# COCONUT CULTIVATION PRACTICES FOR THE NORTH EAST INDIA


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# INTRODUCTION

Coconut, the '*Kalpavriksh'* or 'tree of heaven', plays a significant role in the agrarian economy of many states in India. It is also very closely interwoven into the socio-economic and cultural life of a substantial number of farm families. India ranks first in terms of production and productivity of coconut in the world and third in area under cultivation. As per the 2020-21 statistics coconut was cultivated in India in an area of 21.98 lakh ha with the annual production of 20736 million nuts and productivity of 9430 nuts per ha. It is cultivated in 17 states and three union territories. The four southern states viz., Kerala, Karnataka, Tamil Nadu and Andhra Pradesh together contributes more than 90 % of the area and production of coconut in the country. However, since the last many years coconut cultivation has been spreading to non-traditional areas as well including different states in the North East region of the country. Assam, Tripura and Nagaland are the major North Eastern states having coconut cultivation, together covering about 26,480 ha (as per 2020-21 statistics) and a total annual production of 175.88 million nuts.

The average productivity of coconut in these three states is only 6642 nuts per ha which is much less than the national average of 9430 nuts per ha. Other North Eastern states viz., Arunachal Pradesh, Nagaland, Manipur, Meghalaya and Mizoram are also having small extent of coconut cultivation. There is ample scope for enhancing the area under coconut cultivation in the North Eastern states having congenial agro-ecological situations pertaining to climate and soil. Besides, the productivity and income from the existing coconut holdings can also be considerably increased through better integration of technologies, especially improved varieties, integrated nutrient management, cropping/farming systems and integrated pest and disease management.

The technical feasibility and economic viability of many of the recommended technologies for higher productivity and income from coconut farming have been demonstrated through the research conducted and front line extension programmes organized by ICAR Research Centre, Kahikuchi and also by the Horticultural Research Station, Assam Agricultural University, Kahikuchi. However, field level utililization of the technologies recommended for coconut cultivation is not at a satisfactory level due to various factors.

The scientific cultivation practices for realizing higher productivity and income from coconut farming in the north east states of India are discussed hereunder.

**Climate and soil**

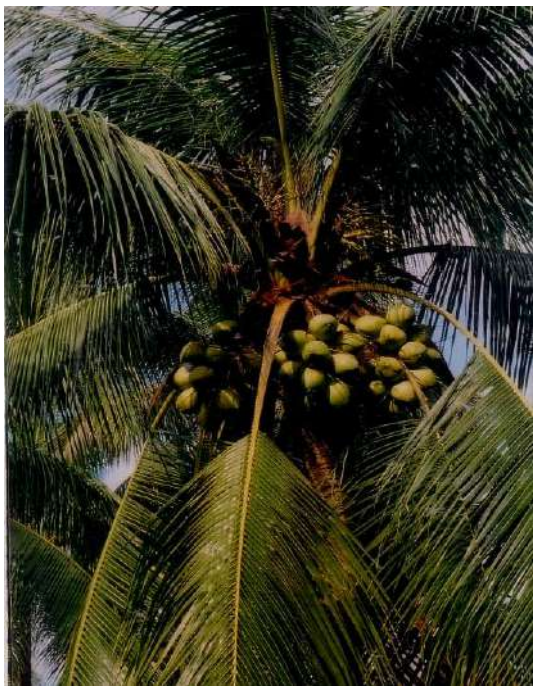
The coconut palm is grown under varying climatic and soil conditions. It is essentially a tropical plant, growing mostly between 20° N and 20° S latitudes. The ideal mean temperaturefor coconut growth and yield is 27±5°C and relative humidity more than 60 per cent. Most of the north eastern hilly regions are suitable for coconut cultivation, especially Assam and Tripura. However gawahati(Assam) recorded minimum temperature ranges between 07.50 to 25.50 and maximum temperature between 19.10°C to 33.40°C. Minimum temperature below 10°C hindering reproductive growth of coconut and failing of emergence of inflorescence during this period. Even those emerged inflorescence aborted and fail to produce nuts because of low temperature during the months of December to February is one of the constraint for archieving higher productivity in the north eastern region. However this could be overcome by adopting agronomic practices namely, thick mulch in the basin of coconut palms and irrigating coconut palms during this period. Very high humid conditions right through the growth of palms is not considered good. The coconut palm grows well up to an elevation of 600 m above mean sea level. However, near the equator, productive coconut plantations can be established up to an elevation of about 1000 m abovemean sea level. The palms tolerate a wide range in intensity and distribution of rainfall. However, a well distributed rainfall of about 2000 mm per year is the best for proper growth and high yield. In areas of inadequate rainfall and uneven distribution, irrigation is needed. The palm requires plenty of sunlight and it does not grow well under shade or in too cloudy regions. About 2000 hrs of sunshine in a year is considered necessary for the healthy growth of the palm. The natural habitat of coconut is the coastal belt of the tropics where sandy and red sandy loam soils are predominant. The cultivation of coconut has slowly extendedto inland areas, even to the hill tops, having varied soil conditions. It grows well in almostall types of soils including sandy, laterite, swampy, alluvial, black and saline soils, provided they have proper drainage system, permitting unrestricted root development, aeration and absence of rock or a hard substratum within 2 m of the surface. The predominant soil type is alluvial where coconut is cultivated. This soil is more fertile and helps in attaining higher productivity. However waterlogging during monsoon period is the common problem in the coconut cultivated region and necessitates proper drainage measures for reaping the full productivity potential of alluvial soil type. It tolerates salinity and a wide pH ranging from 5.0-8.0.

# IMPROVED COCONUT VARIETIES FOR NORTH EAST INDIA

The Central Plantation Crops Research Institute (ICAR-CPCRI), under the Indian Council of Agricultural Research, and the State Agricultural Universities under the All India Coordinated Research Project on Palms (AICRPP) have developed improved and speciality varieties and for cultivation in different agro-ecological zones of the country. The varieties suitable for cultivation in North East India are described below.

## *A. Dwarf varieties*

**Kalpa Jyothi:** It isa tender nut variety of dwarf habit with potential in landscaping as an ornamental palm. The palms of this variety have a compact spherical canopy and drooping frond tip. Fruits are yellow, medium-sized and oval in shape, with good quality of tender nut water (~380 mL). The quality of tender nut water is 'good' in taste with total soluble solids (TSS) of $5.9^0$ Brix. The nutritive value of tender nut water is excellent with total sugars – 6.2 g/100 mL, free amino acids -1.7 mg/100 mL, sodium – 36 ppm, potassium – 1998 ppm. Flowering commences early, within 3-4 years of planting. Under good management, the palm yields 114 mature nuts/palm/year. When harvested for tender nuts, fruit yield is expected to be at least one and half folds higher. It serves as parental palm for production of hybrids *viz*., KalpaSamrudhi (MYD-Malayan Yellow Dwarf x WCT - West Coast Tall) and KalpaSrestha (MYD x TPT - Tiptur Tall).



## *B. Tall varieties*

**Kamrupa**

It is a high yielding, dual purpose variety, suitable for copra and tender nut production. The palms are tall in habit with spherical canopy and large number of leaves. Fruits are green, medium-sized and oblong with 161 g copra/nut and copra yield of 2.86 t/ha with oil content of 65%. The tender nut water content is around 253 mL and is organoleptically graded as “good”. The tender nut water has total sugar content of 5.16 g/100 mL, sodium - 39 ppm and potassium - 2294 ppm. Flowering commences about 6-7 years of planting under irrigated condition. The variety yields around 101 nuts/palm/year under good management. This variety is relatively tolerant to low temperature stress during winter.

**Kalpa Mitra:** A high yielding variety, suitable for copra and oil production. It is also suitable for production of ball copra. Fruits are large and oval with 241 g copra/nut. The palms of this variety are tall in habit with stout trunk and spherical canopy with large number of leaves. The palms commence flowering 7-8 years after planting in the field, under rainfed conditions. The variety is relatively tolerant to moisture deficit stress and gives yield of 80 nuts/palm/year, under average management. The average yield of this variety is around 3.37 t copra/ha, with estimated oil yield of 2.24 t oil/ha. The average quantity of tender nut water is 495 mL. Based on organoleptic evaluation, the tender nut water is classified as "average" in taste. The nutritive value of tender nut water is: total sugars - 5.7 g/100 mL; free amino acids - 1.3 mg/100mL; potassium - 2150 ppm; sodium - 23.5 ppm.

**Kera Chandra:** A high yielding, dual purpose variety suitable for copra and tender nut production. Fruits are green, round shaped and weighs 1031 g having a copra content of 189 g/nut. The palms of this variety are tall with spherical canopy. The palms commence flowering

5 years after planting. Under rainfed conditions, the variety yields 110 nuts/palm/year, 3.68 t copra/ha/year and 2.43 t oil/ha/year. The average quantity of tender nut water is 450 mL which is characterized with total sugars - 5.86 g/100 mL; TSS-$6^0$ Brix; sodium - 24 ppm; potassium - 2273 ppm. Organoleptic evaluation of tender nut water graded it as 'very good'. The variety is characterized with relatively high tolerance to moisture-deficit stress.

**Kera Keralam:** A high yielding variety suitable for copra and oil production. It is also amenable for ball copra production. It is a tall variety with spherical canopy which commences flowering after 6 years of planting under rainfed conditions. Under irrigated and optimum growth conditions, flowering advances to 4-5 years after planting. The fruits are green yellow, and oval-shaped having the copra content of 176 g/nut. Under rainfed conditions, the variety yields 109 nuts/palm/year; 3.36 t copra/ha/year; 2.28 t oil/ha/year, whereas under irrigation the palms yield 147 nuts/palm/year; 4.53 t copra/ha/year and 3.08 t oil/ha/year. Sensory evaluation of tender nut water has graded it as 'average' and the mean tender nut water content is 341 mL; with total sugar content of 5.5 g/100 mL; free amino acids 2.41 mg/100 mL; TSS-$6.3^0$ Brix; sodium - 29 ppm; potassium - 2421 ppm. The variety is moderately tolerant to moisture-deficit stress and hence recommended for cultivation under water-limiting conditions.

***C. Hybrid varieties***

**Kalpa Samrudhi(MYD x WCT):** A high yielding, semi tall, dual purpose D x T hybrid, recommended for copra and tender nut production. The variety is produced by crossing selected Malayan Yellow Dwarf palms (female parent) with pollen from elite West Coast Tall palms (male parent). The palms are regular bearers and commence flowering about 3-4

years after planting, under good management. The variety bears green fruits, with 220 g copra/nut. The quantity of tender nut water is around 346 mL and is of very good quality (TSS - $6^0$ Brix). The nutritive value of tender nut water is as follows: total sugars - 4.17 g/100 mL; free amino acids - 2.08 mg/100 mL; potassium - 2370 ppm; sodium - 35.1 ppm. The average annual nut yield of this variety is 117 nuts/palm/annum, under normal management, with an estimated annual copra yield of 4.5 t/ha and oil yield of 3.04 t/ha. This variety is relatively tolerant to moisture deficit stress and exhibits higher nitrogen use efficiency.

**Chandra Sankara (COD x WCT):** A high yielding dual purpose D x T hybrid, suitable for copra/oil and tender nut production. It is produced by crossing selected Chowghat Orange Dwarf palms (female parent) with pollen from elite West Coast Tall palms (male parent). The variety is semi tall in habit, bears brown, medium-sized fruits, with 208-225 g of copra/nut. It commences flowering in 3-4 years after planting, much earlier than the WCT parent, andproduces, on an average, 110-123 nuts/palm/year, with an estimated copra yield of 4.40-4.82 t copra/ha and 2.99 t oil/ha. The quantity of tender nut water is around 347 mL and is of very good quality (TSS – $6.58^0$ Brix). The nutritive value of tender nut water is as follows: total sugars – 5.99 g/100 mL; free amino acids – 1.73 mg/100 mL; potassium - 2193 ppm; sodium – 23.77 ppm. This variety is relatively sensitive to low moisture stress and performs well only under irrigation and good management.

**Kera Sankara(WCT x COD):** A high yielding, dual purpose T x D hybrid, recommended for copra and oil production, and produced by crossing elite West Coast Tall palms (female parent) with pollen from selected Chowghat Orange Dwarf palms (male parent). The variety bears

brown, medium-sized, oblong fruits, with 187 g copra/nut. It commences flowering within four years of planting, much earlier than the WCT parent, under good management. The average yield is 108 nuts/palm/year, with an estimated copra yield of 3.78 t copra/ha and 2.40 t oil/ha. The quantity of tender nut water is around 351 mL and good to taste (TSS – $7.00^0$ Brix). The nutritive value of tender nut water is as follows: total sugars – 6.61 g/100 mL; free amino acids – 1.47 mg/100 mL; potassium - 2274 ppm; sodium – 33.30 ppm. This hybrid variety exhibits low moisture-stress tolerance and produces reasonably good yield under water limiting condition.

**Nursery agro-techniques**

Selection of seed nuts and seedlings are very important in coconut cultivation as the performance of the new progeny can be known only several years after planting. If the seed nuts and seedlings happen to be of poor quality, the new plantation will be low yielding and uneconomic, causing considerable loss of time and money to the grower. The fact that, coconut is a cross-pollinated palm and it does not breed true, makes the selection of seed nuts and then of seedlings in the nursery all the more 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**

In tall varieties, seed nuts should be collected from mother palms which should have attained an age of 20 years. Wherever possible, it is advisable to select middle-aged trees as they will be in their prime of life and it is easier to spot good yielder from mediocre/poor yielder. The important features are: a) straight stout trunk with even growth and closely spaced leaf scars, b) spherical or semi-spherical crown with short fronds, c) short and stout bunch stalks without tendency drooping, d) more than 30 leaves and 12 inflorescences carried evenly on
the crown, e) inflorescence with 25 or more female flowers, f) consistent yield of about 80 nuts under rainfed conditions and 125 nuts under irrigated conditions, g) 150 g per palm copra per nut and h) absence of disease and pest incidence. In dwarf varieties, seed nuts can be collected from mother palms which have attained an age of 12 years or more and yielding more than 60 and 100 nuts per year under rainfed and irrigated condition, respectively. Further, it should have a minimum of 30 leaves with a nut weight more than 400 g.

**Collection of seed nuts**

Seed nuts can be collected from September to February. Fully matured nuts *i.e.* about 12 months old should be harvested. Care should be taken not to damage the seed nuts while harvesting. Nuts which are too big or too small in the bunch and also the nuts of irregular shape and size should be discarded. Seed nuts of tall varieties are to be sown 2-3 months after collection, whereas dwarfs should be sown within 15-30 days after harvest.

## Raising nursery

Well drained, coarse textured soil near dependable irrigation water source should be selected for raising the nursery. The seed nuts can be sown in flat beds if there is no drainage problem. The seeds are to be sown in raised beds, if water stagnation is a problem. Nursery can be raised either in the open with artificial shade or in gardens where the palms are tall and the ground is not completely shaded (Fig. 1). The seed nuts should be sown in long and narrow beds at a spacing of 40 cm x 30 cm during December to February, either vertically or horizontally in 20-25 cm deep trenches. Advantage of Vertical planting cause less damage during transit of seedling. However, in delayed planting, when the nut water goes down considerably, adopt horizontal sowing it is good to go for horizontal sowing of seednuts with widest of the three segments upwards which helps in the plumule emergence.

Fig. 1. Raised nursery between the interspace of coconut.

## Selection of seedlings

Only good quality seedlings are to be selected from the nursery for field planting. In tall varieties, vigorous seedlings which are one year old, more than 100 cm in height with 5-6 leaves and girth of 10 cm at the collar should be selected for planting. In dwarf varieties, the girth and height of good quality seedlings should be more than 8

cm and 80 cm, respectively. Early splitting of leaves is another character preferred for selecting good seedlings. Generally, one year old seedlings are preferable for planting. However, for planting in water-logged areas, 1½ to 2 years old seedlings are to be preferred.

**Polybag nursery**

Good quality seedlings can be raised in polybags. Germinated seeds can be transplanted in polybags (500 gauge thickness) of 45 cm x 60 cm dimension with 8-10 holes at the bottom (Fig. 2). The commonly recommended potting media are top fertile soil mixed with sand (3:1) or top fertile soil, sand or coir dust and well rotten and powdered cattle manure (3:1:1). Potting mixture containing sand + vermicompost (3:1) is also ideal for raising polybag seedlings. Recent studies show that coir pith can also be used as potting mixture. Application of 25 g each of biofertilisers such as *Azospirillum* spp. and Phosphobacterium *Bacillus* sp., to the polybags results in production of vigorous seedlings. Use of Plant Growth Promoting Rhizobacteria (PGPR) based bioinoculants, '*Kera Probio*', (talc formulation of *Bacillus megaterium*) @ 25 g/seedling and '*Ker*AM' (Arbuscular Mycorrhizal bioinoculant) @ 50 g/seedling also helps in producing robust coconut seedlings. The advantage of polybag seedlings is that, there is no transplanting shock since the entire ball of earth with the root system can be placed in the pits and the seedlings establish early and more vigorously. But the disadvantages include difficulty for transportation and higher cost of seedling production. Care should be taken not to throw away the polybags in the coconut plantation.

Fig. 2. Poly bag nursery

## Plantation Establishment

### Selection of the site

Soils with a minimum depth of 1.2 m and good water holding capacity are preferred for coconut cultivation. Shallow soils with underlying hard rock, low lying areas subject to water stagnation and clayey soils with impeded drainage are to be avoided. However, in lands reclaimed by heaping alternate layers of sand and clay, coconut thrives well. Proper supply of moisture either through evenly distributed rainfall or irrigation and proper 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 should be leveled before digging pits. The depth of pits will depend upon the type of soil. Planting in pits of 1 m x 1 m x 1 m filled with top soil and mixed with 10 kg powdered farm yard manure to a height of 50 cm is generally recommended. The coconut seedlings are then planted in the centre of the pit by making small hole within the pits and the soil around the seedlings must be firmly pressed (Fig. 3). Care should be taken that the collar region of the seedlings is not filled up with soil in the planting process. Ensure slow filling of pits to facilitate vertical and horizontal penetration of roots for better anchorage and withstand wind pressure in future. After first year of planting, pits should be widened 2 m circumference (radius 1.0 m) and the soil should be added in the pits to cover a depth of 40 cm. In the second year, widening should be made to a circumference of 3 m (radius 1.5 m) and the soil should be covered to fill the pit, leaving 30 cm from the top. Similarly third year after planting, basins should be widened to form a circular basin with a circumference of 4 m (radius 2m) and to a depth of 20 cm. In regions having high water table, very near the ground level, trenches can be taken in the interspaces or while making pits, the excavated soil may be used to create a mound to a depth of at least one metre and planting can be accordingly taken up, to ensure proper anchorage to the growing seedling. In regions having high water table, very near the ground level, trenches can be taken in the interspaces or while making pits,

the excavated soil may be used to create a mound to a depth of at least one metre and planting can be accordingly taken up, to ensure proper anchorage to the growing seedling. Two layers of coconut husk (with concave surface facing up) can be arranged at the bottom of the pit before filling up. This will help in conserving the moisture. The seedlings, after field planting, are to be protected from heavy wind by staking and from sunlight by proper shading using plaited coconut leaves or any other suitable shading materials (Fig. 4).

Fig. 3. Planting coconut seedling.

Fig. 4. Proper Shading of Garden.

**Spacing**

For realizing better yield from coconut, optimum plant density must be maintained in the field. A spacing of 7.5 m x 7.5 m to 8.0 m x 8.0 m in the square system is generally recommended for coconut. This will accommodate 177 and 156 palms per ha, respectively. For facilitating multiple cropping in coconut gardens, it is advisable to go for wider spacing of 10 m x 10 m so as to provide ample opportunity to accommodate a number of perennial and annual cropsin the interspaces.

**Time of planting**

In well drained soils, seedlings can be transplanted during March-May. In low lying areas subject to inundation during monsoon periods, it is preferable to plant the seedlings after the cessation of the monsoon (September-October).

**Management of juvenile palms**

Adequate care should be taken during the early years of growth of young palms for realizing high yield. The field planted seedlings should be shaded and irrigated adequately from September to May. Irrigation with 45 litres of water once in 4 days has been found satisfactory in all soil types. If it is drip irrigation, daily 10 litres of water need to be provided. Provision of proper drainage is important in areas prone to water logging. The pits should be cleared of weeds periodically. Soil washed down and covering the collar region of the seedlings during the rainy days 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. By fourth year, the basin should be fully prepared to a radius of 1.8 m from the trunk. The palms should be frequently examined for any insect or fungal attack and necessary remedial measuresshould be taken up promptly.

**Nutrition**

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. It is always advisable to test soil in the coconut garden (once in 3 years) based on the results of which, type and dosage of chemical fertilizers can be decided.

**Collection of soil and leaf samples from coconut based cropping system**

For coconut, soil samples should be collected from the coconut basin, 1 m away from the bole of the palm and at two depths *viz.,* 0-30 cm and 30-60 cm. For shallow rooted intercrops, soil samples should be collected from the interspace at 0-15 cm depth. For deep rooted intercrops, samples should be collected from different layers of 30 cm soil depths vertically up to the extent of the active root zone of the crop. At the sampling point, the crop residue and other undecomposed plant tissue or foreign material in the surface should be removed. Spade can be used for sampling at 0-15 cm depth (shallow rooted annual intercrops). With spade, V-shape pit of 15 cm depth should be dug and uniform thick slice of soil should be collected from the exposed surface. A tube or screw type augur will be convenient to collect the soil samples from more than 15 cm depth. If the tools are not available, a pit of 30 cm

depth can be dug and soil samples collected. Then dig further, for 30-60 cm depth to collect the soil. The soil samples collected should be then mixed thoroughly (by breaking the big clods by hand or wooden mallet) on a clean piece of cloth and reduce it to half a kg of soil by quartering method (**Quartering method**: thoroughly mix the soil samples, divide it into 4 equal parts, then reject the 2 opposite quarters and mix the remaining 2 portions; then again divide into 4 parts, reject the opposite quarters and then mix the remaining two parts; repeat the same process until the sample is reduced to half a kilogram). Then dry the samples in shade The dried soil samples should be packed in separate clean an, dry cloth bags and properly labeled Leaf samples should be collected from the $14^{th}$ frond (counted from the spindle leaf). The leaflets from two sides of the middle portion of the frond should be collected. The tip and bottom portion of the leaflets should be cut leaving the middle 10 cm length. The midrib should be removed. The leaf samples should be cleaned and dried in shade. The air dried samples can be packed and sent to the laboratory with proper labelling.

The soil and leaf samples should be labelled with full details like name of the farmer, sample number, depth, crop, cropping system, description of the field etc. along with the request for the fertilizer recommendation based on the soil test value for the specific crop/crops of interest.

Nutrient deficiency can be diagnosed based on visual symptoms and common deficiency symptoms in coconut are presented in Table 3. However, it is not advisalbe fertiliser application based on visual symptoms and it is often too late to correct the problem, especially with perennial crops. It is always advisable to analyse the soil and leaf once in three years and based on the results, fertilizer application should be done

**Table 3. Essential nutrients of coconut palm and deficiency symptoms**

| Nutrient | Deficiency symptoms |
|---|---|
| Potassium  | The first symptom of potassium deficiency is visible in the older functional leaves. They are characterized by yellowing of the leaflets with orange tinge, followed by necrosis. In severe cases, the necrotic spots coalesce, giving leaves a scorched appearance. In advanced stages, only a strip along the midrib remains green, widening towards the base of the leaflet. The samepattern can be observed in the entire leaf.<br>When holding such a leaf against the light, a green triangle in the leaf with its base in the lowest leaflets, narrowing towards the tip of the leaf may be observed. A gradual reduction in the number of inflorescences, nuts and copra content affect the overall copra out-turn. The growth of the palm slowsdown, the trunk narrows and the internodes become shorter. |
| Boron  | Symptoms appear on newly emerging leaves, inflorescence and nuts. Leaf symptoms appear as leaf wrinkling and manifested as sharply bent leaflet tips, failure of the leaves to split, crown choke disorder, leaves have a serrated zig zag appearance, failure of newly emerging spear leaves to open normally. In a chronic stage, multiple unopened spear leaves may be visible at the apex of the canopy. Boron deficiency also occurs in inflorescence and nuts resulting in poor nut setting, increase in button shedding and immature nut fall. The inflorescence and nuts become necrotic leading to barren nuts. |
| Nitrogen  | Nitrogen deficiency begins as a uniform light green discoloration / yellowing (uniform chlorosis) of the oldest leaves. Yellowing starts from the tip to the base of the lower leaves and will proceed upwards. As the deficiency progresses, younger leaves will also become discoloured. Older leaves appear golden yellow in colour. Growth virtually stops when N deficiency is severe and shedding of leaves occur. |
| Magnesium  | Magnesium deficiency appears on the oldest leaves of palms as broad chlorotic (yellow) bands along the margins with the central portion of the leaves remaining distinctly green. In severe cases, leaflet tips may become necrotic. Older leaves become bronzed and give a dry appearance. Leaflets show necrosis and turn to reddish brown with translucent spots, yellowing starts at the tip and spreads to the base. |
| Zinc | Zinc deficiency is characterized by formation of small leaves wherein the leaf size is reduced to 50%. Leaflets become chlorotic, narrow and reduced in length. In acute deficiency, flowering is delayed. Zinc deficiency will also lead to button shedding. Its occurs mostly in saline soils. |
| Copper | Deficiency leads to coppery bluish leaf. Rolling of terminal leaves due to lossof turgor. Leaves appear to be bleached grey. Fail to produce flowers. |

**Application of chemical fertilizers**

Ensure manuring should be undertaken under optimum soil moisture conditions. Under rain fed conditions were unimodal rainfall distribution pattern is observed application of chemical fertilizer should be undertaken twice in a year, whereas 3-4 times application of chemical fertilizer is preferred under bimodal rainfall distribution. The first application of chemical fertilizer should be done three months after planting and the quantity of fertilizer to be applied is approximately one tenth of the recommended 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. 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 rock phosphate (in acidic soil) or 2 kg super phosphate (in other soils) and 2 kg of muriate of potash (MOP). It can be also applied through 700 g Di ammonium phosphate (DAP), 815 g of Urea and 2 kg of MOP. However it is always advisable, based on soil test value the chemical fertilizer should be applied. Fertilizers may be applied in two split doses for the rainfed palms. After the receipt of summer showers, when the soil pH is acidic 1 kg of dolomite or agricultural lime should be applied within the radius of 1.8 m and forked in. Agricultural lime is a soil amendment used to conditioning the soil by raising the pH level. It is made from crushed limestone that contains natural nutrients to promote healthy plant growth. When lime is added it dissolves and releases a base that countracts or neutralizes the soil acidity. After an interval of 15-30 days one-third of the recommended dose of fertilizers may be spread around the palms and forked in.

The second dose of chemical fertilizer along with recommended dose of organic manures should be applied towards the fag end of monsoon season (September).

In case of irrigated condition nutrients may be applied in 4 equal splits through soil application. If fertigation is adopted Chemical fertilizers should be applied at monthly interval. The water soluble fertilizer Urea and MOP applied through fertigation. Fertigation should be started from September to April at monthly interval. Since phosphorus is highly immobile in the soil and water soluble phosphorus immediately fixed in the acidic pH that necessitates the source of phosphorus for acid soil is rock phosphate (acid soluble phosphatic fertilizer). When the soil ph is between 7 and more the source of P should be met from water solublephosphatic fertilizer viz. single super phosphate, Di ammonium phosphate, triple super phoste etc.m, . Phosphatic fertilizer shall be applied through soil application. When the soil available phosphorus reaches more than 20 PPM, phosphorus application can be skipped. This necessitates the importance of

soil testing. Accumulation of higher level of phosphorus would leads to reduce the uptake of zinc. Neutral to higher pH the source of phosphorus should be water soluble fertilizers namely, single super phosphate, Di-ammonium phosphate etc. these water soluble fertilizers should be applied through soil application based on soil testing.

**Table 4. General fertilizer recommendation for coconut (g/palm)**

| Age of coconut palm | Feb-Mar | | | September- October | | |
|---|---|---|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ | N | $P_2O_5$ | $K_2O$ |
| First year | Planting in Feb-Mar | | | 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 |

**Application of soil amendments**

In soils with acidic nature, in addition to the recommended level of fertilizers, 1 kg of dolomite or 1 kg of lime may be applied per palm per year. Dolomite/ lime may be broadcasted and incorporated in the basin one month prior to the application of chemical fertilizer. For coconut palms showing yellowing of leaves due to magnesium deficiency, 0.5 kg of magnesium sulphate can be applied in the basin along with other fertilizers during September-October. Deficiency of the micronutrients, especially boron, is also observed in coconut palms in certain localities. About 100 g of borax is to be applied at quarterly intervals till the symptom disappears.

**Organic manuring**

Organic manuring is most important part in coconut nutrition. The source of organic manure could be green manure, green leaf manure, animal manures, concentrate and compost. Green manuring involves cultivation of leguminous plants 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 stage of legumes. Growing of leguminous green manure crops in the basin of adult coconut plantations and incorporation of biomass generated resulted in substituting nitrogen fertilizer for coconut up to 30 per cent. Besides incorporation of green manures improve soil physical, chemical, biological properties. It reduces the weed growth and runoff. Suitable leguminous species for green manuring in the coconut garden based on different are *Pueraria phaseoloides, Mimosa invisa, Calopogonium mucunoides,* cowpea (*Vigna unguiculata*), sunhemp (*Crotolaria juncea*), horse gram (*Macrotyloma uniflorum),* daincha (*Sesbania aculata*) and *Sesbania spinosa etc* (Fig. 5). They contribute about 15-25 kg of biomass and 100-200 g of nitrogen in coconut basins during a growth period of 60-120 days in monsoon season. Pelleting of inoculated seeds with neutral or inert materials enhances nodulation by introduced *Rhizobia* in acidic soils.


Fig. 5. Green manuring crops.

Once its attaining 50 per cent flowering stage the crop may be incorporated in the basin and over that recommended chemical fertilizer could be applied. Perennial green manure crop glyricidia could be planted along with the border of the coconut gardens and it can be pruned at the interval of once in three months. Similarly animal manures namely farm yard manure, poultry manure, goat manures could be used for organic nutrition in coconut. The animal based manures should be decomposed properly and the C: N ratio should be less than 12:1. The normal composting period may be ranged from 3-5 months. Compost, vermicompost and coir pith compost are the excellent source of organic nutrition for the coconut. Among these vermicompost produced from coconut leaves is the ideal one. Since coconut produce 4-6 tones of dried coconut leaves and this could be effectively converted into vermincompost by utilizing earth worms. Concentrated organic manures namely, oil cakes (Ground nut, gingelly, coconut, pongamia, neem), fish manure could be used as organic manure. However quality of the organic manure should be ensured. In order to reap the full benefits of organic manures care should be taken for the application of organic manures. The time of organic manure application should be towards the end of monsoon season that ensure optimum moisture for effective composting and nutrients availability to the coconut palms. For this circular basin of 1.8 m radius and 20 cm depth may be dug during August-September and green leaf or compost or farm yard manure or Bio gas slurry or coir pith compost or vermicompost or goat manure or poultry manure may be applied in the basin at the rate of 50 kg per palm. Green leaf manures, compost and vermicompost can be applied as fresh manure. Since manure pit is the breeding site for the rhinoceros beetle care should be taken to prevent the entry of rhinoceros beetle in to the manure pits. The manure pit should be properly covered with nylon mesh. Undecomposed farm yard manure should not be put as heap in the garden. The remaining two-third of the recommended dose of fertilizers may be spread over the green leaf or compost and covered. Wherever irrigation facilities are available, it is advisable to go for more number of split doses, preferably four split doses (March, June, September and December). The manuring should be avoided during rainy days and when there is lack of moisture in the soil.

Preferably organic manures should be prepared in the garden itself as in-situ. It should be avoided procurement of spurious organic manures at exorbitant price and applied in the coconut palms. Burning of organic materials should be avoided.

**Application of Bio-inoculants**

In the rainfed condition after opening the basin application of dolomite followed and covered with green leaf manures which is mixed with 5 kg of neem cake and fortified with 100 g of trichoderma. After that remaining dose of chemical fertilizers applied and left for 10 days, after 10 days applied Biofertilizer formulations of nitrogen fixing bacteria, Azospirillum brasilense and phosphate solubilising bacteria, *Bacillus subtilis* are used as inputs in organic coconut cultivation as soil application @ 100 g per palm per year along with organic amendments. ‘Kera Probio’, a talc formulation of *Bacillus megaterium*, effective for raising robust coconut seedlings has been developed at ICAR-CPCRI. Similarly an *Arbuscular*

*Mycorrhizal* Fungal (AMF) bioinoculant, 'KerAM', has been developed which is a soil based AMF bioinoculant for coconut seedlings (Fig. 6). It always advisable to use location specific consortia. Care should be taken to use only biofertilizer containing adequate number of living micro organism and before the expiry period mentioned in the packet. It has been observed that in many instances desired results are not obtained due to the use of preparation not containing the required number of metabolically active micro organism.


Fig. 6. *Arbuscular Mycorrhizal* Fungal (AMF) bioinoculant, 'KerAM', 'Kera Probio', a talc formulation of *Bacillus megaterium*,

**Vermicomposting using coconut leaves**

Fallen coconut leaves in the coconut garden can be effectively converted into rich verimcompost using the earthworm *Eudrilus* sp. Vermicompost preparation can be done in cement tanks or in trenches made in the coconut garden or in the coconut basin itself. The weathered coconut leaves collected from the garden should be kept for two weeks after sprinkling with cowdung slurry. Cowdung should be used at the rate of one tenth of the weight of the leaves. Afterwards earthworms (*Eudrilus* sp.) are to be introduced at the rate of one kg for one tonne of the material. Care should be taken to provide sufficient moisture for the decomposing material by frequent sprinkling of water. Adequate shade also should be provided to avoid direct sunlight. Vermicompost will be ready in about 2½ - 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* sp. capable of composting coconut plantation wastes are being supplied from ICAR-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. Vermicompost is a finely divided peat-like organic material with excellent structure, porosity, aeration, drainage and water holding capacity. It has appearance and many characteristics of peat. It can influence a number of soil physical, biological and chemical processes which have their bearing on plant growth, development

and yield and is a better source of organic matter than other composts. Application of vermicompost improves the soil aggregation, aeration, and water holding capacity; root growth, microbial activity and the overall crop production capacity of the soil. The vermicompost produced from coconut leaves using the technology developed at ICAR-CPCRI is now available by the trade name 'Kalpa Organic gold' (Fig. 7)


Fig. 7. Vermicomposting by using coconut leaves.

**Water management and irrigation**

Water resources are dwindling day by day and become scarce in agriculture usage. Further the impact was aggravated with climate change. Hence it is imperative to utilize the water resources judiciously and effectively. Drip irrigation is the more effective good agriculture practices for water management of coconut. Drip irrigation saves water, energy and labour and the WUE is high. Drip irrigation is a micro irrigation system in which the water is applied to the root zone at the rate at which the palm can take up. Four pits with a size of 30 x 30 x 30 cm have to be dug one meter away from the bole of the palm at equidistance and the pits filled with raw coir pith (Fig. 8). The water has to be delivered to the pit through conduit tube placed in slanting

position. Based on a study conducted at ICAR- CPCRI, it was concluded that yield of coconut with drip irrigation daily @ 66% of the evoporation was adequate. Thus, there is 34 per cent saving of water in drip irrigation. This is applicable to varieties and hybrids and also in different soil types. The number of dripping points should be six for sandy soils and four for other soil types. The rate of water application should be 2-4 litres per hour per emitter. The timing of drip irrigation from September to May. After the end of the post monsoon season when the available soil moisture is reached more than 50%, drip irrigation should be commenced. Because of operation reasons if the drip irrigation is delayed then the based should be flooded there after drip irrigation should be started. Mulching should be invariably practiced to extract the full benefits of drip irrigation. Wherever coconut based cropping system is practiced sprinkler of perfo irrigation shall be preferred.

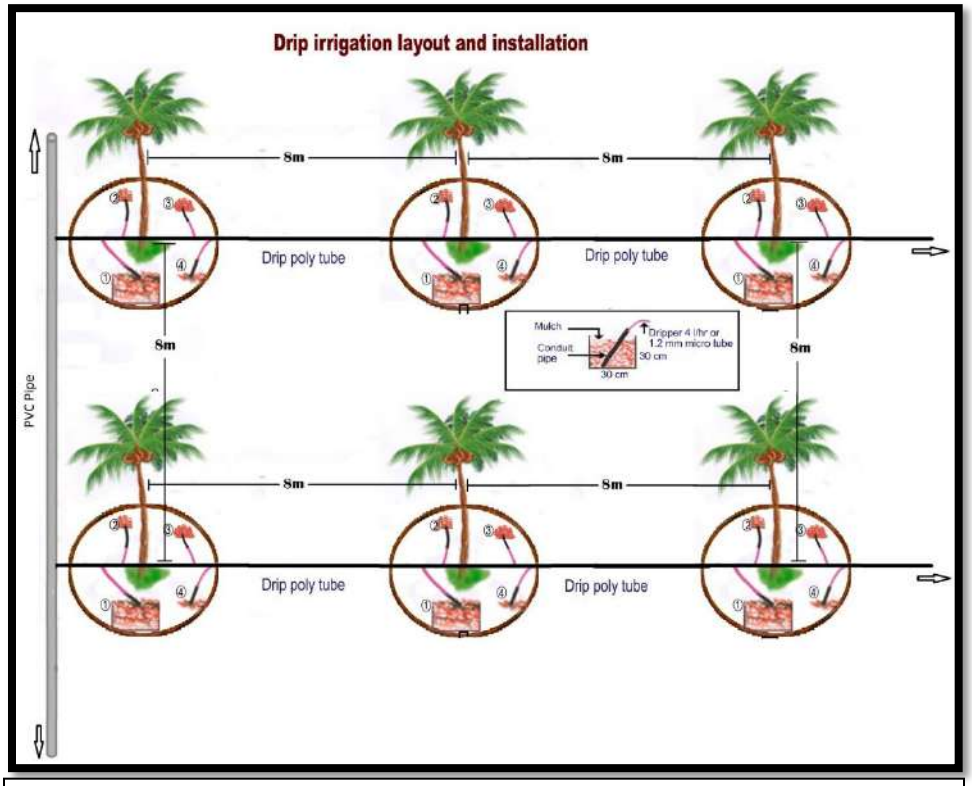



Fig. 8. Drip irrigation layout in the coconut basin.

**Soil and moisture conservation measures**

It is advisable to use *insitu* moisture conservation measures by collection, conservation and judicious utilization of water resources. This will help to reduce soil erosion, and improve the nutrient availability. In order to conserve soil moisture in the coconut plantation, mulching with various types of organic materials *viz.*, Coconut leaves (in two to three layers), husk (in two to three layers- 250 to 300 husks/basin) and coir pith (10 cm thickness -approx. 50 kg/palm) can be practiced which helps to reduce soil temperature and evaporation from soil surface and create

conditions for proper root growth and proliferation of soil flora and fauna (Fig. 9). The best time for mulching is before the end of the monsoon and before the top soil dries up. In order to conserve soil moisture in the coconut plantations, mulching with various types of organic materials can be practiced. The best time for mulching is before the end of the monsoon and before the top soil dries up. For mulching, cut coconut leaves into two or three pieces. To cover 1.8 m radius of coconut basin, 10 to 15 fallen coconut leaves are required and can be spread in two to three layers.

Fig. 9. Mulching of coconut basin by using palm leaves, coirpith and husk.

Coconut husks are also used as surface mulch around the base of the palm. It can hold moisture to the tune 3 to 5 times of its weight. Approximately 250 to 300 husks will be required for mulching one coconut basin. Mulching is usually done up to a radius of 2 m leaving approximately 30 cm near the palm. Two layers of husk may be buried in the coconut basin with the concave side facing upwards. These layers facilitate absorption of moisture. Above this, another layer of coconut husk is placed with the convex side facing upwards to arrest evaporation. Effect of this mulch lasts for about 5-7 years.

Coconut husk burial in layers with the bottom layers facing up and top layer facing down, in the trenches (50 cm width x 50 cm depth and convenient length) dug out in the interspace of coconut will also helps in soil moisture conservation. Half-moon bund (Fig 10) around coconut

basin reinforced with two rows of pineapple- this measure can also be taken up where ever there is mild slope (15-20%) of land. Here the bund prevents runoff and water gets collected within the basin and percolates down. Pineapple would help to protect the bund and stabilize the same in addition to giving fruit yield. If the land is highly sloped then trenches of 50 cm width x 50 cm depth and convenient length would be made in between two rows of coconut palms and filled with coconut husk and bunds should be stabilized with crops like pine apple (Fig 11). One can go for catch pits also. Though there is no standard dimension for catch pits, we may go for catch pits of 1.5 m length x 0.5 m width x 0.5 m depth with a bund at the downstream. This pit also may or may not be filled with coconut husk.

Fig. 10. Half moon bund with pineapple border

Fig. 11. Contour trench filled with coconut husk

Fig. 12. Husk Burrial

In the leveled coconut gardens trenches can be opened in the interspace with the dimension of 1 x 0.6 with convenient length (Fig 12). The excavated top soil can be put into the basin of the coconut palms. The trenches should be filled with husk/coconut leaves which helps in improving the water infiltration and water holding capacity and proper aeration. Growing crops like *Calopogonium, Pueraria*, cowpea etc., in coconut gardens with mild to steep slopes not only acts as green manure crops, but also helps as cover crops to protect the soil from beating effect of rain especially during high intensity of rainfall, thus, enabling in rainwater to percolate down. This also helps in preventing the soil as well as nutrient loss.

**Cropping/farming systems**

Coconut based cropping systems by raising compatible subsidiary crops and/ or integrating with livestock enables to increase the productivity and net returns from unit area of coconut plantations. Farm resources like land, labour, sunlight, water and nutrients can be effectively utilized in such a system and higher productivity could be achieved as a result of synergistic interaction among the crop and crop-livestock components. Crop diversity involving a number of annual, biennial or perennial crops as inter/mixed crops in perennial stands of coconut also promote the productivity and sustainability of the system (Fig. 13).

Coconut as a monocrop does not fully utilize the basic resources such as soil and sunlight available in the garden. The growth habit and planting methods of coconut make it highly suitable for intercropping in the interspaces of the coconut garden. Coconut palm like all monocots has a typical adventitious root system. Under favourable conditions, as many as 4000 to 7000 roots are found in the middle-aged palms. About 74 per cent of the roots produced by a palm under good management do not go beyond 2 m lateral distance and 82 per cent of the roots were confined to the 31 to 120 cm depth of soil. Thus, in a coconut garden the active root zone of coconut is confined to 25 per cent of the available land area and the remaining area could be profitably exploited for raising subsidiary crops. The orientation of leaves in the coconut crown helps penetration of sunlight into the soil and provides opportunities for exploitation of land and solar energy for inter/mixed cropping. Inter/ mixed crops are to be selected based on the age of the palms, size of the crown, availability of sunlight in the garden and agro climatic condition of the growing region.

Fig. 13. Coconut based cropping systems.

Coconut offers scope for intercropping in the initial stage of the growth of palms and mixed cropping in the later part of life of palms. A variety of intercrops like tubers and rhizomatous spices (tapioca, elephant foot yam, sweet potato, greater yam, lesser yam, chinese potato, colocasia, Ginger (Var. Nadia) and turmeric), pulses and oilseeds (cowpea, green gram, black gram, ground nut), vegetable crops (pumpkin, ash gourd, chillies, potato, french bean, snake gourd, amaranthus, brinjal, bottle gourd, ridge gourd, *Coccinia* sp., *Dolichos* bean, Cauliflower, curry leaf and tomato), fruit crops (Banana (Var. Chenichampa, Robusta, grand nine) pineapple, assam lemon and papaya), flowering crops (*Heliconia* sp., *Anthurium* sp., *Jasminum* sp., gerbera, tuberose, gladiolus and marigold) and fodder grass and legumes can be raised in coconut gardens up to 5 to 7 years.

During the second growth phase of palms, *i.e.*, 5-20 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 Robusta, Grand Naine etc., fodder grass, shade loving medicinal plants

*etc*. which can tolerate shade can be cultivated in this phase.

After the palms attain a height of 5 to 6 m (above 20 years) *i.e.*, in older plantations, the crops mentioned in the initial stage and perennials like cocoa, vanilla, black pepper, cinnamon, clove and nutmeg, sapota and medicinal and aromatic crops Patchouli, Indian long pepper (*Piper longum*) can be grown as mixed crops along with the intercrops. Perennials are recommended as intercrops in the third stage only when the spacing adopted for coconut is 7.5 to 8.0 m. However, perennials can be grown as intercrops from the initial stage onwards by planting coconut at a wider spacing of 10 m and above. 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. Package of practices of intercrops should be followed as per the recommendation by Agricultural Universities of the region.

**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 (Fig. 14). The biomass other than the economic part is recycled within the system. From the experimental plot on HDMSCS maintained at HRS Kahikuchi, which involves coconut and other crops like black pepper, ginger, assam lemon, banana and pineapple, it is observed that an average annual net income of 3 to 4.5 lakh rupees 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.

Fig. 14. Coconut based HDMSCS

## INTEGRATED PEST MANAGEMENT IN COCONUT

The key pests on coconut in the north-east region are coconut rhinoceros beetle (*Oryctes rhinoceros* Linn), red palm weevil (*Rhynchophorus ferrugineus* Oliv.), white grubs (*Leucopholis coneophora* Burm.), coconut eriophyid mite (*Aceria guerreronis* Keif.), rugose spiralling whitefly (*Aleurodicus rugioperculatus* Martin) and the rodents. In the nursery, rugose spiralling whitefly and termites are found as dominant. In the changing weather conditions, correct identification of the pest damage and area-wide implementation of pest management solutions in a farmer-participatory manner through community approach would reduce the damage potential considerably.

### 1. Coconut rhinoceros beetle (*Oryctes rhinoceros* Linn)

It is a cosmopolitan ubiquitous pest reported from all coconut growing regions in the country including north-east. Adult beetles bore into the spear leaf which results in V-shaped (diamond-shaped) cuts upon unfurling of leaflets. Other life stages including eggs, grubs and pupae are found in the manure pits, wooden logs *etc.* Breaking and hanging down of spear leaf and presence of chewed up fibres from the feeding point are other characteristic damage symptoms. Beetles also enter into the collar region of juvenile palms causing dead-heart (drying of spear leaf) symptoms. When the new leaf emerges, it becomes twisted with-elephant-tusk like symptoms and perverted leaflets. Beetles also feed on the unopened inflorescence leading to their necrosis and drying (Fig. 1).

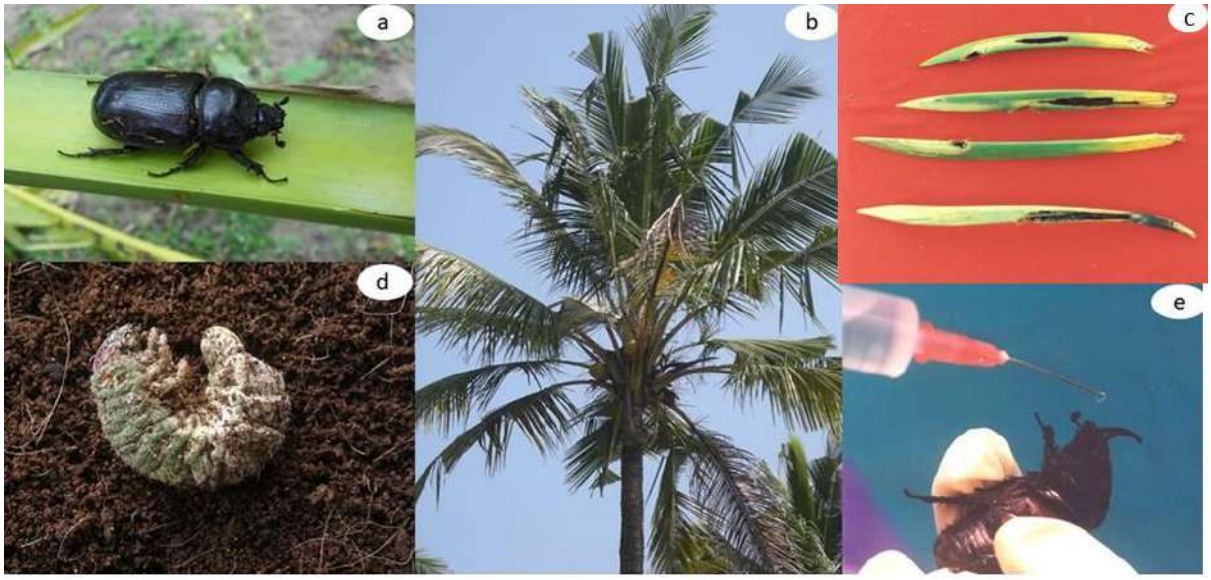



**Fig. 1 Coconut rhinoceros beetle**
a) Adult beetle b) 'V' shaped cut on coconut fronds c) spathe damage d) grub infected with *Metarhizium* e) *per os* inoculation of adult beetle with *Or*NV

### Management

- Regularly monitor and identify any damage on the spear leaf of the juvenile palm or at the collar region of seedlings.

- Hook out the beetle, if any chewed up fibres are noticed from the leaf axils.
- Tying fish nets along the spear leaf to entangle the alighting beetles
- In juvenile palms, place naphthalene balls (4 g / axil) and fill with sand or place chlorantraniliprole (0. 4% GR) or fipronil (0.3% GR) [3 g in perforated sachet/ axil] on top most 3-4 leaf axils.
- In adult palms, fill the top most 3-4 leaf axils with 250g neem cake/ maroti (*Hydnocarpus wightianus*) cake / pongamia cake mixed with equal volume of sand during May-June and December-January
- Incorporate *Clerodendruminfortunatum*, a weed, into the manure pits to induce larval-pupal abnormalities in feeding grubs.
- Apply entomopathogenic green muscardine fungus (*Metarhizium majus*) into the breeding pits (manure pits, wooden logs *etc*) @ 5 x $10^{11}$spores / $m^3$
- Release 10-12 virosed (*Oryctes rhinoceros* nudivirus) beetles for auto-transmission of nudivirus.
- Crop diversity induced by intercropping and ecological engineering principles would disorient pests and provide continuous income and employment as well.

**2. Red palm weevil (*Rhynchophorus ferrugineus* Oliv.)**

It is the hidden enemy and the most destructive pest on coconut and other palms including date palm and arecanut. All life stages of the pest are confined within the palm. Choking of spear leaf and improper emergence and wilting are observed often on the infested palms. Yellowing of middle whorls at the site of attack is quite prominent due to improper nutrient absorption. Presence of feeding bore holes on fronds, trunk and exudation of brown viscous fluid are other diagnostic symptoms. Gnawing sound by the feeding apodous grubs could be heard by placing our ear on the trunk. At the advanced stage of infestation, the crown gets toppled and the palm dies (Fig. 2).


**Fig. 2 Red palm weevil**

a) Adult beetle b) grubs inside damaged trunk c,d) damage symptoms e) capsule formulation of EPN

**Management**

- Periodic monitoring and regular crown cleaning are very crucial.
- Destroy crown toppled palms in a garden to avoid lateral spread of the pest.
- Avoid causing any physical injury to palms and cut the petioles at least 1 m away from the trunk.
- Prophylactic application of entomopathogenic nematode (*Steinernema* sp.) cadavers as capsules on the leaf axils
- Spot application of 0.02% imidacloprid 17.8 SL @1 ml per litre of water through the bore holes.
- Follow all regular management practices against coconut rhinoceros beetle

**3. White grubs (*Leucopholis coneophora* Burm.)**

This subterranean pest especially the grubs feed on the roots of coconut and cause yellowing of leaves, premature nut fall, delayed flowering, retardation of growth and reduction in yield. Since grubs are hidden in soil, symptom diagnosis is very crucial in the identification of pest damage. Grubs initially feed on organic materials, roots of grasses and intercrops before feeding on the palm roots. Adults emerge from the soil during the month of May-June. The pest is very severe in certain sandy belts of the country.

**Management**

- Repeated summer ploughing to expose the immature stages for predation
- Handpicking of adult beetles during evening of two weeks after the onset of monsoon.
- Application of neem cake in the palm basin @ 5 kg /palm for regeneration of roots.
- Soil application of aqua suspension of entomopathogenic nematode, *Steinernema carpocapsae* @ 1.5 billion/ha during October-November and need based repeated application (Fig. 3)


**Fig. 3 Coconut white grub**
a) Aaults b) grubs c) Kalpa EPN (CPCRI SC 1) d) Summer ploughing

**4. Coconut eriophyid mite (*Aceria guerreronis* Keif.)**

Appearance of elongated white streaks below the perianth on young buttons is the first visible symptom of mite infestation. A yellow halo develops around the perianth, which turns into yellow triangular patch pointing towards the distal end of the button. Yellow patch turns into brown and later become necrotic along the periphery of the perianth. As the nut grows, the injuries form warts leading to longitudinal fissures on the nut surface (Fig. 4). Drying and shedding of immature nuts is reported in severely infested coconut palms.


**Fig 4 Coconut Eriophyid mite**
a) Eriophyid mite b) Different stages of attack c) Damage symptom on mature nuts d) *Hirsutella thompsonii*

**Management**

- Crown cleaning should be taken up routinely.
- Spray 2% neem oil-garlic emulsion or 0.004% azadirachitn (10,000 ppm ai) @ (4 ml/ litre) on bunches after pollination or root feeding with neem formulations containing azadirachtin (50,000 ppm ai) at 7.5 ml or azadirachtin 10,000 ppm at 10 ml with equal volume of water three times during March-April, October-November and December-January.
- Spray 20% palm oil-sulphur (0.5 %) emulsion on bunches after pollination.
- Application of talc-based preparation of *Hirsutella thompsonii* @ 20 g / litre/ palm containing 1.6 x $10^8$cfu per gram with a frequency of three sprayings per year during March-April, October-November and December-January.
- Adopt integrated nutritional management practices such as application of NPK fertilizer as per recommended levels, recycling of biomass or raising of green manure crops in coconut basins and *in situ* incorporation during flowering, timely summer irrigation and adoption of appropriate moisture conservation measures.

**5. Rugose spiralling whitefly (*Aleurodicus rugioperculatus* Martin)**

It is an exotic pest reported in the country during 2016. Presence of whitefly colonies on the lower surface of palm leaflets and appearance of black coloured sooty mould deposits on the upper surface of palm leaflets are characteristic visual symptoms of pest attack (Fig. 5). In severe cases, advancement in senescence and drying of old leaflets was observed. Leaflets, petioles and nuts were also attacked by the whitefly pest and a wide array of host plants including banana, bird of paradise, *Heliconia* sp. were also reported.


**Fig 5 Rugose spiralling whitefly (RSW)**
a) RSW infested frond b) RSW c) Neem oil spray d) RSW puparia with parasitoid exit hole (inset *Encarsia guadeloupae)* e) Sooty mould scavenger beetle feeding on sooty mould (inset *Leiochrinus nilgirianus*) f) *Apertochrysa sp.*

**Management**

**i. Main field**

- Pesticide holiday approach and complete dispensation of any insecticide spray to conserve abundant natural enemies and bio-scavenger in the system.
- Installation of yellow sticky traps on palm trunk and along field borders
- Conservation biological control for natural build-up of the aphelind parasitoid (*Encarsia guadeloupae*) and augmentative release of parasitized pupae on palm leaflets (10 cm) in to emerging zones of whitefly outbreak
- *In situ* preservation of the sooty mould scavenger beetle (*Leiochrinus nilgirianus*) for effective bio-cleansing of palm leaflets (This beetle can eat and clean the sooty mould deposits on palms)
- Encourage good palm health by soil-test based application of nutrients, organic recycling of residual biomass & irrigation.
- Water spray by jet propulsion mode to dislodge the whitefly colonies and in severe cases, neem oil (0.5%) spray on lower surface of palm leaflets
- Heterogenous landscaping with crop habitat diversification in coconut system reduces the incursion potential of exotic whiteflies.

**ii. Coconut nursery**

- ✓ Complete destruction of adult whiteflies and immature stages on coconut seedlings before it is distributed to farmers.
- ✓ Enforce strict domestic quarantine protocols and encourage movement of whitefly-free coconut seedlings and other ornamental palms
- ✓ Installation of yellow sticky trap along borders and overhead shade net in nursery to entrap the sooty mould deposit and ensure uniform growth of seedlings.
- ✓ Water spray by jet propulsion mode to dislodge whitefly colonies during the routine irrigation process.
- ✓ Timely disposal of seedlings and regular culling out of old seedlings to avoid pest incursion in nurseries

**6. Rodents (*Rattus rattus* Wroughtoni)**

The arboreal black rat is nocturnal and live mainly on the crown of the palm. They breed throughout the year with peaks during February-March and July-August. They make small holes (about 5cm diameter) near the perianth region of tender nuts and feed on the inner contents. The damaged nuts fall from the attacked bunch. Nuts of 3 to 6 month maturity are mostly preferred. Unopened spathe, female flowers and leaf stalks are also attacked.

**Management**

- Ensure correct crop geometry in coconut plantations
- Removal of dried leaves, spathes and matrix regularly from the crown exposes the nesting places of arboreal rats to predators
- In older coconut plantation, banding the coconut trunk with G.I. sheet 25 to 30 cm wide, at a height of 2 m above ground level
- Use of rodent traps like bamboo trap, wooden box trap, PVC tube trap etc for effective trapping and killing
- Placement of 10g bromodiolone wax blocks two times at an interval of 12 days on the palm crown of one tree out of every 5 trees is recommended for effective control of black rat. If the damage is restricted to certain palms, only such palms require baiting

## INTEGRATED DISEASE MANAGEMENT IN COCONUT

Major diseases of coconut in the northeast India are stem bleeding, basal stam rot, bud rot and grey leaf spot. Proper identification of the disease and adoption of integrated disease management practices in a farmer participatory manner through community approach would reduce the crop loss considerably.

### Stem Bleeding

Causal organism:*Thielaviopsis paradoxa*


Stem bleeding

**Symptoms**

Diseased palms can be identified by the presence of longitudinalstreakswith reddish brown liquid exudation at the base of the trunk.Thesestreaks gradually formpatches. The tissues below the lesions rot. The trunk gradually tapers at the apex and crown size gets reduced leading to heavy reduction in yield.

**Management**

- Apply talc formulation of *Trichodermaharzianum*in paste form on bleeding patches followed by regular water misting in the smeared area for rejuvenating the *T. harzianum* population. Removal of diseased tissues is not needed in case of *T. harzianum*paste application
- Apply 5kg of neem cake per palm, fortified with *T. harzianum* during September – October.
- Root feeding of Hexaconazole5EC @ 2% (100 ml solution per palm) at quarterly intervals
- Smearing of fungicide: Remove disease affected tissues using a chisel and smear the chiselled portion with hexaconazole 5EC (0.2%). Coal tar should be applied after 1-2 days on the treated portion to cover the wound. Destroy the chiselled diseased tissues by burning.
- Avoid making wounds with implements during inter-cultural operations
- Avoid trash burning in coconut basins /near trunk.

### Basal Stem rot/Thanjavur wilt/*Ganoderma* wilt/Anaberoga

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

**Symptoms**

The characteristic symptom of the disease is extensive rotting and dis-colouration of roots. Crown symptoms include wilting of leaflets, yellowing followed by drying and drooping of leaves from the outer whorls of leaves. The spear leaf and surrounding two or three young leaves will remain erect and healthy. Ultimately all the leaves droop and fall off leaving the decapitated stem. Exudation of reddish-brown viscous fluid from the basal portions of the trunk of the affected palm is a characteristic symptom.In advanced stages, basal portion of the stem decays completely. There will be heavy button shedding. The affected palms produce barren nuts. Fruiting bodies of *Ganoderma*spp.appear at the base of the trunk in some palms just above the soil level

prior to wilting or after the death of the palm. The time taken from the initial appearance of bleeding patches in the stem to the death of the palms is from 6 to 54 months, the average being 24 months.

Drying and drooping of leaves

Bleeding patches on base of trunk

Basidiocarp of pathogen

**Management**

The disease can be effectively managed by following an integrated approach with cultural, chemical and biological methods.

- Remove and destroy dead/disease advanced palms to reduce the spread of pathogen,
- Isolate diseased palms from healthy palms by digging isolation trenches of 1 m deep and 30 cm wide,

- Avoid flood irrigation or ploughing in infected gardens to prevent spread of the inoculum,

- Application of 50 kg of farmyard manure per palm per year.
- Soil application of *T. harzianum* enriched neem cake @ 5 kg/palm at quarterly intervals up to one year, followed by mulching and irrigation around the palm
- Intercropping with banana is desirable as its root exudates are found to inhibit the growth of pathogens.
- Root feeding with Hexaconazole5EC @ 2% (100 ml solution per palm) at quarterly intervals.
- If *Xyleborus*sp. beetleattack is found in the stem, smearing with insecticide may be done.

## Bud rot

Causal organism**:** *Phytopthora palmivora*

**Symptoms**

Withering of the spear leaf marked by a pale colour is the primary visible symptom of the disease. The affected spear leaf turns brown, hangs down and can easily be pulled out as the basal portion of the spindle is completely rotten emitting a foul smell. Subsequently younger leaves next to the spear leaf also fall away one by one leaving only outer whorl of matured leaves in the crown. Ultimately palm succumbs to the

disease.The bud rot pathogen also causes water soaked lesions on nuts and nut fall commonly called as '*Mahali*'.

Withering of spear leaf

Rotting and toppling of spindle

Death of the palm

**Management**

Bud rot disease can be effectively managed by adopting integrated management practices.

- Field sanitation :All the dead and disease advanced palms (beyond recovery) should be removed. Destroy the affected portion of the crown by burning. This will help to reduce the inoculum load in the plantation and reduce the fast spread of the disease.
- Curative treatment: Curative measures have to be adopted when the spear leaf has just started showing symptoms of withering. In the early stage of the disease, remove the spear leaf by pulling it out and cut and remove the infected tissues completely. Two or three healthy leaves adjacent to the spindle may have to be removed if necessary for easy removal of all rotten portions and thorough crown cleaning. The wound should be treated with Bordeaux paste 10% or Chlorothalonil 75WP solution (3g in 300ml of water). The treated wound should be covered with polythene coverto prevent entry of rain water.Proper aeration should be ensured and this protective covering should be retained till normal shoot emerges.The diseased tissues should be burnt after their removal.

- Prophylactic treatment: It is important to give prophylactic treatment to all palms in disease endemic areas before the onset of monsoon by spraying 1% Bordeaux mixture.

  or

  Placement of 2 perforated fungicide sachets of Chlorothalonil 75WP (3 gm each) in the inner most leaf axils just before the onset of monsoon season and continue at bi-monthly intervals till the end of rainy period

- Nutrient management: The recommended fertilizer may be applied in split doses.
- Pest management: Damage by coconut rhinoceros beetle attack predisposes the palm to bud rot infection. Hence, prophylactic measures to prevent beetle infestation have to be undertaken in bud rot endemic areas.
- Cultural practices**:** Improved drainage and wider spacing will help in reducing the relative humidity and subsequent build-up of the pathogen inoculum

## 4. Grey leaf spot

Causal organism: *Pestalotiopsis palmarum*

### Symptoms

Grey leaf spot

The disease is characterized by the appearance of minute yellow spots with a grey brown margin. The spots turnoval in shape and centre of the spots becomes greyish white while the intensity of brown colour of the margin increases. Many spots coalesce to form large irregular necrotic patches. The leaves in advanced stage of infection present a blighted appearance affecting the photosynthetic efficiency of palms.

### Management

- Remove and destroy the affected older leaves
- Crown spraying with 1% Bordeaux mixture

## Harvest

Harvesting of coconuts is a skilled job and is generally performed by experienced climbers by climbing up to the top of the tree.Among the coconut climbing devices a paddle type climbing device, Chemberi Joseph model, is the widely used device. CPCRI has developed a safety attachment for this climbing device to safeguard the safety of the climber.



# POST HARVEST PROCESSING

Coconut cultivation in the north east region is mostly confined to small and marginal holdings located in a scattered manner. To realize more income and to generate employment opportunities from coconut there is potential for establishing enterprises, mostly small scale processing units, on production and marketing of value added coconut products. 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 themarket fluctuations, there is a need for value addition in coconut through product diversification and byproduct utilization.

## Production of quality copra using copra dryers

The conventional system of copra drying is by spreading the cups on any open surface forsun drying. It takes about 5-8 days for getting copra and the quality deterioration due todeposition 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 wastes can be used as fuel. Time required for drying is 34-36 hours. This dryer is useful during the monsoon season where sun drying is not possible.

### Shell fired copra dryer

Shell fired copra dryer developed by CPCRI is anatural 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 with capacity of 500 nuts per batch is also developed by CPCRI.

### Copra moisture meter

Moisture content of copra needs to be 4-6% to enhance shelf life and to get good quality coconut oil. 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% 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. Coconut of 7–8 months age in which there is no decrease in quantity of

tender nut water and the kernel is sufficiently soft is more suitable for making SBTN. The main steps involved in the making Snow Ball Tender Coconut are: removal of husk of 7–8 month maturity 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 is 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 could 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 tablespoon 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 two minutes. Transfer the slices to the sugar solution (which was 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 in the sugar solution and reuse it. The quantity of chips to be obtained is about 50 per cent of the fresh kernel weight. On an average, about 150 gram of chips can be obtained from a coconut.

**Virgin Coconut Oil**

Virgin coconut oil is the oil obtained from fresh, mature endosperm (kernel-meat) of thecoconut by mechanical or natural means, with or without use of heat, no chemical refining,bleaching or de odorizing and maintains the natural aroma and nutrients. It is called “virgin”because the oil obtained is pure, raw and pristine. Virgin coconut oil is suitable for humanconsumption in its natural form. It is the purest form of coconut oil, crystal clear, containsnatural vitamin E and with very low, free fatty acid content (0.1%). It has a fresh coconutaroma ranging from mild to intense, depending on extraction process.The different processes involved in VCO production are Hot-processing method, Natural fermentation method, Centrifugation process and extraction from dried grating (EDG) method. The choice of the technology to be adopted depends to a great extent on the scale of operation, the degree of mechanization, the amount of investment available and the market demand.The modified hot process method for producing VCO also follows the same principle, except for controlled heating to prevent the oil from turning yellow and maintain the moisture contentless than 0.2% to prolong its shelf life. Hot process comprises of two stages: extraction/preparation of coconut milk and cooking the milk to get VCO.

In fermentation method, the VCO can be produced in a home-scale operation using ordinary kitchen utensils after extracting the coconut milk. The oil produced in this method is water clear in colour. The VCO produced could turn sour if the fermentation period is prolonged and the fermentation process conditions are not controlled properly. Fermentation method comprises of two stages: extraction/preparation of coconut milk and fermentation of the milk for VCO production.

In centrifugation method, the coconut milk is subjected to mechanical phase separation process. Coconut milk and hot water is fed in a three-way centrifuge equipment where the oil separates out from the top and the water and sludge comes out through separate outlets. It produces the best quality oil with sweet coconut aroma and the oil produced in this methodis water clear in colour. Centrifuge method comprises two stages: extraction/preparation of coconut milk and centrifugation of the milk for VCO production.

**Kalparasa (coconut sap)**

Kalparasa (coconut sap) or 'neera' in Sanskrit means life essence of coconut tree. It is the phloem sap extracted from the unopened inflorescence. From the cut end of the inflorescence the sap oozes out. The trickled sap is traditionally collected in earthen pot and during the process it gets fermented. Lime coating inside the collection pots to a certain extent prevents fermentation but not fully in the traditional technique. The coco-sap chiller technology developed by ICAR-CPCRI, wherein the sap is collected under low temperature keeps the sap a fresh and unfermented without addition of any chemicals. The sap thus collected can be stored for any length of time under refrigerated condition (-1 to -3$^{o}$C). Furthermore, the sap collected in this closed container is free from contaminants like insects, ants, pollen, dust, etc. It can be directly sold as fresh juice, packaged and sold or processed into value added natural products like sugar, jaggery, honey, syrup, *etc*. without the addition of chemicals. The sale of neera as a fresh juice and its products has been demonstrated to improve the livelihood of farmers, tappers and those who are dependent on coconut sector.

**Coconut sugar and jaggery**

Coconut sap contains about 15% sugars and considerable amount of nutrients, which can easily be converted to prepare various value added products. Coconut sugar and jaggery are obtained by evaporating the water of unfermented sap at 115°C. The viscous liquid, fairly thick hot (Brix 60$^{o}$ to 70$^{o}$) is cooled to get coconut honey or syrup. Further, on heating the sap becomes more viscous and thicker in consistency, and is poured to moulds of either coconut leaf or steel to obtain jaggery. Some more heating with continuous stirring to avoid charring, changes the viscous syrup into crystal form and at this stage it is immediately cooled. While cooling, it is stirred continuously to break the lumps. The sugar thus obtained is sieved to get uniform particle size and to produce quality product. Coconut sugar is also known as coconut palm sugar, coco sugar or coco sap sugar. Unlike cane sugar which supplies only calories, coconut sugar supplies calories and nutrients. It has high mineral content as compared to brown sugar and refined cane sugar, and is a rich source of potassium, magnesium, zinc and iron. In addition to this, it contains all essential amino acids required for protein synthesis, and rich in B complex Vitamins like B1, B2, B3 and B6. When compared to brown sugar (prepared from sugarcane molasses), coconut sugar has double the amount of iron, four times the magnesium and over 10 times the amount of zinc.

A dark chocolate has been developed by using coconut sugar and cocoa cream and butter as main ingredients. A chocolate drink also has been developed with similar ingredients.

From the coconut kernel gratings after removal of coconut milk, a crispy food item, 'Kalpa Krunch' has been developed. It is a value added, healthy, ready to eat, extrudate product from coconut. It is possible to make Kalpa Krunch with different tastes and flavours.

Another product of coconut is the coconut frozen delicacy, which is a vegan ice cream. Tender coconut water, coconut milk and tender coconut pulp constitute 80% of this delicious product. It is highly nutritious and a premium product.

**Mushroom cultivation using coconut by-products**

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 1:1ratio 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 sajorcaju*are the suitable mushroom species for cultivation using coconut by products.

**For further details on coconut cultivation and for technical guidance, please write to:**

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# CHALLENGES AND PROSPECTS OF COCONUT CULTIVATION IN THE NORTH EAST INDIA

The coconut sector in the northeast region has been witnessing substantial growth over the past two decades (Table 1).During the period from 2000-2001 to 2020-2001, area under coconut in Assam, the major producer of coconut in the North East region, got reduced by 0.95% while production of coconut increased by 9.2% and productivity increased by 10.25%. In Tripura, area under coconut cultivation increased by 48.71%, production increased by 163.43% and productivity increased by 76.97%during the same period. In Nagaland the increase in area, production and productivity of coconut during the period from 2000-2001 to 2020-2001 was 18.89%, 75.10% and 47.75% respectively. However, as per the 2020-21 statistics, the above three north eastern states together contributed only 1.2% of the total area and 0.85% of the total production of coconut in the country.

Table 1. Trend in coconut cultivation in the North East India

| State/region | Area ('000 ha) | | Production (million nuts) | | Productivity (nuts/ha) | |
|---|---|---|---|---|---|---|
| | 2000-01 | 2020-01 | 2000-01 | 2020-01 | 2000-01 | 2020-01 |
| Assam | 21 | 20.8 | 136 | 148.51 | 6476 | 7140 |
| Tripura | 3.1 | 4.61 | 7 | 18.44 | 2258 | 3996 |
| Nagaland | 0.9 | 1.07 | 5.1 | 8.93 | 5667 | 8373 |
| Total | 25 | 26.48 | 148.1 | 175.88 | 5924 | 6642 |
| All India | 1823.9 | 2198.98 | 12678.4 | 20736.12 | 6951 | 9430 |

(Source: Horticulture Division, Dept. of Agriculture & Cooperation, Ministry of Agriculture & Farmers Welfare, Government of India)

**Assam:** Among theNorth Eastern states Assam has the largest area under coconut cultivation. It is cultivated in 20,800 ha with a production of 148.51 million nuts and productivity of 7,140 nuts per ha. Coconut plays an important role in the socio-cultural life of the people of Assam. It is mostly raised in small and marginal holdings as homestead crop.Though coconut is grown in most of the districts of Assam, its cultivation is mainly confined to Central and Lower Brahmaputra Valley Zone of Assam. Nagaon district has the maximum area under coconut (2,490 ha) followed by Barpeta (1,636ha) and Nalbari (1,390). Coconut is grown in most of the districts of Assam covering the Upper (Charaideo, Dhemaji, Dibrugarh, Golaghat, Jorhat, Lakhimpur, Majuli, Sivasagar and Tinsukia), Central (DimaHasao, Hojai, East KarbiAnglong, West KarbiAnglong, Morigaon and Nagaon), Lower (Baksa, Barpeta, Bongaigaon, Chirang, Dhubri, Goalpara, Nalbari, Kamrup (M), Kamrup (R), Kokrajhar and South Salmara-Mankachar), Hills and Barak Valley (Cachar, Hailakandi and Karimganj) and North Assam (Biswanath, Darrang, Sonitpur and Udalguri). The agro-ecological situation of these districtsis congenial for coconut cultivation. Coconut can perform well under the soil types such asred sandy loam, alluvial red loam and laterite soils andsub-tropical weather condition receiving an annual rainfall of 1,840 mm to 3,200 mm prevailing in these areas. The low

productivity of coconut in Assam, which is less than the national average, is mainly attributed to the lack of adoption of scientific cultivation practices including improved varieties, multiple cropping and integrated farming systems, integrated nutrient management and integrated pest and disease management. If nurtured properly, coconut can be a good source of income for the farmers, even in the small holdings under homestead system.

**Tripura:**Tripura ranks second among theNorth Eastern statesafter Assam in the area under cultivation of coconut. Coconut is cultivated in 4,610 ha with a production of 18.44 million nuts and productivity of 3,996 nuts per ha.The agro-ecological situation prevailing in Gomati, West Tripura and South Tripura districts is congenial for coconut cultivation. Coconut can perform well under the soil types such asreddish yellow brown sandy soils, red loam and sandy loam soils, older alluvial soils andsub-tropical weather condition receiving an annual rainfall of 1,979.6 to2,745.9 mm prevailing in these areas. The land utilization pattern in the state indicate the huge potential for area expansion of plantation crops including coconut. In Tripura, coconut is cultivated in small and marginal holdings without much care and hence the productivity realized is very low. If farmers are empowered to take up scientific crop management practices coconut productivity in the state can be enhanced substantially.

**Nagaland:** In Nagaland,coconut is cultivated in a small extent only. It is cultivated in 1,070 ha with a production of 8.93 million nuts and productivity of 8,373 nuts per ha.The soil is acidic, very rich in organic carbon but poor in available phosphate and potash content. $P^H$ of soil ranges from 4.8 to 6.8. Dimapur, Peren, Wokha, and Chumoukedimaare the districts in Nagaland having good potential for coconut cultivation.

**Arunachal Pradesh**: Out of the 26 districts in Arunachal Pradesh, eight districts have coconut cultivation in a very limited scale; total area under coconut being 220 ha. Highest production of coconut is in Changlang district (45.53 million nuts) and highest area under coconut cultivation is in Namsai district (96 ha).

**Manipur :**Potential area for coconut cultivation in Manipur includes Pherzawl, Jiribam and Tamenglong districts.

**Meghalaya:** Meghalaya is known for the highest amount of rainfall it receives. Theannual average rainfall received is 11,000 mm, highest in the world.The potential areas for coconut cultivation in Meghalaya include West Garo Hills, East Garo Hills, South Garo Hills, South- West Garo Hills, North Garo Hills and Ri-Bhoi districts.

**Mizoram**: The potential area for coconut cultivation in Mizoram includesMamit, Kolasiband Lawgtlai districts.

**Challenges and prospects of coconut cultivation in the North Eastern Region**

Major challenges and prospects of coconut cultivation in the North Eastern states are briefly discussed below.

**Quality planting material**

Though North Eastern states have great potential for expanding area under coconut cultivation, lack of quality planting material is a major constraint for implementing appropriate interventions on area expansion of coocnut. Besides, cutting and removal of unproductive senile palms and replanting also requires seedlings of improved varieties. Public sector agencies including the State Agriculture/Horticulture Departments, ICAR institutions, SAUs, CDB etc do not have the necessary infrastructure facilities for producing sufficient quantity of coconut seedlings of improved varieties to meet the demand for seedlings. Nurseries in the private sector often do not follow scientific nursery management practices and supply inferior quality seedlings. Farmers who produce coconut seedlings also do not possess adequate knowledge about mother palm selection, seednut collection and nursery management practices. The nurseries and farms under various public sector agencies need to take up interventions for raising mother palm orchards of improved coconut varieties to produce more number of quality coconut seedlings. Similarly, efforts are required to identify ideal mother palms of coconut in farmers' gardens and utilize them for seedling production. Decentralized community coconut nurseries can also be promoted with active involvement of Farmer Producer Organizations (FPOs) to enhance the availability of coconut seedlings.

**Adoption of scientific cultivation practices**

Low productivity of coconut in the existing coconut gardens in theNorth Eastern states can be mainly attributed to the low level of adoption of recommended cultivation practices. Non-adoption or low level of adoption of improved varieties, technologies for irrigation and soil and water conservation, integrated nutrient management, integrated pest and disease management etc results in low productivity of coconut. Appropriate interventions are to be formulated and implemented to empower the farmers of the region for the better integration of available technologies for the management of their coconut gardens to realise higher productivity and income.

**Fragmented holdings**

Coconut cultivation in the North Eastern states is mostly confined to fragmented small and marginal holdings. These holdings suffer due to the resource limitations, both bio-physical as well as socio-economic resources.Hence, individual farmers are unable to adopt latest technologies for enhancing productivity and income from their coconut holdings. Group approaches are to be facilitated among the small and marginal coconut growers to overcome the resource limitations in the fragmented holdings and to better utilize technologies to achieve higher productivity and income. Three–tier FPO set up consisting of Coconut Producer Societies (CPSs), Coconut Producer Federations (CPFs) and Coconut Producer Companies (CPCs) is being facilitated in coconut sector by the Coconut Development board (CDB). These are formed with the

main objective of socio-economic development of farmers through productivity improvement, cost reduction, efficient aggregation, processing for value addition, better by-product utilization and efficient marketing of the produce. So far 29 CPSs have been registered in Assam under the CDB. These FPOs are to be empowered to take up group initiatives to strengthen the coconut sector. There is a need to facilitate formation of more number of FPOs in coconut sector by development and extension agencies in other north eastern states also.

**Extension support for scientific coconut cultivation**

Low level of awareness and knowledge of farmers is one of the reasons for the low level of adoptionof recommended scientific practices of coconut cultivation resulting in poor productivity of coconut in the region.Participatory extension interventions ensuring the active involvement of farmers by the concerned agencies including Coconut Development Board and State Agriculture/Horticulture Departments for the capacity development of farmers to enhance their knowledge about scientific coconut cultivation thus assume much significance. Since coconut is not a major crop in the region, only few schemes are implemented by the State Agriculture/Horticulture Departments to provide extension support and to provide incentives to coconut growers and other stakeholders. Considering the vast scope for expanding area under coconut in the region and the fact that there are many farmers already taken up coconut farming providing extension support to the growers is highly relevant to motivate the farming community.

**Promoting coconut based cropping/farming systems**

In the north eastern states, coconut is mostly cultivated as a monocrop in the small and marginal holdings. Compared to coconut monocropping, adoption of multiple cropping and integrated farming system in coconut gardens fetches higher income and employment opportunities. Different models ofcoconut based cropping/farming systems suitable for the north east region have been developed by CPCRI and SAUs. However, adoption of such cropping/farming systems is very low due to various reasons. Hence, farmers are to be made aware about the advantages of adopting coconut based cropping/farming systemsand suitable interventions to promote the same are to be implemented.

**Community action for integrated pest and disease management**

Coconut growers of the region face difficulties due to the crop loss caused by incidence of pests like rhinoceros beetle, red palm weevil, eriophyid miteand white fly, disease like stem bleeding etc. Though technologies for the integrated management of these pests and diseases are made available, their field level adoption is very low. Community approaches on a contiguous area basis is to be encouraged among the coconut growers to effectively adopt IPM/IDM practices to avoid crop loss.

**Removal of senile and unproductive coconut palms and replanting**

Large number of coconut palms in the existing coconut gardens are old, senile and with very low productivity which adversely affect coconut production in the region. Hence, it is suggested to remove such old and senile palms and replant with quality seedlings of improved varieties suitable for the region to enhance coconut productivity.

**Promoting value addition**

Value addition through product diversification is a viable strategy suggested to enhance income from coconut farming. Large number of value added products can be produced and marketed using coconut kernel, tender coconut, coconut water, shell, leaves and timber. However, due to various factors the level of value addition in coconut is abysmally low in the north eastern states. Hence, appropriate interventions are to be formulated and implemented to promote coconut based enterprises on production and marketing of value added coconut products. FPOs in coconut sector can also be encouraged to take up such enterprises.

Improvement in the general infrastructure for the development of farm sector and specific interventions in coconut sector as discussed above surely will usher in a bright future for coconut in the North East India.