Training Manual
on
Package of Practices for Major Horticultural Crops

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Tribal Sub Plan

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1. Coconut

Coconut (*Cocos nucifera*) is a commercial crop in India. Kerala, Tamil Nadu, Andhra Pradesh and Karnataka are major coconut producing states in India. Kerala accounts for 54.7% of the total area and 42.3% of the production, followed by Tamil Nadu and Karnataka.

Climate and Soil

Coconut can be successfully cultivated up to 600m above mean sea-level, though it is cultivated even above 900m. Well-distributed rainfall of 800–2,500mm/year is ideal. In regions, where prolonged dry spell occurs, irrigation is essential. Coconut can also withstand water logging during the rainy season. To get highest yield mean annual temperature of 27°C with a diurnal variation of 5°–7°C is optimum. Low temperature particularly below 15°C results in cold injuries to the palms, resulting in abnormal fruit development. Warm and humid conditions are desirable for its cultivation in coastal region of south India. The humidity should be 80–90%. The relative humidity below 50% affects opening of the stomata. Since coconut palms love sunlight, its growth is affected in overcrowded plantations and mixed cropping systems. Sunshine of 2,000hr/year or more is suitable for profuse growth and productivity.

Laterite, lateritic red, sandy, alluvial sandy, alluvial coastal, and black soils are good for coconut cultivation. Laterite and lateritic soils in humid tropical zones in the western and eastern belts of India are the predominant soils wherein coconut is extensively cultivated. These are highly weathered, moderately deep to deep loamy to clayey, well-drained and predominantly acidic with a pH of 4.5–6.8.

Varieties

There are 2 types of varieties of coconuts, e.g. tall and dwarf. The tall palms are most commonly cultivated. They grow to a height of 25–30m, the pre-bearing age being 6–10 years. Tall palms are normally cross-pollinated as there is no overlapping of male and female phases. Medium-to-large sized nuts in tall palms mature in 12 months. Andaman Giant Tall, Katchal Tall, Nicobar Tall and Andaman Ordinary Tall are the tall types cultivated in A&N Islands.

Dwarf palms are short-statured, their pre-bearing age is 3–4 years. Dwarf palms yield heavily though they have an irregular bearing habit. They are identified by colour of fruits—orange, yellow, and green.

Selection of mother palms

Select mother palms having the following characters:

1. Regular bearing habit and yielding not less than 80 nuts / annum.
2. Age 20 years or more (5 years after reaching full bearing capacity). If the mother palms are the progeny of elite planting material and gives consistently higher yields for a period of not less than 6 years, seed nuts can be collected from such palms. There is no need for insisting 20 years as minimum age for mother palms in such conditions.
3. More than 30 fully opened leaves with short strong petioles and wide leaf base firmly attached to the stem.
4. Bearing at least 12 bunches of nuts with strong bunch stalks.
5. Bearing nuts of medium size and oblong shape.
6. Husked nuts should weigh not less than 600 g.
7. Mean copra content of 150 g per nut or more.

Avoid palms which (i) have long, thin and pendulous inflorescence stalks (ii) produce long, narrow, small sized or barren nuts (iii) show shedding of immature nuts in large numbers and (iv) are grown under favourable environmental conditions.

Propagation

Coconut is propagated only through seedlings. Seedlings should receive utmost attention since the performance of these seedlings can be judged only after several years of planting when the yield stabilizes.

Selection of seedlings is an important criteria for obtaining quality planting material. Early germinated nuts having a faster rate of leaf production is correlated with early flowering and high nut production. Those seed nuts which germinate within 3 months after sowing are suitable for planting and it is advisable to reject all the sprouts which appear 5 months after sowing. Short stem with good girth at collar, tendency to

produce large number of leaves, dark green in colour and early splitting of the leaves are characteristics of quality seedlings which subsequently result in high-yielding palms.

In India, 9–12 months old seedlings are generally transplanted. Pruning of roots in seedlings up to 12 months does not cause any damage. However, in certain parts of Karnataka and Andhra Pradesh, 2–3 years old seedlings are also planted particularly in areas subjected to flooding and poor drainage in soil. However, in such cases, considerable root damage occurs to seedlings, resulting in delayed establishment and early growth retardation.

Cultivation

Planting

The preparation of land for field planting depends upon topography, soil type and watertable. In undulating and slopy lands, after clearing under growth, soil conservation measures should be adopted to prevent soil erosion. Adequate drainage is also necessary in the initial years in waterlogged areas so that the roots of coconut palms do not come in contact directly with water. In waterlogged areas, coconut should be planted on raised mounds or bunds.

The major criterion for deciding optimum spacing for coconut is that the canopies of coconut plants should not touch each other between eighth and twentieth year of planting. At a spacing of 7.5m × 7.5m about 74% of the roots of coconut palm do not go beyond 2m laterally and 82% of the roots are confined between 30 and 120cm depth in soil. Thus the active root zone of coconut utilizes only 25% of the available land. In view of this there is a scope for variation in spacing adopted depending on soil type, varieties, inter- and mixed cropping. In square system of planting, a spacing of 7.5m or 9m is ideal for tall varieties, accommodating 175 and 124 palms/ha respectively. In triangular system, a spacing of 9m accommodates about 140 palms. Hedge system of planting is also adopted particularly in case of establishment of seed-gardens with dwarfs and talls planted in alternate rows in different spacings to facilitate easy hybridization. In single hedge systems, a spacing of 9m from row-to-row and 5m within rows should be adopted.

Pits of 1m × 1m × 1m size are prepared during summer months. However, surface planting is also adopted particularly in Karnataka and coastal Maharashtra. In lowlying areas, coconuts are planted on raised mounds/bunds. Organic wastes are put into the planting pits and burnt before planting. Furdan @ 5g/pit is also added. The pits are filled up to 0.25–0.30m depth with a mixture of top soil, sand and wood-ash. A small pit to accommodate the nut portion of the seedling is deepened in the filled up portion of the pit. The seedlings are planted at the centre of pits. The soil around the pit is firmly pressed. Care should be taken to see that the collar of the seedling is not covered by the soil. Suitable supports are given so that the roots are not affected by wind. The planting season varies from place-to-place. However, most appropriate time of planting is during the beginning of the monsoon period (May–June) and October–November in the lowlying areas.

The young seedlings planted in fields require adequate shade during first year of planting. Shading properly reduces initial mortality of plants. Keep the field weed-free. Regular irrigation should be given during summers.

Manuring and fertilization

Coconut palms should be manured from the first year of planting itself. The productivity of coconut is adversely affected if its palms are not fed property in the beginning. A dose of 0.5kg N, 0.32kg P_2O_5 and 1.2kg K_2O/year is optimum for an adult palm. However equivalent quantity of FYM or compost can be followed under organic cultivation. The first dose of fertilizer should be applied 3 months after planting. The dosage should be gradually increased.

The fertilizer should be applied under optimum soil moisture condition. The one-third dose of fertilizer is applied immediately after the onset of south–east monsoon and the remaining dose at the end of the monsoon. A shallow trench of 1.8m radius around the base of the coconut is made. One-third of the fertilizer dose is applied around the basin covered with organic manure and soil. Application of farmyard manure (50kg/palm) is essential to supplement inorganic fertilizer. For phosphatic fertilizer, rock phosphate is cheapest and best, particularly for acidic soil. The application of P can be skipped for a few years if available P in the soil is more than 20ppm. Basin cultivation of green manure crops like *Calopogonium* and *Mimosa imvisa*

during the monsoon season can generate up to 25kg green manure which can be incorporated into the basin before flowering. Compared to the local talls, hybrids particularly D×T are found to be most efficient users of applied nutrients.

Irrigation

Response of coconut palms to irrigation is location-specific and depends on climate, soil, topography and ground water table. Moisture stress increases leaf fall, lowers growth rate of reproduction, resulting in lower leaf area and reduction in light interception. The effect of moisture stress is reflected by the reduction of yield due to reduction in number of bunches, number of female flowers/inflorescence and setting percentage besides shedding of tender nuts. The size of nut and copra content are also reduced due to moisture stress. During summer months in coastal Kerala and Karnataka, 200 litres water once in 4 days in the basin of 1.8m radius is recommended. The irrigation requirement of coconut depends on amount of rainfall, its distribution, soil characteristics, climatic condition, annual temperature, relative humidity and pan evaporation. Drip irrigation economizes use of water, besides improving the water-use efficiency. In drip irrigation, 30–40 litres water/day is optimum for west coast condition. Sprinkler or perfo spray is recommended in coconut plantations with inter- and mixed crops and coconut-based cropping system. Mulching with coconut husk, coir dust, green leaves and dry coconut leaves not only improves water-retention capacity but also reduces the soil erosion hazards. It helps in controlling weeds apart from conservation of soils moisture.

Harvesting and Postharvest Management

On an average, coconut yields 44 nuts/palm/year. However, under scientific cultivation West Coast Tall gives 80 nuts/palm/year in coastal Kerala and Karnataka. The hybrids yield 100–140 nuts/palm/year. Coconut ripen in 12–13 months from the opening of the inflorescence. To get maximum yield of copra and oil only fully mature nuts should be harvested. Immature nuts provide 6–33 and 5–33% less copra and oil respectively. Superior, golden-brown, quality fibre with elastic and good tungston strength is obtained from 10-month-old nuts.

The harvested nuts are stored in heaps under shade for a few days since the stored nuts are easy to husk. The moisture content of the meat decreases,

whereas thickness of the meat layer increases. However, storage of harvested nuts is beneficial if fully matured nuts are harvested. Postharvest management of coconut involves its conversion into copra and coconut oil. Coconut husk is used to manufacture coir mat, cushion and other products.

Two forms of copra are manufactured. They are edible copra and milling copra. However, milling copra is manufactured commercially. There are 2 types of edible copra—ball copra and cup copra. Ball copra is produced by storing fully mature unhusked nuts for 8–12 months on a raised platform usually made of bamboos. As the water eventually dries out the nut is dehusked and shell broken carefully to remove copra from inside in a ball form. For preparation of edible quality cup copra, fully mature nuts are stored for a long period. The selected nuts are dehusked, cut into cups and dried under the open sun. Cup copras are used for household edible preparation in northern India, since fresh coconuts are not available for edible purpose.

Milling copra is most popular coconut in southern states. In Kerala, 60–65% of the total coconut produced is converted into milling copra. It is made by sun-drying though often it is combined with kiln drying during the monsoon period. A number of economically feasible copra dryers using sunlight, farm wastes as fuel and even electrical dryers have been developed. Various capacity dryers are being fabricated and marketed by the Kerala Agro Industries Corporation.

Desiccated coconut is prepared in small-scale units mainly in Karnataka. It is a partially defatted product, yielding superior quality coconut oil also.

2.Arecanut

Arecanut or betel nut or *supari* (*Areca catechu*) is chewed both as raw nut and after processing. While ripe arecanut is favoured in Assam, Kerala and Northern parts of West Bengal, *chali*is more popular is Western and Northern parts of India. Processed green nut *kalipak* is the choice in Karnataka and Tamil Nadu. Owing to the medicinal properties, it is used in treating leucoderma, cough, fits, worms, anaemia and obesity. Arecanut is of utmost importance in many religious ceremonies. Tannins in arecanut are being used for dyeing clothes, ropes and for tanning leather. Plastic, hard boards and craft paper of satisfactory strength can be made from its husk. The leaf sheath is a good material for making throw-away cups and plates, plyboards, decorative veneer panels and picture mounds. Its stem forms a useful building material in the villages. Arecanut is mostly grown in Kerala, Karnataka, Assam, West Bengal and Tamil Nadu.

Climate and Soil

Though arecanut grows up to 1,000m above mean sea-level, its quality is affected adversely at higher altitudes. In most of the states, it is grown in the plains. The crop flourishes well at a temperature range of 14°-36°C. Extremes of temperature and wide diurnal variations are not conducive for desirable performance. The largest area of arecanut is found in gravelly laterite soils of red clay. In parts of Karnataka, arecanut is planted in fertile clay soils with an admixture of tank silt. Sticky clay, sandy, brakish and calcarious soils are not favourable for its cultivation.

Varieties

Mangala, Sumangala, Sreemangala, Mohitnagar, Samrudhi and SAS 1 are released varieties for various arecanut-growing regions of India.

Propagation

Arecanut is propagated only through seeds. Seed nuts are collected from selected high-yielding mother palms, 5 years after their first bearing. Apart from high yield,

the age of first bearing and higher percentage of nut set (above 50%) are important characters to be considered for selection. Lowering the ripe bunches using a rope is advantageous. Only fully ripe nuts with a minimum weight of 35g are selected.

The whole nuts are sown in sand beds 5–6cm apart, with their stalk ends pointing upwards. Sand is spread just to cover the nuts. The nursery should be irrigated daily. Germination starts in about 40 days and the sprouts are retained in the primary nursery till they produce 2–3 leaves which usually takes 3–4 months. The seedlings are transplated to secondary nursery beds at a spacing of 35–45cm. The beds can be of any size but 150cm wide and 15cm high are convenient. A basal dose of well-decomposed cattle manure (5 tonnes/ha) may be applied in the secondary nursery. Partial shade should be provided through Pandal or by growing *Cocciniaindica*. Copious irrigation during summer and proper drainage during monsoon are essential. Weeding and mulching should be done periodically.

Instead of transplanting sprouts in the secondary nursery, they can also be raised in polythene bags of 25cm × 15cm size. The bags should be filled with a potting mixture containing loam or top soil, dried and powdered farmyard manure and sand in 7:3:2 ratio.

Cultivation

Planting

Since arecanut palm is very delicate, the field should have protection from exposure to south-western sun by way of either hillocks or tall evergreen trees. The land should have irrigation facility. Feasibility of drainage is another prerequisite where water table is high.

The spacing of 2.7m × 2.7m is adequate. Square, rectangular, triangular and quincunx systems of planting are used. Planting in proper alignment helps prevent sun scorching of the stem. In square system planting, the north-south line should be deflected at an angle of 35 degrees towards west.

About 12–18 months old seedlings are used for planting. Selected seedlings are removed with a ball of earth for transplanting. If they are raised in polythene bags, transporting can be done straightway to any distance without damage.

May–June or the onset of monsoon is best time for planting. In clayey soils having waterlogging, it is taken up in August–September. Pits of 90cm × 90cm × 90cm size are dug and filled with a mixture of top soil, farmyard manure and sand or top soil to a height of 50–60cm from bottom. The seedlings are planted in the centre of the pit, covered with soil to the collar level and firmly pressed. Where higher watertable prevails, seedlings are planted in shallow pits or in extreme cases on mounds raised for the purpose. In such conditions, earthing-up is required in subsequent years to prevent exposure of roots.

Manuring

Manuring is done around the palm in basins 15–20cm deep and 1m wide. The quantity of fertilizers recommended is 100:40:140g NPK/palm/year. However equivalent quantity to substitute the recommended dose of nutrients through FYM or compost can be adopted under organic cultivation.

The fertilizers are applied in 2 split doses during April–May and September–October. These are broadcast around the base of each palm and forked. Application of 25kg organic manure as green leaf, compost or farmyard manure is recommended. These can be applied as single dose. In acidic soils, application of lime is necessary. The lime requirement in each soil has to be determined and the required quantity should be broadcast around the basins preferably during dry months and mixed with soil by forking.

Aftercare

To ensure adequate drainage, one drain channel should be provided for every 2 rows of palms. The channels should be at least 15–30cm deeper than the depth at which the seedlings are planted. The drains are to be cleaned at the beginning of monsoon each year. The planted pits are also to be provided with outlets and emptied to the drains.

Young seedlings are best protected by raising banana crop during the early years. This also helps the farmers to get some income till the areca palm starts giving revenue. Protecting the stem from sun scorching is important since the parts once damaged

cannot be recouped. From the beginning of October, the exposed stems of palms are to be covered with dry leaves of arecanut or by white opaque polythene film.

The cultural practices followed by cultivators in different parts of India vary. Light digging in October–November is required to break up any crust formed at the soil surface and to uproot weeds. Mulching the interspaces of arecanut gardens is another field operation which prevents soil erosion during heavy rains and adds humus to the soil.

Irrigation

Areca is grown as a rainfed crop in West Bengal, Assam and southern parts of Kerala. Since irrigation increases its yield, it is recommended to irrigate during long dry spell. In West Coast, watering once in 7 days during November–December, once in 6 days during January–February and once in 3–5 days during March–May is recommended. Irrigation of 30mm depth when CPE is 30mm is the best. For efficient water use, drip irrigation is recommended.

Multiple cropping

Multiple cropping and intercropping in arecanut gardens provides an additional income. The intercrops should be tolerant to shade, should not compete with arecanut for various resources and should have marketing feasibility. Banana, pineapple, elephant-foot yam, tapioca, dioscorea, sweet potato, ginger and turmeric are ideal crops for intercropping depending on the region where cultivated. Cocoa is most popular crop for multiple cropping system. Cocoa is planted at 2.7m spacing between alternate rows of standing arecanut palms. Black pepper trained on arecanut is another popular multiple cropping system. Cinnamon, coffee, betel vine and cardamom are also grown along with arecanut in certain areas.

Harvesting and Postharvest Management

The bunches are harvested when they are fully ripe if the end use is *chali* or *kotapak* (dried ripe nuts). About 6–7 months old nuts which are dark green and soft are harvested to produce *kalipak*.The most important trade types of arecanuts are dried

ripe nuts (*chali* or *kotapak*), *kalipak* and scented *supari*. To prepare *chali* or *kotapak*, ripe nuts are dried under the sun for 35–40 days. These are then dehusked and marketed as whole nuts.

3. Banana

Banana and plantain (*Musa* sp.) are one of the important fruits widely cultivated in India for its great socio-economic significance, dessert fruit for millions apart from a staple food owing to its rich and easily digestible carbohydrates with a calorific value of 67–137/100g fruit. Due to itsmultiple uses starting from underground stem up to the male flower. Hence, it is referred as *Kalpatharu* (a plant of virtues). In India, banana contributes to 31.72% of the total fruit production. India is the largest producer of banana in the world. Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa and West Bengal are major banana-growing states, the highest productivity being 52.18 tonnes/ ha in Maharashtra followed by Gujarat (40 tonnes/ha). The lowest productivity is from the north-eastern region.

Climate and soil

Banana is well-suited for cultivation from humid subtropical to semi-arid subtropics up to 2,000m above mean sea-level. In India, it is successfully grown from 8°N to 28°N latitudes with a temperature of 15°–35°c and a rainfall of 500–2,000mm/year. Mean temperature of 20°–30°c is optimum for its growth. Water stagnation in poorly-drained soils also leads to slow growth. The plants collapse in extreme cases. Apart from temperature and water, wind poses a major constraint in banana production. High wind results in uprooting and collapse of plants. Avoidance of bunching during the period of high wind velocity is advocated through adjustment in time of planting.

Banana can be grown in all kinds of soils having good drainage. In sandy loam soil plants grow faster compared to vertisol or clay loam soil. Though soil pH of 6.5–7.5 is optimum, banana can be grown in soils having a pH up to 8.5 with suitable amendments. More organic amendments are essential in sandy as well as heavy soils.

Varieties

The Dwarf Cavendish, Robusta, Katta Champa, Mitta Champa, Karpooravalli, Korangi, Red Banana & Rathalu are commonly cultivated in Andaman & Nicobar Islands.

Production systems

Depending upon resource availability, cultivars, traditions and marketing, different production systems are adopted.

Homestead or backyard cultivation

In traditional growing regions, homestead cultivation of banana is common. The choice of cultivars is governed by family requirements and quality preference of the household. Backyard cultivation is traditional because of the ease in establishment, availability of area around farmhouse, minimum capital investment, ease of monitoring and sharing of labour among family members. Homestead farming is characterized by improper spacing, inadequate use of fertilizer and pesticides, high productivity and longer crop duration.

Multistorey system: It is commonly followed in plantations of Tamilnadu, Karnataka and Kerala where crops with different canopy levels are planted. High-density planting with coconut and arecanut forming the upperstorey followed by banana, next with tapioca and lower-most storey with colocasia, turmeric, ginger and garlic. High input management is its important feature. Semi-tall banana Poovan and Ney Poovan are preferred in this system. This kind of production systems are highly suitable to farmers of Andaman & Nicobar islands

Propagation

Banana is propagated through suckers or corms. Sword-suckers with a well-developed rhizome, conical in shape with lanceolate leaves and actively growing central buds, weighing 500–750g are generally used. Propagation through shoot-tip culture is cost-effective for the production of disease-free plants. *In-vitro*propagated banana is

becoming popular. Micropropagation has been preferred over conventional propagation owing to its faster multiplication, uniformity in planting material and disease-free material from transmissible pests and diseases. *In-vitro* propagated plants are becoming a commercial reality along with fertigation.

Time of planting

Time of planting is determined by the choice of cultivar, agroclimatic conditions and market demand. March-April is the ideal time for planting of banana because of occurrence of Sigatokaleafspot in Dwarf Cavendish in A&N islands, by adjusting time of planting, bunch emergence in rainy season can be avoided.

System of planting

Depending on tradition, resource availability and existing constraints planting systems vary in different regions. Pit planting is commonly followed in garden land system of cultivation. Pits of 60cm × 60cm × 60cm size are dug, filled with a mixture of soil, sand and farmyard manure in a 1: 1: 1 ratio. Suckers are planted in the centre of the pit and soil around is compacted. This is mostly followed for Dwarf Cavendish, Rasthali, Robusta, Poovan and Karpuravalli banana.

Manuring and fertilization

All the macro- and micro-elements are required by banana. Among macronutrients, N is most essential element. For normal plant growth and development 100–250g of N/plant is advised depending on nutrient status of soil and cultivar. Urea is commonly used as a source of N. It should be applied in 3–4 splits. Application of 150g N in vegetative phase and 50g N in reproductive phase enhances the yield and delays the leaf senescence. Application of 25% N as farmyard manure and 1kg neem cake is beneficial. The application of 25% N in organic form, 75% N in inorganic form along with growing of green manure crops like *Crotalaria* is ideal.

The P requirement of banana is comparatively low. Superphosphate forms the major source of P followed by the application of rock phosphate 50–95g/plant at planting. In acidic soils, triple superphosphate or diammonium phosphate is

recommended. Phosphorus is applied in single dose at the time of planting and quantity of P_2O_5 depends upon soil type and varies from 20 to 40g/plant. Application of K (100g) in 2 splits during vegetative phase and 100g in 2 splits during reproductive phase is recommended. Application of 200–300g K_2O is recommended depending upon cultivar. Invariably, plantains require higher K than other group of cultivars. Calcium influences yield through its interaction with N, P and K. In acidic soils, use of dolomite ($MgCO_3$) and limestone ($CaCO_3$) as soil amendments is common. Magnesium, an important component of chlorophyll assumes a vital role in normal growth and development of the plant. In acute deficiencies foliar spraying of $MgSO_4$ is found to relieve the plant. The application of Zn (0.1%), B (0.005%) and Mn (0.1%) improves yield.

Water management

Depending on water availability, banana is grown either as rainfed or irrigated or wetland crop. Water requirement of banana varies from 1,800–2,200mm. In A&N islands, banana is mostly cultivated as rainfed crop and it is also cultivated as irrigated crop (Only Dwarf Cavendish) Normal furrow and basin and trench systems are followed. The furrow or basin system is useful if water availability is not a constraint.

Weed management

Weeds reduce yield up to 40–50% depending upon cultivar and soil. First 6 months of growth are most critical for weed growth. The plantation has to be kept completely weed-free by following regular hand- weeding. Apart from cultural practices, chemical control using 0.4% Glycel spray is also effective. But an integrated management of weeds by intercropping cowpea, soil mulching with sugarcane trash and paddy straw and one spraying of Glycel is economical.

Aftercare

Desuckering once in 45 days is a common practice in banana plantation. In a young plantation of up to 2–3 months, emerging small suckers are simply headed back with a sharp knife. In later stages , removal along with their rhizomes is a must. For that a

crow bar of 1 m with a flattened, spoon-like edge is used and care is taken not to damage the mother plant. Cutting back the sucker and pouring kerosene (4ml) into the small gouged cavity made in the centre or injection of kerosene from the side of the sucker just above the meristem can also be adopted.

Intercropping

Intercropping is a common practice in banana orchards to check weed growth, improve soil health and to augment the additional income. In initial years, soybean, cowpea, beans and yam are grown.The crops which can attract nematodes or soil-borne diseases should be avoided. Brinjal or cucurbits should not be grown.

Mulching

Mulching helps conserve soil moisture and suppress weed growth. Organic mulching also improves soil health. Sugarcane trash @ 10 tonnes/ ha provides effective mulching for conservation of moisture. Paddy straw, dried leaves and *Pongamia*leaves can also be used. Experiments have proved the superiority of polythene sheet mulching for better conservation of moisture and suppressed weed growth.

Management of Orchards

As the young plants grow, and lower leaves dry, they are separated from pseudostem and fall apart. To avoid weakening of the pseudostem, it is a common practice to tie all the leaf sheaths with a dried banana leaf. This operation is done periodically at bimonthly intervals. Dried or diseased leaves are also required to be removed at regular intervals to reduce disease load and also to give exposure to sunlight. For maximum yield, a minimum of 10–12 leaves are required to be retained on the mother plant.

Propping

Strong wind is a threat for successful banana production. Bamboo or *Casurina*poles are commonly used. These poles have effective life of 3–4 years. Props using

polythene wire can also be practised. Propping should be done immediately after bunch emergence to avoid overloading on the prop.

Denavelling

Removal of male bud after completion of the female phase is referred to as 'denavelling'. It serves the dual purpose of saving movement of food into unwanted sink and also earns additional income as it is used as vegetable.

Bunch Covering

Bunch covering is practised for Cavandish and Silk groups of bananas to get attractive colour. Under subtropical condition, covering of bunch by using perforated polythene bags increases the yield by 15–20%. Covering bunches by dried leaves is also practised to avoid direct exposure of peduncle to sun. Uncovered peduncle when exposed to sun is scorched and secondary infection of *Colletotrichum*causes poor filling of fingers.

Harvesting and Postharvest management

The harvest indices such as number of days from flower emergence, pulp : peel ratio, weight : length ratio, disappearance of the angles, thumping sound of fruits, brittleness of the floral remnants and their natural shedding, dullness of the fruit skin colour and odour are used for bunch harvesting. Banana bunch development continues over a period of 90–150 days depending on the variety. Maturity standards mentioned are accomplished in Dwarf Cavendish in 113–130 days. Lower temperature delays maturity while higher temperature advances it. For long distance transportation, harvesting is done at 75–80% maturity. Ripening in closed chambers is widely practised in India. Bunches are dumped in 'ripening rooms'. Ethylene is generated in a room to give uniform ripening. Smoking and use of acetylene are not good. An attractive colour in banana can be obtained by slow ripening under controlled condition (15°–18°c with lower ethylene concentrations).

Banana Bunchy Top

Sigatoka leafspot disease

Sigatoka leaf spot *(Mycosphaerella* sp.)

1. Cut and burn all severely affected leaves.
2. Spray 1% Bordeaux mixture soon after the appearance of the initial symptoms of the disease. The disease appears with the commencement of southwest monsoon.

Five to six sprayings at fortnightly intervals are to be given depending upon the severity of the disease.

3. Power oil (mineral oil) 1% emulsion is also effective in controlling the disease.

4. Spray carbendazim (0.1%) or give alternate sprays of tridemorph (0.05%), mancozeb (0.2 %) and carbendazim (0.1%) soon after the appearance of initial symptoms of the disease. Three to four sprayings at fortnightly intervals are to be given depending on the severity of disease.

4. Papaya

Papaya (*Carica papaya*) requires less area for tree, is easy to cultivate, comes to fruiting in a year, and provides more income/ha next to banana. It has a high nutritive and medicinal value. Papain prepared from dried latex of its immature fruits is used in meat tenderising, manufacture of chewing gum, cosmetics, for degumming natural silk and to give shrink resistance to wool. Besides, it is also used in pharmaceutical industries, textile and garment cleaning, paper and adhesive manufacture, sewage disposal, etc.

Climate and Soil

It grows well in tropical condition but it can also also grows well in the subtropical regions of the country up to 1,000m above mean sea-level. It is very much sensitive to frost, strong winds and water stagnation.It can grow in a wide variety of soils, provided these are well-drained and aerated. A rich, well-drained sandy loam soil is ideal for its cultivation. Soils with high pH (8.0) and low pH (5.0) should be avoided.

Varieties

A large number of local varieties are cultivated. However, the varieties such as Pusa Delicious, Pusa Majesty, Pusa Giant, PusaDwarfPusaNanha, Co1, Co2,Co3,Co4,Co5,Co6,Co7, Coorg Honey DewSunrise Solo and Arka Surya are commonly cultivated in India.

Propagation

Papaya is commercially propagated by seed. Gynodioecious varieties breed true-to-type and are preferred by commercial growers. Since papaya is commercially grown by seed, production of quality seed is most important for successful production and establishing papaya-based industries in the country.

Seedling raising

About 250–300g seeds are sufficient for a hectare. The seedlings can be raised in nursery-beds 3m long, 1m wide and 10cm high as well as in pots or polythene bags.

The seeds should be sown 1cm deep in rows 10cm apart and covered with fine compost or leaf-mould. Light watering should be done with watercan in the morning. The nursery-beds may be covered with polythene sheet or dry paddy straw to protect seedlings. Tender seedlings should also be protected from heavy rainfall. Dusting of insecticides to protect the seedlings against insect pests is also advised. Damping off is most serious disease. Treating seeds with 0.1% Monosan (phenyle mercury acetate), Ceresan, Agrosan or Thiram dust before sowing is the best preventive measure to check it. The nursery-beds should also be treated with 5% formaldehyde solution before sowing. If disease appears in the nursery, Bordeaux mixture (1%) or copper oxychloride (0.2%) should be sprayed.

The seedlings raised in polythene bags stand transplanting better than those raised in seed-beds. Perforated polythene bags of 20cm × 15cm size of 150–200 gauge can be used as a container. They are filled with a mixture of farmyard manure, soil and sand in equal proportion. Four to five seeds are sown in each bag. After germination only three seedlings are retained.

The seedlings may be transferred to nursery-beds or pots or polythene bags to avoid overcrowding and further check of growth of. This is also done when the field is not ready for planting. Generally 15–20cm tall seedlings become ready for planting in about two months.

Field preparation

Since papaya does not withstand waterlogging, a well-drained upland should be selected for its cultivation.The seedlings are planted in pits of 60cm × 60cm × 60cm size. The pits are dug about 15 days before in summer and filled with top soil along with 20kg farmyard manure, 1kg neem or karanj cake and 1kg bone-meal or fish-meal. Tall and vigorous varieties are planted at greater spacing, while medium and dwarf ones at closer spacing.

Planting

Papaya is planted during spring (February–March), monsoon (June–July) and autumn (October–November). Spring planting is done in areas where the climatic condition is

mild throughout the year. Planting distance is determined by the integration of light interception, cultivar and economic consideration. A spacing of 1.8m × 1.8m is normally followed for most of the cultivars. Planting of papaya seedlings should be preferred in the evening. The seedlings from nursery-beds are lifted with a ball of earth and planted in the field. Plants raised in polythene bags are planted after removal of polythene. Three seedlings should be planted in each pit followed by light irrigation. Only one seedling may be planted with pure gynodioecious varieties. It is also important to keep some extra plants reserved in the nursery or in polythene bags for gap filling in the field.

Aftercare

Proper care should be taken to save the seedlings in the field especially against insect pests and heavy rainfall in early stage. In frost-prone areas, they should be protected with small thatches or polythene structure. Some extra seedlings reserved in the nursery may be utilized for gap filling.Weeds grow luxuriantly in papaya fields and exhaust most of the applied nutrients. In the beginning, they also compete for light, air and water, resulting in poor fruiting. Deep hoeing is recommended during first few months to check weed growth. Hoeing should not be done in rainy season or after fruiting since its plants are shallow-rooted. Overgrowth of weeds also causes waterlogging condition and makes the plants vulnerable to root-rot and foot-rot in rainy season. Therefore weeding should be regularly done, especially around the plants. Application of Fluchloralin or Alachlorin or Butachlorine (2.0g/ha) as pre-emergence 2 months after transplanting can control all weeds for 4 months.

Removing unwanted male plants

It is necessary to keep 10% male plants in papaya orchards for good pollination, where dioecious varieties are cultivated. As soon as the plants flower, extra male plants should be uprooted.

Manuring and fertilization

Papaya is a heavy feeder and needs heavy doses of manures and fertilizers. Apart from the basal dose of manures applied in the pits, 200–250g each of N, P_2O_5 and K_2O are recommended for getting high yield. Application of 200g N is optimum for fruit yield but papain yield increases with increase in N up to 300g. A dose of 250g N, 250g P and 500g K/plant is recommended. However equivalent quantity to substitute the recommended dose of nutrients through FYM or compost can be adopted under organic cultivation.

Deficiency of lime and B has often been observed in papaya orchards. Spraying of 0.5% zinc sulphate (twice) and one spray of Borax (0.1%) may be done depending upon the nutrient status of soil.

Irrigation

Optimum soil moisture is essential for growth, yield and quality of fruits. Under low moisture conditions, floral sex shifts towards female sterility, resulting in low yield. At the same time, over-irrigations may cause root-rot disease. Thus efficient water management is required in papaya cultivation. Number of irrigations depends upon soil type and weather conditions of the region. Protective irrigation is required in the first year of planting. In the second year when its plants are ladden with fruits, irrigation at fortnightly interval in winter and at 10 days interval in summer is needed from October till May.

Apart from the organic manures, a dose of chemical fertilizers containing N (50g), P (50g) and K (75g) should be applied as topdressing. Chemical fertilizers should be applied after flowering. The same quantity should be repeated in each month from July to October. Precaution should be taken that these fertilizers are applied at least 15cm away from the plant in a circular fashion. Water should be immediately applied after each topdressing

Local Papaya in Neil Island

Local Papaya in Neil Islands

Harvesting and Postharvest management

The fruits should be left on tree until they fully mature. Usually fruits are harvested when they are of full size, light green with tinge of yellow at epical end. On ripening, fruits of certain varieties turn yellow while some of them remain green. When the latex ceases to be milky and become watery, the fruits are suitable for harvesting. While picking fruits from the tree, care must be taken that they are not scratched, and are free from any blemishes, otherwise these are attacked by fungus and start decaying during marketing. On an average each plant of improved varieties bears 30–45 fruits, weighing 40–75kg in one fruiting season. On an average, yield of 60–75 tonnes/ha may be expected in a season from an orchard of papaya.

5. Pineapple

Pineapple (*Ananascomosus*) is an important fruit crop in India. A good source of vitamins A and B, pineapple is fairly rich in vitamins C, calcium, magnesium, potassium and iron. It is also a source of bromelin, a digestive enzyme.The cultivation of pineapple is confined to high rainfall and humid coastal regions in the peninsular India and hilly areas of north-eastern region of the country. The pineapple is grown commercially in Assam, Meghalaya, Tripura, Mizoram, West Bengal, Kerala, Karnataka and Goa, and on a small scale in Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh, Orissa, Bihar and Uttar Pradesh.

Climate and Soil

The pineapple is a crop of humid tropics. The fruit grows well near the sea coast as well as in the interior, so long as the temperatures are not extreme. The optimum temperature for successful cultivation is 22°–32°C. Leaves and roots grow best at 32°C and 29°C respectively. Their growth ceases below 20°C and above 36°C. A high temperature at night is deleterious and a difference of at least 4°C between day and night temperature is desirable. It can be grown up to 1,100m above mean sea-level, if the area is frost-free. Although optimum annual rainfall for its commercial cultivation is 100–150cm, it grows remarkably well under a wide range of rainfall. In areas where the rainfall is less, supplementary protective irrigations are necessary during dry season.The plants come up well in any type of soil except on very heavy clay soil. Sandy loam soils are ideal. The soil should be 45–60cm in depth without hard pan or stones. Low-lying areas with high watertable should be avoided. The plants prefer a soil pH of 5.0–6.0.

Varieties

The important varieties are Kew,Giant Kew,CharlotteRothchild,Queen, Mauritious,Jaldhup and Lakhat.

Propagation

Pineapple is propagated mainly through vegetative method. There are three types of planting materials in pineapple namely, suckers,slips and crown. The performance of the plant depends on vigour, growth rate, timetaken for bearing, fruit size and quality of planting material. In suckers and slips, larger planting material gives more vigorous plants. Of the types and sizes of propagules tried, slips and suckers weighing about 350 and 450g respectively are ideal for higher yield with better produce.

Cultivation practices

Planting

Planting time is very important for natural flowering period, which differs from region-to-region. By the time of natural flowering, if the plant does not attain the optimum physiological maturity, either it escapes flowering the next season or if flowering is induced in the same season, the plant, bear very small fruits. The best time of planting is April–June. Delaying in planting as late as September, delays crop at least by 7–9 months. The peak flowering under these conditions comes during January–March. System of planting varies according to land and rainfall.

Planting methods

There are 4 planting systems—flat-bed, furrow, contour and trench.Plant density of pineapple depends on growth of the plant and system of planting. Adoption of low-planting densities has been the major constraint in India, contributing to high cost of production. The plant density of 63,400 plants/ha (22.5cm × 60cm × 75cm) is ideal for subtropical and mild humid conditions, whereas for hot and humid conditions a plant density of 53,300 plants/ha spaced at 25cm from plant-to-plant within a row, 60cm from row-to-row and 90cm from trench-to-trench (25cm × 60cm × 90cm) provides high yield.

Manuring and fertilization

Pineapple is a shallow feeder with high N and K requirement. Since these nutrients are prone to heavy losses in soils, practices relating to time of application and form of

fertilizer determine their efficient use. For medium-fertile soils in West Bengal, N (12–16g), P_2O_5, (2–4g) and K_2O (10–12g)/plant are optimum or equivalent dose organic fertilizers may be applied.

Intercultural operations

i.Earthing up: This is an essential operation in pineapple cultivation aimed at good anchorage to the plants. It involves pushing the soil into the trench from the ridge where trench planting is a common practice. As its roots are very shallow, the plants are eventually lodged especially under flat-bed planting in heavy rainfall areas. Lodging of plants at the time of fruit development results in lopsided growth, uneven development and ripening of fruits. It is more important in ratoon crop as the base of ratoon plants shifts up, crop after crop. High-density planting minimizes its necessity as the plants prop each other preventing lodging.

ii.Weed control: Weeds could be effectively and economically controlled by application of Diuron (3 kg/ha) or a combination of Bromacil + Diuron @ 2kg/ha each as pre-emergent spray and repeated with half of the dose, 5 months after first application. The quantity of each herbicide should be mixed in 1,000 litres of water for a hectare of crop.

iii.Mulching: It is essential to conserve soil moisture. Though mulching is not a common practice in India, use of dry leaves or straw is in practice in south India. Mulching with black polythene and saw-dust results in better growth of plants than white polythene and paddy-straw.

iv.Removal of suckers, slips and crowns: Suckers start growing with the emergence of inflorescence, whereas slips grow with the developing fruits. The fruit weight increases with increasing number of suckers/plant, while the increased number of slips delays fruit maturity. Crown size has no bearing on the fruit weight or quality. Hence desuckering can be delayed as much as possible, while the slips are

recommended to be removed as soon as they attain the size required for planting. Removal of crown is not required as it mars the appeal of the fruit and also makes handling difficult. Partial pinching of crown consisting of the removal of the innermost whorl of leaflets along with growing tips 45 days after fruit set is ideal to get fruits of better size and shape.

Irrigation

Although pineapple is cultivated mostly under rainfed conditions, supplementary irrigation can help produce good-sized fruits in areas having optimum rainfall. Irrigation can also help establish an off-season planting to maintain its year-round production. In scanty rainfall and during hot weather irrigating pineapple once in 20–25 days is advisable.

Use of growth regulators

Flowering in pineapple Kew could be induced with the application of Ethephon or ethrel (2-chloroethyl phosphonic acid) (100ppm). The concentration of Ethephon could be reduced to 25ppm by combining it with 2% urea and 0.04% sodium carbonate. The application of 50ml solution/plant containing calcium carbide (20g/litre) or Ethrel (0.25ml/litre) causes flower induction. Flower induction should be done when the plants attain at least 35–40 functional leaves, so that the plants produce fruits of normal size.Application of NAA (200–300ppm) 2–3 months after fruit set increases 15–20% fruit size. To get the year-round availability of pineapple, it should be planted at regular intervals round the year. Using suckers and slips of different sizes and crowns as planting material and applying flower-inducing chemicals also provide its availability round the year.

Harvesting and Postharvest Management

Pineapple plants flower 10–12 months after planting and fruits become ready 15–18 months after planting. With a slight colour change at the base of developing fruits, it could be harvested for canning purpose. But for table purpose, the fruits could be

retained till they develop golden yellow colour. The fruits with the crown, can be kept without damage for 10–15 days after harvesting.

6. Mango

Mango (*Mangifera indica*), the king of fruits, is grown in India for over 400 years. More than 1,000 varieties exist today. It is grown in almost all the states. India shares about 56% of total mango production in the world.

Climate and soil

Mango can be grown on a wide variety of soils under varied climatic conditions. It can be grown from alluvial to lateritic soils except in black cotton soil having poor drainage. It grows well in soils with slightly acidic pH. It does not perform well in soils having pH beyond 7.5. Soils having good drainage are ideal for mango. The temperature between 24 and 27°C is ideal for its cultivation. Higher temperature during fruit development and maturity gives better-quality fruits. The areas experiencing frequent showers and high humidity are prone to many pests and diseases. Thus it can be grown best in regions with a rainfall between 25cm and 250cm. Regions having bright sunny days and moderate humidity during flowering are ideal for mango growing.

Varieties

India is the home of about 1,000 varieties. Most of them are the result of open pollination arisen as chance seedlings. However, only a few varieties are commercially cultivated throughout India. In India, mango is available from March to mid-August The North Indian cultivars are alternate-bearer whereas south Indian ones are generally regular-bearer. About 20 varieties are grown commercially. They are **Alphonso,Banganapalli,BombayGreen,Chausa,Dashehari, Fazli, GulabKhas, Himsagar, Kesar, Kishenbhog, Langra, Mankurad, Neelum, PairiTotapuri.** A number of selections/hybrids of mango have been evolved. These include Clone C-51 from Dashehari selected at the CISH, Lucknow, and an off-season selection, Niranjan, selected at Parbhani. New clonal selections from Langra and Sunderja have been made at Varanasi and Rewa. A clonal selection, Paiyur 1, has been made from Neelum, in addition to few dwarf polyembryonic selections made in the north-eastern region.As a result of systematic hybridization, several hybrids have been released.

However, only a few such as Amrapalli, Mallika, Ratna and ArkaPuneet are becoming quite popular.

Propagation

Mango is a highly heterozygous and cross-pollinated crop. There are 2 types of mango varieties. Most of the varieties in south are polyembryonic and thus give true-to-type seedlings. In north, there are monoembryonic and need to be propagated vegetatively. Mango is propagated on mango rootstock. For raising rootstock, the seeds of mango are sown within 4–5 weeks after extraction otherwise they lose their viability. For sowing the seeds, raised beds are prepared with a mixture of farmyard manure, red soil and sand. In some places, seeds are sown directly in polythene bags. After germination, the leaves turn green in 2–4 weeks. These seedlings are transplanted to polythene covers containing red soil, sand and farmyard manure. Addition of nitrogenous fertilizer to polythene covers after the establishment of plants helps in quick growth of seedlings. The seedlings thus raised should be used for grafting at different ages. Several methods of grafting are practised. They are: ***Inarching, Veneer and side grafting and Epicotyl/stone grafting***.

Cultivation practices

Planting

The square and rectangular systems plantings are ideal. The main field is brought to fine tilth. Pits of 1m × 1m× 1m size are dug. These are exposed to sun for about 30 days. Before planting, pits are filled with well-rotten farmyard manure. The top and sub-soil are taken out reparately while digging the pits. The grafts should be planted during rainy season. In the *in-situ* grafting, rootstocks are planted in the main field. Then they are raised for 6 months to 1 year. Then the scions of the variety that need to be grown are taken and grafted. This is usually done when humidity is high. After grafting the scions are covered with polythene covers.

High-density planting

High-density planting helps increase the yield/unit area. In north India, mango Amrapali is found amenable for high-density planting with a spacing of 2.5m × 2.5m. Soil drenching with paclobutrazol (2 ml/tree) induces flowering during off year. It has become a commercial practice in Konkan region of Maharashtra.

Training and pruning

Training is an important practice during the first few years after planting. It is essential to space the branches properly and to help in intercultural operations.

Manuring and fertilization

The nutritional requirement of mango varies with the region, soil type and age. A dose of 73g N, 18g P_2O_5 and 68g K_2O_5 / year of age from first to tenth year and thereafter a dose of 730g N, 180g P_2O_5 and 680g K_2O should be applied in 2 split doses during June–July and October respectively. However equivalent quantity to substitute the recommended dose of nutrients through FYM or compost can be adopted under organic cultivation. Organic manures and phosphatic fertilizers should be applied immediately after harvest, whereas ammonium sulphate should be given before flowering.

Intecropping

In mango, intercropping helps check weed growth and reduces nutrient losses. Intercropping blackgram–wheat–mango and brinjal–onion–mango gives better monetary benefits. Besides, taking up cover crops like sunhemp, cowpea, pea and berseem help prevent soil erosion.

Irrigation

The water requirements mainly depend on the age, soil type and climate. however, young plants up to 2-year-old should be watered regularly. The newly-planted grafts need about 30 litres of water every week. Irrigating grown-up trees after fruit set at 10-day interval increases their yield.

Harvesting

Mangoes should be harvested with pedicel. Injury to the fruits during harvesting brings down their quality and also makes them prone to fungal attack. Several types of harvesters have been developed. These devices are simple and efficient in harvesting. Yield in mango varies with the variety. However, on an average mango yields 8 tonnes/ha.

7. Black pepper

Black pepper (*Piper nigrum*), the king of spices, is being cultivated on a large scale in India. Over the years (1992–96), there has been expansion in area under black pepper in India. Indian pepper reaches homes in 75 countries, the North American region being the major importer of Indian pepper. In India, it is grown in Kerala, Karnataka, Tamil Nadu, Andaman and Nicobar Islands and Pondicherry. India is also a major consumer of black pepper.

Climate and Soil

Black pepper is a crop of warm humid tropics. It requires adequate rainfall (200–250 rainy days with a total annual rainfall of 2,000–3,000mm) and a dry spell of 30–45 days before flowering with the onset of rains and high humidity (75–95%). The hot and humid climate of submountainous tracts of Western Ghats are ideal for its cultivation. It grows successfully up to 1,500m above mean sea-level. The crop tolerates temperature between 10°C and 40°C. Black pepper thrives best on virgin, well-drained, red, lateritic or alluvial soils rich in humus. The pH of 4.5–6.0 is ideal. Pepper is grown in red loam, sandy loam, clay loam, and red lateritic sandy clay loam soils; but virgin soils rich in humus of the hill slopes of the Western Ghats are best-suited for its cultivation.

Varieties

So far 10 varieties and hybrids have been released for cultivation On an average the yield ranges from 1.09 tonnes/ha (Panniyar 5) to 2.677 tonnes/ha (Sreekara). Panniyar 1 and Panniyar 3 are the F_1 hybrids.

Propagation

Black pepper has 3 types of aerial shoots—terminal shoots, runner shoots originating from base of vines and fruit-bearing lateral branches with limited growth. It is propagated through shoot-cuttings. Seed propagation is also possible but not followed. Runner shoots are generally used. The lateral shoots on rooting give rise to

bush black pepper. Runner shoots from high-yielding and healthy vines are kept coiled on wooden pegs fixed at the base of the vine to prevent shoots from coming in contact with soil and striking roots. The runner shoots are separated from vines during February–March and after trimming leaves, cuttings of 2–3 nodes each are planted either in nursery beds or in polythene bags filled with fertile soil. Adequate shade should be provided and watering be done frequently. The cuttings strike roots and become ready for planting in May–June. Rapid multiplication of black pepper has become popular in India. It is advantageous because besides multiplication being rapid there is better field establishment of vines and more vigorous growth. The protocols are also available for its micropropagation through direct regeneration from explants of leaf, stem, terminal and side buds. The tissue cultured plants of black pepper are also now available.

Cultivation

Planting

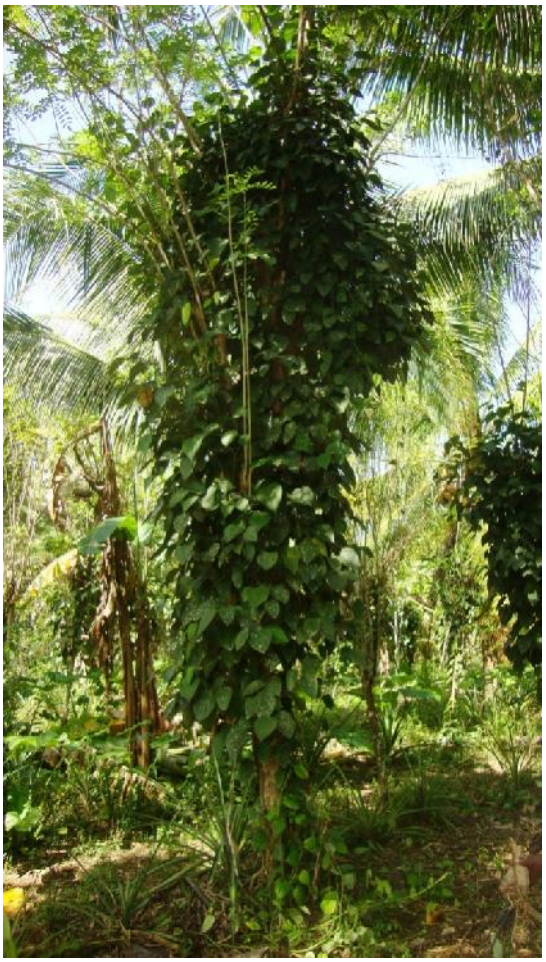
Black pepper, being a climber, needs standards for support. Pepper is also trained on coconut, arecanut, jackfruit tree etc. in a mixed homestead farming. The live standards are used at a spacing of 2.7 × 2.7m, accommodating 1,100 vines/ha in its monocropping system. But in multiple cropping system, prevalent in Kerala, only 540–560 vines/ha are accommodated. With the onset of south-west monsoon, 2–5 rooted cuttings of black pepper are planted individually in pits on the northern side of the standard.

Training/pruning

As the black pepper cuttings grow, the shoots are tied to standards as often as required. The young vines should be protected from hot sun during summer by providing shade using coconut leaves. Regulation of shade by lopping branches of standards before the south-west monsoon, is necessary not only for providing optimum light to vines, but also for enabling standards to grow straight. Adequate

mulch with green leaf should be given (before the end of north-east monsoon) after digging around standards at 1m radius.

Black pepper on Arecanut



Black pepper on Glyricidia standards

Manuring and fertilization

Major pepper-growing tracts in Kerala and Karnataka have in general satisfactory level of N, but are poor in P, K, Ca, Mg and Zn. An application of 140gN, 55g P_2O_5 and 270g K_2O/vine/year is optimum. The dose of 50kg N along with 100kg P_2O_5 and 200kg K_2O/ha is also good in Kerala. The specific recommendations are: NPK at 100:40:140 g/vine/year for Panniyur region, northern part of Kerala and similar agroclimatic conditions, NPK at 50:50:200g/vine/year and for Calicut and similar agroclimatic region, NPK at 140:55:70g/vine/year. One-third of the recommended dose is applied during the first year which is increased to two-thirds in the second year. Full dose is

given third year onwards. The fertilizers are applied in 2 doses, the first half in April with the onset of monsoon and the second half in August–September. The fertilizers are applied at a distance of about 30cm all around the vine and at a depth of about 15cm and the soil is forked in after application. Besides, organic manure in the form of cattle manure or compost is given @ 10kg/vine in May. Application of lime @ 500g/vine during April–May in alternate years is also recommended.

Aftercare

If the terrain of the land is slopy or uneven, carry out contour bunding or terracing to prevent soil erosion. Carry out digging around the standards and vines at 1m radius from the base or in the entire plantation, twice during the year, the first at the onset of monsoon and the second towards the end of north-east monsoon. Weeding around the plants is to be done according to necessity. In the early stages, the vines are tied to the standards, if found necessary. When pepper is grown on plantation scale, growing of cover crops is recommended. When such cover crops are grown, they are to be cut back regularly from the base of the plants to prevent them from twining along with the pepper vines. Lowering of vines after 1 year's growth promotes lateral branch production. Intercropping of pepper gardens with ginger, turmeric, colocacia and elephant-foot yam is advantageous. Banana as an intercrop in yielding gardens, reduces pepper yields. Therefore, banana is not recommended beyond 3–4 years after planting of pepper. However, in the early years, banana provides shade to young plants and protects them from drying up during summer months.

If pepper is grown in open places, shading and watering of young seedlings may be done during summer months for the first 1–3 years. The young plants may be completely covered with dry arecanut leaves, coconut leaves or twigs of trees until summer months are over. Mulching the basins of pepper vines during summer months is highly advantageous. Saw-dust, arecanut husk and dry leaves are suitable mulching materials. Removal of unwanted terminal shoot growth and hanging shoots should be done as and when necessary.

Prune and train the standards in March–April every year to remove excessive over-growth and to give them a proper shape. The effective height of the standards is to

be limited to 6m. A second pruning of the standards is to be limited to 6m. It is done in July–August, if there is an excessive shade in the garden.

After regular bearing for about 20 years, the vines of most varieties start declining in yield. The age of yield decline varies from variety-to-variety and also depending on agroclimatic factors and management practices. So, underplanting should be attempted at about 20 years after planting or when a regular declining trend in yield appears. The old and senile vines must be removed 3–5 years after underplanting, depending on the growth of young vine.

Irrigation

Irrigating pepper plants from November/December till the end of March and withholding irrigation thereafter till monsoon break, increases pepper yield by about 50%. The depth of irrigation recommended is 10mm (100 litres water/irrigation at 8–10 days interval) under Panniyur condition. The water is to be applied in basins taken around the plants at a radius of 75cm. The basins may be mulched with dry leaves or other suitable materials.

Harvesting and Postharvest management

Pepper berries mature and become ready for harvesting in 180–200 days. In high altitude areas, this period may be more by about 30–45 days. If spikes are harvested before attaining full maturity, 15–20% reduction in the weight of processed material may result.

Black pepper is produced by sun-drying the mature pepper berries for 3–5 days after their separation from spikes by threshing. To give a uniformly lustrous black colour to the finished product and to prevent mouldiness of the berries, a heat treatment is recommended as described here.

Collect suitable quantity of separated berries in a perforated basket/vessel or clean gunny bag. Dip the berries along with the container in boiling water for one minute, take out, drain and spread on a clean surface for sun-drying.

White pepper is produced by collecting fully mature berries (yellow or orange), retting them in clear water for 5–7 days, removing the outer skin completely and

drying the seed after thorough washing and cleaning. Black pepper starts yielding from third year onwards. Average pepper yield in India is 273kg/ha, while it is 425kg/ha in Indonesia, 2,000kg/ha in Malaysia and 431kg/ha in Sri Lanka.

The major products are white pepper, canned tender green pepper, bottled green pepper in brine, dehydrated green pepper, pepper oleoresin and pepper oil.

8. Cinnamon

Cinnamon (*Cinnamomumverum*) is an evergreen tree reaching to a height of 6–15m. The National Conservatory of Cassia Germplasm consists of 30 accessions. A few high quality lines have been selected from this collection and are in pre-release stage. Cinnamon and cassia are the oldest known spices. The dried inner barks of these two species are the products of commerce. The oldest cinnamon plantation is the Anjarakandy Estate (250ha) in Cannanore district of Kerala. It is cultivated in Kerala, Karnataka and Tamil Nadu. Its cultivation is more prevalent in hilly regions of the Western Ghats.

Climate and Soil

Cinnamon is a hardy plant. It tolerates a wide range of soil and climatic conditions. In the West Coast of India, its trees are grown in laterite and sandy patches with poor nutrient status. It comes up well up to an elevation of about 1,000m. It is mostly raised as an unirrigated crop. An annual rainfall of 200–250cm is ideal for its cultivation.

Varieties

Only 2 varieties have been released for commercial cultivation. They are: Navashree and Nithyashree.

Navashree is a superior selection. It has high and stable regeneration capacity (6–7 shoots/year), high yield (average yield 56kg/ha in the first 4 year), high bark recovery (40.6%), in addition to excellent quality characters (bark oil 2.7% with a very good cinnamaldehyde content 73%, bark oleoresin 8%, leaf oil 2.8%). Its very young flushes are purple which turn green in 7–10 days. It is recommended for all cinnamon-growing regions in the country, both in plains and in high altitudes (in open condition).

KonkanTej and Yercaud1, have also been released for commercial cultivation in Karnataka and Tamil Nadu, respectively.

Propagation

Cinnamon is commonly propagated through seed, though it can be propagated by cuttings and air layers. Under the West Coast conditions, cinnamon flowers in January and fruits ripen during June–August. The fully ripe fruits are either picked up from the tree or fallen ones are collected from the ground. Seeds are removed from fruits, washed free of pulp, and sown without much delay, as the seeds have a low viability. The seeds are sown in sand beds or polythene bags containing a mixture of sand, soil and well-powdered dried cowdung in a 3:3:1 ratio. The seeds germinate within 10–20 days. Frequent irrigation is required for maintaining adequate moisture level. The seedlings require artificial shading till they become 6 months old.

Cultivation

Planting

The pits of 50cm × 50cm × 50cm size are dug at a spacing of 3m × 3m. They are filled with compost and top soil before planting. Cinnamon is planted during June–July to take advantage of the monsoon for the establishment of seedlings. One-year-old seedlings are planted. In each pit, 5 seedlings can be planted. In some cases, the seeds are directly dibbled in pits that are filled with compost and soil. Partial shade in the initial years is advantageous for healthy and rapid growth of the plants.

Manuring and fertilization

Two weedings in a year (June–July and October–November) and one digging of soil around the bushes (during August–September) are done. A fertilizer dose of 20g N, 18g P_2O_5 and 25g K_2O/seedling is recommended for the first year. This dose is increased gradually to 200g N, 180g P_2O_5 and 200g K_2O for grown-up plants of 10 years and above. However equivalent quantity to substitute the recommended dose of nutrients through FYM or compost can be adopted under organic cultivation. The fertilizers are to be applied in 2 equal split doses in May–June and September–October. The cinnamon leaves, after distillation for oil, are used as a mulch in its plantations.

Irrigation

It is raised mostly as unirrigated crop. But an annual rainfall of 200–250cm is ideal. In the initial 2–3 years, watering is given during summer months twice a week. The quantity of water depends upon the soil moisture level and growth of plants.

Harvesting and Postharvest management

Two-year-old plants are coppiced during June–July to a height of about 15cm from the stump. This operation encourages the development of side shoots from the stump (Copicing). This is repeated for every side shoot, developing from the main stem during the succeeding seasons, so that the plants assume the shape of a low bush of about 2m height and a bunch of canes suitable for peeling crop up in a period of about 4 years. Regular peeling operations could be commenced in case of seedling bushes, from fourth or fifth year, depending upon the extent of development of peeler shoots.

Shoots are harvested from September to November. Usually coppicing is done in alternate years. The shoots having finger thickness and uniform brown colour are ideal for bark extraction. A 'test cut' can be made on the stem with a sharp knife to judge the suitability of time of peeling. If the bark separates readily, the cutting can be commenced immediately. The stems are cut close to the ground when they are about 2 years old, as straight as possible, 1.0–1.25m length and 1.25cm thickness. Such shoots are bundled after removing leaves and terminal shoots.

Cutting is followed by scraping and peeling operations. The peeling is a specialized operation, requiring some skill and considerable experience. It is done by using a specially made knife, which has a small and round end with projection in one side to facilitate ripping of the bark. The rough outer bark is first scrapped off. Then with brass rod, the scrapped portion is polished to facilitate easy peeling. A longitudinal slit is made from one end to the other. Then working the knife between the bark and wood, the bark is ripped quickly. The shoots cut in the morning are peeled on the same day. The peels are gathered and kept overnight under shade. They are dried first in shade for a day and then in the sunlight for 4 days. During drying, the bark contracts and assumes the shape of quill. The smaller quills are inserted into larger ones to form compound quills.

The quills are graded from ‘00000’ being the finest quality, to ‘0’ the coarsest quality. The small pieces of the bark, left after preparing the quills are graded as ‘quillings’. The very thin inner pieces of bark are dried as ‘featherings’. From the coarser canes, the bark is scrapped off, instead of peeling, and this grade is known as ‘scrapped chips’. The bark is also scrapped off without removing the outer bark and is known as ‘unscrapped chips’. The different grades of bark are powdered to get ‘cinnamon powder’.

9. Clove

Clove (*Syzygiumaromaticum*) of commerce is the dried aromatic, fully-grown but unopened flower buds. Cloves have been used in India since ancient times. It is an evergreen tree.

Climate and soil

Clove grows well in rich, loamy soil of the humid tropics. It can be grown successfully in all the areas except in the coastal sandy belt. It comes up well in the red soil of the midland of Kerala as well as in the hilly terrains of the Western Ghats at higher elevations.

Propagation

The seeds should be collected from fully ripe fruits. Fruits for seed collection, popularly known as mother of clove, are allowed to ripen on trees itself and drop down naturally. Such fruits are collected from the ground and sown directly in nursery or soaked in water overnight. The pericarp is removed before sowing. The second method gives quicker and higher germination. Only fully developed and uniform-sized seeds which show signs of germination by the presence of pink radicle are used for sowing. Though the ripe fruits can be stored for a few days by spreading them in a cool shaded place, it is advisable to sow the seeds immediately after harvesting. Heaping the fruits or keeping them tied up in airtight bags hastens the death of the seeds. Approach grafting of clove on its own rootstock is successful.

Cultivation

Beds of 15–20cm height, 1m width and convenient length are made. They are made of loose soil-sand mixture over which a layer of sand may be spread (about 5–8cm thick). Seeds can be sown in pure river sand beds but care should be taken to prevent leaching of salts in rain. Seeds are sown at 2cm spacing. The seed beds are protected from direct sunlight. If small quantity of seeds is available, they can be sown directly in polybags filled with soil and cowdung mixture. They should be kept in a shady, cool place. The germination commences in about 10–15 days and may last for about 40 days. The germinated seedlings are transplanted in polythene bags (30cm × 15cm),

containing a mixture of soil, sand and well decomposed cowdung in a 3:3:1 ratio. The seedlings are again transplanted after one year to large polythene bags containing the same potting mixture. The 18–24 months old seedlings are ready for transplanting in the field. The nurseries are sually shaded and irrigated daily to ensure uniform seedling stand. To avoid damage by crickets, 5% BHC dust may be applied in the nursery.

Planting

The pits of 75cm × 75cm × 75cm size are dug at a spacing of 6–7m. If planted as an intercrop, the spacing is to be adjusted based on the spacings of the major crop. The pits are partially filled with compost, green leaf or cattle manure and covered with top soil. The seedlings are transplanted in the main field during onset of rainy season in June–July, in lowlying areas towards the end of the monsoon (September–October). Clove prefers partial shade. It comes up well at higher elevations, having well-distributed rainfall. Under Indian conditions, it is best suited for mixed cropping in older coconut or areanut gardens or in coffee estates. Intercropping with banana is very good. Its seedlings are planted together with coconut, banana, jackfruit and mango. Training and pruning is not recommended.

Manuring and aftercare

Apply 50kg manure or compost and bone-meal or fish meal to a bearing tree/year. Organic manures can be applied as a single dose at the onset of the rainy season in trenches dug around the tree. The application of inorganic fertilizers @ 20g N(430g urea), 18g P_2O_5 (110g superphosphate), and 50g K_2O (80g of muriate of potash) /tree/year is recommended. The dose can be increased to 300g N (600g urea), 250g P_2O_5 (1,560g superphosphate) and 750g K_2O (1,250g muriate of potash)/year for a grown-up tree of 15 years or more. However equivalent quantity to substitute the recommended dose of nutrients through FYM or compost can be adopted under organic cultivation. The fertilizers must be applied in 2 equal split doses in May–June and September–October in shallow trenches dug around the plant normally about 1–

1½m away from the base. The plant basin must be always kept weed free and mulched.

Irrigation

In the first 3–4 years, extreme care should be taken especially during summer months. Plant based water application has to be very scrupulously followed.

Postharvest Management

Clove trees flower from the fourth year of its planting under good soil and management conditions. But full bearing stage is reached only after 15 years. The flowering season is September–October in plains and December–January at high altitudes. The unopened buds are harvested when they begin to turn pink. At this time, they are less than 2cm long. The opened flowers are not valued as a spice. Harvesting should be done using step ladders without damaging the branches, as it adversely affects the succeeding growth. It is a common practice among the growers not to leave the trees to bear fruits (mother of clove), as it has an adverse effect on subsequent tree growth.

The harvested flower buds are separated from the cluster by hand and spread in the drying yard for drying. The correct stage of drying when the stem of the bud becomes dark brown and the rest of the bud lighter brown. Well-dried cloves are only one-third the weight of the original. About 11,000–15,000 dried cloves weigh one kilogram.

10. Nutmeg

Nutmeg (*Myristicafragrans*) is an evergreen, conical tree reaching a height of about 10m. It produces 2 distinctly different spices—nutmeg and mace. Nutmeg is the dried kernel of seed, whereas mace is dried aril surrounding the seeds.

Climate and soil

Nutmeg thrives well in warm, humid, conditions in locations with an annual rainfall of 150cm and more. It grows well up to 1,300m above mean sea-level. Clay loam, sandy loam and red laterite soils are ideal for its cultivation. Dry climate and waterlogged conditions are not good for nutmeg.

Varieties

There are no released varieties of nutmeg in India. However 10 nutmeg accessions with high fruit set have been identified as promising lines. One line, A9/4, is in the pre-release stage. Sixty elite trees have been identified based on a survey. They could be used as parent trees for multiplication of planting materials along with other selections.

Propagation and rootstock

Nutmeg is usually propagated by seeds. Its trees being perennial and dioceious in nature, an alternate method for vegetative propagation is in progress. Epicotyl grafting, approach grafting and patch budding have proved successful in nutmeg. However, epicotyl grafting is adopted widely for its propagation.

Cultivation

Nursery

Naturally split, healthy fruits harvested during June–July are used for raising nursery. The seeds are extracted from the pericarp and sown immediately in sand beds of convenient length, 1–1.5m width and 15cm height, prepared using river sand. Regular watering is necessary for good germination. The germination commences from 30–90 days after sowing. About 20 days old sprouts are transplanted to polythene bags

containing a mixture of good soil, sand and well-decomposed cowdung in a 3:3:1 ratio. About 18–24 months old seedlings are used for transplanting in the field.

Planting

The planting in the main field is done at the onset of rainy season. The spacing varies widely. Even a spacing of 6–7m appears to be inadequate. For graft 5m × 5m spacing is optimum. Pits of 0.75m × 0.75m × 0.75m size are dug and filled with organic manure and soil 15 days earlier to planting.

The plants should be shaded in the early stages to protect from sun scorch. Permanent shade trees are planted when the site is on a hilly slope when nutmeg is grown as a monocrop. It can best be grown as an intercrop in old coconut gardens, where light shade conditions are suitable. The coconut gardens along the river- beds and adjoining areas are best-suited for its cultivation. Nutmeg requires irrigation in summer.

Generally organic manures are applied for nutmeg. Bone-meal is very popular among the growers. Manures are applied in shallow trenches or pits dug around the plants. However, a dose of 20g N(40g urea), 18g P_2O_5 (110g superphosphate) and 50g K_2O (80g muriate of potash) during the initial year and 500g N (1,090g urea), 250g P_2O_5 (1,560g superphosphate) and 100g K_2O (1,670g muriate of potash)/year in subsequent years for a fully grown up tree of 15 years or more is recommended. However equivalent quantity to substitute the recommended dose of nutrients through FYM or compost can be adopted under organic cultivation.

Aftercare

Nutmeg can be grown as an intercrop in coconut, clove, arecanut and coffee gardens. Regular mulching of plant basins after slashing weeds and shading in summers in the early years are very essential. Banana can be raised for shade in early growth phase of nutmeg at 1m away from nutmeg on three sides.

Irrigation

Nutmeg needs sufficient water for its growth, requiring irrigation in summer season. The quantity/frequency of watering depends upon the region and the condition of the plant.

Harvesting and Postharvest management

The female nutmeg tree starts fruiting from the sixth year, the peak harvesting period reaches after 20 years. The fruits are ready for harvesting 9 months after flowering. Flowering and harvesting continue throughout the year. But June– August is the peak period. The fruits ripen and become ready for harvesting when their pericarp splits open. Harvesting is done by a bill hook. The fruits are split open, the outer fleshy portion is removed, and the mace is manually separated from the nut. The nuts and mace are dried separately on a drying yard, or on a platform arranged in a kitchen. The scarlet coloured mace gradually becomes yellowish-brown and brittle when drying is completed. The fresh pericarp can be used for making pickles, jams and jellies.

11. Ginger

Ginger (*Zingiber officinale*) is one of the oldest spices with a distinct flavour and pungency. It has a wide range of uses that include culinary, flavourant in soft drinks, alcoholic and non-alcoholic beverages, confectionery, pickles, pharmaceutical preparations. India is the largest grower of ginger and also the largest producer of dry ginger in the world. Other countries cultivating ginger extensively are West Indies, Brazil, China, Japan and Indonesia. In India Kerala, Orissa, Andhra Pradesh, Himachal Pradesh, Meghalaya and West Bengal are important ginger growing states. About 60% of the area is confined to Kerala, accounting for 25% of the country's total production.

Climate and soil

Ginger grows well in warm and humid climate. It is cultivated up to 1,500m above mean sea-level. However, an optimum elevation for its successful cultivation is 300–900m. Moderate rainfall at sowing till the rhizomes sprout, fairly heavy and well-distributed showers during the growing period and dry weather about one month before harvesting are optimum requirements for its successful cultivation. Early planting helps in better growth and development of rhizomes and higher yields.

A rich soil with good drainage and aeration is ideal for its cultivation. It grows well in sandy or clayey loam, red loam and lateritic loam soils. Drainage is absolutely necessary for the prevention of disease incidence. Ginger should not be grown in the same site year-after-year.

Varieties

Several cultivars are grown in different areas in India. Ginger is always propagated by cuttings of rhizomes known as seed rhizome or sets. Rhizome sets should be treated with 0.3% Dithane M-45 solution for 30 minutes to control fungal diseases. If required, they may also treated with 0.05% Malathion and 200ppm Streptocycline. For planting, rhizome bits of 15–20g @ 1,200–1,800kg/ha may be used.

Cultivation

Planting

The land should be ploughed 4–5 times to bring the soil into fine tilth. Beds of 1m width, 15cm height and 3m length or of any convenient length are prepared at 40cm spacing. About 2,000 beds of 3m × 1m size are prepared in one hectare land. Being irrigated crop, ridges are formed 40cm apart. The optimum spacing is 30cm × 30cm under bed system of planting. A bed of 3m ×1m can accommodate 40 plants.

Manuring and fertilization

A basal dose of 25–30 tonnes of farmyard manure with NPK 75 : 50 : 50 kg/ha is recommended. Whole of P_2O_5 and half of K_2O may be applied at the time of planting. Half of N is applied 40 days after planting and the remaining N and K_2O month after that. Application of neem cake (2 tonnes/ha) as basal dressing helps reduce the incidence of soft rot of ginger and increases the yield.

Weeding and mulching

Mulching enhances germination, increases organic matter, conserves soil moisture and prevents washing of soil due to heavy rains. Two weedings are generally given to the crop. The first weeding is done just before the second mulching and repeated depending on the intensity of weed growth. If necessary, weeding is to be repeated for the third time. Mulching of ginger beds helps in soil and water conservation. The first mulching is done at the time of planting with 12.5 tonnes of green leaves/ha and the second after 40 days with 5 tonnes of green leaves/ha.

Rotation and intercropping of ginger

The crops most commonly rotated with ginger in Kerala are tapioca, chilli, rice, gingelly, ragi, groundnut and maize. Ginger is also grown with maize as a mixed crop and as an intercrop in coconut and arecanut gardens.

Ginger as intercrops in coconut plantation

Ginger as sole crop

Harvesting and Postharvest management

It is ready for harvesting in about 8 months, depending on variety, when the leaves turn yellow and start drying. The average yield is 15–30 tonnes/ha. If the crop is for green *ginger*, it is harvested in 5–6 months. Rhizomes are washed thoroughly in water 2 or 3 times to remove the soil and dirt and sun-dried for a day.

For dry ginger, the outer skin is removed with split bamboos having pointed ends. Only the outer skin is to be peeled since the essential oil of ginger remains near the skin, and dried in the sun for a week. The yield of dry ginger is 16–25% of the green ginger.

Big plumpy rhizomes free from diseases are selected immediately after harvesting. They are treated with a solution containing 0.05% of Malathion and 0.3% Dithane M-45 for 30 minutes. Drain the solution and dry the rhizomes under shade. Dried rhizomes are put in a pit of convenient size (2m × 1m) and covered with a plank fitted with 2–3 holes for aeration. In some areas, the rhizomes are loosely heaped over a layer of sand or paddy husk and covered with dry leaves in a thatched shed.

For processing into its products, ginger rhizomes are harvested 5 months after planting. The rhizomes are immature, tender and succulent. They are washed in water to remove soil and processed into salted ginger, preserved ginger in sugar syrup or brine and dry and crystallized ginger.

12. Turmeric

Turmeric (*Curcuma longa*) is used as spice, dye and in cosmetic industry and religious ceremonies. It is cultivated in Andhra Pradesh, Orissa, West Bengal, Tamil Nadu, Karnataka and Kerala. It is an erect, perennial herb grown as an annual crop.

Climate and Soil

Turmeric prefers a warm, humid climate with a rainfall of 1,500mm and temperature of 20°–30°C. It thrives well up to 1,200m above mean sea-level. Well-drained sandy or clayey loam or red loamy soils having acidic to slightly alkaline pH are ideal for its cultivation.

Varieties

Based on maturity group, its cultivars are classifed as short-duration (7 months), medium-duration (8 months) and long-duration (9 months).

Propagation

Whole or split mother rhizome or finger rhizomes are used for planting. Seed @ 2,500kg/ha is optimum. Each planting unit consists of bits of 20–25g each. The seed rhizomes are treated with Dithane M-45 (0.3%) and Ekalux (0.2%) for 30 minutes before storage as well as during the planting time.

It is either planted on raised beds of 1m width and convenient length with 15cm height or on ridges and furrows or in flat system. The spacing is kept 30cm × 15cm or 30cm × 20cm (in beds), 40–60cm × 25cm (on ridges and in furrows) and 50cm × 15cm (in flat system). Repeated cropping in the same area should be avoided.

Cultivation

Manuring and fertilization

A basal dose of farmyard manure @ 40 tonnes/ha may be incorporated at the time of land preparation. A fertilizer dose of 60:50:120kg NPK/ha is recommended. The entire dose of K_2O and half of P_2O_5 is applied as basal dose. Half of N is given 45 days after

planting and the other half with the remaining dose of P_2O_5 is given 3 months after planting.

The general dose of fertilizer should be 30–120kg N, 30–60kg P and 60–120kg K/ha depending on place and growing conditions (irrigated/non-irrigated) in 3 splits. The beds should be earthed up after each fertilizer application.

The crop is mulched immediately after planting with green leaves @ 1,2000–15,000kg/ha. It may be repeated for a second time with the same quantity of green leaves after the second fertilizer application.

Aftercare

First earthing up should be given 50–60 days after planting and the next after 40 days. It cannot withstand prolonged waterlogging and also does not tolerate heavy shade.

Intercropping

Turmeric comes up well under sparse shade also. It can be grown as an intercrop in coconut gardens like ginger or as mixed crop with red gram, chilli, colocasia, vegetables, maize and ragi.

Irrigation

Turmeric can be grown either as a rainfed crop (Kerala, Orissa and north-eastern states) or an irrigated crop (Andhra Pradesh and Tamil Nadu) depending on location. In case of irrigated crop, depending on weather and soil conditions, 15–40 irrigations may be necessary at 7–10 days intervals.

Harvesting and Postharvest Technology

Turmeric takes 7–9 months for harvesting. Drying up of the aerial portion indicates maturity. On an average, a yield of 25–30 tonnes/ha of fresh rhizomes may be obtained. The harvested rhizomes are washed well to remove adhering soil. The fingers are separated and cooked in boiling water for 1hr under slight alkaline condition (100g of sodium bicarbonate or sodium carbonate in 100 litres of water) and sun-dried on bamboo mat or drying floor for 10–15 days. For boiling turmeric, usually copper galvanized/iron or earthern vessels are used. It takes 40–60 minute of boiling to reach the correct stage (soft).

The cleaned fingers (50kg) are taken in a perforated trough of convenient size made of GI or MS sheet with extended parallel handle. The fingers are then immersed in a paddle. The alkaline solution is poured into a pan so as to immerse the fingers. It is boiled till they become soft. Mother and finger rhizomes are generally cured separately.

The dry recovery varies from 15–30% depending on variety, location and cultural practices. The dried turmeric is subjected to polishing either manually by rubbing it on concrete flooring or mechanically in power operated drums. Turmeric powder is added to the drum either as powder or as emulsion for giving bright colour to the rhizome. Cured turmeric is sorted as finger, round 'split', and marked under its varietal/trade name such as Alleppey, Erode, Duggirala, Nizamabad, Rajapuri and Cudlapah.

13. Cassava

Cassava (*Manihot esculenta*) tubers being rich in starch, is an important subsidiary food. It forms a raw material for industry (Starch & Sago) and is a component of animal, fish, and poultry feeds due to stability of starch granules in water. Starch extraction from cassava tubers is easy because of non-availability of non starchy constituents such as protein and lipids. It is processed in to food products like chips, sago, vermicelli, papads etc.

Soil and climate

This crop can be grown between 30^0N and 30^0S latitude and as altitude up to 2000 MSL but it performs better at lower altitudes. It is the most draught tolerant species among the cultivated plants (Partial opening of the stomata and changing the leaf position against sunlight at Noon time). The crop can with stand very high temperature even 35^0C but it cannot with stand frost and the growth ceases when temperature goes down to 10'C. This crop prefers the slightly acidic soil with good soil depth.

Varieties:

Several the high yielding varieties screened for the island ecosystem, the Sree Jaya and Sree Vijaya were found to be high yielding.

Plate.5

Plate. 6

Planting season

Under irrigated conditions, cassava can be planed throughout the year. For rainfed cultivation plant the setts in April-May before the onset of Southwest monsoon and the next best time for planting is August-September, with the onset of Northeastern Showers.

Tapioca grows well in well drained laterite sandy loam (or) red loam soil with a pH.between 4.5-6.5. It requires well aerated soil for uniform tuber development. The soil should be relatively high in organic matter content.

Method of land preparation

1. **Flat bed planting**: for light textural soils
2. **Ridge planting**: for sloppy lands for rainfed crop, prepare ridges across the slope/along the contour to a height of 25-30 cm.
3. **Pit/ mound method**: prepare the pit of 45 cm3 and apply the FYM and mix it with soil and mound to a height of 25-30 cm. (poorly drained soils).

Planting material

Tapioca is propagated from cutting obtained for mature stems, discarding about 10 cm from the lower part and about 25-30 cm from top portion. In traditional system stem of planting, cassava setts of 20 cm length with 10 to 12 buds are used as planting material. However, out of the 10 or 12 buds only two are allowed to sprout and then retained, while the rest are discarded and hence wasted. By minisett technique it is possible to utilize the capability of every bud to sprout and grow as a new plant and thus enhance the multiplication ratio. It is based on the concept that once the bud sprouts, the roots developed would start drawing nutrients from the soil and no more from the mother planting material and therefore the size of planting material actually does not matter as far as sprouting is concerned.

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Time of planting

Under irrigated conditions, planting of cassava can be done throughout the year. As a rain fed crop the best time of planting is April-May with the onset of pre-monsoon showers. The next best season is August-September, with the onset of north-east monsoon showers.

Land Preparation

Soil physical condition influences the plant growth and hence proper tillage is required for the successful cultivation of cassava. Loosening the soil to a depth of 20-25 cm either by tractor ploughing or spade digging facilitate better rooting. Different methods of land preparation, such as pit followed by mound, flat method, mound method and ridge method did not show any significant difference in yield. According to the situation different methods are being followed. In light textured soil flat method of land preparation, in heavy textural soil mound method and under irrigated condition ridges and furrow method of land preparation is suggested.

Selection of planting material

Disease and pest free planting material of 7-10 months maturity having a thickness of 2-3 cm may be selected for planting. For better establishment and root yield stakes obtained from bottom and middle portion of the stem after discarding the 1/3 from the total length of the stem from the top is preferred for the preparation of stakes for planting. While preparing the stakes, it is better to have a smooth circular cut rather than an irregular cut for uniform callus formation and root initiation.

Stake length and depth of planting

A stake length of 15-20 cm is found to be advantageous for higher yield. Shallow planting facilitates production of a greater number of roots. When the soil is sufficiently loose and friable stakes can be planted to a depth of 5 cm. Planting the stakes deeper results in swelling of the mother stem with consequent reduction in root size and yield. This is especially true when the soil becomes compacted.

Method of planting stakes

Different methods of planting stakes such as vertical, (90 ^{0} to the ground), slanted (45° angle) and horizontal, showed that vertical planting resulted in more uniform formation of callus tissue around the cut surface, which helped in the uniform distribution of tuber forming roots all around the base of the plant.

Spacing and plant population

Based on the branching behaviour, cassava genotypes are classified into branching, semi-branching and non-branching types. Non-branching type requires a spacing of 75 x 75 cm while semi-branching and branching types require 90 x 90 cm for optimum production. Normally, one stake is planted/hill but planting two/ hill could improve the total tuber yield but reduce the tuber size resulting adversely the market quality of the tuber.

Shoot number per hill

The sprouts emerging from the top buds are more vigorous than those emerging from the lower nodes of the stake. Removal of excess sprouts by retaining two per plant at opposite sides is better for the production of more number of tubers per plant.

Gap filling

Under field condition, all the stakes planted may not establish due to the use of poor quality planting material and adverse weather conditions, which necessitated gap filling within a reasonable time. At the time of planting stakes in the main field, about 5% of the stakes (600 No.) may be planted separate at a very close spacing of 4 x 4 cm in a nursery area of one square metre with pot watering so that the settlings at the age of 20-25 days old may be uprooted and used for gap transplantation.

Interculture and earthing up

Interculturing is important especially in the early stage of the crop for the control of weeds and to improve the physical condition of the soil. Once the cassava plant puts forth enough canopies to cover the entire field, weeds do not generally become a

problem. The first interculturing shall be sufficiently deep, done at 45-60 days after planting and a shallow interculturing and earthing up given one month after the first. The removal of excess sprouts, after retaining two at opposite sides can be done at the time of first intercultural operation.

Manures and fertilizers

A cassava crop producing a yield of 30 t/ha removes 187 kg nitrogen, 33 kg phosphorus and 233 kg potassium per ha. So in order to maintain the soil productivity the crop has to be manured adequately. For high yielding varieties of cassava, a basal dose of 12.5 tonnes of FYM/compost along with a fertilizer dose of 50 kg nitrogen, 50 kg phosphorus and 50kg potassium is recommended at the time of land preparation. When the crop attains 45-60 days after planting, a top dressing of 50 kg nitrogen and 50 kg potassium/ha has to be applied along with the first intercultural operation. For short duration varieties of cassava and local types a fertilizer dose of 50:25:50 kg N, P_2O_5 and K_2O/ha is recommended in splits of 25:25:25 kg/ ha of N, P_2O_5 and K_2O as basal and 25:25 kg of N and K_2O as top dressing. Application of manures and fertilizers at the above rate can maintain a proper balance of nutrients in the soil. Moreover, it can also maintain the availability of major, secondary and micronutrients in the soil. Nowadays, farm yard manure is a scarce resource. Experiments conducted at CTCRI revealed that green manuring*in situ* with cowpea and incorporation of residue of the crop itself can be used as alternate sources of FYM. In high P soils, P application can be skipped for the first four years, further P at the rate of 25 kg P_2O_5/ ha is enough. Soil application of lime at the rate of 1-2 t/ha was found beneficial in terms of yield and quality of tubers in acid laterite soils. Continuous cultivation of cassava leads to deficiency of micronutrients, particularly zinc. In such cases, soil application of Zn at the rate of 1 g/plant (12.5 kg/ha) at the time of planting can maintain its level in the soil and improve tuber yield.

Inter cropping

Being a long duration crop, tapioca is always cultivated with a companion cropping such as french bean, cowpea, groundnut and black gram which are short duration in nature.

Intercultural operation

Sixty to seventy five days after planting the intercrop is harvested and then the top dressing is done with 50 kg N, cassava crops in earthed up and irrigated. By the spread of the canopy there may not be any further weed growth. When weeding and hoeing are done cone should be taken not to damage the roots. Irrigation is given in 10-15 days interval.

In most of the areas the deficiency of micro nutrient like iron and zinc is commonly seen. The leaves will be pate green (or) Complete yellow to avoid this 0.5% Znso4 and 1% ferrous sulphate solution are sprayed on 60th, 75th and 90th day of planting.

Plant Protection

Tuber rot

Tuber rot is caused by *Phytophthora drechisleri*. Infected tubers show brown discoloration of internal tissue, rotten and emit foul smell and unfit for consumption (or) marketing.

Control measures

i. Provide drainage
ii. Remove the infected tubers.
iii. Incorporate *Trichoderma viridae* in the soil.

Harvesting and yield

The tuber maturity is indicated by the cracks formed in the soil, yellowing and falling of leaves. Harvesting is done by removing the soil from base of the plants. The plants are cut leaving 1-2 feet of the basal and of the stem.

14. Sweet potato

Sweet potato (*Ipomea batata)* is an herbaceous trailing perennial but cultivated as annual crop. The adventitious roots developing from stem cuttings modify in to tubers by the accumulation of starch. The tubers area rich in carbohydrates (18-29% starch), 1-2%, 0.5-2% reducing sugars. The carotene content ranges from 4 mg to 12 mg per 100g of tuber depending upon the cultivator. sweet potato is cultivated for human food and animal feed.

Soil and climate

Sweet potato is widely grown in tropical, subtropical and warm temperate areas throughout the world between 40^0N and 32^0S. This crop prefers a sandy loam with high organic matter content and good drainage is ideal. The heavy clay, saline and alkaline soils are not suitable. A pH range of 5.6-6.6 is considered to be the optimum for getting high yield. Short days promote tuber development.

Varieties

About 25 varieties were screened for their yield potential. Among them the variety Sree Bhadra and Acc. 440038 recorded the highest yield (32.8t/ha) followed by SB-198/115. However, the varieties such as CARI-SP1 and CARI-SP2 were found to be high yielding under island condition.

Nursery raising

The apical cuttings are found to be the best to secure high yields from sweet potato. A vine length of 20-40 cm with at least 3-5 nodes is found to be optimum for tuber production in different parts of India. The cut vines with intact leaves when stored under shade for two days prior to planting in main field promote better root initiation, early establishment of vines and high tuber yield. The leaves can be removed where the vines are to be transported to distant places to reduce the bulk. This method can be adopted for multiplication of planting material which involves transportation costs.

Field preparation and planting

The field is ploughed 2-3 times after incorporating 20-25 tonnes of FYM/ha. While ploughing care should be taken not to go very deep as this will encourage the production of longer roots giving very deep and becoming very slander. Hence, the preparation of soil up to the depth of 15-20 cm is sufficient for good crop.

The cuttings can be planted either on ridges with a spacing of 60 x 20 cm (or) even in flat beds where there is no problem of heavy rains and water stagnation. In some areas, long vines of 40cm length are used and planting is done in such a way that the middle portion of the cutting is burried by exposing both the ends.

Planting Season

This crop can be cultivated through the year. However, it can be planted in June-July, August-September and February-March.

Manuring

Farm yard manure (or) compost may be broadcasted @ 10 tonnes/ha. A basal dressing of 20 kg of nitrogen, 80kg of phosphorus and 120 kg of potash has to be before planting

Irrigation

The first irrigation is given immediately before planting and then the life irrigation can be given on the third day irrigation may be given in the morning and evening for two days in cases no rain in received. Moisture stress should be avoided during the period of initiations.

Inter cultivation

One weeding is necessary at 20th-25th day after planting. A quantity of 20kg of nitrogen is applied as top dressing and incorporated in to the soil. The vines should be turned 45-50 days after planting so as to prevent the production of more and more adventitious roots at each and every node.

Plant protection

Sweet potato weevil (*Cylasformicarius)*

Sweet potato weevil is the most dangerous pest causing very severe damage to the crops. The weevil is a tiny black ant like insect with distinct long snout and is 5-8 mm in length. Female lays eggs on the base of vines. The emerging grub feed the vines and its lifecycle is completed in a month. The emerging adults live for 90-120 days.

Nature of damage

Weevil feeds on the base of plants cause proliferation and hyper trophy of tissues resulting in the detachment of the aerial parts from roots. The grubs bore and make number of holes and tunnels in the tuber. Even slightly damaged tubers are unsuitable for consumption due to bitterness.

Control measures

(i) Dip the vine cuttings in fenthion (or) Fenitrothion (or) Monochrotophos 0.05% solution for 10 minutes before planting.

IPM practices for Sweet potato weevil.

Field sanitation (destroy the alternate host)

Crop rotation – Paddy-Paddy-Sweet potato- Paddy

Paddy –Cowpea- Sweet potato

Colocasia – Sweet potato

Pheromone trap

Semio chemical released by the female weevil to attract the male weevil for mating. Install the pheromone trap at 10m interval in the sweet potato crop form the day of planting.

Harvesting

The plants are ready for harvest about 110-125 days after planting. Remove the vines and dig the tubers with injuring the tubers.

Plate.11 &Plate.12 .

Sweet potato field day at farmers field in South Andaman

15. Colocasia

Colocasia or taro (*Colocasia esculanta*) is most important and one of the oldest tuber crops of the tropical and subtropical regions. The tubers, leaves and petioles are used as vegetables. The tubers contain starch (10-15 X), protein 91-2.5%), minerals, phosphorus and iron compared to other tubers.

Climate and Soil

Taro requires ware and humid conditions with mean temperature of 21-27^{0}C a well distributed rain fall of 700-1000mm during growth period. This crops comes up in all types of soils but performs better in well drained fertile loamy soils. It can stand well in heavy soils and with stand water logged condition the pH of 5-5-7.0 is idea.

Varieties

The performance of taro varieties such as Sree Rashmi, Sree kiran and Sree Pallavi were found to be good but all of them are susceptible to phytophthora leaf blight as compared to local varieties.

Plate.11 **SreeRashmi**

Plate12.**Sree Pallavi**

Plate 13.**Andaman Local**

Planting season: April- May.

Propagation: Colocasia is propagated vegetatively mostly by small cormels weighting 20-25g, healthy, disease and injury free and uniform sized planning materials.

Field Preparation

The field should be ploughed thoroughly. Then the ridges and furrows are formed at a spacing of 45-60 cm. Corms or cormels are planted on one side of the ridges at a spacing of 30-45 cm and depth of 5-7.5 cm. To plant one hectare 37000 seed tubers will be required, which is about 300kg/ha.

Colocasia needs adequate soil moisture at the time of planting for corm sprouting and development. This crop can with stand water logged condition.

Mulching

Seed tubers start sprouting 30-45 days after planting. Mulching helps to hasten sprouting, control weed growth, regulate soil temperature and retain soil moisture, mulching with dry grass (or) leaf.

Gap filling

Generally, 5-10% of the seed tubers fail to sprout in field condition. Hence, about 2000-2500 corms /cormels/ha may be planted in nursery at a close spacing so that sprouted tubers from nursery can be used for gap filling.

Fertilizer Application

The application of 80: 60: 60 : N : P :K kg / ha is economical dose for Colocasia. Half dose of N and K, and full dose of P is given at the time of planting, while the remaining half dose of N and K should be applied in two split doses first 7-10 days after sprouting and second a month later. Earthing up should be done after each top dressing.

Intercultural operation

Weeding: Weeding should be done at periodically interval to promote growth and development of corms and cormels. After weeding, earthingup is to be done along with pruning of side shoots.

Plant Protection

1. Aphids, flea beetle, leaf eating caterpillar, scale insects and taro leaf hoppers, are the major pests attacking the crop. To control these pests, the crop should be sprayed with quinalphos (or Dimethoate 0.05% spray). Mealy bugs and scale insects damage cormels and corms and hence select corms free of these pests for planting.
2. **Diseases**:

(i). Colocasia blight: This disease is caused by *phytophthoracolocasiae*. The major symptoms are oval (or) irregular purplish (or) brownish lesions with water soaked periphery appearance or leaves. In severe cases, the entire leaf lamina and the petioles are affected giving a blighted appearance and collapse of the plant.

Plate 14a.Taro Blight damage

Plate 14b. Leaf eating caterpillar

Integrated Disease management of taro blight.

- Use of field resistant varieties like mutakeshi, Jhankri and Tripura local.
- Early planting to avoid heavy monsoon rains.
- Use of healthy planting materials.
- Rouging the off types.
- Spray fungicides like Mancozeb (0.2%) or Meta laxly (0.05%).
- Treat the seed tubers with bio control agent's viz. *Trichoderma viridae*.

Harvesting

The crop matures in 150-180 days after planting. One month prior to harvest all the suckers may be wrapped around the base of the mother plant and cover with soil by earthing up and withheld the irrigation for arresting further vegetative growth. By using hand hoes (or) spades, the entire plant is to be pulled out and then the corms are separated. Damage to tubers should be avoided while harvesting. The dasheen colocasia has higher yield potential as compared to eddoe type. The average yield ranges from 12-15 ton/ha.

16. Elephant foot yam

Elephant foot yam (or) suran is as under ground stem tuber which is gaining popularity because of its yield potential and culinary properties. Due to introduction of high yielding, non-acrid varieties, this is being adopted for commercial cultivation in allover India. The corms are rich sources of carbohydrate and minerals like calcium and phosphorus. The tubers are used in various ayurvedic preparations to control piles, dysentery, asthma, swelling of lungs, vomiting, abdominal pain and as blood purifier.

Climate and soil

Amorphophallus grows very well in tropical and subtropical humid climate with a mean annual temperature of 30-35^{0}C and a well distributed rain fall of 1000-1500 mm spread over a period of 6-8 months. It can come up on variety soils but a well drained sandy loam soil (or) sandy clay loam soil with a the pH of 5.5-7.0 is ideal for the growth of this crop.

Varieties

Gajendra, Sree Padma

Plate.15 Gajendra corm

Plate 16.Gajendra plant

Propagation

(i) **Use of corm pieces**

Amorphophallus is usually propagated by offsets (or) corms the off sets are miniature tubers arising from the mother corm. In some varieties/types the daughter corms are

not produced in which the mother corm is cut vertically in to pieces of 750-1000g weight in such a way that each piece has portion of central bud from where the future bud initiates after planting. Dipping of planning material in their cow dung slurry followed by during in a shaded place is effective in entrancing the sprouting. Amorphophalus tubers have long dormancy period which can be broken by treating them with thiourea (0.1%), GA3 and ethrel 50-100 ppm.

Plate.17. Preparation of setts

Plate 18.Setts or corm pieces

Plate.19 Cormels

Field preparation and planting

The land is prepared by ploughing two the three times. Pits of 60 x 60 x 45 cm are dug at a spacing of 90 x 90 cm (or) 75 x 75 cm and the pits are filled with 4-5 kg of FYM and top soil. The planting material is placed vertically in the pits and is then covered with soil and compacted lightly. Shallow planting is ideal as the deep planting would interfere with intercultural operations, besides, most of its feeder roots are found on the surface. The ideal planting time is March-April.

Manures and Manuring

The FYM/compost @ 4-5 kg at the time of planting is applied. As base dressing of 40 kg of N, 60 kg of P and 50 kg of K is applied at the time of planting. The cut pieces of corms are dipped in cowdung slurry, dried in shade and then planted in pits at a depth of 20 cm. top dress with 40 kg N and 50 kg out one month later along with shallow intercultural operations.

Intercultural operations

Mulching: Immediately after planting, the pits are mulched with dried leaves which will induce better sprouting by conservation of moisture and helps controlling weed grown, regulates soil temperature. Paddy straw (or) green (or) dried leaves are use as mulch.

Weeding: One (or) two manual weeding is necessary, first at 45 days after planting and the second, one month after the first. The top dressing operation can be combined with this intercultural operation.

Irrigation: Immediately after planting the first irrigation is to be given to et uniform sprouting. Subsequent irrigation before monsoon can be given depending or the requirement and care should be taken to avoid water stagnation in the field.

Plate.20.Intercropping coconut garden

Plate 21. Intercropping arecanut garden

Cultivation of Elephant foot yam as an intercrop in the existing coconut gardens

Coconut and arecanut are the important plantation crops of Andaman & Nicobar islands. Presently, coconut occupies 50 % of the area (20,927ha) whereas arecanut is grown in 4046 ha. Further, horizontal expansion of area is limited in these islands, orientation should be more on the utilization of the existing available areas in the interspaces of these coconut and arecanut gardens. Intercropping of elephant foot yam is an age old practice in different parts of the country, however this technology is becoming popular in these islands very recently. Due to heavy rainfall prevailing in these islands fertilizer applied to coconut is subjected to severe leaching loss which ultimately affects the yield of main crop as well as intercrop. However, with a view to optimize the fertilizer requirement suitable to this island conditions for growing amorphophallus as an intercrop in coconut garden an experiment was conducted with 4 levels of fertilizers combinations in 20 year old coconut garden. The study revealed that application of 120:90:50 kg NPK ha-1 recorded maximum tuber weight (3.17 kg) the highest yield (18.31 t ha^{-1}) followed by application of 80:60:100 kg NPK ha^{-1} with a yield of 15.27 t ha^{-1}.

Plant protection

(i) **Collar rot** : This disease is caused by a soil borne fungus *sclerotiumrolfsii*and *Rhizactoniasolani*.

Symptoms

Brownish lesions first occur on collar regions which spread to the entire pseudo stem and cause complete yellowing of the plant. In severe case pseudo stem toppled dorm.

Plate 22. Collar rot disease Control

This disease occurs mainly due to poor drainage water logging and mechanical injury at collar regions.

The disease can be managed by

- Using disease free planting materials.
- Field sanitation.
- Providing proper drainage facility.
- In cooperation of neem cake.
- Use of biocontrolagents viz., *Trichodermaharzianum*.

  Drenching the soil with 0.2% captan.

Harvesting : This crop becomes ready for harvest 8-9 months after planting. The harvesting is done in November-December. The maturity is indicated by yellowing and drooping of the leaves. A light irrigation is necessary before harvest. The corms are dug out, cleaned and stored in well vent elated rooms ever for several months without damage. The come yield ranges from 75-100 t/ha.

17. Greater yam

Greater yam *(Dioscorea alata* L.) belongs to the family Dioscoreaceae. The genus Dioscorea has several species which are edible (*D. alata, D. esculenta*and *D. rotundata)* and for medicinal purpose (*D. floribunda)*. Among the above-mentioned species, the *D alata*is commonly and mostly grown in India. The Greater yam performs better in warm humid tropical and Sub tropical condition and it is known for high production and productivity unit area. In Tripura, the greater yam performs better than any other States of India because of the favourableagroclimatic Condition. It is considered as subsidiary Starch food among the tribal masses. Further, it is used for various purposes like preparation of fries, chips and flakes. This crop has tremendous potential/scope grow in coconut &arecanut gardens.

Climate

The Greater yam is widely cultivated in tropical regions of the world where there is a good combination of adequate moisture and good drainage. The optimum temperature verges from 30-35^{0}C. The high temperature (> 40^{0}C) coupled with dry conditions, the growth is affected at the same time if temperature goes down below 20^{0}C the growth becomes poor. This crop is highly susceptible to frost. However, this crop prefer the subtropical warm humid condition/climate

Soil

Greater yam performs better in ample moisture condition and it is relatively tolerant to dry condition. However, for better tuber grown and high yield, the maintenance of optimum moisture regime from 14th to 20th week of growth. A deep, well drained sandy loam soil with pH range of 6-6.5 is ideal for the tuber development. Heavy soils are not suitable because of water logging leads to poor tuber development and rotting of the tuber and of the tuber. In Tripura, the soils are acidic and the peak growth period (16th-20th week of the plant) coincides with the rainy season, hence the irrigation is not required (or) otherwise on (or) two irrigation would be required.

Varieties

Eight varieties of greater yams were evaluated. Among them varieties, maximum number of tubers/vine (4 nos) was obtained in the variety DA-68 which also recorded highest yield (21.8 t/ha) followed by DA-199.However, individual tuber weight was maximum in the variety DA-199 (739.43 g) whereas the least tuber weight was recorded in the variety DA-210 (308.2 g). The variety IGDA-1 recorded maximum length of tuber followed by DA-199.

Plate 23.CARI-DA1

Plate 24. SREE RUPA

Field preparation

The field must be prepared by ploughing field 3-4 times. Pits of the size 45x45x45 cm. is prepared at spacing of 1x1m, these pits are filled up with farm yam manure @ (2.0-2.5 kg/pit 20-25 tonnes/ha) and mixed with the topsoil, then mounds (or) ridges are farmed.

Propagation

The most common method of propagation is by tuber and it is practiced commercially by cutting the tuber in to several pieces (Top, middle, bottom) which are called as setts. The cut pieces of tuber must have the dormant bud (or) eye in it. To get healthy plant and high yield the use of tip portion to the tuber would be ideal as compared to middle and bottom of the same tuber when used as setts. There is a positive association between size of the setts and emergence early and produce large canopy, which inturn provides large photosynthetic area with increasing in photosynthetic efficiency leading to high dry matter production. The optimum set size would be 250-300gm/ piece/pit. Around 2500-3000 kg/ha is required to cover 1 ha of land. Aerial tubers/bulbils can also be used as planting material.

Tuber dormancy

The tubers exhibit definite period of dormancy due to the presence of batatasins (poly phenolic compounds) which is useful to extend to storage life of tubers. The period of dormancy varied from 2-3 months depending on the species. The cutting of the tuber in to pieces/ setts is done 1-2 days before the scheduled date of the planting. This helps the cut surface of heal before planning. Dusting ash at cut surface is a common traditional practice. Treating the cut surface with pesticide also can be done.

Plate 25.Cut tubers or setts

Plate.26. Sprouted tubers

A major hindrance in the popularization of high yielding varieties is its very low multiplication ratio. Yam is propagated vegetatively and seed yam (whole tuber) is the ideal source of planting material. Traditionally yam is cultivated by making setts of 250 g from mother seed yam. These are planted in mounds formed over pits at a spacing of 90 x 90 cm.From 1 kg mother seed yam only four setts could be obtained limiting the multiplication ratio to just 1:4.

Season

The photoperiodism plays a major not in aerator yam production. The day length is critical, the day lengths greater than 12 hours favours vine growth and shorter days favorer tuber formation and tuber yield. It is a sun loving crop and cannot tolerate the shade. Hence, the planting is done March-April which suits this requirement.

Planting

The cat tubers are dipped in cowdung stump and 0.2% Dithane M-45 and dried in shade. The /pieces/setts are planted at the centre of the mounds at a depth of 30-40cm.

Intercultural operations

Mulching: Mulching with paddy straw (or) crop residues (or) organic stubbles would be beneficial immediately after planting for early sprouting and better growth and development. Greater yam takes about 3-4 weeks for sprouting and another 8 weeks for sufficient vegetative cover.

Weeding: Greater yam is sensitive to competition of weeds during the early part of their growth. The weeds interferes the greater yam, when it is in leaf development and tuber bulking Weeding and earthing up to mounds are the essential intercultural operations. Two weeding will be sufficient the check the weed growth and to provide favourable conditions for the growth of plants. The first weeding should be done at the first week after 50% sprouting and second after a month. The earthing up is carried out usually along with fertilizer applications. During rainy season, the washing

away of soil from the base of the plant is common in Tripura. Hence, earthing up is very important to cover up the growing tuber which is exposed by rain as well as to bring back the fertile soil eroded by rains from the yam rhizosphere.

Manuring: Greater yam responds well to the fertilizer application. The basal dose is 60: 60 : 80 kg NPK/ha to top dressing should be done on 40th day of planting with 40kg nitrogen/ha.

Staking: Basically it is a vine crop; hence, the vines have to be staked for better yield. The staking is done with the help of bamboo poles of 3-4 m length and 10-15 cm thick so that the leaves are exposed to sun light and encourages more photosynthesis Yield from the staked plants are generally higher than those of non staked plants.

Yam as intercrop in Plantation crops

Yams are the most preferred and popular intercrop in plantation crops especially coconut and areca nut gardens as well as horticultural crops like banana and papaya.
In coconut garden with the palms spaced at 7.5 x 7.5 m apart, only 25% of the land is being utilized by the palm and with the palms of more than 25 years of age only 45-50% of the sunlight is intercepted and the remaining is infiltrated on to the ground. In young coconut plantations (>10 years), plenty of sunlight is available to intercrops. In order to utilize this natural resources efficiently along with soil nutrients and water, easily adaptable and cultivable yams and aroids are recommended. Intercropping in coconut and areca nut gardens is an age-old practice and economic gains due to intercropping had been well documented. In such cropping, coconut palms and areca nut generate the cash income and Yams and aroids partially meet the food requirements of the farm family. The adaptability of tuber crops to low input conditions makes them desirable as intercrops.

In a newly established coconut garden intercropping of yam was proved economically viable. However, as the canopy cover extends with the age of the palm, the performance of the intercrop may differ. Studies also reported that there is no reduction of yield level at 25% shade in yams when grown under different shade

conditions and higher tuber length, mean tuber girth and tuber yield/plant were obtained with larger sett size and planting at wider spacing under established coconut garden. Closer planting of 60 x 60 cm was recorded with higher yield due to more number of plants per unit area. However, the highest net returns of 37750/- and benefit cost ratio of 2.06 was realised when greater yam was planted with 200 g sett size at 90 x 90 cm spacing under coconut.

Harvesting and yield: Greater yam comes to harvest 8-9 months after planting that too when large scale leaf yellowing and drying of leaves. The tuber is dug without causing injury. The tuber yield of this crop would be 30-35 ton/ha.

Diseases

Anthracnose: Anthracnose of *D. alata* is caused by *Colletotrichumgloeoporoides*. This disease is wide spread and occurs in all dioscorea species grown in India.

Symptoms: This disease first appears as dark brown pin-held like spots on the leaves and stems. Spots on the stem spread, coalesce providing a glazed black colour to the stem which gives charred appearance externally. The leaf spots also enlarge and coalesce and the leaves dry and wither. If the young leaves are infected the whole leaf is blighted and killed.

Control:

- burning the crop residues, which is a main source of inoculum's would help to reduce the intensity and spread of the disease.
- Use of resistant varieties recommended by CTCRI, Trivandrum / Bhubaneshwar
- Spray of 0.5% Zineb (0r) ferbam at 10 days interval could control the disease effectively.

Cercospona leaf spot: The disease is caused by Cercospora sp. affect the Diuscorea sp. in all the places where crop is grown but it is severe in warm humid regions with good rainfall.

Symptoms: Dark brown spots coalesce as the disease progress.

Control: Spray of Bavistin (0.05%), Dithane M45 (0.25%) at 15 days interval commencement of the disease.

Pests

Spotted Beetle: They feeds on young leaves and tender vines. Adult is 8 mm long with blue elytra and yellow body. Eggs are laid in groups of 10-12 on leaves (or) vines. The grub is yellowish with thick fleshy abdomen and it carries in excrement on its back. It will appear in May and is found up to November. In severe cases they causes excessive defoliation.

Control: Spraying Malathion (or) Carbaryl (0-05%)

18. Tannia (or) Xanthosona

Tannia (or) Xanthosoma (*Xanthosonasagitifolius*) is a herbaceous edible species grown in Eastern and Southern states of India. This crop is getting popularity in Maharashtra, Gujarat and other parts of non traditional areas of India. The plants are looks like colacasia but there is a cleavage of basal portion of leaves at petiole attachment area, much bigger and attain a height of 2 M. but it has the nutritive value similar to Colocasia.

Climate and Soil

It grows well in warm and humid condition with mean temperatures of 21-27^{0}C and a well distributed rainfall of about 1000-1500 mm during growth period. In areas where rainfall is less, supplementary irrigation is required for successful production. It requires well drained, fertile sandy loam to day soil with a pH 5.5-6.8 is ideal for its cultivation.

Varieties: There are no specific released varieties of tannia in India only local selections with low acridity and good texture.

Two local varieties

(i) Big mother corm with numerous slender tubers.

(ii) Mother corm with 4-5 short cormel.

Plate 27.South Andaman Tannia

Plate 28. North Andaman Tannia

Propagation: Corms and cormels are used as planting material. Healthy cormels of bigger size and 20-25 cm long are commonly used. The setts from the top portion of

the main corm with a thickness of 5-10 cm containing apical bud are also used for propagation.

Field preparation: Ploughing should be done 2-3 times to a depth of 20-25c until the soil is brought to a fine tilth. Pits of 60X60x45 cm are dug at a spring of 90 x 90 cm and then the pits are filled with 3-4 kg of FYM and top soil.

Method of Planting: The cut pieces of corms are dipped in ash and planted vertically in the pits and is then covered with soil and compacted lightly. Usually the seed cornels (or) cut pieces are planter 5-6 cm depth.

Season: March-April.

Manures and fertilizers: Application of 10-15 t /ha of FYM at the time of last plough. The synthetic fertilizers dose of 80: 60: 80 kg /ha of NPK is economical. Half dose of N and K and full dose of P are applied at the time of planting. Remaining dose of N and K is applied in 2 split doses. First 7-10 days after sprouting and second 30 days after first applicative.

Intercultural operations

Weeding: Weeding and earthing up should be done at the time of fertilizer application lower leaves and petioles should be removed when start drying.

Irrigation: Irrigation is required immediately of the planting and on 3rd day as life resignation there after once in a week up to 30-45 days after planting. It cannot with stand water logging. During summer and drought periods it is essential to give 5-6 shallow irrigation to maintain soil moisture.

Pests and diseases

Pests

There are no major pest attacking this crop, however, the flea beetle, leaf eating cater pillar and leafhoppers do affect this crop. To control these pests, the crop should be sprayed with endosulphan at 0.05% (or) carbaryl at 0.2%.

Diseases

(i) Leaf Blight: this disease is caused by *Phytophthorasp*

Symptoms

(i) Yellowing of the marginal leaves (or) brownish necrotic lesions with water soaked periphery appear on leaves. In severe cases, the entire leaf lamina and the petioles are affected giving a blighted appearance and collapse of the plant.

-The disease can be managed by which has running.

-Shade for planting.

-Use healthy planting material.

-Spraying fungicides viz., Mancozeb (0.2%) or Metalaxyl (0.05).

-Tract the seed tubers with bio control agents viz. *Trichodermaviridae*.

Harvesting: Crop is ready for harvesting 8-9 months after planting. The leaves are harvested along with the petiole. Petioles are used as vegetables. By using how S (or) spades, the entire plant is to be pulled out and thin the corms are separated. After harvesting, curing of the corms and cormels is done in sun light for 4-5 days. The comes and cormelscab be stored embedded in dry soil (or) sand for a period of 4-5 months under ventilated dry and semi dark condition. The average yield ranges from 30-35 t/ha.

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