obtained by mixing vermicompost and water at 1:10 ratio can be successfully used for drip fertigation.

10. Plant Protection

10.1. Pests and their Management

Important pests of arecanut and their major damage symptoms are given in Table 3.4.

Table 3.4: Pests of Arecanut and their Damage Symptoms

Name of Pest	*Damage Symptom*
Spindle bug (*Carvalhoia arecae* Miller and China)	Inhabit the inner most leaf axils, usually below the spindle. Both the nymphs and adults suck sap and the infested portions develop necrotic patches leading to drying. Spindle fails to unfurl and severe infestation leads to stunting of the palm.
Pentatomid bug [*Halyomorpha marmoreal* (F.)]	The later instar nymphs and adult bugs pierce the tender nuts and suck the kernel sap resulting in drying of kernels and dropping of tender nuts. There will be characteristic pinprick black marks at the feeding sites, which subsequently enter into the kernel.
White grub/root grub (*Leucopholis burmeisteri* and *L. lepidophora* Blanch)	Root/white grubs occur mostly in sandy and sandy loam soils and are voracious feeders of arecanut roots. The early instar grubs feed on the roots of grasses and other humus, while the second and third instar grubs feed on tender and mature roots of the palm. In severe cases, the bole of the palm is also eaten up. Feeding on arecanut seedling roots results in dropping and drying of leaves. The affected seedlings come off easily since the entire root system is usually eaten up. The palms with continuous infestation show a sickly appearance, with yellowing of leaves, tapering of stem, and reduction in yield. In case of severe attack and loss of roots, the palms may topple down. Root grubs also feed on roots of intercrops such as banana, cocoa, tapioca, yams *etc.*
Inflorescence caterpillar (*Tirathaba mundella* Walker)	The caterpillars feed on the inflorescences especially the tender female flowers and rachillae, web them into a wet mass with silken threads and take shelter in it. Burrowing and feeding activities produce visible damage symptoms in the form of frass production and a sticky, gummy exudate. Mature caterpillars can damage newly opened inflorescences also. In severe cases, they bore into the tender buttons and tender nuts as well. Delayed spathe opening, yellowing of spadices, presence of small holes with frass and drying patches on the spathe are the external symptoms of attack.
Red mite (*Oligonychus indicus* Hirst. and *Raoiella indica* Hirst.)	The reddish mites are easily seen against green leaves. Heavy infestations of the mites are typically on the lower surface of the leaves, and yellow speckles and blotches on the leaves are seen from the feeding damage. Yellowing of the leaves may often be severe. In severe infestations yellowing of leaves is quite prominent.

The farmers can adopt an integrated approach for managing pests. Use as many different control measures as possible *viz.*, cultural, mechanical, physical, biological *etc.* (Table 3.5).

10.2. Disease and their Management

The important diseases of arecanut, their symptoms and management under organic production are given in Table 3.6.

11. Harvesting and Post-harvest Management

11.1. Harvest

Harvesting of nuts at correct stage is very important for obtaining quality product. The stage of harvesting depends on the type of produce to be prepared for the markets. Two types of final product are seen in arecanut. Ripe nuts are

Table 3.5: Cultural/Biological Control Measures for Pests of Arecanut

Name of Pest	*Control Measure*
Phytophagous mite	Cultural control: Collect and destroy the heavily infested and drying leaves of young palm in the initial foci of colonization
Scales	Biological control: Release *Chilocorus nigritus* periodically @ 4-5 beetles/ palm
	Conserve predators such as coccinellid beetles (*C. nigritus* and *C. circumdatus*)
Spindle bugs	Cultural control: Digging and forking of the soil before and after the monsoon will help in eliminating the various developmental stages of the beetle
Root grub	Cultural control: Deep summer ploughing to expose the immature stages for avian predation.
	Mechanical control: Collection and destruction of beetles emerging from the soil during pre-monsoon showers in the evening hours. Install light traps @ 1 trap/acre and operate between 6 pm and 10 pm
	Biological control: Conserve and augment entomopathogenic nematodes such as *Heterorhabditis* spp. and *Steinernema* spp.
	Application of neem cake @ 2 kg/palm/year at the base of the plant during June-July
Inflorescence caterpillar	Mechanical control: Affected spadices may be opened and if all the female flowers have been damaged the inflorescence should be removed and burnt

Figure 3.6: Harvested Mature Nuts.

harvested for production of dry nuts called 'chali', while green nuts at 6-7 months age are harvested for tender nut processing.

Table 3.6: Diseases of Arecanut and their Management

Disease	*Symptoms*	*Management*
Koleroga/mahali/fruit rot (*Phytophthora palmivora* and *P. meadii*)	Initial symptoms appear as dark green/yellowish water-soaked lesions on the nut surface near the perianth (calyx). The infected nuts lose their natural green lusture, quality and, hence, have a low market value. The lesions on the fruits gradually spread covering the whole surface before or after shedding which consequently rot. As the disease advances the fruit stalks and the axis of the inflorescence rot and dry, sometimes covered with white mycelial mats. Infected nuts are lighter in weight and possess large vacuoles. When infection occurs later in the season, it leads to rotting and drying up of nuts without shedding (known as 'Dry Mahali'). The fruit bunches infected towards the end of rainy season may remain mummified on the palm and such nuts provide inoculum for bud rot or crown rot or the recurrence of fruit rot in the next season. The disease spreads through heavy winds and rain splashes. The severity, persistence and spread of fruit rot are related to the pattern of rain. The disease appears usually 15 to 20 days after the onset of regular monsoon rains and may continue up to the end of the rainy season. Continuous heavy rainfall coupled with low temperature (20 to 23 °C), high relative humidity (>90 per cent) and intermittent rain and sunshine hours favour the outbreak of fruit rot.	Collect all the infected nuts and other plant parts and destroy. Spray 1 Bordeaux mixture on fruit bunches. Also cover the bunches with poly bags
Inflorescence die back (*Colletotrichum gloeosporioides*)	Disease appears on rachillae of the male flowers and then in the main rachis as brownish patches which soon spreads from tip downwards covering the entire rachis causing wilting. The female flowers of the infected rachis shed and the whole inflorescence shows 'die back' symptom. The fruiting bodies of the fungus (conidia) appear as concentric rings in the discolored areas. The disease is severe mostly during dry condition (February-March). Button shedding followed by die-back of inflorescence is a severe problem in arecanut plantations during monsoon periods. The spread is through air borne conidia.	Remove the fully affected inflorescence and destroy them to prevent spread.
Yellow leaf disease	Yellowing of tips of leaflets in 2 or 3 leaves of outermost whorl. Brown necrotic streaks run parallel to veins in unfolded leaves. The yellowing extends to the middle of the lamina. Tips of the chlorotic leaves dry up. In advanced stage all the leaves become yellow. Yellowing of leaves is conspicuous during October to December. Finally the crown leaves fall off leaving a bare trunk. Root tips turn black and gradually rot. The disease is caused by Phytoplasma and transmitted by plant hopper (*Proutista moesta*).	Remove and destroy the diseased palms in the mildly affected areas to prevent the spread. Adopt biomass recycling and excess application of phosphorus 100g/palm in the form of rock phosphate.

Contd...

Table 3.6–*Contd...*

Disease	*Symptoms*	*Management*
Basal stem rot/foot rot/ anaberoga/Ganoderma wilt (*Ganoderma lucidum*)	The leaflets in outer whorls become yellow, which spreads to the whole leaf and the leaves droop down covering the stem. Later, the inner whorl leaves also become yellow. Subsequently all the leaves droop, dry up and fall off, leaving the stem alone. Then the stem becomes brittle and easily broken by heavy wind. The base of the stem shows brown discoloration and oozing of dark fluid. Bracket shaped fructifications of the fungus called 'anabe' appears at the base of the trunk. Roots become discoloured, brittle and dried. When infected trunk is cut open brown discoloration can be seen up to one metre from ground level. The disease is severe in neglected, ill-drained and over-crowded gardens especially with hard, black loamy acid soils of higher iron and calcium contents. The disease is soil borne, but secondary spread is through air-borne spores.	Improve drainage. Avoid dense planting. Avoid flood irrigation and water flowing from infected palms to healthy palms. Avoid repeated ploughing and digging in the diseased gardens. Balanced manuring. Cutting and burning of dead palms along with the bole and roots should be followed strictly.
Bud rot or crown rot (*Phytophthora meadii*)	Initial symptom is the characteristic change of spindle leaf colour from green to yellow and then brownish. The leaves rot and the growing bud rots causing death of the palm. The affected young leaf whorl can be easily pulled off. The outer leaves also become yellow and droop down one by one leaving a bare stem.	Remove and destroy the diseased palms in the mildly affected areas to prevent the spread.

11.2. Post-harvest Management

Arecanut is processed by two methods in different states: 'chali' fully ripe dehusked graded nuts accounting for about 80 per cent of production, and saraku, semi-ripened, dehusked, boiled, coloured and dried nuts accounting for about 15 per cent. The most popular type of arecanut is dried whole nuts.

Figure 3.7: Spreading Harvested Nuts for Drying.

11.2.1. Processing of Ripe Nut for Making Chali (Dry kernel)

After harvesting, fully ripened fresh nuts are sun dried for 40-45 days. Spread the nuts in single layer and turn them once in a week for uniform drying and better quality of produce. Ensure proper drying to avoid fungal infections. The dry nuts are dehusked manually or mechanically, graded based on the size and quality, and marketed. Good quality chali should be free from immature nuts, surface cracking, husk sticking, fungal and insect infection.

11.2.2. Processing of Tender Nut (Immature nut)

To prepare tender processed nuts, the nuts to be are harvested at 6- 7 months maturity when they are green and soft. The processing consists of dehusking, cutting nut into halves and boiling with water dilute extract from previous boiling. After boiling, arecanut pieces are coated with 'kali', which is a concentrated extract after boiling 3-4 batches of arecanut, to get good quality processed nuts. These nuts are generally sun dried, though occasionally oven drying is followed. The well-dried product should be crisp, dark brown in colour, glossy in appearance and well-toned astringency.

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