



Development of e-Courses for B.Sc.(Agriculture) Degree Program



HORT 282 PRODUCTION TECHNOLOGY OF SPICES, AROMATIC, MEDICINAL AND PLANTATION CROPS

Production Technology of Spices, Aromatic, Medicinal Plant Crops

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GINGER

Ginger: *Zingiber officinale* Rosc **Family:** *Zingiberaceae*

Ginger is a herbaceous perennial, the rhizomes of which are used as a spice. India is a leading producer of ginger in the world and during 2006-07 the country produced 3.70 lakh tonnes of the spice from an area of 1.06 lakh hectares. Ginger is cultivated in most of the states in India. However, states namely Kerala, Meghalaya, Arunachal Pradesh, Mizoram, Sikkim, Nagaland and Orissa together contribute 70 per cent to the country's total production.



Botany

It is a herbaceous perennial with underground rhizomes having serial leafy shoots of 0.5 to 0.75 m height, sheathy, linear with 15 cm. Flowers borne on a spike, condensed, oblong and cylindrical with numerous scar bracts, yellow with dark purplish spots, bisexual, epigynous, stamens only one, ovary inferior, three carpellary, fruit is an oblong capsule, seeds glabrous and fairly large.

Climate and soil

Ginger grows well in warm and humid climate and is cultivated from sea level to an altitude of 1500 m above sea level. Ginger can be grown both under rain fed and irrigated conditions. For successful cultivation of the crop, a moderate rainfall at sowing time till the rhizomes sprout, fairly heavy and well distributed showers during the growing period and dry weather for about a month before harvesting are necessary. Ginger thrives best in well drained soils like sandy loam, clay loam, red loam or lateritic loam. A friable loam rich in humus is ideal. However, being an exhausting crop it is not desirable to grow ginger in the same soil year after year.

Varieties

Several cultivars of ginger are grown in different ginger growing areas in India and they are generally named after the localities where they are grown. Some of the prominent indigenous cultivars are Maran, Kuruppampadi, Ernad, Wayanad, Himachal and Nadia. Exotic cultivars such as Rio-de-Janeiro have also become very popular among cultivators. High altitude research station, Pottangi, Orissa has released three improved varieties Suprabha, Suruchi and Surari.

Season

The best time for planting ginger in the West Coast of India is during the first fortnight of May with the receipt of pre monsoon showers. Under irrigated conditions, it can be planted well in advance during the middle of February or early March. Burning the surface soil and early planting with the receipt of summer showers results in higher yield and reduces disease incidence.

Land Preparation

The land is to be ploughed 4 to 5 times or dug thoroughly with receipt of early summer showers to bring the soil to fine tilth. Beds of about 1 m width, 15 cm height and of convenient length are prepared with an inter-space of 50 cm in between beds. In the case of irrigated crop, ridges are formed 40 cm apart. In areas prone to rhizome rot disease and nematode infestations, solarization of beds for 40 days using transparent polythene sheets is recommended.

Planting

Ginger is propagated by portions of rhizomes known as seed rhizomes. Carefully preserved seed rhizomes are cut into small pieces of 2.5-5.0 cm length weighing 20-25 g each having one or two good buds. The seed rate varies from region to region and with the method of cultivation adopted.

In Kerala, the seed rate varies from 1500 to 1800 kg/ha. At higher altitudes the seed rate may vary from 2000 to 2500 kg/ha. The seed rhizomes are treated with Mancozeb 0.3% (3 g/L of water) for 30 minutes, shade dried for 3-4 hours and planted at a spacing of 20-25 cm along the rows and 20-25 cm between the rows. The seed rhizome bits are placed in shallow pits prepared with a hand hoe and covered with well rotten farm yard manure and a thin layer of soil and levelled.



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Manuring

At the time of planting, well decomposed cattle manure or compost @ 25-30 tonnes/ha has to be applied either by broadcasting over the beds prior to planting or applied in the pits at the time of planting. Application of neem cake @ 2 tonnes/ha at the time of planting helps in reducing the incidence of rhizome rot disease/ nematode and increasing the yield.

The recommended dose of fertilizer for ginger is 75 kg N, 50 kg P₂O₅ and 50 kg K₂O per

ha. The fertilizers are to be applied in split doses (Table 3). The beds are to be earthed up, after each top dressing with the fertilizers. In zinc deficient soils basal application of zinc fertilizer up to 6 kg zinc/ha (30 kg of zinc sulphate/ha) gives good yield.

Fertilizer schedule for ginger (per ha)

Fertilizer	Basal application	After 45 days	After 90 days
N	-	37.5 kg	37.5 kg
P ₂ O ₅	50 kg	-	-
K ₂ O	-	25 kg	25 kg
Compost/ Cow dung	25-30 tonnes	-	-
Neem cake	2 tonnes	-	-

Ginger Mulching

Mulching the beds with green leaves/organic wastes is essential to prevent soil splashing and erosion of soil due to heavy rain. It also adds organic matter to the soil, checks weed emergence and conserves moisture during the latter part of the cropping season. The first mulching is done at the time of planting with green leaves @ 10-12 tonnes/ha. Mulching is to be repeated @ 7.5 tonnes/ha at 45 and 90 days after planting, immediately after weeding, application of fertilizers and earthing up.

Intercultivation

Weeding is done just before fertilizer application and mulching; 2-3 weedings are required depending on the intensity of weed growth. Proper drainage channels are to be provided when there is stagnation of water.

Earthing up is essential to prevent exposure of rhizomes and provide sufficient soil volume for free development of rhizomes. It is done at 45 and 90 days after planting immediately after weeding and application of fertilizers.

Crop rotation and mixed cropping

Crop rotation is generally followed in ginger. The crops most commonly rotated with ginger are tapioca, ragi, paddy, gingelly, maize and vegetables. In Karnataka, ginger is also mixed cropped with ragi, red gram and castor. Ginger is also grown as an intercrop in coconut, arecanut, coffee and orange plantations in Kerala and Karnataka. However, crop rotation using

tomato, potato, chillies, brinjal and peanut should be avoided, as these plants are hosts for the wilt causing organism, *Ralstonia solanacearum*.

Plant protection Diseases

Soft rot

Soft rot is the most destructive disease of ginger which results in total loss of affected clumps. The disease is soil borne and is caused by *Pythium aphanidermatum*. *Pythium vexans* and *P. myriotylum* are also reported to be associated with the disease. The fungus multiplies with build up of soil moisture with the onset of south west monsoon. Younger sprouts are the most susceptible to the



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pathogen. The infection starts at the collar region of the pseudo stem and progresses upwards as well as downwards. The collar region of the affected pseudo stem becomes water soaked and the rotting spreads to the rhizome resulting in soft rot. At a later stage root infection is also noticed. Foliar symptoms appear as light yellowing of the tips of lower leaves which gradually spreads to the leaf blades. In early stages of the disease, the middle portion of the leaves remain green while the margins become yellow. The yellowing spreads to all leaves of the plant from the lower region upwards and is followed by drooping, withering and drying of pseudo stems.

Treatment of seed rhizomes with Mancozeb 0.3% for 30 minutes before storage and once again before planting reduces the incidence of the disease. Cultural practices such as selection of well drained soils for planting is important for managing the disease, since stagnation of water predisposes the plant to infection. Seed rhizomes are to be selected from disease free gardens, as the disease is also seed borne. Application of *Trichoderma harzianum* along with Neem cake @ 1 kg/bed helps in preventing the disease. Once the disease is located in the field, removal of affected clumps and drenching the affected and surrounding beds with mancozeb 0.3% checks the spread of the disease.

Bacterial wilt

Bacterial wilt caused by *Ralstonia solanacearum* Biovar- also a soil and seed borne disease that occurs during south west monsoon. Water soaked spots appear at the collar region the pseudo stem and progresses upwards and downwards. The



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first conspicuous symptom is mild drooping and curling of leaf margins of the lower leaves which spread upwards. Yellowing starts from the lowermost leaves and gradually progresses to the upper leaves. In the advanced stage, the plants exhibit severe yellowing and wilting symptoms. The vascular tissues of the affected pseudo stems show dark streaks. The affected pseudo stem and rhizome when pressed gently extrudes milky ooze from the vascular strands. Ultimately rhizomes rot.

The cultural practices adopted for managing soft rot are also to be adopted for bacterial wilt. Seed rhizomes must be taken from disease free fields for planting. The seed rhizomes may be treated with Streptocycline 200 ppm for 30 minutes and shade dried before planting. Once the disease is noticed in the field all beds should be drenched with Bordeaux mixture 1% or copper oxychloride 0.2%.

Leaf spot

Leaf spot is caused by *Phyllosticta zingiberi* and the disease is noticed on the leaves from July to October. The disease starts as water soaked spot and later turns as white spot surrounded by dark brown margins and yellow halo. The lesions enlarge and adjacent lesions coalesce to form necrotic areas. The disease spreads through



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rain splashes during intermittent showers. The incidence of the disease is severe in ginger grown under exposed conditions. The disease can be controlled by regular spraying of Bordeaux mixture 1% or mancozeb 0.2%.

Nematode pests

Root knot (*Meloidogyne* spp.), burrowing (*Radopholus similis*) and lesion (*Pratylenchus* spp.) nematodes are important nematode pests of ginger. Stunting, chlorosis, poor tillering and necrosis of leaves are the common aerial symptoms. Characteristic root galls and lesions that lead to rotting are generally seen in roots. The infested rhizomes have brown, water soaked areas in the outer tissues. Nematode infestation aggravates rhizome rot disease. The nematodes can be controlled by treating infested rhizomes with hot water (50°C) for 10 minutes, using nematode free seed rhizomes and solarizing ginger beds for 40 days. In areas where root knot nematode population is high, the resistant variety IISR-Mahima may be cultivated. *Pochonia chlamydosporia*, a nematode biocontrol agent can be incorporated in ginger beds (20 g/bed at 10^6 cfu/g) at the time of sowing.



Insect pests

Shoot borer

The shoot borer (*Conogethes punctiferalis*) is the most serious pest of ginger. The larvae bore into pseudostems and feed on internal tissues resulting in yellowing and drying of leaves of infested pseudostems. The presence of a bore-hole on the pseudo stem through which frass is extruded and the withered and yellow central shoot is a characteristic symptom of pest infestation. The adult is a medium sized moth with a wingspan of about 20 mm; the wings are orange-yellow with minute black spots. Fully grown larvae are light brown with sparse hairs. The pest population is higher in the field during September-October.

The shoot borer can be managed by spraying Malathion (0.1%) at 21 day intervals during July to October. The spraying is to be initiated when the first symptom of pest attack is seen on the top most leaves on the pseudostem. An integrated strategy involving pruning and destroying freshly infested pseudostems during July-August (at fortnightly intervals) and spraying Malathion (0.1%) during September-October (at monthly intervals) is also effective against the pest.

Rhizome scale

The rhizome scale (*Aspidiella hartii*) infests rhizomes in the field (at later stages) and in storage. Adult (female) scales are circular (about 1 mm diameter) and light brown to grey and appear as encrustations on the rhizomes. They feed on sap and when the rhizomes are severely infested, they become shriveled and desiccated affecting its germination. The pest can be managed by treating the seed material with Quinalphos (0.075%) (for 20-30 minutes) before storage and also before sowing in case the infestation persists. Severely infested rhizomes are to be discarded before storage.

Minor pests

Larvae of leaf roller (*Udaspes folus*) cut and fold leaves and feed from within. The adults are medium sized butterflies with brownish black wings with white spots; the larvae are dark green. A spray with carbaryl (0.1%) or dimethoate (0.05%) may be undertaken when the infestation is severe.

Root grubs occasionally feed on tender rhizomes, roots and base of pseudostems causing yellowing and wilting of shoots. The pest can be controlled by drenching the soil with chloropyrifos (0.075%).

Harvesting and curing

The crop is ready for harvest in about 8 months after planting when the leaves turn yellow, and start drying up gradually. The clumps are lifted carefully with a spade or digging fork

and the rhizomes are separated from the dried up leaves, roots and adhering soil.

For preparing vegetable ginger, harvesting is done from sixth month onwards. The rhizomes are thoroughly washed in water and sun-dried for a day.

For preparing dry ginger, the produce (harvested after 8 months) is soaked in water for 6-7 hours. The rhizomes are then rubbed well to clean the extraneous matter. After cleaning, the rhizomes are removed from water and the outer skin is removed with bamboo splinters having pointed ends. Deep scraping



may be avoided to prevent damage of oil cells which are just below the outer skin. The peeled rhizomes are washed and dried in sun uniformly for 1 week. The dry rhizomes are rubbed together to get rid of the last bit of skin or dirt. The yield of dry ginger is 19.25% of fresh ginger depending on the variety and location where the crop is grown.

Fresh ginger (with relatively low fibre) harvested at 170-180 days after planting can be used for preparing salted ginger. Tender rhizomes with a portion of the pseudostem may be washed thoroughly and soaked in 30% salt solution containing 1% citric acid. After 14 days it is ready for use and can be stored under refrigeration.

Storage of Seed rhizomes

In order to obtain good germination, the seed rhizomes are to be stored properly in pits under shade. For seed material, bold and healthy rhizomes from disease free plants are selected immediately after harvest. For this purpose, healthy and disease-free clumps are marked in the field when the crop is 6-8 months old and still green. The seed rhizomes are treated with a solution containing quinalphos 0.075% and mancozeb 0.3% for 30 minutes and dried under shade. The seed rhizomes are stored in pits of convenient size in sheds. The walls of the pits may be coated with cow dung paste. The seed rhizomes are placed in pits in layers along with well dried sand/saw dust (put one layer of seed rhizomes, then put 2 cm thick layer of sand/saw dust). Sufficient gap is to be left at the top of the pits for adequate aeration. The pits can be covered with wooden planks with one or two small openings for aeration. The seed rhizomes in the pits may be checked once in about 21 days by removing the plank and shriveled and disease affected rhizome are to be removed. The seed rhizomes can also be stored in pits dug in the ground under shade.

1. Ginger belongs to the family _____
2. Mention the exotic cultivars of ginger _____

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3. Ginger is propagated by _____
4. Essential intercultural operations in ginger _____
5. Popular exotic cultivars of ginger _____

TURMERIC

(*Curcuma longa*, Zingiberaceae)

Turmeric is the dried rhizome of *Curcuma longa*, an herbaceous plant, and native to tropical south East Asia. The rhizome has 1.8 to 5.4 percent curcumin, the pigment and 2.5 to 7.2 percent of essential oil. It is used as an important condiment and as a dye with varied application in drug and cosmetic industries. In India, it is grown in an area of 104,500 ha producing annually 3, 28,800 tonnes. Although, India is leading in its production (75% of world output), the average productivity and quality are not satisfactory and these limit our export to about 10 to 15 percent of our production only, annually 18 to 20 crores worth of turmeric are exported. In India, Andhra Pradesh is the leading state followed by Maharashtra, Tamil Nadu, Orissa, Kerala and Bihar.

Botany

It is a herbaceous perennial with a thick under ground rhizome giving rise to primary and secondary rhizomes called fingers. The leaves are broadly lanceolate with long stalks. The flowers are born on separate peduncle arising directly from the rhizome. There are four important species of curcuma. They are (a) *Curcuma longa*, the widely cultivated type (b) *C. aromatica*, the Cochin turmeric or kasturi manjal (c) *C. angustifolia*, East Indian arrow root having plenty of starch in its rhizome and (d) *C. amada*, mango ginger, which has the taste and flavour of raw mango.



Climatic and soil

Turmeric can be grown in diverse tropical condition from sea level to 1500m in the hills, at a temperature range of 20 to 30°C with a rainfall of 1500 to 2250 mm per annum. It is also grown as an irrigated crop. It is grown in different types of soil from lights black, loam and red soils to clay loams, but it thrives best in a well drained sandy rich in humus content.

Varieties

Preparation of land

The land is prepared with the receipt of early monsoon. Soil is brought to a fine giving about four deep ploughings. Weed, stubbles, roots etc. are removed. Immediately after the receipt of pre- monsoon showers, beds of 1 to 1.5m width and 15cm between beds is prepared. Planting is also done by forming ridges and furrows.

Planting

Kerala and others west costal areas, crop can be planted during April – May with the receipt of pre-monsoon showers. In Andhra Pradesh and Tamil Nadu, sowing is done during May – June or July – August. Since turmeric is a shade loving plant, castor or *Sesbania grandifolia* may be raised along the borderlines in the field.

Seed material

Whole or split mother rhizomes weighing 35 to 44g are used for planting. Well developed healthy and disease free rhizomes are to be selected. Rhizomes are treated with 0.3 percent Malathion for 30 minutes before storing. Two system of planting viz. flat beds and ridges and furrows (45cm) methods are adopted in India. Small pits are made hand hoe in ridges with a spacing of 15cm covered with soil or dry powdered cattle manure. The optimum spacing in furrows and ridges is about 45 cm between the rows and 15 cm between the plants. A seed rate of 1500-2000 Kg of rhizomes is required for one hectare.

Manure and manuring

Farm yard manure @ 10t/ha is applied as basal dressing.

Manure	Tamil Nadu (Kg/ha)	Kerala (Kg/ha)
Neem cake	200 – Basal	-
N	125kg N - 25kg each at basal, 30,60,90 and 120 days after planting respectively	30kg N - 20,10kg N at 40 and 90 days after planting respectively
P ₂ O ₅	60 kg as basal	60 kg as basal
K ₂ O	60 kg as basal	60 kg – half as basal and half at 90 days after planting
FeSO ₄	30 kg as basal	-

Mulching

The crop is to be mulched immediately after planting with green leaves or banana pseudostem or sugarcane trash at the rate of 12 to 15 tonnes per hectare. It may be repeated

for second time after 50 days with the same quality of green leaves after weeding and application of fertilizers.

After cultivation and growing as intercrop

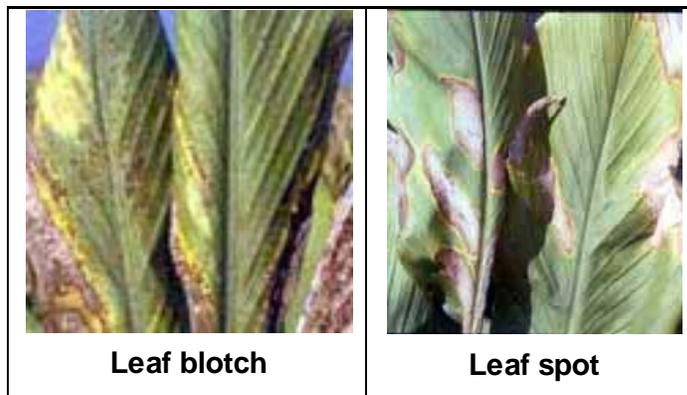
Weeding may be done thrice at 60, 120, and 150 days after planting depending upon weed intensity. It can be grown as be raised as mixed crops with chillies, colocasia, onion, brinjal and cereals like maize, ragi, etc. In some places, double inter cropping viz., Fenugreek + Onion in turmeric field 15 to 20 irrigations in heavy soils and 35 to 40 in light soil. Moisture stress affects the growth and development of the rhizome bulking stage.

Plant protection

Diseases

Leaf blotch

Leaf blotch is caused by *Taphrina maculans* and appears as small, oval, rectangular or irregular brown spots on either side of the leaves which soon become dirty yellow or dark brown. The leaves also turn yellow. In severe cases the plants present a scorched appearance and the rhizome yield is reduced. The disease can be controlled by spraying mancozeb 0.2 per cent.



Leaf spot

Leaf spot is caused by *Colletotrichum capsici* and appears as brown spots of various sizes on the upper surface of the young leaves. The spots are irregular in shape and white or grey in the centre. Later, two or more spots may **coalesce** and form an irregular patch covering almost the whole leaf. The affected leaves eventually dry up. The rhizomes do not develop well. The disease can be controlled by spraying zineb 0.3 per cent or Bordeaux mixture 1 per cent.

Rhizome rot

The disease is caused by *Pythium graminicolum* or *P. aphanidermatum*. The collar region of the pseudo stem becomes soft and water soaked, resulting in collapse of the plant and decay of rhizomes. Treating the seed rhizomes with mancozeb 0.3 per cent for 30 minutes prior to storage and at the time of sowing prevents the disease. When the disease is noticed in the field, the beds should be drenched with mancozeb 0.3 per cent.



Nematode pests

Root knot nematodes (*Meloidogyne* spp.) and burrowing nematode (*Radopholus similis*) are the two important nematodes causing damage to turmeric. Root lesion nematodes (*Pratylenchus* spp.) are of common occurrence in Andhra Pradesh. Wherever, nematode problems are common, use only healthy, nematode-free planting material. Increasing the organic content of the soil also checks the multiplication of nematodes. *Pochonia chlamydosporia* can be applied to the beds at the time of sowing @ 20 grams/bed (at 10^6 cfu/g) for management of nematode problems.

Insect pests

Shoot borer

The shoot borer (*Conogethes punctiferalis*) is the most serious pest of turmeric. The larvae bore into pseudo stems and feed on internal tissues. The presence of a bore-hole on the pseudo stem through which frass is extruded and the withered central shoot is a characteristic symptom of pest infestation. The adult is a medium sized moth with a wingspan of about 20 mm; the wings are orange-yellow with minute black spots. Fully-grown larvae are light brown with sparse hairs. Spraying Malathion (0.1%) at 21 day intervals during July to October is effective in controlling the pest infestation. The spraying has to be initiated when the first symptom of pest attack is seen on the inner most leaf.

Rhizome scale

The rhizome scale (*Aspidiella hartii*) infests rhizomes in the field (at later stages of the crop) and in storage. Adult (female) scales are circular (about 1mm diameter) and light brown to grey and appear as encrustations on the rhizomes. They feed on sap and when the rhizomes are severely infested, they become shrivelled and desiccated affecting its germination. Treat seed material with quinalphos (0.075 per cent) (for 20-30 minutes) before storage and also before sowing in case the infestation persists. Discard and do not store severely infested rhizomes.

Minor pests

Adults and larvae of leaf feeding beetles such as *Lema* spp. feed on leaves especially during the monsoon season and form elongated parallel feeding marks on them. The spraying of Malathion (0.1 per cent) undertaken for the management of shoot borer is sufficient to manage this pest.

The lace wing bug (*Stephanitis typicus*) infests the foliage causing them to turn pale and dry up. The pest infestation is more common during the post monsoon period especially in drier regions of the country. Spraying dimethoate (0.05 per cent) is effective in managing the pest.

The turmeric thrips (*Panchaetothrips indicus*) infests the leaves causing them to roll, turn pale and gradually dry up. The pest infestation is more common during the post monsoon period especially in drier regions of the country. Spraying dimethoate (0.05 per cent) is effective for the management of the pest.

Harvesting

Depending upon the variety, the crop becomes ready for harvest in seven to nine month. Usually it extends from January – March. Early varieties mature in 7 to 8 month, medium varieties after 9 month. The land is ploughed and the rhizomes are gathered by hand picking or the clumps are carefully lifted with a spade. Harvested rhizomes are cleaned of mud other extraneous matter adhering to them. The average yield per hectare is 20 to 25 tonnes of green Turmeric.



Preservation of rhizomes

Rhizomes for seed purpose are generally stored after heaping under the shade of a tree in well ventilated shed and covered with turmeric leaves. Sometimes the heap is plastered with earth mixed with cow dung. The seed rhizomes can also be stored in pits with sawdust. The pits can be covered with wooden planks with one or two holes for aeration.

Processing of turmeric

Processing of turmeric involves three steps 1. Curing, 2. Polishing and 3. Colouring

1. Curing

Fingers are separated from mother rhizomes and are usually kept as seed material. The fresh turmeric is cured before marketing. Curing involves boiling of fresh rhizomes in water and drying in the sun.

Traditional method of curing

In the traditional method, the cleaned rhizomes are boiled in copper or galvanized iron or earthen vessels, with water just enough to soak them. In certain places, cow dung slurry is used as boiling medium. From hygienic point of view, such rhizomes fetch poor market value. Boiling is stopped when froth comes out and white fumes appear giving out a typical odour. The boiling lasts for 45 to 60 minutes when the rhizomes are soft. Over cooking spoils the colour of the final product. While under cooking renders the dried product brittle.

Improved scientific method of curing

In this method of curing the cleaned fingers (approximately 50 kg) are taken in a perforated trough of size 0.9x0.55x0.4 m, made of GI or MS sheet with extended parallel handle. The perforated trough containing the fingers is then immersed in the pan. The alkaline

solution (0.1% sodium carbonate or sodium bicarbonate) is poured into the trough so as to immerse the turmeric fingers. The wholesome is boiled till the fingers become soft. The cooked fingers are taken out of the pan by lifting the trough and draining the solution into the pan. Alkalinity of the boiling water helps in imparting orange yellow tinge to the core of turmeric.

The drained solution in the pan can also be used for boiling another lot of turmeric along with the fresh solution prepared for the purpose. The cooking of turmeric is to be done within two or three days after harvesting. The mother rhizomes and the fingers are generally cured separately.

The cooked fingers are dried in the sun by spreading 5 to 7 cm thick layers on bamboo mat or drying floor. A thinner layer is not desirable, as the colour of the dried product may be adversely affected. During night time, the materials should be heaped or covered. It may take 10 to 15 days for the rhizomes to become completely dry. The yield of the dry product varies from 20 to 30 percent depending upon the location where the crop is grown.

2. Polishing

Dried turmeric has poor appearance and a rough dull outer surface with scales and root bits. The appearance is improved by smoothing and polishing outer surface by manual or mechanical rubbing.

Manual polishing: It consists of rubbing the dried turmeric fingers on a hard surface or trampling them under feet, wrapping in gunny bags.

Improved method: The improved method is by using hand operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal mesh. When the drum filled with turmeric is rotated at 30 rpm, polishing is effected by abrasion of the surface against the mesh as well as by mutual rubbing against each other as they roll inside the drum. The turmeric is also polished in power- operated drums. The yield of polished turmeric from the raw materials varies from 15 to 25 percent.

3. Colouring

It is done to give a good appearance and better finish to the product. This is done to half polished rhizomes in two ways, known as dry and wet colouring.

Dry colouring: Turmeric powder is added to the polishing drum in the last 10 minutes in dry process.

Wet colouring: In this process, turmeric powder is suspended in water and mixed by sprinkling inside the polishing basket. For giving a brighter colour the boiled, dried and half polished fingers are taken in baskets which are shaken continuously when an emulsion is poured in. When the fingers are uniformly coated with the emulsion, they may be dried in the

sun. The composition of the emulsion required for coating, 100 kg of half boiled turmeric is as follows, Alum 0.04 kg, Sodium bisulphate 30 g, Turmeric powder 2.00 kg, Conc. HCl 30 ml and Castor seed oil 0.14 kg

1. Scientific name for turmeric _____
2. In turmeric the primary and secondary rhizomes are called _____
3. The important species of curcuma which has the taste and flavour of raw mango.
4. Name the plant which is used as shade plant in the turmeric field
5. Seed material used for propagation in turmeric?

PEPPER

(*Piper nigrum*, Piperaceae)

Black pepper, the king of spices, is obtained from the perennial climbing vine, *Piper nigrum* which is indigenous to the tropical forests of Western Ghats of South India. It is one of the important and earliest known spices produced and exported from India. It is grown in about 1.36 lakhs ha land with an annual production of 32 thousand tonnes, largely distributed in Kerala (94%), Karnataka (5%), the rest being Tamil Nadu, Andhra Pradesh and north eastern states especially Assam. India accounts for 54 per cent of the total area under pepper in the world but its share of production is only 26.6 per cent where as the other countries like Brazil, Indonesia, Malaysia accounts for lesser percentage of area but with more share in the total production due to their productivity. Annually, India is exporting about 41000 tones of black pepper earning a foreign exchange of Rs.240 crores.

Botany

It is a climbing evergreen plant and grows to a height of 10m or more. The vines branch horizontally from the nodes and do not attain length, but the full grown vines completely cover the standard presenting the appearance of bush. Based on growth habits, morphological characters and biological functions, five distinct types of stem portions can be identified in the shoot system of a pepper vine.



1. Main Stem which originate from a seed or from a stem cutting. It climbs on a support with the aid of aerial or adventitious roots.

2. Runner Shoots are produced from the basal portion of the main stem, growing at right angle to the main stem, usually restricted up to 50 cm from the ground

3. Fruiting branches (Plagiotropes) are produced from the nodes of the main stem and they grow laterally more or less at right angles to the main stem, bearing the spikes.

4. Topshoots (Orthotropes): After a period of vertical growth, the top portion of the main shoots attains a bushy appearance with shorter, thicker internodes and profuse branching with

large number of adventitious roots at the nodes. This portion of the main shoot is called top shoots or orthotropes.

5. Hanging shoots (Geotropes): In a fully grown vine, some of the plagiotropes at the top portion are seen to give rise to a special type of shoots which hang down and grow geotropically.

The leaves are broadly lanceolate, but wide variations occur in leaf shape and are arranged alternately. The inflorescence is a catkin produced at the nodes opposite to the upper leaves. Flowers are very minute. Monoecious or dioecious or hermaphrodite forms occur in different varieties. High yielding forms should have more percentage of bisexual flowers and in cultivated varieties these flowers will be more than 80 per cent. In case, if it is less, it is compensated by the higher per cent of female flowers. The male flowers are very few, 1 to 19 per cent in different varieties. The fruit is a single seeded berry, which has a thin, soft pericarp surrounding the seeds. It takes approximately six months to mature after flowering. Fruit setting depends upon the sex of the vine; season etc. and it will be normally about 50 percent in cultivated varieties. Sometimes, spike shedding occurs to the extent of 14 to 65 percent causing considerable loss. Spraying of IAA 50 ppm or planofix 50 ppm and or zinc 0.5 per cent at the time of berry setting stage reduces spike shedding.

Climate and soil

Pepper is a plant of humid tropics requiring adequate rainfall and humidity. The hot and humid climate of sub mountainous tracts of Western Ghats and Eastern Ghats is ideal for its growth. It grows successfully between 20⁰ north and south latitude and from sea level up to 1500 meters above MSL. The crop tolerates temperatures between 10⁰ and 40⁰C. A well distributed annual rainfall or 125-200 cm considered ideal for pepper.

Pepper can be grown in a wide range of soils such as clay loam, red loam, sandy loam and lateritic soils with a pH of 4.5 to 6.0, though in its natural habitat, it thrives best on virgin soil rich in organic matter.

Varieties

Majority of the cultivated types of pepper are monoecious. Over 75 cultivars of pepper are being cultivated in India; Karimunda is the most popular of all the established cultivars at Kottanadan, Narayakkodi, Aimpiriyam, Neelamundi, Kuthiravally, Balancotta, Kulluvally, Malligesara and Uddagare. Recently a number of improved cultivars have been evolved and released for cultivation.

Improved varieties of Black pepper

	Name	Percentage	Other attributes
1.	Panniyur-1	F1 hybrid between Uthirankotta X Cheriyakaniakadan	2.5kg/vine, 1200 kg/ha, more adaptable to open conditions, sensitive to excess shade, dry recovery: 35.3% oleoresin: 11.8% essential oil: 3.5% piperine 5.3%
2	Panniyur-2 (Krishna)	OP seedlings of Balankotta	4.5kg/vine, 2828 kg/ha, shade tolerant, medium sized berries, dry recovery: 35.7%, oleoresin: 10.9%, piperine: 6.6%.
3	Panniyur-3 (Shima)	F1 hybrid between Uthirankotta X Cheriyakaniyakadan	4.4kg/vine, 2169 kg/ha, excessive vegetative vigour, long spike, bold berries, prefers open condition, dry recovery: 27.8% Oleoresin: 12.6%. Piperine: 5.2%
4	Panniyur-4	Selection from Kuthiravally type II	2.3kg/vine, 1419 kg/ha, stable in yield, performs well even under adverse conditions, dry recovery: 34.7%, oleoresin: 9.2%
5	Panniyur-5	O.P Progeny of Perumkodi	2.75kg / vine, 3075 kg/ha, suitable for intercropping in Arecanut gardens dry recovery: 35.7%, Piperine:5.3%, Oleoresins:12.33%, essential oil:3.80%
6	Sreekara	A selection from Karimunda(K.S.14)	4.8kg/vine, 2352 kg/ha, tolerant to drought dry recovery 35%, piperine: 5.0%, Oleoresins: 13%, essential oils: 7%
7	Subhakara	A selection from Karimunda (K.S.27)	4.2kg/vine, 2677 kg/ha, dry recovery: 35%, piperine: 3.4%, oleoresins: 12%, essential oils:6%.
8	Panchami	A selection from Aimpiyan coll.856	5.2 kg/vine, 8320 kg green pepper/ha, piperine 4.7% oleoresins: 12.5%, essential oil 3.4%, dry recovery 34.0%
9	Pournami	A selection from Ottaplackal type coll. No. 812	4.7 kg/vine, 7526 kg of green pepper/ha, Piperine 4.1%, oleoresins 13.87, Essential oil 3.4%, dry recovery 31%, tolerant to root knot nematode
10	PLD-2	Clonal Selection from Kottanadan	4.7 kg per vine, 31.13% dry recovery, oleoresin 15.45%, essential oil 4.8%, piperine 3.0%

Propagation

Pepper is propagated by cuttings raised mainly from the runner shoots. Cuttings from the lateral branches are seldom used, since in addition to reduction in the number of fruiting shoots, the vines raised from them are generally in raising pepper in pots.

Runner shoots from high yielding and healthy vines are kept coiled on wooden pegs fixed at the base of the vine to prevent the shoots are separated from the vine in February-March and after trimming the leaves, cuttings of 2 to 3 nodes each are planted either in nursery beds or polythene bags filled with fertile soil. Cuttings from middle 1/3 of the shoots are desirable as they are high yielding. Adequate shade is to be provided and irrigated frequently. The cuttings will strike roots and become ready for planting in May-June.

A rapid multiplication technique has been developed by the National Research centre for Spices, Calicut. In this method, a trench of 0.75 m deep rooting medium (preferably forest soil, sand and cow dung mixture at 1:1:1. Split halves of bamboos with Septa with 8 to 10 cm diameter and 1, 25 to 1.50 m length are fixed at 45° angles on a strong support. The bamboos can be arranged touching one another. Rooted cuttings are planted in the trench at the rate of one cutting each for one bamboo. The lower portions of the bamboo are filled with a rooting medium (coir dust and cattle manure mixture 1:1) and the growing vine is tied to the bamboo in such a way as to keep the nodes pressed into the rooting medium. The tying could be done with the dried banana sheath fibre. The vines are irrigated regularly. As the vines grow up, filling up the bamboo with rooting medium and tying each node, pressing it down to the rooting medium are to be continued regularly. For rapid growth, each vine is fed at 15 days interval with 0.25 litres of nutrient solution prepared by dissolving urea (1 kg), super phosphate (0.75 kg), Muriate of potash (0.5 kg) and Magnesium Sulphate (0.25 kg) in 250 litres of water.

When the vine reaches the top in about 3 to 4 months, the terminal bud is nipped off and the vine is crushed at about three nodes above the base, in order to activate the axillary buds. After about 10 days, each vine is cut at the crushed point and removed from the rooting medium and each node is separated. Such cuttings with the bunch of roots intact are planted in polybags filled with pot mixture and kept in a cool humid place. Care should be taken to keep the axil above the soil. The buds start developing in about 3 weeks when the polybags can be moved and kept in semi shade. Subsequent harvesting can be held at every 2-2 ½ months time. The advantages of this method are :1) Multiplication is rapid(1:40),(2) the root system is well developed, and (3) a better field establishment and more vigorous growth as a result of better root system.

Establishment of plantations

Selection of site

When black pepper is grown in slopes, the slopes facing south should be avoided and the lower half of northern and north eastern slopes preferred for planting so that the vines are not subjected to the scorching effect of the southern sun during summer.

Preparation of land and planting standards

With the receipt of the first rain in May-June, primary stem cuttings of *Erythina* sp.(Murukku) or *Garuga pinnata* (kilinjil) or *Grevillea robusta* (silver oak) are planted in pits of 50 cm x 50 cm x 50 cm size filled with cow dung and top soil, at a spacing of 3 m x 3 m which would accommodate about 1110 standards per hectare (Seedlings of *Alianthus malabarica* (Matti) can also be planted and the black pepper vines can be trailed on it after 3 years when they attain sufficient height). Whenever *E. indica* is used as standard, application of phorate 10 G @ 30 g may be done twice a year (May/June and September/October) to control nematodes and stem and root borer. When *E. indica* and *G. pinnata* are used, the primary stems are cut in March/April and stacked in shade in groups. The stacked stems start sprouting in May. The stems are planted in the edge of the pits dug for planting black pepper vines. Planting Pits of 50 cm³ at a distance of 30 cm away from the base, on the northern side of supporting tree are taken with the onset of monsoon. The pits are filled with a mixture of top soil, farmyard manure @ five kg/pit and 150 g rock phosphate. Neem cake @ one kg and *Trichoderma harzianum* @ 50 g also may be mixed with the mixture at the time of planting. With the onset of monsoon, two-three rooted cuttings of black pepper are planted individually in the pits on the northern side of each standard. At least one node of the cutting should be kept below the soil for better anchorage.

Cultural practices

As the cuttings grow, the shoots are tied to the standards as often as required. The young vines should be protected from hot sun during summer by providing artificial shade. Regulation of shade by lopping the branches of standards is necessary not only for providing optimum light to the vines but also for enabling the standards to grow straight. Adequate mulch with green leaf or organic matter should be applied towards the end of North East monsoon. The base of the vines should not be disturbed so as to avoid root damage.

During the second year, the same cultural practices are repeated. However, lopping of standards should be done carefully from the fourth year onwards, not only to regulate height of the standards, but also to shade the black pepper vines optimally. Lopping may be done twice

(during June and September) in a year. Excessive shading during flowering and fruiting encourages pest infestations.

From the fourth year, two diggings are usually given, one during May-June, and the other towards the end of south-west monsoon in October-November. Growing cover crops like *Calapogonium mucunoides* and *Mimosa invisa* are also recommended under West Coast conditions as an effective soil cover to prevent soil erosion during rainy season. Further, they dry during summer, leaving thick organic mulch.

Manuring and fertilizer application

Manuring and fertilizer application for pepper vines is to be done for black proper establishment and growth of plants. Recommended nutrient dosage for black pepper vines (3 years and above) are as follows.

NPK 50:50: 150 grams/vine/year (General recommendation)

NPK 50:50: 200 grams/vine/year (for Panniyur and similar areas)

NPK 140:55: 270 grams/vine/year (for Kozhikode and similar areas)

Only one-third of this dosage should be applied during the first year which is increased to two-thirds in the second year. The full dose is given from the third year onwards. It is better to apply the fertilizers in two split doses, one in May-June and the other in August- September. The fertilizers are applied at a distance of about 30 cm all around the vine and covered with a thick layer of soil. Care should be taken to avoid direct contact of fertilizers with roots of black pepper. Organic manures in the form of cattle manure or compost can be given @ 10 kg/vine during May. Neem cake @ 1 kg/vine can also be applied. Application of lime @ 500 g/vine in April-May during alternate years is also recommended. When biofertilizer like *Azospirillum* is applied @ 100 grams/vine, the recommended nitrogen dose may be reduced by half to 70 g/vine. In soils that are deficient in zinc or magnesium, foliar application of 0.25 per cent zinc Sulphate twice a year (May-June and September-October) and soil application of 150 grams/vine magnesium Sulphate, respectively is recommended.

Plant protection

Foot rot disease

Foot rot (quick wilt disease) caused by *Phytophthora capsici* is the most destructive of all diseases and occurs mainly during the south west monsoon season.

Symptoms

- One or more black spots appear on the leaves which have a characteristic fine fibre like projections at the advancing margins which rapidly enlarge and cause defoliation.

- The tender leaves and succulent shoot tips of freshly emerging runner shoots trailing on the soil turn black when infected. The disease spreads to the entire vine, from these infected runner shoots and leaves, during intermittent showers due to rain splash.
- If the main stem at the ground level or the collar is damaged, the entire vine wilts followed by shedding of leaves and spikes with or without black spots. The branches break up at nodes and the entire vine collapses within a month.
- If the damage is confined to the feeder roots, the expression of symptoms is delayed till the cessation of rain and the vine starts showing declining symptoms such as yellowing, wilting, defoliation and drying up of a part of the vine. This may occur during October-November onwards. These vines may recover after the rains and survive for more than two seasons till the root infection culminates in collar rot and death of the vine.

Management

The disease can be controlled by adopting integrated disease management strategies.

Phytosanitation

- Removal and destruction of dead vines along with root system from the garden is essential as this reduces the build up of inoculum (fungal population).
- Planting material must be collected from disease free gardens and the nursery preferably raised in fumigated or solarized soil.

Cultural practices

- Adequate drainage should be provided to reduce water stagnation.
- Injury to the root system due to cultural practices such as digging should be avoided.
- The freshly emerging runner shoots should not be allowed to trail on the ground. They must either be tied back to the standard or pruned off.
- The branches of support trees must be pruned at the onset of monsoon to avoid build up of humidity and for better penetration of sunlight. Reduced humidity and presence of sunlight reduces the intensity of leaf infection.

Chemical control

After the receipt of a few monsoon showers (May-June), all the vines are to be drenched at a radius of 45-50 cm with any one of the below four combinations

1. Copper oxychloride 0.2 per cent @ 5-10 litres/vine + A foliar spray with Bordeaux mixture one per cent is also to be given
2. Potassium phosphonate 0.3 per cent @ 5-10 litres/vine + A foliar spray with 0.3 per cent potassium phosphonate

3. Metalaxyl mancozeb 0.125 per cent @ 5-10 litres/vine + A foliar spray with metalaxyl mancozeb 0.125 per cent may also be given.

4. Apply Trichoderma around the base of the vine @ 50 grams/vine (this quantity is recommended for a substrate containing Trichoderma @ 10¹⁰ cfu) + A foliar spray with potassium phosphonate 0.3 per cent (or) Bordeaux mixture one per cent is also to be given.

Drenching and spraying are to be repeated once again during August- September. A third round of drenching may be given during October if the monsoon is prolonged.

Pollu disease (Anthracnose)

This disease is caused by *Colletotrichum gloeosporioides*. It can be distinguished from the pollu (hollow berry) caused by the beetle by the presence of characteristic cracks on the infected berries. The disease appears towards the end of the monsoon. The affected berries show brown sunken patches during early stages and their further development is affected. In later stages, the discolouration gradually increases and the berries show the characteristic cross splitting. Finally, the berries turn black and dry. The fungus also causes angular to irregular brownish lesions with a chlorotic halo on the leaves. The disease can be controlled by spraying Bordeaux mixture one per cent.

Spike shedding

Spike shedding especially in varieties like Panniyur-1 at higher elevations like Coorg and Idukki is one of the emerging diseases. It is seen in serious condition when the pre-monsoon showers are delayed and flowering and spiking occur during June-July. These spikes predominantly produce female flowers instead of bisexual flowers. Heavy spike shedding may occur due to lack of pollination. Irrigation of vines from second fortnight of March coupled with prophylactic spraying with Bordeaux mixture one per cent or carbendazim 0.2 per cent reduces the intensity of spike shedding.

Stunt disease

This disease which is caused by viruses is noticed in parts of Kannur, Kasargod, Kozhikode, Wayanad and Idukki Districts of Kerala and Kodagu, Hassan and Uthara Kannada districts of Karnataka. The vines exhibit shortening of internodes to varying degrees. The leaves become small and narrow with varying degrees of deformation and appear leathery, puckered and crinkled. Chlorotic spots and streaks also appear on the leaves occasionally. The yield of the affected vines decreases gradually. Two viruses namely **Cucumber mosaic virus** and a **Badna virus** are associated with the disease. The major means of spread of the virus is through the use of infected stem cuttings. The disease can also be transmitted through insects like aphids and mealy bugs.

The following strategies are recommended for the management of *the disease*.

- Use virus free healthy planting material
- Regular inspection and removal of infected plants; the removed plants may be burnt or buried deep in soil
- Insects such as aphids and mealy bugs on the plant or standards should be controlled with insecticide spray such as dimethoate or monocrotophos @ 0.05 per cent.

Phyllody disease

This disease which is caused by **phytoplasma** is noticed in parts of Wayanad and Kozhikode districts of Kerala. The affected vines exhibit varying stages of malformation of spikes. Some of the floral buds are transformed into narrow leaf like structures. Such malformed spikes show leafy structures instead of floral buds, exhibiting Phyllody symptoms. In advanced stages, the leaves become small and chlorotic, and the internodes are also shortened.

The affected fruiting laterals give a witches broom appearance. Severely affected vines become unproductive. In severely affected vines the entire spike is converted into small branches which appear chlorotic and the vines decline rapidly. The infected vine becomes unproductive within two to three years. The infected vines are to be destroyed to prevent the further spread of the disease.

Slow decline (slow wilt)

Slow decline is a debilitating disease of black pepper. Foliar yellowing, defoliation and die-back are the aerial symptoms of this disease. The affected vines exhibit varying degrees of root degeneration due to infestation by **plant parasitic nematodes**. The diseased vines exhibit foliar yellowing from October onwards coinciding with depletion of soil moisture. With the onset of south west monsoon during May/June, some of the affected vines recover and put forth fresh foliage. However, the symptoms reappear in subsequent seasons after the cessation of the monsoon and the diseased vines gradually lose their vigour and productivity. The affected vines show varying degrees of feeder root loss and the expression of symptoms on the aerial parts occur after a considerable portion of the feeder roots are lost. The root system of diseased vines show varying degrees of necrosis and presence of root galls due to infestation by plant parasitic nematodes such as *Radopholus similis* and *Meloidogyne incognita* leading to rotting of feeder roots. The damage to feeder roots is caused by these nematodes and *P.capsici* either independently or together in combination. There is no spatial segregation of plant parasitic nematodes and *P. capsici* in the soil under field conditions. Hence, it is necessary to adopt a combination of fungicide and nematicide application for the management of the disease.

- Severely affected vines which are beyond recovery should be removed from the plantation and destroyed.
- The pits for planting should be treated with phorate 10 G @ 15 grams or carbofuran 3 G @ 50 grams at the time of planting.
- Nematode free rooted cuttings raised in fumigated or solarized nursery mixture should be used for planting in the field.
- Phorate 10 G @ 30 grams or carbofuran 3 G @ 100 g/vine should be applied during May/June (with the onset of south west monsoon) and September/October. Along with nematicides the basins should be drenched with either copper oxychloride 0.2 per cent or potassium phosphonate 0.3 per cent or metalaxy 0.125 per cent.

In areas severely infested with root knot nematodes, cuttings of the resistant variety Pournami may be planted. Biocontrol agents like *Pochonia chlamydosporia* or *Trichoderma harzianum* can be applied @ 50grams/vine twice a year (during April-May and September-October). The fungus load in the substrate should be 108 cfu/g. While applying nematicides, the soil should be raked in the basin of the vine lightly without causing damage to the root system and the nematicide should be spread uniformly in the basin and covered with soil immediately. Sufficient soil moisture should be ensured at the time of nematicide application. The control measures should be taken up during early stages of the disease.

Insect pests

Pollu beetle

The pollu beetle (*Longitarsus nigripennis*) is the most destructive pest of black pepper and is more serious in plains and at altitudes below 300 meters. The adult is a small black beetle measuring about 2.5 mm x 1.5 mm, the head and thorax being yellowish brown and the fore wings (elytra) black. Fully-grown grubs are creamy-white and measure about five mm in length.

The adult beetles feed and damage tender leaves and spikes. The females lay eggs on tender spikes and berries. The grubs bore into and feed on the internal tissues and the infested spikes turn black and decay. The infested berries also turn black and crumble when pressed. The term pollu denotes the hollow nature of the infested berries in Malayalam. The pest infestation is more serious in shaded areas in the plantation. The pest population is higher during September-October in the field. Regulation of shade in the plantation reduces the population of the pest in the field. Spraying quinalphos (0.05 per cent) during June-July and September-October or quinalphos (0.05 per cent) during July and Neem gold (0.6 per cent) (Neem-based insecticide) during August, September and October is effective for the

management of the pest. The underside of leaves (where adults are generally seen) and spikes are to be sprayed thoroughly.

Top shoot borer

The top shoot borer (*Cydia hemidoxa*) is a serious pest in younger plantations in all black pepper areas. The adult is a tiny moth with a wing span of 10-15 mm with crimson and yellow fore wings and grey hind wings. The larvae bore into tender terminal shoots and feed on internal tissues resulting in blackening and decaying of affected shoots. Fully-grown larvae are grayish green and measure 12-15mm in length. When successive new shoots are attacked, the growth of the vine is affected. The pest infestation is higher during July to October when numerous succulent shoots are available in the vines. Spray quinalphos (0.05 per cent) on tender terminal shoots; repeat spraying at monthly intervals (during July-October) to protect emerging new shoots.

Leaf gall thrips

Infestation by leaf gall thrips (*Liothrips karnyi*) is more serious at higher altitudes especially in younger vines and also in nurseries in the plains. The adults are black and measure 2.5-3.0 mm in length. The larvae and pupae are creamy white. The feeding activity of thrips on leaves causes the leaf margins to curl downwards and inwards resulting in the formation of marginal leaf galls. Later the infested leaves become crinkled and malformed. In severe cases of infestation, the growth of younger vines and cuttings in the nursery is affected. Spray dimethoate (0.05 per cent) during emergence of new flushes in young vines in the field and cuttings in the nursery.

Scale insects

Among the various scale insects recorded on black pepper, mussel scale (*Lepidosaphes piperis*) and coconut scale (*Aspidiotus destructor*) causes serious damage to black pepper vines at higher altitudes and also to older cuttings in nurseries in the plains. Females of mussel scales are elongated (about one mm length) and dark brown and that of coconut scales circular (about one mm in diameter) and yellowish brown. Scale insects are sedentary; remaining permanently fixed to plant parts and appears as encrustations on stems, leaves and berries. They feed on plant sap and cause yellowing and wilting of infested portions; in severe cases of infestation the affected portions of vines dry up. The pest infestation is more severe during the post monsoon and summer periods.

Clip off and destroy severely infested branches. Spray dimethoate (0.1 per cent) on affected vines; repeat spraying after 21 days to control the infestation completely. Initiate control measures during early stages of pest infestation. In nurseries spraying Neem oil 0.3per cent or

Neem gold 0.3 per cent or fish oil rosin three per cent is also effective in controlling the pest infestation.

Minor pests

Leaf feeding caterpillars, especially *Synegia* sp., damage leaves and spikes of younger vines and can be controlled by spraying quinalphos (0.05 per cent). Mealy bugs, gall midges and aphids infest tender shoots especially in nurseries. Spraying of dimethoate (0.05 per cent) may be undertaken if infestations are severe.

Mealy bug infestation on roots can be controlled by drenching with chloropyriphos (0.075 per cent) and undertaking control measures against *Phytophthora* and nematode infections.

Harvesting and curing

Pepper vines start yielding usually from the 3rd or 4th year. The vines flower in May-June. It takes 6 to 8 months from flowering to ripening stage. Harvesting is done from the November to February in the plains and January to March in the hills. When one or two berries on the spikes turn bright or red, the whole spike is plucked.



Berries are separated from the spikes by rubbing them between the hands or trampling them under the feet. After the separation, the berries are dried in the sun for 7 to 10 days until the outer skin becomes black and shrunken and assumes the characteristic wrinkled appearance of commercial black pepper.

For making good quality black pepper of uniform colour, the separated berries are collected in a perforated bamboo basket or vessel and the basket with the berries is dipped in boiling water for one minute. The basket is then taken out and drained. The treated berries are sun dried on a clean bamboo mat or cement floor.

White pepper of commerce is prepared by removing the outer skin and the pulp below it before drying the berries. Spikes with fully ripe berries are filled in gunny bags and steeped in flowing water for about 7 days. Outer rind of the berries is then removed by rubbing them with hands in a bucket of water and further cleaning the seeds with fresh water. The cleaned seeds are dried for 3 to 4 days. The seeds which are now dull white in colour are further cleaned by winnowing and polishing them by rubbing with a cloth. The recovery of white pepper is about 25 per cent of ripe berries while that of black pepper is about 33 percent.

Considerable advances have been made in recent years in the diversification of value and added processed products from the pepper which has great demand. They include 3 major groups viz., (a) green pepper based products canned or bottled green pepper in brines, cured green pepper, frozen green pepper, freeze dried green pepper, dehydrated green pepper, green

pepper pickles, green pepper flavoured products white pepper (whole) or powder etc., (b) black pepper based products-Black pepper powder, pepper oleoresins, pepper oils etc and (c) pepper by-products which have medicinal, culinary and industrial uses. These processed products earn more foreign exchange per unit weight /volume.

Yield

Pepper vines attains full bearing stage in the 7th or 8th year after planting and it starts declining after 20 to 25 years and replanting has to be done thereafter. One hectare plantation of 7 or 8 years old gives about 800 to 1000kg of black pepper.

BUSH PEPPER

It is a method of cultivating the vine in the form of bush. One year old healthy fruiting branches are selected with 3 to 5 nodes and all the leaves except the flag leaf are removed and planted in a shaded area in the nursery, either in trenches or in polybags (45X30 cm) containing moist coir dust. Before planting, the cuttings are dipped in 1000 ppm of IBA for 45 seconds. After planting, the trenches are covered with polythene sheets and in the case of polybags; the mouth is tightly tied with coir thread to avoid moisture loss. They normally root in 30 to 50 days. Such rooted cuttings are planted in pots or fields after sufficient hardening treatment. Cuttings grow like a bush and flower in the same year itself. These bushes produce more and more of fruiting branches only. Adequate manuring i.e., 2 to 5 kg of FYM along with 10g of NPK 1:1:2 mixtures may be given per bush at 3 months interval. Watering and plant protection may be adopted according to necessity. Under average management a good bush pepper plant may yield 1.5 kg green pepper in a span of 2 to 3 years.

1. Scientific name for pepper _____
2. Mention the chromosome number for pepper _____
3. Important varieties of pepper is _____
4. Alkaloid content present in pepper _____
5. Important disease of pepper _____

CARDAMOM

(*Elettaria cardamom*, Zingiberaceae)

Cardamom, popularly known as Queen of Spices is native to the evergreen rainy forests of Western Ghats in South India. It is cultivated in about 1, 00,000 ha mainly confined to the Southern States viz; Kerala, Karnataka and Tamil Nadu accounting for 60,31 and 9% of the total area respectively. Our annual production is about 40000 metric tonnes and nearly 40% of which is exported to more than 60 countries earning a foreign exchange of nearly 60 million rupees. Cardamom is used for flavouring various preparations of food, confectionary, beverages and liquors.

Botany

Cardamom is an herbaceous perennial having underground rhizomes. The aerial pseudostem is made of leaf sheaths. Inflorescence is a long panicle with racemose clusters arising from the underground stem, but comes up above the soil. Flowers are bisexual, fragrant, fruit is trilobular capsule. Flower initiation takes place in March – April and from initiation to full bloom, it takes nearly 30 days and from bloom to maturity, it takes about 5 to 6 months. Honeybee is the principal pollinating agent and it increases the fruit set considerably when compared to flowers prevented from bee visits. Cardamom flowers remain open for about 16 to 18 hours and stigma receptivity and pollen viability are maximum during morning hours.



Four to five beehives per ha should be maintained and pesticides spraying should be maintained and pesticides spraying should be carefully monitored to avoid any damage to the bees. Large cardamom or Nepal cardamom or Great Indian cardamom is the dried fruits of *Amomum subulatum*. It is the native of Eastern Himalayan region and is now cultivated in Sikkim, Darjeeling and Assam hills in about 23000 ha in India with an annual production of 3250 tonnes. About 150 tonnes are annually exported earning around Rs 70 lakh. It is a perennial crop, propagated from the seeds or cut bits of the rhizome. It starts bearing in 3 to 5 years after

planting and the economic age of the plantation is 12 to 15 years. The fruits are about 2.5 cm long, ovoid and triangular in shape brown or pink in colour when ripe. They contain 40 to 50 seeds. Average yield is 300 to 1000 kg from 4th or 5th year.

Climate and Soil

The natural habitat of cardamom is the evergreen forests of the Western Ghats. It is grown in the areas where the annual rainfall ranges from 1500 to 4000 mm, with a temperature range of 10 to 35 C and an altitude of 600 to 1200 m above MSL. Rainfall distribution should be good and summer showers during February – April are essential for panicle initiation, otherwise it will affect the yield. With the denudation of the forests in the Western and Eastern Ghats, the favourable ecosystem has been affected destabilizing the macroclimate and rainfall in the cardamom growing tracts, resulting in poor growth and yield.

Varieties

Based on the size of the fruit, two varieties are broadly recognized via; Elaterid cardamom var. major consisting of wild indigenous types and var. minor comprising the cultivated types via; Mysore, Malabar and Vazhukka (natural breed between Mysore and Malabar). These types are identified mainly based on the nature of panicle and shape and size of fruits as follows.

Particulars	Mysore type	Malabar type	Vazhukka
Plant stature	Robust Erect	Medium sized Prostrate	Robust Semi-erect
Panicle	Bold, elongated	Round or oblong	Round to oblong
Capsule	Higher altitudes (900-1200 m	Lower latitudes (600-	Wide range
Adaptability	MSL) in Kerala	900m MSL)	

Recently a number of improved cultivars have been released for cultivation.

New cardamom varieties

	Name	Details
1.	Coorg Cardamom Selection-1 (CSC-1)	Malabar type, released by IISR, Cardamom Research Centre, Appangala an open seedling of clone no.37. 408kg dry capsules / ha. Dry recovery 22%, Essential oil content: 8.7%
2.	ICRI-1	Malabar type. Released by Indian Cardamom Research Institute, Myladumpara. 325 and 650 kg dry capsules / ha respectively under rainfed and irrigated. Dry recovery: 22.9%, Essential oil: 8.3%

3.	ICRI-2	Mysore type. Released by ICRI, Myladumparai, adaptable for Vandenmedu and Anamalai hills. 375 and 760 kg dry capsules / ha respectively under rainfed and irrigated. Dry recovery: 22.5%, Essential oil: 9%
4.	Mudigree-1	Malabar type, Released by RRS, Mudigree, suitable for Malanad region of Karnataka state. 250 to 300kg dry capsules / ha. Dry recovery: 20%, Essential oil: 8%
5.	PV-1	Malabar type. Released by Cardamom Research Station, Pampadumpara. 500 kg dry capsules / ha. Dry recovery: 20%, Essential oil: 6.8%
6.	SKP-14	Malabar type. Released by ICRI, Regional station, Saklespur, Karnataka. 430 and 590 kg dry capsules / ha respectively under rainfed and irrigated.
7	IISR, Kodagu-Suvasini (CCS-1)	Malabar type, 745 kg/ha, suitable for Karnataka, dry recovery 22%, essential oil 8.7%.
8	IISR-Avinash (RR 1)	Malabar type, 847 kg/ha, suitable for Karnataka and Wayanad, dry recovery 20.8%, essential oil 6.7%.
9	IISR-Vijetha-1	Malabar type, 643 kg/ha, suitable for Karnataka and Wayanad, dry recovery 20.8%, essential oil 7.9%.

Propagation and nursery

Cardamom is propagated mainly through seeds and also through suckers each consisting of atleast one old and a young aerial shoot.

1. Clonal Propagation: The suckers are commonly used for gap filling but suckers may not be available in larger numbers. Therefore, a rapid Clonal multiplication technique evolved by Indian Institute of Spice Research, Cardamom Research Centre, Appangala, is proved to be quick, reliable and economic for production of large number of quality planting materials. The site selected for this method should have a gentle slope and have a water source nearby it. Trenches of 45cm width, 45 cm depth and of any convenient length may be taken across the slope or along the contour at 1.8 m apart. The top 20 cm depth soil is excavated separately and heaped on the upper side of the trench. The lower 25 cm is excavated and heaped on the lower side of the trenches all along the line. The top soil is mixed with equal portions of top soil is mixed with equal proportions of humus rich jungle soil, sand and cattle manure and filled back by leaving a depression of 5 cm at the top to facilitate mulching for retention of soil mixture.

Suckers, each consisting of one grown up tiller and a growing young shoot, are placed at a distance of 0.6 m distance in the trenches during March-October. Regular cultural operations are to be followed including high fertilizer dosed 100:50:200 kg NPK/ha in 6 split doses at 60 days interval along with Neem cake at 250 g/plant. Irrigation should be provided atleast twice in a week. Overhead pandal at a height of 3.6 m covered with coir mat or leafy twigs of any shade tree may be provided during the non-rainy season. Within a period of 12 months, a plant would produce atleast 32 to 42 suckers, which may yield atleast 16 to 21 planting units per ha of clonal nursery within 12 months of planting

2. Seed propagation: Seedlings are normally raised in primary and secondary nurseries. The nursery site should be selected on gentle sloppy lands, having an easy access to a water source. Raised beds are prepared after digging the lands to a depth of 30- 45 cm. The beds of 1 m width and convenient length raised to a height of about 30 cm are prepared. A fine layer of humus rich forest soil is spread over the beds. Seeds should be collected from well ripe capsules. Immediately after the harvesting, the husk is removed and the seeds are washed repeatedly in water for removing the mucilaginous coating. After draining the water, the seeds are to be mixed with wood ash and dried in shade for a day. In order to ensure uniform and early germination, seeds should be sown immediately after extraction. If the sowing is delayed, pre-sowing treatment of seeds with 25% Nitric acids for 10 minutes is advisable to get a quick and higher germination. One kg of seed capsule may produce 5000 seedlings (600g seeds).



Sowing may be taken up during November- January and is done in rows. Deep sowing of seeds has to be avoided for quick and better germination. Seedbeds are to be dusted with Lindane. Beds are mulched to a thickness of 2 cm with paddy straw or any locally available

material and are watered regularly. The germination commences in about a 30 bags and may continue for a month or two. After germination, the mulch is to be removed. An overhead pandal with a height of 2 m is quite desirable. Materials like coir mat, plaited leaves or tree twigs which do not shed their leaves may be used but the coir mat is preferable as it provides uniform filtered sunlight. The excess seedlings are to be thinned out after 75-80 days sowing. The thinned out seedlings can be used for gap filling within the nursery bed or for raising secondary nursery. When the seedlings attain 5-6 leaf stages, light earthing up is to be done. This would encourage better tillering and proper growth of seedlings.

Generally in Kerala and Tamil Nadu, the seedlings are transplanted to the secondary nursery when they attain four to six leaf stages. The beds are prepared in the same manner as that of a primary nursery. The seedlings are transplanted in March- May at a spacing of 20x20 cm and mulched immediately. The beds are covered with an overhead pandal and are watered regularly. Recently, instead of raising secondary nursery beds, the seedlings are also raised in poly bags containing rich forest soil. Manuring at the rate of 90g N, 60g P₂O₅ and 120g K₂O per bed of 5x1 size , in three equal split doses at an interval of 45 days is recommended to produce healthier seedlings. The first dose of fertilizer may be applied 30 days after transplanting in the secondary nursery. In Karnataka, ten month old seedlings are used for planting in the main yield, while in Kerala and Tamil Nadu, 18 months old seedlings are commonly used.

Preparation of land

All under growth should be cleared and excess shade trees or branches should be thinned out to have an even overhead canopy. Pits of 45x45x30 cm size are dug in April – May and filled with a mixture of top soil and compost are well-decomposed farm yard manure. In sloppy land, contour terraces may be made and pits may be taken along the contour and a close planting (2mx2m) is advisable along the contour. The spacing adopted in Karnataka for the Malabar type is 2x2 m o between plants and rows. In Kerala region 2-3 m on either side is adopted. Staggered trenches may be taken across the slope to conserve run off rainwater. The soil collected in trenches may be utilized for earthing up during the post monsoon period.

Planting

The planting is carried out during the rainy season commencing from June. Under Eastern Ghats hills July planting is adopted. Seedlings are to be adopted. Seedlings are to be planted up to the collar region for better growth. Cloudy days with



light drizzle are ideal for planting. In some parts of tea estates in South India, redgum (*Eucalyptus* sp) is planted in flat valley bottom at a regular spacing. Cardamom under planted in this redgum areas produce better growth as equal to natural jungle areas. Recently, mixed cropping of cardamom in Arecanut, rubber and coffee plantations is gaining an impetus especially with small growers which assure greater significance in the light of frequent dry spells and fluctuating price structure.

Mulching

It is an important cultural practice in cardamom. Fallen leaves of the shade trees are utilized for mulching. Sufficient mulch should be applied during November – December to reduce the ill effects of drought, which prevails for nearly 4 to 5 months during summer. Exposing the panicle above the mulch is beneficial for the pollination by bees.

Weeding

Depending upon the intensity on weeds, 2-3 weeding are necessary in a year. The first round of weeding is to be carried in May – June, the second in August – September and the third in December – January. In sloppy land slashing of weeds is alone to be carried out otherwise it encourages to more soil erosion. Weedicides like paraquat @ 625 ml in 500 liters of water may be sprayed in the interspaces between rows leaving 60 cm around the plant base.

Trashing

Trashing consists of removing old and drying shoots of the plant once in a year with the onset of monsoon under rainfed conditions and 2-3 times in high density plantations provided with irrigation facilities.

Shade regulation

Cardamom being a **pseophyte** is very sensitive to moisture stress. Shade helps to regulate soil moisture as well as temperature and provides congenial microclimate for cardamom. Excess shade is also detrimental and shade has to be regulated so as to provide 50-60% filtered sunlight. Cardamom plants can tolerate less shade in areas where well distributed and adequate rainfall is received. In South India many trees are available in the natural habitat to provide shade but an ideal shade tree should have a wide canopy, minimum side branching and it should not shed the leaves during the flowering phase of cardamom so as not to affect pollination. Some of the common shade trees in cardamom estates are **Palangi** (*Atrocarpus fraxinifolius*), Jack, Red cedar (*Cedrella tuna*), Karimaram (*Diospyros ebenum*) and Elangi (*Mimusops elangi*). The temporary shade trees like *Erythina lithosperma* and *E. indica* are the most unsuitable as they compete for nutrients and soil moisture.

In order to provide adequate light during monsoon, shade regulation may be taken up before the onset of monsoon. A two tier canopy with a height of not more than 3 m below the lower and higher canopy may be maintained. Areas exposed to western side should have adequate shade.

Earthing up

After the monsoon is over, a thin layer of fresh fertile soil, rich in organic matter may be earthed up at the base of the clump, covering up to the collar region by scrapping between the rows or collecting soil from staggered trenches/check pits. This encourages new growth.

Irrigation

In order to overcome the dry spell during summer, it is necessary to irrigate the crop to get maximum production as it helps in initiation of panicles, flowering and fruit set. Depending on the moisture holding capacity of soil and topography of the soil and topography of the estates, they may be irrigated at an interval of 10 to 15 days till the onset of monsoon. Sprinkler irrigation and or drip irrigation at the rate of 4 litres per clump per day during dry month's increases the yield.

Harvesting and Processing

Cardamom plants normally start bearing two years after planting. In most of the areas the peak period of harvest is during October- November. Picking is carried out at an interval of 15-25 days. Ripe capsules are harvested in order to get maximum green colour during curing.



After harvest, capsules are dried either in fuel kiln or in electrical drier or in the sun. It has been found that soaking the freshly harvested green cardamom capsules in 2% washing soda for 10 minutes prior to drying helps to retain the green colour during drying. When drier is used, it should be dried at 45 to 50°C for 14 to 18 hours, while for kiln, over night drying at 50 to 60°C is required. The capsule kept for drying are spread thinly and stirred frequently to ensure

uniform drying. The dried capsules are rubbed with hands or coir mat or wire mesh and winnowed to remove any foreign matter. They are then sorted out according to size and colour, and stored in black polythene bag to retain the green colour during storage. These bags are then kept in wooden chambers.

Plant protection

Important pests and diseases affecting cardamom are given below with their typical damages/symptoms and control measures.

Pest/Disease	Damage/symptoms	Control measures
Pests Thrips (<i>Sciothrips acrdamomi</i>)	Adults and nymphs such sap and cause damage to leaves, shoots, inflorescence, and thrips affected capsules fetch lower price.	Regulate shade in thickly shaded area, spray monocrotophos 0.025% during March to September
Shoot, panicle, capsule/borer (<i>Conogethes punctiferalis</i>)	Larvae bore the unopened leaf buds, panicles causing drying of feed on young seeds causing the capsules empty, incidence occur throughout year, but more pronounced during March-April, May-June and September-October.	Spraying monocrotophos or fenthion 0.075% at early stage of infection.
Aphids (<i>Pentalonia nigronervosa</i>)	Nymphs and adults suck the sap and act as vector of the mosaic or 'Katte' Virus.	Spray 0.05% dimethoate.
Parasitic nematodes (<i>Meloidogyne incognita</i>)	Occurs in nursery and main field. Poor germination and establishment in the nurseries, stunted and poor growth of plants, shedding of immature capsules in the main field, heavy galling and abnormal branching of roots.	Treat the plants in the nursery with carbofuran 3 g @ 5 kg i.e. /ha or in the main field with carbofuran 5-g a.i./clump and apply 0.5kg of Neem cake per clump twice a year.
Diseases Katte diseases (Viral disease)	Spindle shaped, slender chlorotic flecks appear on youngest leaves, later there develop into pale green discontinuous stripes as leaves	Use healthy seedlings, rougue the infected plants.

	mature, mosaic symptoms are marked, infected clumps are stunted, smaller in size, with slender tillers and shorter panicles.	
Azhukal capsule rot (<i>Phytophthora meadii</i>) (<i>P.nicotianae</i> var. <i>nicotianae</i>)	Occurs in heavy rain zones, affected capsules turn brownish black in colour, often rotting extends to tillers and rhizomes also.	Do trashing; remove infected and dead plants etc. During pre monsoon months. Spray 1-% Bordeaux mixture during May and repeat again in August.
Damping or rhizome rot (<i>Pythium vexans</i> and (<i>Rhizoctonia solani</i>)	Excessive soil moisture and poor drainage favour this disease in the nursery, infected seedlings collapse at collar region and die in patches, and entire clump dies in grown up plants.	Pre treat the nursery with 1:50 formaldehyde; drench the soil after germination with 0.2% copper oxychloride.

1. Queen of spices is _____
2. Native of cardamom is _____
3. Inflorescence of cardamom is known as _____
4. Cultivated types of cardamom are _____
5. Cardamom is propagated mainly through _____

CORIANDER

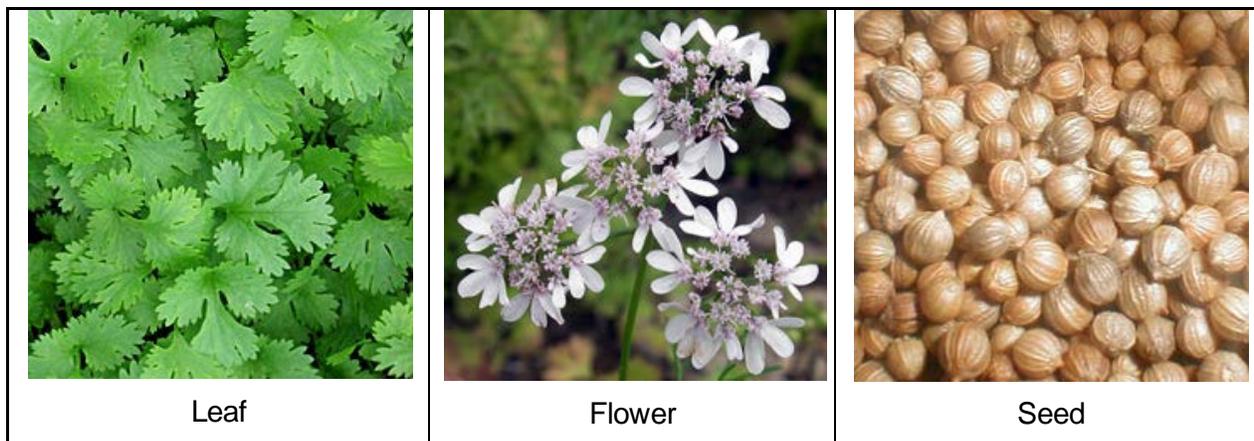
(*Coriandrum sativum*, Apiaceae)

Coriander is an annual herb, mainly cultivated for its fruits as well as for the tender green leaves. It is native of the Mediterranean region and is now commercially grown in India, Morocco, U.S.S.R, Hungary, Poland, Rumania, Czechoslovakia, Guatemala, Mexico and the U.S.A. In India, it is grown in Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan and Madhya Pradesh. It is grown in about 3.51 lakhs hectares with an annual production 1, 67,700 tonnes of grains. Major portion is though consumed locally; a small quantity is being exported now. But our country has ambitious plan to increase the report of coriander to a tune of 9000 tonnes by 2000 A.D.

The fruits have a fragrant odour and pleasant aromatic taste. The odour and taste are due to the essential oil content which varies from 0.1 to 1.0 percent in the dry seeds. These essential oils are used for flavouring liquors, cocoa preparations in confectionary and also to mask the offensive odours in pharmaceutical preparations. The dried ground fruits are the major ingredient of the curry powder. The whole fruits are also used to flavour foods like pickles, sauces and confectionary. The young plants as well as the leaves are used in the preparation of chutney and are also used as seasoning in curries, soups, sauces and chutneys. It has medicinal properties too. Fruits are said to have carminative, diuretic, tonic, stomachic and aphrodisiac properties.

Botany

Coriander belongs to the family Apiaceae. It is a smooth, erect annual herb 30-70 cm high lower leaves broad with crenately lobed margins, upper leaves finely cut with lineary lobes, flowers small, white or pink in compound terminal umbels, fruits- schizocarp, globular, yellow-brown, ribbed 2 seeds, and ripe seeds are aromatic.



Climate and soil

It is a tropical crop and can be grown throughout the year for leaf purposes, but for higher than grain yield it has to be grown in specific season. A dry and cold weather free from frost, especially during flowering and fruit setting stage favours good grain production. Cloudy weather during flowering and fruiting stage favours pest and disease incidences. Heavy rain affects the crop. As an irrigated crop, it can be cultivated on almost all types of soils provided sufficient organic matter is applied. Black cotton soils with high retentivity of moisture are best under rainfed conditions.

Varieties

Varieties	Parentage	Special Characters	Duration	Yield/ha (Kg)
CO 1	A pure line selection	Tall plant, many umbels per plant, suitable for green and grains	110	500
CO 2	Reselection from culture P2 of Gujarat	High yield, dual purpose variety, tolerant to drought, oil 0.3%	90 -110	600 - 700
CO 3	Reselection from Acc.No. 695	High yield, dual purpose, medium size grain, oil 0.3 - 0.4%	103	640
Gujarat coriander 1	Selection from local	High yield, more number of branches, seeds bolder and greenish in colour	112	1100
Gujarat coriander 2	Selection from CO 2	High yield, more number of branches, umbels large, bold seeds, no lodging	110 -115	1500
Rajendra Swati	A mass selection from Germplasm type	High yield, suitable for intercropping, fine seeded, rich in oil, resistant to stem gall	110	1200 – 1400
Rcr 41	Recurrent selection from UD 41	High yield, tall erect, suitable for irrigated areas, resistant to stem gall	130-140	1200

Swathi	Mass selection	High yield, semi erect, suitable for delayed sowing resistant to stem gall	80-90	885
Sadhana	Mass selection	High yield, suitable for rainfed areas, semi erect, resistant to aphid and mites	95-105	1000

Field preparation

For raising crop, the land is ploughed 3 to 4 times following rains and field must be planted immediately to break the clods and to avoid soil moisture. For irrigated crop the land is ploughed twice or thrice and beds and channels are formed.

Season of cultivation

In the North and Central parts of India and Andhra Pradesh, It is mostly grown as a rabi season crop and hence sowing is done between middle of October and middle of November. Still late sowing is recommended in places vulnerable for frost damage. In certain pockets of the above area, late kharif crop is sometimes sown in August-September. In Tamil Nadu, as an irrigated crop, coriander is raised in June-July and Sep-Oct. In the first season, it matures early before the end of Aug-Sep. In the second season, it matures late with an extended growth phase during Jan-Feb. The growth and the yield of second season crop is found to be better than the first season crop. Under rainfed conditions, it is sown during Sep-Oct, at the onset of North east monsoon and harvested during Jan-Feb.

Sowing

A seed rate of 10 to 15 kg per hectare is required. Seeds are stored for 15-30 days record better and early germination than freshly harvested seeds. Seeds are soaked in water for 12 to 24 hours before sowing also enhances and treated with thiram at 2g per kg of seeds. For irrigated crop, sowing is generally done in rows spaced at 30-40 cm apart with 15 cm between hills. Soil depth should not exceed 3.0 cm. Three to five seeds are sown a hill and later on thinned to two plants per hill. Under rainfed condition seeds are broadcast and covered with country plough. Germination takes place in 10-15 days.

Manuring

About 10 tonnes of farm yard manure is applied at the time of last preparation. In addition, the following fertilizers may be applied. Irrigated crop 15:40:20Kg/ha NPK as basal and 15 kg N at 30DAS, Rainfed crop 20:30:20 kg NPK/ha

Irrigation

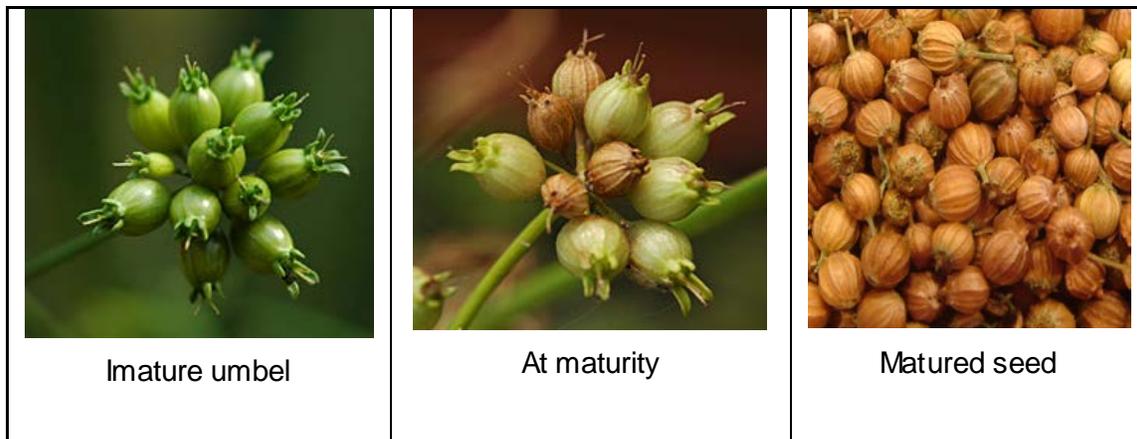
First irrigation is given 3 days after sowing and thereafter at 10 – 15 days interval depending upon the soil moisture available in the soil.

After cultivation

The first hoeing and weeding are given in about 30 days. Thinning the plants is also attended simultaneously, leaving only 2 plants per hill. Depending upon the growth 1 or 2 more weeding are done.

Harvesting

The crop will be ready for harvest in about 90 -110 days depending upon the varieties and growing seasons. In certain varieties, harvesting 50% leaves at 60 days 75 days may be done which will fetch additional income but without affecting the grain yield. Harvesting has to be done when the fruits are fully ripe and start changing from green to brown colour. Delaying of the harvest should be avoided lest shattering during harvest and splitting of the fruits in subsequent processing operations. The plants are cut or pulled and piled in to small stacks in the field wither for 2- 3 days the fruits are then threshed out from the plants by beating with sticks or rubbing with the hands. The produce is winnowed, cleaned and dried in partial shade. After drying, the produce is stored in gunny bags lined with paper. The rainfed crop yields on an average 400 – 500 kg/ha and the irrigated crop 600 -1200 kg/ha.



Plant protection

At the seedling stage coriander is often attacked by the leaf eating caterpillars and semi-loopers and at the flowering stage by the aphids. Spraying the crop with methyl demeton (0.05 %) is recommended to control aphids but at flowering stage the use of any insecticide would kill the bee population affecting pollination in the crop.

Powdery mildew (*Erysiphe polygoni*) is a serious disease which ruin the crop if allowed unchecked in the initial stage itself. Spraying wettable sulphur 0.25 % or 0.2 % solution of

karathane twice at 10-15 days interval is recommended. Grain mold is caused by *Helminthosporium* sp, *Alternaria* sp, *Carvularia* sp and *Fusarium* sp. It can be controlled by spraying carbendazim 0.1 % 20 days after grain set.

1. Coriander belongs to the family _____
2. Coriander is originated from _____
3. Important varieties of coriander are _____
4. Fruits are botanically named as _____
5. Maturity indices for coriander is _____

CUMIN

(*Cuminum cyminum*, Apiaceae)

Cumin, commonly known as Jeera, (*Cuminum cyminum*) belongs to Apiaceae family, widely cultivated in Gujarat, Rajasthan and in some parts of Madhya Pradesh and Uttar Pradesh as Rabi crop. Cumin is mainly used in flavouring foods. It is also used in Ayurvedic medicines.

Climate and soil

Cumin is a tropical plant. It grows well in sub-tropical climate too. High humidity during flowering & fruit set, causes fungal diseases in this crop. Cumin can be cultivated in all types of soils but well drained sandy loam and medium soils are suitable for the crop.

Varieties

Improved varieties like S-404, MC-43, Gujarat Cumin-1(GC-1), GC-2, GC-3, RS-1, UC-198, RZ-19, etc., evolved by Agricultural Universities of Gujarat and Rajasthan having higher yield potential are useful for cultivation. The maturity days are 110 to 115 days depending on variety.

Botany

It is an herbaceous annual plant, with a slender branched stem 20–30 cm tall. The leaves are 5–10 cm long, pinnate or bipinnate, thread-like leaflets. The flowers are small, white or pink, and borne in umbels. The fruit is a lateral fusiform or ovoid achene 4–5 mm long, containing a single seed. Cumin seeds are similar to fennel and anise seeds in appearance, but are smaller and darker in color.



Flower	Seed
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Sowing and Seed rate

Sowing is done from 1st week of November to 1st week of December by broadcasting or in rows drilled at 30 cm. Seed rate vary from 12 to 15 kg / ha, depending upon method of sowing & type of soil. Sowing of seeds should be done at a depth of 1 – 2 cm after treatment with Ceresan or thiram or Difoltan @ 3.0 g per kg. Soaking of seeds for 8 hours before sowing is helpful in getting good germination. Soaked seeds should be dried in shade to facilitate broadcasting. Sowing at higher depths, affect the germination of seeds adversely. Crop rotation should be followed to avoid incidence of pest and diseases.

Land preparation

Soil is brought to fine tilth by 2-3 ploughings with harrow or deshi plough. Stubbles of previous crops should be collected and removed from the field. Clods should be broken and field should be leveled with the help of plank. Beds of 4 m x 3 m size with provision of irrigation channels should be prepared before sowing of seeds to facilitate proper irrigation and intercultural operations.

Manures & Fertilizers

15 – 20 MT FYM, 30 kg Nitrogen & 15 kg Phosphorus per ha is recommended for cumin crop. Whole quantity of FYM should be mixed into the soil at the time of land preparation and 15 kg Nitrogen & whole quantity of Phosphorus should be applied as basal dose. Another, 15 kg Nitrogen should be applied as topdressing one month after germination of seeds.

Weeding

The crop should be kept free from weeds for proper growth and development of plants. Generally 2-3 hand weeding are required to keep the weeds under check. In drilled crop light intercultural operation is beneficial. 1st weeding and hoeing should be done after 30-40 days from the date of sowing.

Irrigation

Based on type of soil, crop requires 4-6 irrigation. 1st light irrigation should be given immediately after sowing and second irrigation should be given after 6-10 days from 1st irrigation. Subsequent irrigations should be given after 30, 45, 65 and 80 days from 1st irrigation. Irrigation at the time of flowering and fruit set are essential. At maturity stage irrigation should be stopped.

Plant Protection

Aphid

Aphid is a major pest of cumin crop, it sucks the sap of tender parts and reduces the yield. Spraying of 0.03% solution of Dimethoate or 0.025% solution of Methyl demeton or 0.04% solution of Monocrotophos is recommended to control the aphid.

Leaf eating Caterpillar

This pest causes damage to the foliage of plants reducing yield of the crop. It can be controlled by spraying of 0.02% solution of Phosphomidon in the early stage of crop.

b) Diseases

Fusarium wilt

Infected plants show peculiar symptoms of dropping of tips and leaves, leading to mortality of the entire plant. Attack of wilt is severe in younger plants. There is no chemical control for this disease. Crop rotation and use of Neem cake are helpful in checking spread of the fungus vis-à-vis disease. Seeds collected from disease free plots should only be used for sowing.

Alternaria Blight

The blight affected plants show very minute brownish necrotic spots, which later turn to blackish. Mostly diseased plants fail to produce seeds. If seeds are produced they remain shriveled, light in weight and dark in colour. For the control of this disease seed treatment and spraying of 0.2% solution of Dithane-M-45 4 times at 10 days interval commencing from 40 days after sowing is recommended. Add 1 ml soap solution / liter water for better efficiency of fungicide. The crop should be kept free from weeds. Crops requiring more irrigation and mustard crop should not be grown in vicinity of this crop.

Powdery mildew

Affected plants in early stages show minute whitish spots on leaves, petiole, stem pedicel and seeds. In severe condition, it looks as the plants have been dusted with white powder. At later stages of attack seeds become white and shriveled and light in weight. Crop should be dusted with 300 mesh Sulphur dust @ 25 kg/ha to control this disease as soon as the symptoms are noticed. Spraying of wettable Sulphur or Dinocap (Karathane or Thiowet) can also be used to control the disease @ 20-25 g per 10 liter of water at the initial stage of this disease. If needed second spray should be given 15-20 day after first spray.

Harvesting

Generally cumin crop takes about 110-115 days to reach maturity. Crop becomes ready to harvest, when plants turn yellowish brown. Harvesting should be done early in the morning by cutting/uprooting the whole plants. Harvested crop should be dried in the threshing yard thrashed to separate the seeds. Seeds should be cleaned by winnowing.

Yield: 600 to 700 kg/h

1. Cumin is widely cultivated in _____ and _____
2. Improved varieties of cumin is _____
3. Mention the seed rate for cumin _____
4. Yield of cumin ranges from _____
5. Important disease in cumin _____

FENUGREEK

Trigonella foenum-graecum, Fabaceae

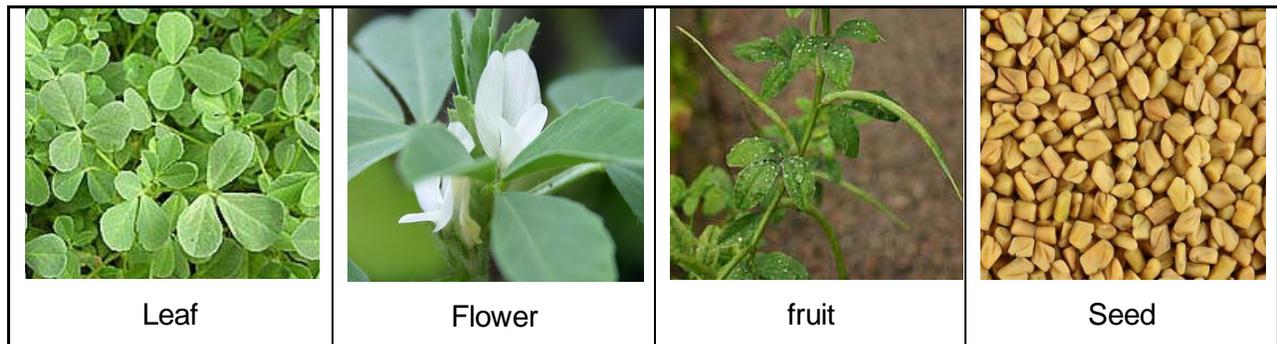
Fenugreek, a native of south Eastern Europe and west Asia, is cultivated as a leafy vegetable, condiment and as medicinal plant. The fresh tender leaves and stem are consumed as curried vegetable and the seeds are mainly used as spice for flavoring almost all dishes. It has a high medicinal value as it prevents constipation, removes indigestion, stimulates spleen and liver and is appetizing and diuretic.



In India, it is grown in about 0.30 lakhs ha producing annually about 30000 tonnes of seeds. Out of this 1000 to 3000 tonnes are exported to Saudi Arabia, Japan, srilanka, korea and U.K., thus earning a foreign exchange worth of Rs.170 lakhs annually. The major states growing fenugreek in India is Rajasthan, Madhya Pradesh, Gujarat, Uttar Pradesh, Maharastra and Punjab.

Botany

It is an annual herb reaching a height of about 0.9 m, leaves are light green pinnately trifoliate, flowers-papilionaceous, fruits- legume, long, narrow, curved, tapering with a slender point and containing small deeply furrowed seeds. There are two species of the genus *Trigonella* which are of economic important viz., *T. foenum graecum*, the common methi and *T.corniculata*, the kasuri methi. These two differ in their growth habit and yield. The latter one is a slow growing type and remains in rosette condition during most of its vegetative growth period.



Climate and soil

It has wide adaptability and is successfully cultivated both in the tropics as well as temperature regions. It is tolerant to frost and freezing weather. It does well in places receiving moderate or low rainfall areas but not in heavy rainfall areas. It can be grown on a wide variety of soil but clayey loam is relatively better. The optimum soil pH should be 6-7 for its better growth and development.

Varieties

Variety	Parentage	Special Characters	Duration	Yield/ha
CO 1 (TNAU,CBE)	Reselection from TG 2336	Dual purpose quick growing, suited for intercropping, high seed protein	90	685 Kg grain, 4.5 t of green
Rajendra Kanti (Dholi,RAU)	Mass selection	High yield, medium height, bushy suited for pure as well as intercropping. Seed protein 9.5%	120	1200 -1400 Kg grain
RMt – 1 (Jobner, RAU)	Pure line selection from Nagpur type	High yield, moderately branched, moderately tolerant to root rot and powdery mildew, Seed protein 21%	145	1500 kg grain
Lam Sel. 1 (Guntur, APAU)	A selection from Germplasm	High yield, bushy plant type. Seed protein 53%	68	740 Kg grain

Land preparation and sowing

Land is prepared by ploughing thrice and beds of uniform size are prepared. Broad casting the seed in the bed and raking the surface to cover the seeds is normally followed. But, line sowing is advocated in rows at 20-25 cm apart which facilitates the inter cultural operations. Sowing in the plains is generally taken up in Sep-Nov while in the hills, it is grown from March. Approximately 20 kg of seed is required for one hectare and the seed takes about 6-8 days to complete its germination.

Manures and fertilizer

Besides 15 tonnes of farm yard manures, a fertilizer dose of 30 Kg N, 25Kg P₂O₅ and 40Kg K₂O per ha is recommended as basal. 20 kg N at 30 days after sowing. To obtain more successful leafy growth, nitrogen should be applied after each cutting.

Irrigation

First irrigation is given immediately after sowing and subsequent irrigation is applied at 7 to 10 days interval.

Intercultivation

Hoeing and weeding during the early stages of plant growth are required to encourage proper growth. Thinning may be done on 20-25 days to keep the distance between the plants at 10-15 cm and to retain 1-2 plants per hill. In about 25-30 days, young shoots are nipped off 4" above ground level and subsequent cuttings of leaves may be taken after 15 days. It is advisable to take 1-2 cuttings before the crop is allowed for flowering and fruiting. When the pods are dried, the plants are pulled out and dried in the sun and seeds are threshed by beating with stick or by rubbing with hands. Seeds are winnowed, cleaned and dried in the sun. They may be stored in gunny bags lined with paper.

Yield

500-700 kg of seeds and about 4000-5000 kg of leaves may be obtained per hectare in crops grown for both the purposes.

Plant protection

Root rot is a serious disease and can be controlled by drenching carbendazim 0.05% first at the onset of the disease and another one month.

1. Native of fenugreek is _____
2. Fenugreek belongs to the family _____
3. Two economic important species of fenugreek are _____ and _____
4. Improved cultivars of fenugreek are _____
5. Serious disease of fenugreek is _____

LEMONGRASS

(*Cymbopogon flexuosus*, Poaceae)

Lemongrass commonly known as “East Indian Lemongrass” is a perennial and multicut aromatic grass. The prefix ‘lemon’ owes to its typical lemon like odour, which is mainly due to the presence of citral, a cyclic monoterpene.



Lemongrass is the source of Lemongrass oil, a good source of natural citral, which is used as a basic raw material for synthesis of β -ionone used for synthesis of a number of useful aromatic compounds and

Vitamin- A. Lemongrass oil is thus used as a main substitute for ‘Cod liver oil’. Citral itself is used in perfumery for various grades of soaps detergents, cosmetics and flavour agent for soft drinks. Consumption of Lemongrass in Ayurvedic preparation like Balm is also increasing. The present domestic requirement is about 150 MT/year and about 70 MT is exported every year. The total world production is estimated to 1300 MT/year.

The crop provides maximum herb yield from second and third year after planting and thereafter declines. The leaves yield essential oil on steam distillation containing 70-90% citral.

Soil & Climate

It flourishes in a wide variety of soils ranging from rich loams to poor laterite; also suitable to ‘jhum fallow’, hill slopes and flood free degraded land, best suited to well drain sandy loam. Water logged conditions should be avoided as they are unsuitable for its cultivation.

It requires a warm humid climate with plenty of sunshine and rainfall ranging from 1800 to 3000 mm. High temperature and sunshine are conducive to the development of oil in the plant.

Varieties

The following varieties are recommended for commercial cultivation:

(i) For irrigated condition C.K.P-25 released by RRL, Jammu

(ii) Krishna developed by CIMAP both for irrigated and rainfed and also hill slopes (iii) Nima a dwarf variety developed by CIMAP found promising. The citral content of Nima is much higher than Krishna. Oil recovery is in between 0.8-1.0 %.

(iv) Another suitable variety for NE region is Jor Lab L-2 developed by RRL, Jorhat.

Preparation of root slips

It is propagated vegetatively by obtained from well-grown clumps. Tops of culms are cut off within 20-25 cm above ground. The culm (root portion) is divided into slips containing 2-3 tillers. The lower sheath is removed to expose young roots and the old roots are clipped off keeping the slip 25-30 cm long

Spacing

45 x 45 cm in plains or 60 x 45 cm in sloppy land with a requirement of slips 45,000-50,000/ha.

Planting

Planting is done in May-June. However, with irrigation planting can be done during any month of the year except December-January. One or two slips are planted into each hole, about 5-8 cm deep. It is better to plant on ridges in high rainfall areas. Slips are transplanted firmly into the ground. Plants get established well within 25-30 days after planting.

Manures and fertilizer application:

FYM: 10 t/ha to be applied and mixed well at the time of final land preparation.

Fertilizer

N, P₂₀₅ & K₂₀₋₁₅₀: 60: 60 kg/ha/year should be applied along with adequate quantity of organic matter. Before planting, the field is thoroughly prepared and the full dose of phosphorus and potash is incorporated. The nitrogen is applied in six equal split doses at two monthly intervals. For economic use of fertilizers the soil should be analyzed first.

Irrigation

Irrigation is given immediately after planting when planting is done in dry days. Thereafter two irrigations are given at 10 days interval to establish the crop. During dry season after each harvest one irrigation and subsequently application of recommended dose of fertilizers are to be followed for optimum herb production. For undulating areas sprinkler irrigation is advisable.

Weeding and interculture

Lemongrass has the weed suppression capacity. One hand weeding at 25-30 days followed by one hoeing at 40-60 days after planting is enough to control weeds. After each harvest a nominal weeding and earthing up of plants is beneficial for the next flush.

Mulching

Distillation waste (spent grass) applied as organic mulch @ 3 tons/ha in between the rows has been found very effective in controlling weeds and maintaining soil moisture as well.

Pests and Diseases

Lemongrass may be attacked by leaf blight caused by *Carbularia veruciformis* that can be controlled by benzimidazole like Benlate 50 WP at 0.2% @ 550-750 litre/ha at 10 days interval.

The most important pest is scale insect, which produces yellow spot on the stem and sucks the sap of the leaves and stem. The insect can be controlled by spraying 0.5 % Dimethoate.

Age of harvesting

Citral is considered as quality marker of lemongrass oil, which is influenced by age of crop. At harvesting Citral content of Krishna variety in Assam condition as influenced by age of cutting is given below:

Time of harvesting	Crop age at harvesting	Citral content in oil
April	52 days	71%
May	85 days	84%
June	129 days	76 %

This shows that after first cutting the subsequent harvests should be done within 2 – 3 months interval. But always crop should be harvested before flowering for both quality and oil yield.

Harvesting

First harvest is taken at 4 months age of the crop and subsequent harvests are at 2 – 3 months intervals. Harvesting is done by cutting the grass 10 cm above the ground level. During first year 3 cuttings and subsequently 5 cuttings per year can be taken subject to weather conditions and irrigation management. Both immature and over mature crops give low yield and oil of poor quality. The optimum period of harvesting when grown on hilltop or upper slopes is 75 days while at foothill and plains it is 60 days.

Seasonal variation in oil recovery (Var. Krishna) as observed in Assam:

Months	Oil recovery in stainless steel unit (w/v)
July	0.7 %
August	0.55 %

September	0.56 %
October	0.88 %
November	0.78 %

Yield

The average herb yield /ha and oil production is as under:

Year	1st year	2nd year	3rd year	4th year
Herb yield (q)	215	360	360	215
Oil yield at 0.7 % recovery (kg)	150	250	250	150

Distillation

The oil extracted from the wilted herb by steam distillation in stainless steel unit. The factors influencing the oil production during distillation are: (i) Storage of the plant material, (ii) Treatment (wilting and cutting into pieces) of the material and (iii) The method of distillation.

The major source of loss is by oxidation and resinification of the essential oil. So if the material is to be stored before processing, it should be kept in a dry atmosphere with limited air circulation. The essential oils are present in the oil glands, oil sacks and glandular hairs of the plant. Therefore, before distillation, the day wilted plant material is cut into small pieces enable them to expose directly as many oil glands as is possible. Once the plant material has been reduced in size, it must be distilled immediately to avoid oil loss. The wilted leaves are steam distilled which takes about 3 hours. Dipping the chopped lemongrass in sodium chloride solution for 24 hours at 1-2 % concentration before distillation has been found to increase the citral content.

Utilization of spent material

The residue thrown out after the extraction of oil is called spent grass. Cattle relish it when it is hot or is converted into silage by adding a dilute solution of molasses. Besides a good source of manure and mulching material the spent is used as fuel for distillation after drying and also cheap packing material for fragile objects.

1. Lemongrass is commonly known as _____
2. Lemongrass oil is used as a main substitute for _____
3. Lemongrass oil is a good source of natural _____
4. Lemongrass is propagated by _____
5. Lemongrass oil is extracted by _____ method.

CITRONELLA

(*Cymbopogon winterianus*, Poaceae)

Citronella oil is an essential oil containing citronellal, geraniol and hydroxy citronellol and other high value perfumery bases obtained on steam distillation of citronella grass. In Assam production of citronella oil has gone down from 450-500 MT/year in 1986 to less than 100 MT/year mainly due to the following reasons:



- 1) Shift to tea cultivation when tea price was remunerative
- 2) No technological up gradation neither in varietal development nor in oil extraction techniques.
- 3) No quality monitoring as a result of large-scale adulteration gave negative impact to the NE region's products.
- 4) Globalization in trading resulting tough competition with China that produces quality products at lower cost.
- 5) No extension support and marketing networking.
- 6) Optimization of synthetic equivalent derivatives from petrochemicals and turpentine that could partly replace the derivatives ex-citronella oil.

However, its increasing applications in various fields and gradual shift to natural from synthetic have changed the total scenario and again the demand of natural source is increasing. Very high cost of production in the past can be brought down by increasing yield per unit area/unit time and by efficient steam distillation units.

It may be estimated that the global demand could exceed 6500 MT/year replacing partly the synthetic equivalents. At present about 1800 MT is being produced in the world out of which India produces about 600 MT/year. Presently the major producers are China, Vietnam, Indonesia, Argentina, Taiwan, Srilanka, Brazil, Madagascar and India. The oil is used for perfuming soaps, detergents, cosmetics, agarbattis and for making mosquito repellent creams. The oil is also used to isolate citronellol, geraniol. These are in turn converted into citronellal, hydroxy citronellal, synthetic menthol and esters of geraniol and citronellol. These compounds are used for making high grade blended perfumes. Extension of high yielding and high

citronellal rich variety is need of the hour and can create big market. The crop grown in NE region is aldehyde rich therefore; it may regain its lost image in the global market.

Soil and climate

Citronella grows well in Assam where there is abundant sunshine and high humidity (70 % and above). Temperature range between 20°C to 38°C and well-distributed rainfall of 2000-3000 mm are desirable but if irrigation is available citronella can be cultivated in regions of low rainfall also (rain shadow belt).

Citronella grows best in sandy loam soils. Heavy clayey soils, which tend to water log and light sandy soils are not suitable for this crop. It does not tolerate water stagnation. A good amount of organic matter is desirable. The ideal pH range is 5.0-7.0. Soil testing is important for best fertility management and higher productivity.

Land preparation

The land is prepared to fine tilth. Organic, P and K fertilizers are mixed into the soil at this stage. In plains ridges are made at 45 cm apart. Apply at last ploughing 25-30 tons FYM or well decomposed crowding and mixed with the soil. At this time 1.25 kg Semazine or 1.25 kg Diuron in 1250-1500 litre water or 625 g Oxyflorfen or any suitable pre-emergence herbicide may be applied at least 15 days before planting.

Preparation of slips

Citronella is propagated by splitting the clumps of vigorously growing plant of 6-months to one year old into slips. The clump is gently dug out and separated into number of slips containing 2- 3 tillers/slip. The fibrous roots and leaves are trimmed off at 25 – 30 cm height before planting. One-year-old clump on an average, gives about 50 slips.

Varieties

Jor lab C-2 released by RRL, Jorhat is recommended. It is advisable to procure breeder material for multiplication from RRL, Jorhat or diseased free material from any dependable sources. For Brahmaputra plains where excess moisture and occasional water stagnation are likely Jalpallavi (a CIMAP variety) is better choice. Its oil content is low about 0.5 –0.6% but its herb yield is much higher.

Time of planting

The ideal planting time is the beginning of monsoon (May-June). Late planting after July may result heavy casualty. Under irrigated condition March-April is also suitable when there will be low weed growth.

Planting

The slips are planted at 45 x 45 cm in plain land at 5-8 cm depth on one side of the ridges half way up the slope in plains or 60 x 45 cm in sloppy land. One slip is inserted in each pit, latter filled with loose soil and firmly pressed keeping the slip vertical. The soil moisture is maintained till the crop establishes. Casualty should be replaced within the next month. 40,000 slips are required to plant one-hectare area.

Closure spacing at planting

Planting may be done at closure spacing at 45 x 22.5 cm and after first harvest every alternate plant from the row is uprooted and used as planting material. This gives good harvest in the first cutting and helps in keeping down the weed problems due to higher plant population. The grass can be intercropped with arecanut and also coconut in the initial 3-4 years of growth as these crops attain bearing stage after about 6-7 years.

Growth

If properly planted about 90% survival is obtained. Plants get established within 15-20 days and after 30-40 days complete green colour appears in the field. During this time a light irrigation should be applied in absence of rainfall.

Interculture

As the crop is planted during monsoon it faces serious weed competition in the initial stages and upto 60 days is found to be critical period. Generally two weedings one at 20-25 and another at 40-45 days after planting should be done. Interculture after each harvest is necessary. In order to get satisfactory results, an integrated method that consists of hand weeding, application of Weedicides and mulch should be used.

Mulching

The spent material (grass after distillation) should be applied as mulch in between the two rows @ 3 tons/ha.

Fertilizer application

For poor and medium fertility soil N, P₂₀₅, K₂₀ @ 200:80:75 kg/ha/year should be applied. In the first year the organic, P and K fertilizers are mixed into the soil at final land preparation. Nitrogen should be applied at 4 equal splits (@ 50 kg N) in the first year- first application at about one month after planting with weeding and rests after each harvest. In subsequent years the basal dose may be applied along with the first dose of N. N as urea is top dressed soon after the regenerated crop is established and thereafter once in every two months. In the subsequent years N dose may be increased by 50 kg for the additional split application.

During rainy season crop may suffer iron deficiency leading to leaf chlorosis resulting decrease in yield and oil quality. This may be rectified by spraying 0.25% ferrous Sulphate solution at 10-15 days intervals for 3-4 times.

Irrigation

Citronella requires sufficient moisture for good growth and yield of herb. When there is no rain, irrigation once in 10-15 days will be required. For undulating areas sprinkler irrigation is suggested. Irrigation increases aldehyde content in oil besides herb yield.

Plant Protection

Diseases

Most important disease is leaf blight or *Carbularia* leaf blight caused by *Carbularia eragrostidis*. This can be controlled by Carbendazim (Bavistin at 1.0g/liter) followed by Benomyl of Benzimidazole group (Benlate 50 wp) @0.2% at 10 days interval.

Insect-pests

During dry season the crop may be affected by yellowing and crinkling disease (due to mites). The emerging leaves become wrinkled and pale. It may fail to open and the part may die. This may be controlled by spraying a mixture of Docofol (Kelthane) @ 2 ml/lit and Ethion (Tafethion, 50 EC) @ 1 ml/lit along with a wetting agent like Triton AE or Enditron AE @ 0.5 ml/lit. In the subsequent years stem borer and in rainfed condition termite may infest the crop. These can be controlled by applying Furadan @ 20 kg/ha or by spraying 0.5 % Dimethoate 400 to 500 kg Neem oil cake. The crop sometimes may show yellowing of growing leaves indicating a mixed deficiency of Zinc, Molybdenum and Sulphur. Two or three foliar sprays of a complete micro-nutrient mixture at fortnightly intervals are sufficient to combat the deficiency.

Harvesting

It is advisable to harvest (a partial harvest) after 3 months to induce tillering. In the first year only 3 cuts besides the partial harvest can be taken, viz., 5 months after planting and 3 months after the previous harvest. From second year onwards, 5-6 harvests can be taken per year at 2 months intervals. Harvesting is done by sickle and cut at 15 cm above the ground. Cutting close to the ground results into mortality of the plant. Harvesting preferably is done before 12 O'clock.

Crop cycle:

The crop can be maintained economically for about 4 years. Then it is to be pulled out and plant with rotational crop. After termination of the crop green manuring can be done.

Withering of the fresh herb

After cutting, the herb is allowed to wilt for 12-24 hours to remove the excess moisture. This wilting allows better packing in the vessel and saving of steam and fuel. Wilting more than 24 hours results loss of essential oil. Cutting the grass into shorter length also gives 10-15 % higher recovery. The harvested grass contains dead leaves, sheaths that should be removed before packing into the vessel.

Distillation of oil

The grass is steam distilled for better recovery. The distillation equipment consists of a boiler, a distillation vessel, a condenser and two receivers / separators. The economic capacity of the unit is 1.0 ton/batch. In hilly areas small size (6-8 q) direct-fired field units are preferred. Preferably the unit should be of stainless still for durability and oil quality. Growers cultivating smaller areas can use properly designed direct-fired field distillation units. Distillation is completed within 3 hours under normal pressure starting from the initial condensation of the oil. Prolong distillation deteriorates oil quality.

The trend of oil recovery is as under-

Distillation time % of the total oil recovery

First hour - 80 %

Second hour - 19 %

Third hour - 1 %

Larger percentage of the major components about 80% in the total oil, such as citronellal, geraniol, citronellol and geranyl acetate is recovered in the first hour of distillation.

Yield

The partially wilted herb yield is in the range of 20-30 t/ha. The average oil recovery is 1 %. Hence the oil yield is about 200-300 kg/ha/year. A crop under average management should not yield less than 200 kg oil/ha/year.

1. Botanical name of citronella is _____
2. Citronella is propagated by splitting the _____
3. What are the major components of citronella oil _____
4. Mention two types of citronella species?
5. Percentage of oil recovery in citronella?

PALMAROSA GRASS

(*Cymbopogon martinii var. motia.*, Graminae)

Oil of palmarosa, also known as Rusa or Rusha or Rosha is the essential oil obtained from the aromatic grass *Cymbopogon martinii var. motia*. The oil obtained from the other form viz. *C. martinii var. sofia* is known as the ginger grass oil. Motia and sofia grasses are almost identical and difficult to distinguish when they are in earlier growth stages. Motia grass has fine yellow stem with dark green leaves and they attain a height of 1.80 - 2.40 m. On the other hand, sofia grass has purple stem, shorter (90-120 cm) than the motia grass. These oils are used as base for the fine perfumery and are valued because of their geraniol content. The oil is useful in imparting rose - like aroma to a wide variety of soaps, tobacco products etc. The oil of palmarosa is commercially preferred to ginger oil.



Climate and Soil

Palmarosa is a hardy plant and can grow in varying altitude right from sea level. It stands well in places receiving rainfall from 75 cm to 150 cm. But it does not withstand stagnant water. It requires exposed sunlight and does not perform well under shady situations.

Palmarosa prefers a well drained soils of neutral to alkaline reaction and can be grown in poor sandy to heavy-fertile soils of arid tracts, saline soil conditions and also in marginal and sub marginal lands.

Varieties

The NBPGR has identified a superior selection viz. IW 31244 and RRL, Bhubaneswar has identified two improved strains viz. RRL (B)- 77 and RRL(B)-71 for commercial cultivation. A high yielding synthetic variety TRISHNA was developed by poly cross progenies of four elite inbred by CIMAP Lucknow. This improved cultivar registers 40% more oil yield and its geraniol content is as high as 93%.

Land preparation

Nursery bed should be prepared out of well pulverised soil and at a raised level. Leaf mould or farm yard manure should be mixed well with the nursery bed. Seed rate is 2.5 Kg per hectare. Best time for sowing is from April to September. Seedlings become ready for transplanting when they are about 15 cm high.

The main field for raising palmarosa should be prepared by ploughing 3-4 times,

followed by forming ridges and furrows at 90 cm apart. The seedlings are transplanted at 60 cm spacing in the ridges. In Kerala, a spacing of 45 x 30 cm is followed but under Delhi condition, a closer spacing of 45 x 15 cm is found to be good in producing higher herbage and oil yield. In North it is recommended as a mixed crop along with Basil to get higher net profit from unit area.

Manures and fertilizers

It responds to application of compost. Under North Eastern condition of India, a fertilizer dose of 60:40:40 NPK kg/ha is followed while under Kerala condition, NPK dose of 25, 50 and 25 Kglha is recommended. Micronutrient like zinc ($ZnSO_4$ 25 Kg /ha) is beneficial to increase the oil yield of palmarosa.

Harvesting

If transplanting is done in May/June, the grass comes to first harvest after six month from transplanting. Harvesting consists of cutting the upper third of the stem along with the leaves. The right time for harvesting is when the plants just begin to bloom as the leaves contain higher oil content during the blooming period. Recent studies at NBPGR, Delhi shows that oil from the whole plant is of good quality and economical to produce as per the table below.

Plant part	Essential oil (fresh weight)	Geraniol (%)
1. Whole plant	0.53	72.4 to 86.5
2. Inflorescence	0.83	72.5 to 84.5
3. Leaves	0.58	92.9 to 94.6
4. Stalk	0.01	-

Besides, superior quality of oil with roseousgreen odour is obtained at an early seed setting stage rather than at full bloom stage when the oil yield is slightly higher.

The grass yield more oil recovery if dried for nearly one week. The steam distillation seems to be better than the other type of extraction. Palmarosa yields 15 to 20 tonnes of herbage per ha in a year with an oil yield of 50-60 Kg per year. The plantation can be maintained for about 8 to 10 years, but the oil yield starts declining from the fifth year.

1. Botanical name of palmarosa grass is _____
2. Percentage of oil recovery in palmarosa _____
3. Method of oil extraction in palmarosa grass?
4. What is the seed rate of palmarosa grass
5. Jam Rosa (RRL – 82) is a hybrid between _____

VETIVER (KHUS)

(*Vetiveria zizanioides*, Poaceae)

Vetiver oil is obtained by steam distillation of roots of vetiver (*Vetiveria zizanioides*). The oil is one of the finest oriental perfumes with a persistent fragrance. The oil is used in the manufacture of soaps, cosmetics, perfumery, agarbathis, soft drinks; pan masala etc. In blended perfumes, oil of vetiver acts as excellent fixatives for volatile compounds. It is known for its cooling properties. It grows well in



wastelands-sandy, marginal land where conventional cropping is uneconomic. Vetiver is extremely hardy and can tolerate submergence for a considerable period as well as withstand drought situation. Cultivation of vetiver for 3-4 cycles improves sandy soils to a greater extent and makes them suitable for growing common agricultural crops more profitably.

Demand and Supply of vetiver oil

In India as well as the World Market, the demand for vetiver oil is increasing day by day due to its unique odour, for which it is used in both flavour and fragrance industries. One more reason for increase in demand is that this oil cannot be substituted with reconstituted oil and cannot be made synthetically. It is used for Base-note in flavour and fragrance and the percent usage varies from 20-50% to 60-70 %. That means it has enough market potential and there is no doubt on its consumption. The internal demand particularly of Northern type oil always falls short of supply. The world production of vetiver oil is around 300 tons per annum of which India contributes about 20-25 tons. Haiti, Indonesia (only Java), and Reunion produce most of the world's vetiver oil. In India it is cultivated in the states of Rajasthan, Uttar Pradesh, Karnataka, Tamil Nadu, Kerala and Andhra Pradesh, with an annual production of about 20 tons of oil. Its demand for perfumes, essence, attar, soap and also as food flavour etc is greater than indigenous production. Quantity wise the Indian vetiver oil, especially North Indian origin is considered to be the best in the world market. The Indian consumption at present is about 100 tons and more than 80 % is met by import.

The vetiver oil from North Indian origin is considered to be the best in the world market.

Improved varieties

KS-1 (Bharatpur type) an improved selection released by CIMAP is recommended for commercial cultivation in Assam. Other improved varieties are Gulabi, Dharaini and Kesar.

Soil and Climate

Vetiver grows in any type of soil but a rich and fairly well drained loam is considered best. The loamy soils, which are loose in texture, are ideal for root growth and harvesting as well. Vetiver plant also grows on a variety of problematic soils like waterlogged soils, sandy soils and areas with high water table and flood prone. A luxuriant growth of healthier root is obtained from plants growing under warm and damp conditions on rich, temporary inundated, marshy land. The Charlands of The Brahmaputra and its main tributaries and newly silted land that turned otherwise unfit for most common agricultural crops may be identified as potential areas for vetiver cultivation. It grows best in areas with warm summer and well-distributed rainfall.

Propagation

Vetiver can be propagated by tillers and slips. Tillers take longer time for growing and therefore, slips are the better planting material for propagation. Preferably it is propagated by slips. Plants are cut at 25-30 cm above ground and dug out for preparation of slips. The culms are divided into slips with 2-3 tillers. These slips are jabbed into ground like seedling. Although the growth may be slow initially, the plants develop quickly once roots are established. The plant responds to fertilizers and irrigation with massive tillering, and each tiller can be broken off and planted.

Raising of initial nursery

A nursery should be set up preferably on light soil so that plants can be pulled up easily. For quick multiplication, nursery should be manured liberally by FYM or Compost @20-25 t/ha. DAP @75 kg/ha may also be applied at the time of planting to encourage fast tillering the slips in the nursery should be planted at 30 x 30 cm apart. After second weeding urea @ 60 kg/ha may be top dressed. The multiplication rate could be about 80-100 in two steps a year. Nursery raised on 300-400 sq. m area may be sufficient for 1 hectare area within 6 months.

Land preparation

Vetiver field should be free of perennial weeds and shrubs. After clearing, the land is deep tilled. With the onset of pre-monsoon shower final land preparation is done.

Field layout and bed formation

For uniform cropping and higher root yield the fields are laid out into beds of convenient size.

Planting time

With pre-monsoon shower April- August is considered most ideal time for commercial cultivation. In flood affected areas the crop should be established before floodwater submerges it. Therefore, it should be planted before 2 months ahead of normal flood.

Planting

After division into slips the fibrous roots are also removed leaving 5-8 cm from the base of the root. These are planted in lines at 45 x 30 cm spacing. Flat bed planting followed by ridging (after 30 days of planting) produces higher roots and essential oil. Planting is done in holes 5-8 cm deep. The soil around the slips is pressed firmly and leveled. From an average sized clump about 20-30 healthy slips can be obtained. One-hectare area requires about 75,000 slips when planted at 45 x 30 cm spacing. If planting is done during rain free period, field should be irrigated immediately after planting.

Manuring and fertilization

In poor soils 40kg each of nitrogen, phosphorus and potassium per acre is applied before final ploughing. In second year of crop growth 40 kg nitrogen is top-dressed after rain in June. In the first year depending on soil fertility and crop growth 20 kg N may be top-dressed at about 4 months after planting. Depending on availability, the crop may be given 10-12 t/ac FYM or compost at planting supplemented with urea one month after planting to stimulate growth.

Fertilizer requirement per crop cycle (18 months)/hectare

A fertilizer dose of 100 kg N, 40 kg P₂O₅ and 40 kg K₂O per hectare is recommended.

In fertilizer form

Basal application:

Urea 90 kg

Single super phosphate (SSP) 250 kg

Muriate of potash (MOP) 67 kg **being transplanted**

Top-dress (after 4 months of planting)

Urea 45 kg

In second year

During June Urea 87 kg

Intercultural operations

Initial growth of vetiver for first 60-70 days is very slow, hence inter row space virtually remain vacant allowing infestation and faster growth of *kharif* weeds which compete with crop plants for light, moisture and nutrients. 2-3 weedings at an interval of about a month are needed during the initial period of growth. In the second year one weeding is done before harvest to facilitate the harvesting and avoid of any root of weeds getting mixed with roots of the crop.

Use of herbicides

Herbicide Atrazine @ 0.5 kg a.i/ha (50% a.i) as pre emergence to weed and before transplanting gives a weed free condition for first 75-90 days, after which the crop is able to cover the ground surface.

Earthing up Vetiver after shoot cutting

Earthing up after weeding is beneficial to the crop. Earthing up encourages root growth at the crown due to better rhizospheric environment provided to the growing plants.

Shoot cutting

The cutting of aerial portion with commencement of winter (November) increases tillering and consequently gives more roots per plant. Shoot cutting is done twice during the crop cycle. First shoot cutting is done at 30 cm height in planting year to achieve regeneration for second year, while second time cutting is done at 15-20 cm height before harvesting to facilitate digging of roots.

Inter cropping

Vetiver slips are planted in rainy season at a spacing of 45 x 30 cm. The crop growth in initial stages is very slow and inters row space remains free for weed infestation, which grow at a faster rate and compete with crop plants for moisture and nutrients. The open space can be used efficiently for raising intercrop without affecting the main crop yield. Growing of early maturing pulses like green gram, black gram, cluster bean (French bean) in *kharif* and toria and coriander in the subsequent *rabi* season found to improve the productivity and also give higher net profit per unit time and space. Cowpea, *Dhaincha* seed can be sown in the row spaces and incorporate them after 50-60 days of growth as green manure. This will add organic matter, which ultimately is helpful for better root growth.

Planting on paddy field levees

Vetiver grows well on the field levees, which can keep them stabilized. To avoid shading effect the foliage can be trimmed time to time. If planted in July – August with *Sali* rice, the root will be ready for harvest in second year Nov-Dec i.e., just after harvest of second crop.

Precaution

Vetiver by its nature grows best by the riverside. The economic part of the crop is its dug up roots upto a depth of 30-40 cm. Therefore, under any situation vetiver for its root production should not be undertaken in areas where soil erosion is a common feature. Though it can be grown even in erosion prone land with proper control measure, harvesting should be restricted to the central area of the standing crop, leaving thick, hedge like boundary line totally undisturbed.

Diseases and pests

Black scale insect

The black scale insects rarely move, the young nymphs settle and insert their mouthparts. They suck the sap of the plant and the growth is checked and vigour is reduced, ultimately the plant may die. Spraying of metasystox @ 0.04% will be effective to control the scale insect.

Harvesting

Harvesting is done in between 15-18 months to get fully developed root system and high quality of oil. Harvesting earlier than 15 months after planting, the immature roots yield oil of poor quality with green earthy odour. Properly developed somewhat thicker roots, yields an oil of better quality and its optical rotation and specific gravity are higher, the odour fuller, richer, more lasting. Oils derived from older roots are usually of darker colour than the oils distilled from the younger roots. If the roots stay in ground for over two years, the yield of oil diminishes considerably as the root system tend to become woody and lose in essential oil content and the oil becomes very viscous with a dark colour but of high quality.

In general the crop is harvested after 15-18 months during the dry season from December to February for best quality oil. Oil content of root starts decreasing after 20 months age considerably. For harvesting, the moist areas are taken up first. The water logged areas become dry enough in February for digging up the roots. After February due to rising temperature, the soil become harder and makes digging very difficult. At this stage the finer roots stay in the ground, which contain more oil resulting low yield per unit area.

Characteristics to determine correct harvesting age

The roots that possess the following characteristics have good oil content. It should

1. Expose a hard surface when the skin is peeled off
2. be thick, hard, long and wiry and
3. Give a very bitter taste when chewed

Digging

The stem portion is cut at a height of 15-20 cm and the clumps are uprooted. About 50-60 % of the roots come away with the clump when dig out by spade or tractor drawn single disc leaving the rest in the soil. The clumps are beaten on a piece of log to remove earth adhering to the roots and the roots are separated from the plants with a sharp knife. As far as possible, re-digging the soil also collects the roots left in the soil. One irrigation may be given before harvesting to facilitate digging if available. For mechanical harvesting a disc plough with single disc mounted on a tractor can be used which uproot the roots from 30-35 cm depth. This

process saves manpower and also gives about 15 % higher root recovery over manual digging. The length of the roots varies from 10-35 cm according to the condition of growth, soil, climate etc of the locality. Thicker roots produce more oil. Very light or almost white roots contain very little oil.

Washing / Cleaning

The harvested roots contain large quantities of earth sticking to them. Immediately after harvest, the roots are washed gently in clean running water to remove the adhering earth taking care so that the finer roots are not lost.

Drying

The cleaned roots are spread on drying grounds. The roots are turned over at regular intervals until dry. During this process foreign matter if any is removed from the mass. The cleaned and dried roots are sent to distillery or storage shed where they are allowed to mature. Drying is done under shade for 1-2 days, which improves the olfactory quality of the essential oil. Prolonged drying in the sun reduces the oil yield. Dry roots can be stored in shade for 60-70 days without loss of oil but quality improves appreciably.

Yield of roots

The age, the soil, climatic conditions and also the strain are important factors governing the yield of roots. On an average, 30-45 q/ha of dry root is obtained under good management. At 0.4% average recovery the oil yield of 12-20 kg oil/ha may be obtained.

Distillation

The essential oil is extracted from the roots by steam distillation. Freshly harvested roots on distillation give higher yield of oil than stored roots; the yield decreases progressively with the period of storage. The roots are soaked for 18-20 hours in water prior to distillation to render the root material soft and thereby further facilitate release of oil. Fresh roots when cut to lengths 2.5 cm – 5 cm increases recovery. As the most valuable quality constituents are contained in the high boiling fractions, the roots must be distilled for a prolonged period ranging from 20-24 hours. North Indian varieties yield 0.4 to 0.8 of oil. During distillation two fractions-lighter and heavier oils are obtained. In the start highly volatile lighter fraction released first and a



considerable amount of which may escape before it gets cooled and collected in liquid phase. To avoid this loss a piece of **marking** cloth after cleaning is tied at delivery outlet in the swollen balloon shape in the receiver keeping it submerged in water. The lighter fraction that is likely to escape along with the steam/gas or running distillate water would be trapped in the cloth. As the distillation progress the heavier fraction will get deposited in the cloth and the lighter will pass through cloth and get collected in the receiver. At the end of the distillation the cloth is squeezed to get the oil. This piece of cloth is repeatedly used till tear off. Before thrown off, the cloth may be washed by diethyl ether (solvent) to get back the adhering oil. This practice helps in increased recovery of oil. Traditionally copper vessel with S.S condenser is found good for vetiver since the oil react with free copper turns bluish in colour which fetches more prices in perfumery market. The traditionally distilled oil which often called "Ruhe khus" done in Kannauj type "Deg Vopka" although recovery is comparatively low fetches the highest price in perfumery market.

Quality aspects

Distillation technique plays an important role in oil quality. By adopting the right steam pressure and by adjusting the post harvest treatment of roots, yield as well as quality can be improved. There are hundreds of small constituents in vetiver oil. However, the 'Khusimol' content in oil, minimum of which should be 14% or more and low in caryophyllene. Besides extraction procedures the oil quality is governed by varietal selection, harvesting at proper age (15-18 months) and during dry period only.

Bi-products

Roots left after oil extraction is used for making cartons and many handicrafts items like Mats, Aasa (for sitting), pen-stand etc. A simple *sharbat* (syrup) can be prepared by using water obtained during distillation, which on analysis found to be tasty and best for health also.

The oil and its Uses

The oil is used extensively in perfume industry and in the manufacture of scented toiletries as fixative and also as odour contributor in base etc. It also has uses in the food industry as flavour agent. The essential oil is reddish dark brown when matured and has a woody, earthy smell that is almost musty. The oil has a strong odour (that may not be to everyone's taste) and should be well diluted to avoid it being too overpowering in a blend. Vetiver oil is used as part of the woody notes for luxury perfumes. The oil of vetiver, patchouli and sandalwood in combination with jasmine and gardenia complex, is the base of the famous *Crepe de Chine* note. In addition to its importance in classical perfumery, vetiver oil is also used as base for many modern men's colognes.

Medicinal uses

Therapeutically, vetiver oil has a profoundly relaxing effect on the nervous system, relieving tension and stress. It can be used to good effect in the treatment of insomnia. In India, vetiver oil is known as the oil of tranquility. In baths or in massage, vetiver is beneficial in the treatment of the symptoms of disorders such as arthritis, rheumatism and a chin, stiff muscles. It is warming and comforting and will help to relieve the tension that is often associated with chronic pain. Vetiver oil also benefits the circulatory system, stimulating and warming, especially when used in combination with massage. In skin care, the antiseptic and slightly astringent properties of vetiver can be used to good effect in the treatment of oily skin that is prone to spots.

1. Vetiver belongs to the family _____
2. Vetiver grass is a native of _____
3. Two main types of the vetiver grass is _____ and _____
4. What are the three different systems of planting adopted by different growers?
5. Vetiver can be propagated through _____ & _____

GERANIUM

Plant Profile

Family	: <i>Geraniaceae</i>
English name	: Geranium
Indian name	: Geranium (Hindi), Pannirsoppur, Pannir patre (Kannada), Geranium (Tamil)
Species and Varieties	: <i>Pelargonium graveolens</i> L.Herit, <i>P.radula</i> , <i>P.fragrance</i> : Algerian or Tunisian, Reunion or Bourbon KKL-1, Sel-8, Hemanti, Bipuli, Kunti
Distribution	: India, South Africa, Belgium, Chinna, Congo Egypt, France, Madagascar, Morocco, Reunion Islands, Spain, former USSR countries
Uses	: Cosmetics, Perfumery

Geranium (*Pelargonium graveolens* L.Herit.) is one of the important aromatic plants, yielding an essential oil which is highly priced for its very profound and strong rose-like odour. The plant is also known as rose geranium. The chief constituent of the oil are geranial and citronellol. The oil also contains α -pinene, β -pinene, α -terpinene, myrcene, α -phellandrene, limonene, cis-ocimene, trans ocimene, p-cymene, terpinolene, cis-roseoxide, trans-rose oxide, methone, trans-linalool, iso-menthone, caryophyllene, geranyl acetate, nerol, geranyl formate, geranyl butyrate and geraniol.



The pure geranium oil is almost a perfume by itself and blends well with all other perfumes. It is widely used in scenting soaps and for the isolation of rhodinal which forms part of most high-grade perfumes. India is importing more than 20 t of this oil from other countries to meet the local demands of the Indian perfumery industries, in addition to an indigenous production of only about 20 t of oil annually.

Origin and Distribution

Geranium is a native of the Cape Province in South Africa. It is commercially cultivated in France, Belgium, Spain, Morocco, Madagascar, Egypt, Reunion Island, Congo, China, India and the former USSR countries. The world production of geranium oil is estimated at 250-300 t, whereas the demand is more than 500 t annually. The first planting of high-yielding *Pelargonium graveolens*, introduced from Reunion Island was grown at Yercaud by a French planter, in the early twentieth century. From that time onwards it has been cultivated as a commercial crop, but only in high altitude areas with a milder climate. However, the crop also comes up well in the South Indian plains. Presently, it is being commercially cultivated mainly in the Nilgiris and Kodaikanal Hills of Tamil Nadu and in and around Bangalore in Karnataka in an area of about 2 000 ha.

Description of the Plant

The commercial oil of geranium is obtained from *Pelargonium graveolens*, L.Herit. ($2n=88$) of the family *Geraniaceae*. There are about 600 species of the genus *Pelargonium*, many of which possess an agreeable odour. Other species like *P.radula*, *P.fragrance* are of lesser importance and have not attained any commercial significance.

Geranium is a bushy, aromatic plant. The stem is cylindrical, woody at the base, pubescent, green when young and turning brown with age. The leaves are alternate, stipulate, simple, with 5 primary lobes and secondary lobes and densely pubescent. The leaves are highly aromatic in nature. The inflorescence is umbellate and hairy. The flower is bisexual, hypogenous, with a pink corolla; the two posterior petals are larger with reddish-purple markings. There are 10 stamens, the filaments are sub equal, united at the base; the anthers are 7, ditheous and shed easily. The ovary is hairy, superior, pentacarpellary and syncarpous; the style is hairy, breaking up distally into five stigma.



Varieties

1. Algerian or Tunisian

This type of geranium is slender with flowers of a dark pink colour. It is being grown in the Nilgiris and is unsuitable for wet conditions. This variety yields 50-60% more oil with a more delicate odour than that of the Reunion type.

2. Reunion or Bourbon

Grown in the Nilgiris and Anamalais, the plant is sturdier with light-pink flowers and more suitable for wet conditions. The oil content is higher during the summer months from April to June. The terminal portion with 6 to 12 leaves contains more oil than the middle and basal portions.

In the evaluation trail of the Algerian and Reunion types, POG-7 and PG-20 respectively at the Horticulture Research Station, Kodaikanal, the clone PG-7 recorded 0.3% essential oil and 2.32 ml of oil per plant, and has been released under the name 'KKL-1'. The Indian Institute of Horticultural Research (IIHR), Bangalore, has found 'Sel-8' a Reunion type, as the highest yielder under Bangalore conditions and has recommended it for cultivation. 'Hemanti' 'Bipuli' and 'Kunti' are the other varieties released by the CIMAP, Lucknow, for cultivation in the plains of North India. Kelkar, Ooty, and IIHR Sel-8 are the other varieties available in this crop.

Soil

Geranium is shallow-rooted crop and, as such, it requires well drained porous soil. The crop is found to perform well in red lateritic soils with a pH of 5.5-8.0, though a calcium rich porous soil is the best.

Climate

Geranium can be grown in temperate, subtropical and tropical climates at various altitudes from 1 000 to 2 200 m. It thrives best in subtropical climates with a temperature ranging from 5 degree C to 23 degree C. However, temperatures below 3 degree C will kill the plant. Warm winters coupled with mild summer temperatures and, well-distributed annual rainfall ranging from 100-150 cm is ideal. However, heavy rainfall results in water-logging, causes root-rot and stunted growth. It has been observed that it grows equally well at much lower altitudes and tolerates higher temperatures up to 43 degree C in the plains when grown under irrigated conditions.

Propagation

Geranium is easily propagated by cuttings, since there is no seed setting in geranium, vegetative propagation is must. Terminal cuttings about 20 cm long and consisting of about 8 nodes are the best suited material for propagation, as they give 80% rooting even without any

treatment. However, the middle portion and basal cuttings are reported to give poor rooting, which can be improved but treating them for 6 minutes with growth regulators like IBA or IAA at 200 ppm. Thus, a rooting of 80% and 6505 respectively can be obtained.

The cuttings are planted in raised beds 3 m long and 1 m wide. The soil should be well mixed with powdered FYM. The cuttings are planted closely at a spacing of 8-10 cm. Before planting, the cut ends of the cuttings are dipped in 0.1% Benlate solution. Before root initiation, temporary shade is provided and the beds are watered regularly. The nursery is sprayed with a 0.2% Urea solution at biweekly intervals and the cuttings are ready for transplanting. They can also be rooted in polythene bags, which help to avoid damage to the root-system while planting in the main field. This practice ensures a high percentage of success in the field.

Recently, its propagation through leaf petioles had also been reported to give a good rooting percentage (75%), which will help to multiply this plant in larger numbers than the traditional method of propagation using 20 cm-long cuttings. The CIMAP, Lucknow, has developed a protocol for large –scale production of geranium cell clones and plants have been obtained under field conditions with improved oil-yield and quality.

Planting and After-care

About 30,000 cuttings are required for planting an area of 1 ha. Before planting, the land should be properly prepared by ploughing (disc) and brought to a fine tilth. Ridges and furrows are made, the application of fertilizer and irrigation should be done a day prior to planting. The cuttings are carefully dug out from the nursery and planted at a spacing of 60 cm x 60 cm. They must be irrigated immediately after planting. Irrigation is continued on alternate days for about 10-15 days and then reduced to twice a week. The schedule is modified during the winter and summer months at intervals of 7 to 10 days, depending on the situation. Though geranium tolerates short periods of drought, water-logging of the crop must be completely avoided. The crop c growth is slow initially; weeds should, therefore, be removed periodically. Intercropping of cowpea or black gram is beneficial during the log phase and they do not affect the geranium crop. It has been experimentally observed at the CIMAP. Lucknow, that polyhouse cultivation reduces weed infestation, the number of irrigations and produced less weed biomass.

Manures and Fertilizers

Prior to transplanting the cuttings, 10 t of good quality FYM, 35 kg N, 35 kg P₂O₅ and 35 kg K₂O/ha are incorporated into the soil in the form of urea, super phosphate and Muriate of potash. A second dose of nitrogen at 35 kg/ha is applied about 2 months after the first application, Further, nitrogen is given in two equal split doses for each harvest-the first dose being just after the crop is harvested and the second two months later. Altogether, 210 kg/ha/yr

of N is applied to the crop in six equal doses to cover three harvests. Application of 30 kg N/ha (15 kg/ha as basal and 15 kg as a foliar spray with 1% urea solution, 45 and 90 days after basal application) is reported to increase herbage yield and oil yield by 447% and 140%, respectively, over the control.

In addition, the application of 20 kg/ha of zinc Sulphate and 10 kg/ha of boron has been reported to increase the herbage yield. Similarly, an application of copper (20 kg/ha) and molybdenum (30 kg/ha/year) in four split doses after each harvest has been found to increase the yield by 37%.

Pests and Diseases

The incidence of pest and disease is not severe in the geranium crop. However, it is found to be affected by wilt disease, caused by the *Fusarium* species, and *Botrydeplodia theobromae*, which are soil borne fungi.

Recently, *Alternaria alternate* has been reported to cause leaf blight in the Terai region and Kumaon Hills of Utter Pradesh and *Sclerotium rolfsii* causes, collar-rot disease and *Rhizoctonia solani* causes root-rot and wilt in the Kodaikanal region of Tamil Nadu.

To avoid wilt disease, the following prophylactic measures are recommended.

- i) Dip the cuttings in 0.03% Benlate solution at the time of planting in the nursery.
- ii) Prior to transplanting the rooted cuttings must be again dipped in 0.03% Benlate solution and then planted.
- iii) The crop is sprayed with 0.03% Benlate solution about 2 weeks before it is harvested. Also after the harvest it is repeated, so that the cut-ends are drenched with the fungicide.
- iv) It has been observed at the CIMAP, Lucknow, that the cultivation of geranium in association with marigold (*Togetes minuta*) improves the survival of geranium plants over the monsoon time in the North Indian plains. Roots-knot nematodes, *Meloidogyne incognita* and *M.hapla*, a have been found to affect the geranium plant. Application of Aldicarb @ 20 kg/ha to the soil reduces the incidence of root-knot.

Harvesting

Geranium is harvested 4 months after transplanting, when the leaves begin to turn light-green and exhibit a change from a lemon-like odour to that of rose. However, this requires careful observation and experience. The crop should be harvested using a sharp sickle and sent for distillation immediately. The use of sharp sickle is important as it minimizes the jerks, pulls and damage to the crop while harvesting. After every harvest, hoeing, fertilizer application and irrigation are done according to the schedule. The plant then puts forth fresh shoots, grows faster, and reaches the next harvesting stage in 4 months. Thus, a total of 3 harvests can be

obtained for 3-6 years. Cultivation under polyhouse conditions is reported to reduce the harvest time by 21 days.

The essential oil is distributed over the green parts of the plant, particularly in the leaves. The oil content is higher during the summer months, from April to June. The terminal portion with 6-12 leaves contains more oil than the middle and basal portions.

Yield

The quality and yield of oil will be better if the crop is harvested at the appropriate time of maturity. For a higher yield, a good plant population in the field is necessary. A minimum of 25,000 plants should be maintained in a hectare in a year which, in turn, may yield 15 kg of oil on distillation. The recovery of the oil ranges from 0.08 to 0.15%, depending upon the season of harvest and type of material. Cultivation under polyhouse cover is reported to increase herb and oil yields up to 53% over the conventional planting of the geranium crop.

Distillation of Oil

The freshly-harvested terminals are used for the distillation of oil. The plant material is stacked near the stills for about 12 to 24 hours. This results in a slight fermentation and splitting of the glycosides, which increases the yield of oil. The oil is extracted by a simple distillation method. The herbage is tightly packed in a still over the perforated grid and tamped down tightly and the still-head is clamped shut. The steam is generated in a separate boiler and conveyed to the still. The oil volatilizes and escapes along with the steam vapours, which is later condensed by passing it through a condenser with running cold water. The condensed oil is separated from the water by the differential density method and clarified by filtering it with activated carbon.

1. Geranium is a native of _____
2. _____ can be obtained as a bye-product from geranium stem and leaves after extraction of oil
3. Oil content of geranium ranges from _____
4. Propagation of geranium is _____
5. Botanical name for geranium _____

DAVANA

Plant Profile

Family	: <i>Asteraceae</i>
Indian name	: Davanam (Sanskrit), Marikolundu (Tamil), Davana (Hindi, Kannada).
Spices and Varieties	: <i>Artemisia pallens</i> Wall.
Distribution	: India
Uses	: Cosmetics, Flavouring beverages & Confectionery

Davana (*Artemisia pallens* Well.) (2n=16), belonging to the family *Asteraceae*, is an important annual aromatic herb, much prized in India for its delicate fragrance. The *Davana* springs are commonly used in garlands, bouquets and religious offerings in most part of the country. The leaves and flowers contain the essential oil valued for its exquisite and delicate aroma and is used in high-grade perfumes and cosmetics. The oil of *Davana* contains hydrocarbons (20%), esters (65%) and oxygenated compounds (15%). The esters are the major constituents responsible for the characteristic smell of



Davana. Saponification of the oil gives 10% cinnamic acid, while the alcohol part gives viscous oil with a high boiling point. It is reported that a new sesquiterpene ketone called *cis-davanone* in the oil is responsible for its characteristic odour. The other constituents isolated from the oil include a sesquiterpene ketone named 'artemone', novel sesquiterpenoids named 'davanafurans' and another ketone named 'isodavanone'.

The essential oil of *Davana* which is a brown, viscous liquid with a rich, fruity odour has acquired a considerable reputation in the international trade, particularly in USA and Japan where it is being used for flavouring cakes, pastries, tobacco and beverages.

Origin and Distribution

The plant grows wild in the temperate Himalayas. It is common in the Kashmir Valley, the Simla and Nainital Hills. It is being commercially cultivated in Karnataka, Maharashtra, Kerala, Tamil Nadu and Andhra Pradesh in an area of about 1000 ha.

Description of the Plant

Davana is an aromatic, erect herb, about 60 cm tall, with much divided leaves and small yellow flowers. The stem and leaves are covered with grayish-white tomentum. The leaves are alternate, petiolate and lobed. The inflorescence is capitulate with flowers which are peduncle to sessile, axillary or forming lax racemes, simple, heterogamous having bisexual disc florets in the centre and a few pistillate ray florets on the periphery.

The outer florets are glabrous except for a few cottony hairs, tubular, generally 3-lobed. The stigma is generally 2-lobed and rarely 3-lobed. The inner florets are glabrous except for a few cottony hairs, tubular, 5-lobed and bisexual: the stamens are 5 in number with free, epipetalous filaments and a ditheous inflorescence: it has syngeneious anthers which are connective, prolonged, tapering style and bifid.

Soil

The crop is found growing on various types of soils from sandy loam to medium black. However, a fertile, well-drained, sandy loam soil which is rich in organic matter is ideal.

Climate

Season is an important aspect to be considered when Davana is grown for extracting essential oil. The oil content in the plants was observed to be maximum, when the crop was grown during the winter season compared to the other seasons. Thus, when the crop is grown for the production of oil, it should be planted during the first week of November. A few light showers with moderate winter conditions and no frost is conducive to the good growth of the plant. High temperature and heavy rains at the time of flowering have not only been found to affect the plant growth adversely, but also reduces the oil content and ultimately the oil yield.

Cultivation

Nursery raising

Davana is propagated by seeds. As the seeds lose viability rapidly, only the seeds from the previous season's crop should only be used for sowing. About 1.5 kg of seed is required to produce enough seedlings to transplant into an area of one hectare.

Usually, nursery-beds 2 m long and 1 m wide are preferred. The surface of the beds should be clod-free. It is then incorporated with finely prepared FYM at the rate of 10 kg per bed. Sowing of seeds at the rate of 1 g/sq m is desirable. The seeds may be sown either dry or after wetting them along with sand for about 48 hours. In the latter case, the seeds are thoroughly mixed with sand @ 4-5 times their volume. To this mixture, water is added so that the sand is sufficiently wet. It is then tied in a cloth bag and stored in a warm place for 48 hours. This will hasten the sprouting of seeds and the radicle will emerge at the end of 48 hours. The

nursery-bed is then flooded with water to make a pool and the sprouting seed and sand mixture is broadcasted all over the bed, homogeneously. This method helps in uniform distribution of seeds. When the seeds have settled down, a thin layer of sand is spread over just enough to cover them. The seeds will germinate within 2-3 days of sowing. Hand watering is done till the seedlings establish themselves (7-10days), after which the beds are irrigated directly through the water channels.

While sowing the dry seeds, they are mixed with sand in the ratio of 1:10 and broadcasted homogeneously all over the bed. A thin layer of sand is then spread uniformly to cover the seeds and the beds are hand watered twice a day. To prevent the ants from carrying away the seeds, an application of 10 kg/ha of Heptachlor to the soil about 10 days prior to sowing has been helpful. Using this method, the germination of seeds is observed in about 4-5 days.

In areas where there are rains at the time of nursery raising, the seedlings may be grown on raised nursery-beds which will also help in reducing the incidence of damping-off disease. As there is a very slow growth of seedlings initially, foliar sprays of urea (0.1%) at weekly intervals, 3 weeks after sowing, may be given to boost their growth.

Transplanting

The seedlings will be ready for transplanting in about 6-8 weeks from the date of sowing. At this stage, the seedlings should be about 10 cm tall. Before transplanting, the field is thoroughly prepared by bringing the land to a fine tilth with repeated ploughings. It is then laid out into plots of convenient size by laying out bunds and channels. The size of the plot depends on the conditions prevailing locally. However, generally, plots of 3-4 m x 1.5-2.5 m size are preferred as it facilitates irrigation, weeding and other intercultural operations.

After the preparation of the plots, the soil is incorporated with 6 t/ha of well decomposed FYM or compost. The plots are irrigated a day prior to transplanting. The seedlings are then transplanted at a spacing of 15 cm between rows and 7.5 cm between plants. Trials have shown that transplanting Davana plants closed together results in higher herbage-yield and, subsequently, higher oil-yield compared to wider spacing, which results in larger plants but lower herbage and oil-yield per unit area.

Manures and Fertilizers

Davana responds well to the application of manures and fertilizers. Well-decomposed FYM at the rate of 6 t/ha is incorporated into the soil at the time of land preparation. Subsequently, a fertilizer dose of 40 kg P and 40 kg K/ha is given at the time of transplanting.

While N is applied at the rate of 120 kg/ha in three equal split doses: the first dose is given at 10 days after transplanting and the subsequent two doses at 15 days' intervals thereafter.

Irrigation

After transplanting, the plots are immediately provided with light irrigation. Later, irrigation is provided daily till the seedlings are well established (10-12 days) and, subsequently, once in 3-4 days depending on the weather conditions.

Interculture

The field is kept weed-free by regular weeding as and when required. In all, about 2-3 hand-weedings during the early period of growth will help to keep the weeds down.

Growth Regulator Application

Growth regulators have been used to boost the growth and yield in many crops. In Davana also, an application of GA at 200 ppm after five weeks of transplanting has been found to increase the herb and essential oil-yield per unit area.

Insect Pests

No serious attack of insect pests has been reported in Davana. However, some insect pests like leaf-eating caterpillars, aphids and termites have been observed to affect the crop.

The application of Aldrex to the plots will control the attack of termites, while the spraying of any systemic insecticide like 0.05% of Monocrotophos or 0.2% of Dimethoate will control the incidence of aphids and the spraying of contact insecticides like 0.2% Metacid will control leaf-eating caterpillars.

DISEASES - Damping-off

This disease is caused by fungus belonging to the *Rhizoctinia* spp. It is usually severe at the nursery stage, particularly when there is high humidity and cloudy weather conditions, resulting in the heavy mortality of seedlings. Controlling the irrigation will reduce the incidence of the disease. Treating the seeds with Emisan @ 0.2% or Ridona MZ at 0.1% before sowing and then drenching the seed-beds with the above chemicals a week after germination controls the disease.

Harvesting

The crop starts flowering after 110-115 days of sowing, which will be around the 2nd or 3rd week of February. In order to obtain the maximum essential oil-yield, the plants should be harvested when about 50% of them have come to the flowering stage. This is usually at the end of February or in the 1st week of March, about 120-125 days after sowing. Harvesting is done by cutting the plants from the base. Although there are reports about the possibility of obtaining a ratoon crop in Davana, it is not practical as the main crop is harvested only during the month

of March and the ratoon starts sprouting by the end of March or the beginning of April which, due to the high temperatures prevailing during these period, results in poor growth of the plants and mutilated flower-buds which may even fail to open. The crops, thus obtained, become uneconomical as the flower-heads are the major contributors of oil.

Distillation

The harvested material, before distillation, is dried under the shade for 2 days. It is better to distill this immediately rather than to store it. The dried material is steam-distilled to obtain good quality oil. However, for the estimation of essential oil under laboratory conditions, particularly of a small sample, the shade-dried material is hydro-distilled.

In the case of hydro-distillation, the material is placed in a glass still and water is added to it, so that around three-fourths of the material is immersed in water and it is then heated. During boiling, the water vapours along with the vaporized oil moves into the condenser, gets condensed and collects in a graduated receive. Based on the amount of oil collected, the oil content of the material can be determined.

However, for commercial purposes, steam distillation should be used. The distillation equipment consists of : (i) A Boiler, which produces the stem; (ii) A Distillation Still in which the material is filled and steam is passed through; (iii) A Condenser, wherein the vaporized oil gets condensed into a liquid form and (iv) A Receiver, to collect the oil.

The boiler and the distillation still are made of steel. The boiler is connected to the distillation still by a steel pipe through which the steam passes. A perforated grid (plate) is placed at the bottom of the still on which the plant material is kept. The distillation still is connected to the condenser through a pipe. The condenser consists of many metallic pipes mounted inside a jacket. It is provided with an inlet and an outlet. Water is passed through the gap between the pipes in order to cool the steam and essential oil vapours into liquid form, which then gets collected in the steel receiver. The oil, being lighter than water and insoluble, floats on the surface of the water.

For distillation, the air-dried herbage is chopped into smaller pieces and then charged into the still. While filling, the material should be tightly packed inside the still, as otherwise steam channels may be formed during distillation resulting in poor yields. About 5-6 hours are required to complete the charge.

After decantation of the top, clear layer of oil, the bottom layer which consists of small quantities of water and oil has to be clarifies. To separate the oil, a saturated solution of sodium chloride is added to this mixture so that a separated layer of water and oil is formed. The lower

water-layer is drained off with the help of a separating funnel and the upper layer of oil is collected.

Yield and Oil Content

The yield of fresh herbage, including flower-heads, is around 12-13 t/ha. Though, under laboratory conditions, the oil content in the whole plant after drying it in the shade for 2 days is 0.29%. An average recovery of around 0.2% under large-scale distillation, yielding 12-13 kg/ha of oil may be considered satisfactory.

When oil is extracted from the whole plant, the flower-heads contribute the major portion of the oil. The contribution of the leaves and stems towards the percentage of oil content in a whole plant is very little. The percentage of oil content in different plant parts, worked out under laboratory conditions on V/W basis, is as follows:

Plant part	Percentage of oil content (2 days, air-dried basis)
Flower-heads	0.53
Herbage (leaves + stem)	0.14
Whole plant	0.29

1. Botanical name of Davana is _____
2. What are the uses of Davana _____
3. The inflorescence present in Davana is _____
4. Davana is propagated by _____
5. Oil recovery percentage of Davana is _____

COCONUT

(*Cocos nucifera*, Palmae)

The coconut palm, *Cocos nucifera* L., is one of the most beautiful and useful palms in the world. It provides a variety of useful products like food, fuel and timber. Every part of the tree is being utilized for some purpose or other and hence, it is called Kalpavriksha meaning tree of heaven which provides all the necessities of life. It is grown in India in about 1.51 million ha. With an annual production of about 9283.4 million nuts. It ranks third in world in area and production, first and second being Indonesia and Philippines respectively. Among the different coconut growing states in India, Kerala, Tamilnadu, Karnataka and Andhra Pradesh account for nearly 90percent in area and production.

Name of the State	Share in area (%)	Share in production of nuts (%)
Kerala	57.74	49.28
Tamilnadu	12.80	23.63
Karnataka	16.24	14.68
Andhra Pradesh	3.94	2.82
Other states (Orissa, Maharastra, Assam, West Bengal, Goa, Daman, Andaman, Pondichery, Tirupura etc.), 9.28 (%), 9.59 (%)		

Among the Southern States though Tamil Nadu has share in area (92, 14,200 ha), its share in production is due to the higher productivity per palm.

Botany

Origin of coconut is believed to be somewhere in South East Asia. Coconut, botanically *Cocas nucifera* has only one species under the genus *Cocos*. It is a tall stately unbranched palm growing to a height of 12m to 24m. The stem is marked by rings of leaf scars which are often not prominent at the base. The palm has an adventitious root system, having numerous thick roots from the base of the stem almost throughout its life. The roots are localized generally at the lower most region of the stem which has been termed the bole. Leaves are large, long, pinnately sect, borne on the crown. The palm is monoecious with relatively few female flowers. Male flowers are numerous small with six stamens and in female flowers, the ovary is tricarpic, usually one ovuled.

Fruit is large, one seed drupe. The outer layers of the pericarp are thick and fibrous. The inner layer (endocarp of shell) is very hard, horny or stony and the thin testa cohering to the endocarp is lined with white albuminous endosperm (meat), enclosing a large cavity, partially filled with sweet fluid. The inflorescence develops within a strong, tough pointed double sheath

called spathe which after full developed splits along its underside from top to bottom and releases the inflorescence. This usually occurs from 75-95 days after the first appearance of its tip in the leaf axil. The primordial of the inflorescence begin to form the leaf axil about 32 months before the opening of the spathe. In bearing coconut palm every leaf axil can produce a spadix and under normal conditions it varies from 12-15 per annum. However, this number may be reduced due to adverse weather condition.

In India, the female flower production is high during the period from March- May and low from September – January. In general, the number of female per inflorescence varies from 10-50. Female flowers normally become receptive 19-20 days after the opening of the spathe. Genetically the dwarf palms are autogamous while tall types allogamous. Both winds and insects are considered to be the main pollinating agents. A large number of buttons (female flowers) fail to develop due to lack of pollination and fertilization, defect in the flowers, physiological disorders, genetic nature of the variety, pests and disease and unfavorable environment etc. Generally, not more than 2 to 40% of the female flowers reach maturity under normal conditions.

Climate and soil

The coconut palm is found to grow under varying climate and soil condition. It is essentially a tropical plant, growing mostly between 20 N and 20 S latitudes. Near the equator, productive coconut plantation can be established up to the elevation of about 1000m from sea level while the further one goes from the equator, the more is the palm confined to lowlands. The palms tolerate wide range in intensity and distribution of rainfall. However a rainfall of about 200cm per year and well distributed throughout the year is the best proper growth and maximum yield. In areas of inadequate rainfall with uneven distribution, irrigation is required. Soil moisture deficit during summer hampers nut production to greater extent. Palm requires plenty of sunlight and odes not grow well under shade. Coconut is adaptable to a wide range of soil conditions, from light sandy soils to heaviest clays with a pH ranging from 5.2 to 8.0. Best soils are deep, friable, loamy soils. In heavier soils, it requires good drainage.

Cultivars and Hybrids

Coconut palms are broadly classified into two groups, the tall and dwarf. The tall cultivars are the common type that occurs throughout the world. The different cultivars of the Tall are known by the place where they are largely cultivated. The tall cultivars largely grown in India are the West Coast Tall and East Coast Tall.

The dwarf varieties are shorter in stature and life span as compared to Talls. They start bearing earlier compared to Talls. The size of the nuts and the quality of copra are inferior to

Talls. The Dwarf cultivars occur with three nut colours viz. green, yellow, and orange. The dwarf cultivars are generally grown for tender nuts and also for hybrid production. The common dwarfs available in India are Chawghat Orange Dwarf, Chawghat Green Dwarf, Malayan Green Dwarf, Malayan Yellow Dwarf, Malayan Orange Dwarf, Gangabondam etc.

The hybrids between Tall and Dwarf forms (TxD) or vice Versa (DxT) show hybrid vigour for growth, earliness and yield. Hence, hybrids have been released recently for cultivation. The important cultivars and hybrids recommended now for cultivation are given below:

TALLS

West Coast Tall (WCT): It is a common tall cultivar, cultivated through out the West Coast region because of its commercial importance, high copra yield (115 to 180 g /nut) and high quality in terms of high oil content (70 to 72%). WCT is a hardy palm, yields economically ranging from 50 to 100 nuts /palm /year (mean of 70 nuts under rainfed condition) for about 60 to 75 years. It is one of the best indigenous types grown from very ancient times in India. The nuts are varying in shape, medium in size with colour varying from green, yellow to brown; varying in husk and kernel content also. This cultivar commences to yield in about 6 to 8 years after planting under favourable conditions. The mean yield of nuts is positively correlated with both annual outturn of copra and oil; whereas it is negatively correlated with mean copra content per nut.

East Coast Tall (ECT): It is a common tall cultivar. The time taken for flowering is 72.9 months. ECT is a hardy palm, yields economically ranging from 73 nuts /palm /year. The average weight of copra is around 125g. The oil content is around 64%.

Laccadive Ordinary (Chandrakalpa): It is a native of Lakshadweep, similar to West Coast Tall in almost all characters, except for the prominent ridges on the triangular nuts and the average yield is comparatively high, 120 nuts /palm /year (range 90 to 180). This type is recommended for commercial cultivation in the country because of high quantity and quality of copra production. About 6200 nuts are required to make one tone of copra. The performance of Laccadive Ordinary has been found to be good in most of the coconut growing states in India; it gave the highest yield of copra /palm at Pilicode (Kerala) and Arsikere (Karnataka); while it gave maximum number of nuts /palm at Ratnagiri (Maharashtra) and Ambajipeta (Andhra Pradesh) research stations.

HYBRIDS

Chandra Sankara: Chawghat Orange Dwarf X West Coast Tall, It is a hybrid. The time taken for flowering is 60 months. On an average a tree of this hybrid can yield 116 nuts/palm/year. The average weight of copra is 215g and oil content is around 68%.

ChandraLaksha: Laccadive Ordinary X Chawghat Orange Dwarf: It is a hybrid. The time taken for flowering is 48 months. On an average a tree of this hybrid can yield 109 nuts/palm/year. The average weight of copra is 195g and oil content is around 69%.

Laksha Ganga: Laccadive Ordinary X Gangabondam: It is a hybrid. The time taken for flowering is 60 months. On an average a tree of this hybrid can yield 108 nuts/palm/year. The average weight of copra is 195g and oil content is around 70%.

Keraganga: West Coast Tall x Gangabondam: Five years for flowering, 100 nuts per tree, 201g copra, 69% oil content.

Anantha ganga: Andaman Ordinary X Gangabondam: Five years for flowering, 95 nuts per tree, 216g copra, 68% oil content.

Varieties released by TNAU, Coconut Research Center – Veppankulam

From this research institute till now one Tall variety (VPM), and three hybrid varieties have been released.

VPM –3: This is a Tall variety. In Tamil Nadu it is suitable for cultivation in rain fed areas. It will start to bear in 5-7 years after planting. On an average a tree of this variety can yield 90 nuts/palm/year. The nuts are larger in size. The average weight of copra is around 176g. It can tolerate drought and can yield higher.

VHC –1: This is the cross between East Coast Tall and Chawghat Green Dwarf variety and was released in 1982. It is a hybrid variety. On an average it can yield 115 nuts/palm/year. The average weight of copra is around 142g. It contains 69% oil.

VHC –2: It is the cross between East Coast Tall and Malayan Yellow Dwarf and was released in 1988. It is a hybrid. On an average a tree is around 142 nuts/palm/year. The average weight of copra is 146g and oil content is around 70%.

VHC-3: It is the cross between East Coast Tall and Malayan Orange Dwarf, and was released in 2000. It is a hybrid. On an average a tree is around 156 nuts/palm/year. The average weight of copra is 162g and oil content is 70.2%.

ALR-1: High yielding tall type, One year earlier flowering compared to WCT, ECT and VPM3, tolerant to drought, 7645 nut gives one tone copra, moderately tolerant to major coconut pest.

Production of Coconut Seedlings

Since coconut cultivation involves substantial pre-bearing investment, greater emphasis must be given for the selection of the right type of planting material. Quality seed nuts and seedlings are obtained through a series of selections made at various stages.

1. Selection of seed gardens

- i. The garden should have palms with record consistently high yields and high proportion of heavy bearers.
- ii. They should not be located under favourable environment.
- iii. They should be free from disease and pests.

2. Selection of mother plants

In order to raise coconut seedlings of superior quality, the selection of mother palm should be done prior to taking seed nuts. The following points may be taken into case of while selecting mother palms.

- i. The palm should be strong, stout and growing straight.
- ii. Leaf scars on the palms should be closely spaced.
- iii. The palms should be regular bearer with annual yield of more than 80 nuts and copra contents not less than 150 g per nut.
- iv. Palms should have reached full bearing stage and have been giving consistently high yields for atleast four years.
- v. Palms of above 60 years should be avoided.
- vi. Palms should have atleast 30 fully opened leaves on the crown
- vii. The leaves should have short strong petioles with wide leaf base firmly attached to the stem. Their arrangement should provide support to the bunches.
- viii. Each leaf axil should have one inflorescence with large number of spikes and one or two female flowers per spike.
- ix. Bunch stalk should be short stout and strong.
- x. Palms should have medium sized nuts (about 1200 g dry weight / nut) with round and oblong shape. Husked be large (about 570 g) with thick kernels.
- xi. Palms, which produce barren nuts or those shedding large number of nuts in the immature stage, should be discarded.

3. Selection of seed nut

For raising seedlings, it is important to collect seed nuts of high quality from the selected mother palms. The selected nuts can be stored under dry and cool places for about 3-4 months without deteriorating their viability. The following points should be considered while selecting seed nuts.

- i. Collect seed nuts from February - May
- ii. Harvest only fully matured nuts (11-12 months old)



- iii. Nuts should not be damaged while harvesting
- iv. Discard the nuts having irregular shape, size and improper development
- v. Select seed nuts of uniform size with thin husk weighing above 100 g.
- vi. Selected seed nuts should float on water vertically. The content of copra should be more than 150 g.

4. Raising of seedlings

- i. Select site with well drained coarse textured soil near dependable water source
- ii. Prepare the raised beds to avoid of water stagnation during rainy season
- iii. Sandy soil is the best for raising seedlings on large scale
- iv. If the soil is not sandy, treat the soil with lidane as a precaution against white grub and termites.
- v. Nursery can be raised either in open with artificial shade or in gardens where the trees are tall and the ground is not completely shaded.



- vi. The seed nuts should be sown in long and narrow beds at a spacing of 40 x 30 cm during May-June in 20-25 cm deep trenches. However the length and width of nursery beds should be kept as per ones convenience.
- vii. The seed nuts with less nut water and seed nuts of dwarf cultivars may be sown horizontally to ensure early germination. Discard nuts in which water has dried.
- viii. Before sowing it is advisable to dip seed nuts in suspension of Lindane (400 g in 100 litres of water) as an additional precaution against white grub and termites.

5. Care and Management of nursery

- i. Regular watering to be done after rainy season
- ii. Mulching and shading should be done after rainy season
- iii. Keep nursery free of weeds
- iv. Conduct regular surveillance for any incidence of pests and diseases

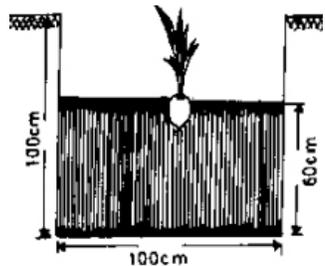
6. Selection of seedlings

Prior to transplanting selection of seedlings is utmost important. The following points will help in selection of superior quality seedlings

- i. Select early germinated seedlings
- ii. Select seedlings which show early splitting, short petiole and broad leaves
- iii. Select seedlings which are ready for transplanting in 9-12 months
- iv. Select seedlings with well developed root system
- v. Select seedlings having thick and short collar region

Preparation of land and planting:

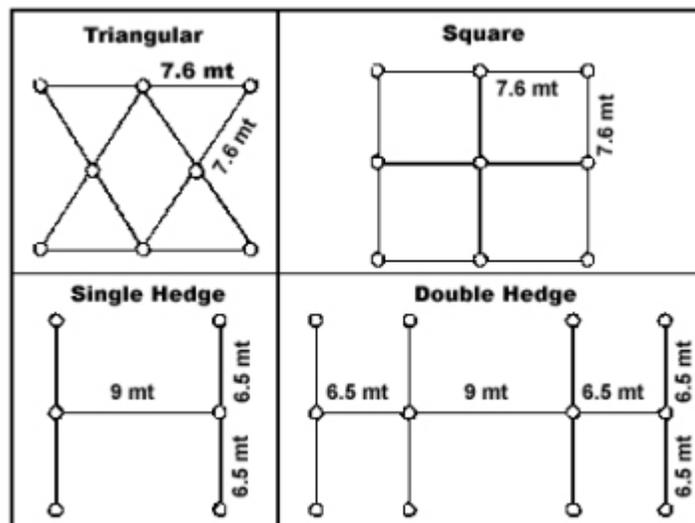
The depth of pits will depend upon the soil type. Normally a pit size of 1.0 X 1.0 X 1.0 m is dug and filled up to 50 cm depth with sand and powdered cow dung. However, when the water table is high, planting at the surface or even on mounds may be necessary but digging pits and filling has to be done.



System of planting

Spacing of palms requires careful consideration.

	Planting system	Spacing
1	Triangular	7.6m
2	Square	7.6x7.6m, 8x8m, 9x9 m
3	Single Hedge	6.5m in rows - 9m between rows
4	Double Hedge	6.5 to 6.5m in rows - 9m between pairs of rows



In well-drained soil, seedlings can be transplanted with the beginning of south-west monsoon. If irrigated facilities are available, it is advisable to take up planting at least a month before the monsoon sets in so that the seedling get well established before the onset of heavy rains.

Care of young palms

Young palms require good care in the early of growth. The transplanted seedling should be shaded and irrigated properly especially during the summer months. Provision of proper drainage is also equally important in areas subject to water logging. The pits should be cleared of weeds periodically. Soil washed down by the rains and covering the collar of the seedlings should also be removed. The pits should be gradually filled up as the seedlings grow.

Manuring

As coconut yields throughout the year it takes heavy amount of nutrients from soil especially N, K and Cl. Therefore, regular Manuring from the first year of planting is essential to ensure good vegetative growth, early flowering and bearing and high yields. The fertilizer requirements of different coconut growing states are given below:

States	Doses (g) /Palm				
	FYM (kg)	N	P ₂ O ₅	K ₂ O	MgO
Kerala-General	50	500	320	1200	-
Kerala-Root wilt areas	50	500	500	1000	500
Karnataka	50	680	450	900	-
Maharastra	50	750	225	900	-
Tamil Nadu	50	560	320	1200	-

The first application of fertilizers should be done three months after planting (nearly 1/10th above dose) while during the second year, one- third of the dosage recommended for adult palm may be applied in two splits doses and during the third year, 2/3 of the dosages recommended for adult palm may be applied and from the fourth year onwards, the full dose recommended may be applied. After the receipt of summer showers, 1/3 of the recommended dose of fertilizers for a year may be spread around the palms within a radius of 1.8 m and forked in. the remaining 2/3 of recommended dose of fertilizer may be spread over 50 kg of the green leaf or compost per palm in circular basins of 1.8 m radius and 25 cm depth during September / October and the basins covered.

Irrigation and soil moisture conservation

The coconut palm responds to summer irrigation. Production of female flowers and setting percentage increases considerably due to irrigation. Since spadix initiation to ripening of nuts takes nearly 42 months, the full benefit of irrigation can be felt only after three years. Under West Coast conditions, 2 cm irrigation once in 4-5 days during December to May is beneficial in sandy loam soils. In areas where water is scarce, drip irrigation system can be adopted. This requires only 30 liters of water per day per palm is against 200 liters per palm in conventional irrigation.



Burying the coconut husk or coir dust is one of the most effective ways of conserving soil moisture. These husks or coir dust can act as sponge and absorb and retain moisture about six and times respectively to their own weight and slowly release to the coconut periods during dry periods. As the husk or dust breaks down slowly, their effect will last for 4 to 6 years and 8 to 10 years respectively. On decomposition they also add K to soil. These husks and dusts can be added in pits or trenches taken in between the trees but in all the cases the depth should be 0.6 m and 1.8 m away from the bole. Husks or dusts can be added in alternate layers with soil.



Intercultivation

Regular Intercultivation is very essential to step up and maintain the production at a high level. Tillage operations like digging the garden with spade, ploughing, forming small mounds before the end of monsoon and making shallow basins with a radius of about 2 m at the beginning of monsoon and filling up at the close of monsoon are beneficial to the trees. Method of Intercultivation will depend upon local conditions, availability of labour, size of holding, soil type, topography and distribution of rainfall. Cover cropping is recommended where inter and mixed cropping is followed to prevent soil erosion in coconut gardens. Leguminous crops such as *Mimosa invisa*, *Stylosanthes gracilis* and *Calapogonium mucunoides* are generally recommended. Green manure crops like sun hemp (*Crotalaria juncea*) and Kolinji (*Tephrosia purpurea*) are also raised and ploughing in during Aug-Sep. These crops can be sown in APRIL-MAY when pre-monsoon showers are received.

Inter and mixed cropping

In pure coconut garden when palms are spacing at 7.5 x 7.5 as much as 75% of the available area is not effectively utilized. Besides, a pure coconut grove utilizes only half of the available light. Hence, a variety of intercrops like pineapple, banana, groundnut, chillies, sweet potato and tapioca can be raised in coconut gardens after the palm attaining the height of 5-6 m. In older plantations cocoa, pepper, cinnamon, clove and nutmeg can be grown as mixed crop. In places where rainfall is not well distributed, irrigation may be necessary during summer months.



However, these crops are to be adequately, separately manured in addition to the manures applied to the coconut palm. Mixed farming by raising fodder grasses such as hybrid Napier grass, guinea grass along with leguminous fodder crops such as *Stylosanthes grassilis*. Coconut gardens can support 4 –5 dairy animals. The cattle manure generated from the system when applied to coconut gardens improves the soil fertility considerably.

Pest management

Rhinoceros beetle (*Oryctes rhinoceros*)



Symptoms

The adult beetle bores into the unopened fronds and spathes. The attacked frond when fully opened shows characteristic triangular cuts.

Control

1. Provide field sanitation to prevent breeding of beetles.
2. Hook out the beetles from the attacked palms by using beetle hook.

3 The topmost three leaf axils around the spindle may be filled with any of the following mixtures as a prophylactic measure:

(a) Sevidol 8G 25 g + fine sand 200 g, which is to be done thrice in a year in April-May, September-October and December-January. (b) Naphthalene balls 10.5 g (approx. three balls) covered with fine sand, once in 45 days.

4. Treat manure pits and other possible breeding sites with 0.01% carbaryl on w/w basis. Treatment will have to be repeated every three months.

5. Release Baculovirus oryctes infected adults @ of 10-15 / ha to bring down the pest population.

6. Inoculation of breeding sites with entomopathogenic fungus *Metarrhizium anisopliae* (@ 5 x 10¹¹ spores / ml) gives effective control.

Red palm weevil (*Rhynchophorus ferrugineus*)

Symptoms

The diagnostic symptoms are the presence of holes on the stem, oozing out of a viscous brown fluid and extrusion of chewed up fibrous matter through the hole, longitudinal splitting of leaf base and wilting of central shoot. Sometimes the gnawing sound produced by the feeding grubs inside will also be audible.



Control

1. Field sanitation should be given prime importance.
2. Avoid making steps or any other injury on the tree trunks to reduce the loci of infestation.
3. Leaf axil filling as suggested in the case of rhinoceros beetle will be useful against the red palm weevil also.
4. When green leaves are cut from the palms, stumps of not less than 120 cm may be left on the trees in order to prevent successful inward movement of the grubs through the cut end.

5. In attacked palms, observe for the bore- holes and seal them except the top most one. Through the top most hole, pour 1% carbaryl or 0.2% trichlorophon or 0.1% endosulfan suspension @ one litre per palm, using a funnel.
6. When the pest infestation is through the crown, clean the crown and slowly pour the insecticidal suspension.
7. As an alternative, apply 1% DDVP or aluminum phosphide (for limited use only) one or two tablets per palm as a curative measure.
8. Coconut log traps with fermenting toddy or pineapple or sugarcane activated with yeast or molasses can be set in coconut plantation to attract and trap the free floating population of red palm weevil. Incorporate any of the insecticide to each trap to kill the weevils trapped.
9. Use of pheromone trap for attracting and killing adult weevils @ one trap per 2 ha.

Leaf eating/black headed caterpillar (*Opisina arenosella*)



Symptoms

The caterpillar feeds on green matter from the lower leaf surface, remaining within galleries of silk and frass. The attack will be severe during summer months from January-May.

Control

1. As a prophylactic measure, the first affected leaves may be cut and burnt during the beginning of the summer season.
2. Arrange for the release of larval / pupal parasitoids, *Goniozus nephantidis*, *Elasmus nephantidis* (brown species) and *Brachymeria nosatoi*.
3. When infestation is very severe and if the biocontrol is not likely to be effective, sprays the undersurface of the fronds with dichlorvos 0.02%, Malathion 0.05%, quinalphos 0.05%, endosulfan 0.05% or phosalone 0.05%.

Note: Application of the insecticides should be followed by liberation of larval and pupal parasites from the 21st day.

Cockchafer beetle (*Leucopholis coneophora*)

Symptoms

The soil inhabiting white grubs cause damage to the roots of coconut palm. The attack is common in sandy tracts. The infested palms turn pale yellow and there will be considerable reduction in yield.

Control

1. Collection and destruction of adults during the monsoon period from adjacent vegetation (in the evening).
2. Plough or dig the infested soil synchronizing with pre-monsoon showers.
3. Treat the soil with phorate 10G @ 100 g/palm or drench with chloropyrifos 0.04% suspension. The treatment should be given twice, first during April-May after the receipt of pre-monsoon showers and second during the month of September.

Note: Wherever possible, light traps may be set up to attract and trap adult beetles.

Coried bug (*Paradasynus rostratus*)

Symptoms

The attacked buttons become deformed with characteristic crevices on the husk below the perianth with gum exudations and the tender nuts become barren.

Control

Apply 0.1% carbaryl or endosulfan suspension on the newly opened inflorescence after the receptive phase of the female flowers and spray the entire crown excluding the leaves and older bunches.

Note: The insecticide may be applied according to the severity of infection in a need-based manner.

Coconut eriophyid mite (*Aceria [Eriophyes] guerreronis*)

Coconut eriophyid mite, a recently introduced pest is spreading at an alarming rate in Kerala. It is a microscopic worm like mite infesting young buttons colonizing under the perianth.

Symptoms

The earliest symptom on 2-3 month old buttons is pale yellow triangular patches seen below the perianth. Later, these patches become brown. Severely affected buttons may fall. As the buttons grow, brown patches lead to black necrotic lesions with longitudinal fissures on the husk. Uneven growth results in distortion and stunting of nuts leading to reduction in copra yield. In severe cases, the losses are compounded because the quality of fibre is reduced and distorted nuts increase the labour requirements for dehusking.



Management

1. Collect and destroy all the fallen buttons of the affected palm.
2. Apply 2% Neem oil + garlic emulsion or commercial Neem formulation azadirachtin 0.004% (Neemazal T/S 1% @ 4 ml per litre of water) or micronized wettable sulphur 0.4 % in the crown on young bunches. In large coconut plantations, dicofol 0.1% can be applied after taking adequate precautions. However, spraying of dicofol should be avoided in homesteads. When rocker sprayer is used 1.0 to 1.5 litres of spray fluid per palm is required. If a hand sprayer is used, the spray solution required may be about 500 to 750 ml. Spraying has to be done on second to seventh bunches from top avoiding un pollinated inflorescence.

Care should be taken to see that spray fluid reaches the perianth region of third, fourth and fifth bunches since these bunches harbour maximum number of mites. Three rounds of spraying are recommended in a year viz., March-April before the onset of southwest monsoon, in August-September during the dry spell between the southwest and northeast monsoons and in December-January after the northeast monsoon so that all the emerging bunches in the vulnerable stage receive one round of spraying. Rational rotation of the above pesticides may be adopted to avoid chances of resistance.

Preparation of Neem oil + garlic emulsion (2%)

To prepare 10 litres of 2% Neem oil + garlic emulsion, 200 ml Neem oil, 200 g garlic and 50 g ordinary bar soap are required. Slice the bar soap and dissolve in 500 ml lukewarm water. Grind 200 g of garlic and take the extract in 300 ml of water. Pour the 500 ml soap solution in 200 ml Neem oil slowly and stir vigorously to get a good emulsion. Mix the garlic extract in the Neem oil + soap emulsion. Dilute this 1 litre stock solution by adding 9 litres of water to get 10 litres of 2 % Neem oil + garlic emulsion.

As per the recommendation of the National Level Steering Committee, a holistic approach has to be adopted in the management of the coconut eriophyid mite. Hence, in addition to the plant protection measures mentioned above, the following measures can be adopted:

1. Improving nutrient status by applying organic manure at the rate of 50 kg and Neem cake 5 kg per palm per year.

Also apply the recommended dose of fertilizers in two split applications.

2. Growing compatible intercrops / mixed crops.

3. Providing adequate irrigation.

Mealy bug

Symptoms

Mealy bugs infest the unopened heartleaf and inflorescence. As a result, the leaves become highly stunted, suppressed, deformed and present a crinkled appearance. It is often confused with the leaf rot symptoms. The affected inflorescences are malformed and do not open. Even if they open, they do not bear nuts.

Button mealy bugs colonize under the perianth lobes of tender nuts. Infested nuts harbouring gravid mealy bugs remain on the spadix, which serve as inoculum for further spread.

Control

Remove and destroy all dried up inflorescence and unproductive buttons. Apply non-residual phosphatic insecticides like dimethoate 0.1%, quinalphos 0.05 %, and fenthion 0.1% at the site of infestation.

Neem garlic emulsion 2% applied on infested bunches checks button mealy bugs.

Rodents

Rats damage tender nuts by forming characteristic holes. Shed nuts can be seen at the base of the palm.

Control

1. Use warfarin-based wax blocks containing 0.025% active ingredient at intervals of three months for reducing rodent population.

2. Place wax blocks of 0.005% bromadiolone in coconut crown of the infested palms at 3 to 4 days interval till the bait is no more consumed.

Disease management

Phytophthora diseases

Phytophthora palmivora has been found to affect seedlings and adult palms causing bud rot and immature nut fall commonly known as mahali.

Bud rot

Symptoms

Palms of all age are liable to be attacked but normally young palms are more susceptible, particularly during monsoon when the temperature is low and humidity is very high.

In seedlings, the spear leaf turns pale and comes off with a gentle pull. In adult palms, the first visible symptom is the colour change of the spear, which becomes pale and breaks at the base and hangs down. The tender leaf base and soft tissues of the crown rot into a slimy mass of decayed material emitting a foul smell. The rotting slowly progresses downwards, finally affecting the meristem and killing the palms. This is accompanied by drooping of successive leaves. Even then, nuts that are retained on the palm may grow to maturity. The disease proves fatal if not checked at the early stages, before damage of the bud.



Management

1. In early stages of the disease (when the heartleaf starts withering) cut and remove all affected tissues of the crown. Apply Bordeaux paste and protect it from rain till normal shoot emerges.
2. Burn all disease-affected tissues removed from the palm.
3. Spray 1% Bordeaux mixture on spindle leaves and crown of disease affected as well as neighboring palms, as a prophylactic measure. Palms that are sensitive to copper containing fungicides can be protected by mancozeb. Small, perforated sachets containing 2 g of mancozeb may be tied to the top of leaf axil. When it rains, a small quantity of the fungicide is released from the sachets to the leaf base, thus protecting the palm.
4. Adopt control measures for rhinoceros beetle.
5. Provide adequate drainage in gardens.
6. Adopt proper spacing and avoid over crowding in bud rot prone gardens.

Mahali

Symptoms

Shedding of female flowers and immature nuts are the common symptoms of the disease. Lesions appear on the young fruits or buttons near the stalk, which later lead to the decay of the underlying tissues and endosperm.

Control

Spray 1% Bordeaux mixture or copper oxychloride preparation (0.5%) on the crown of palms, once before the monsoon and once or twice later on at intervals of 40 days.

Root (wilt) disease

Symptoms

The characteristic symptom is the flaccidity of leaflets. Yellowing of older leaves, necrosis of leaflets and deterioration and decay of root system are other salient features of the disease. The leaflets curve inwardly to produce ribbing so that the whole frond develops a cup like appearance. Abnormal shedding of buttons and immature nuts are also noticed.

Management

Coconut root (wilt) is a non-lethal debilitating disease and the affected palms survive for a long period giving a reasonably good yield. The root (wilt) affected palms are susceptible to diseases like leaf rot and pests like rhinoceros beetle and red palm weevil. So there is a chance of confusing the pests and disease symptom with the root (wilt) disease. Negligence on the management aspects aggravates the malady. Efficient management of palms suspected to be affected by coconut root (wilt) disease demands control of all pests and diseases and imparting natural resistance and health to the palms through proper manuring and agronomic practices. A package of management practices for the effective management of root (wilt) disease is given below:

1. Rogue out palms that are affected severely by root (wilt) and yield less than 10 nuts / palm / year and those, which have contracted the disease before flowering. Replant with disease tolerant material / high yielding hybrids (Chandrasankara).
2. Apply fertilizers for coconut palms in average management at the rate of 0.34 kg N, 0.17 kg P₂O₅ and 0.68 kg K₂O / palm / year in the form of urea, rock phosphate and muriate of potash, respectively. For palms under good management, fertilizers may be given @ of 0.5 kg N, 0.32 kg P₂O₅ and 1.2 kg K₂O / palm / year.
3. In addition to the above, apply 50 kg cattle manure or green manure and 1 kg of lime / palm / year. Magnesium may be supplied @ 500 g MgO per palm per year in the Onattukara region (sandy soil) and 100 g MgO in the remaining areas. The cheapest source of MgO is magnesite (MgCO₃). The magnesium in magnesite is acid soluble. Hence it may be preferred in acid soils.
4. Growing green manure crops like sun hemp, Sesbania, cowpea and Calapogonium in the coconut basin and their incorporation in situ is beneficial as the practice reduces the intensity of the root (wilt) and increases the nut yield. The ideal green manure crops for the sandy and alluvial soils are cowpea and Sesbania, respectively.

5. Under rainfed conditions, apply fertilizers in two splits, 1/3rd at the time of early southwest monsoon and 2/3rd before the northeast monsoon. Under irrigated conditions apply fertilizers in three equal splits (April-May, August-September and December-January).
6. Apply fertilizers and manures in 10 cm deep circular basins at a radius of 2 m from the bole of the palm.
7. When the crop is grown under the bund and channel system, de silt the channel and strengthen the bunds during summer months.
8. Follow strictly all the prescribed prophylactic measures against leaf rot disease, red palm weevil, rhinoceros beetle etc. so as to ensure that the palms are not debilitated. To maintain the productivity of the palms, prophylactic measures are of great importance.

Leaf rot

Symptoms

The first symptom is the appearance of water-soaked brown lesions in the spear leaves of root-wilt affected palms. Gradually these spots enlarge and coalesce resulting in extensive rotting. As the leaf unfurls the rotten portions of the lamina dry and get blown off in wind, giving a 'fan' shape to the leaves. Some times, the symptom becomes very acute and the spear fails to unfurl.

This disease is a fungal complex initiated predominantly by *Colletotrichum gloeosporioides*, *Exserohilum rostratum* and *Fusarium spp.*

Management

1. Remove the rotten portions from the spear and the two adjacent leaves.
2. Pour 300 ml of fungicidal solution at the base of the spear. This can be prepared by mixing hexaconazole 5 EC 2 ml or mancozeb 3 g in 300 ml water.
3. Treat the top two leaf axils with insecticide preparation. This can be prepared by mixing phorate 10 G / sevidol / carbaryl 20 g with 200 g sand.
4. Spray crowns and leaves with 1% Bordeaux mixture or 0.5% copper oxychloride formulations or 0.4% mancozeb in January, April-May and September. While spraying, care has to be taken to spray the spindle leaf.

Stem bleeding

Symptoms

Exudation of the reddish brown liquid through the growth cracks mostly at the basal part of the trunk and bleeding patches higher up in the trunk are characteristic symptoms. One or more lesions, lying close by, may coalesce to form large patches. The



liquid that oozes out dries up and turns black. The tissues beneath the bleeding points decay and become yellowish. The lesions spread upwards as the disease progresses. In advanced stages, the leaf size reduces leading to reduction in crown size. The rate of leaf production slows down. The production of bunches is affected and nut shedding takes place. The trunk gradually tapers towards the apex. The progress of the disease is faster during July to November.

Causal organism

The fungus, *Thielaviopsis paradoxa* is the causal agent. Growth cracks on the trunk, severe summer followed by heavy down pour, water stagnation, and imbalance in nutrition, excess salinity and stress can act as predisposing / aggravating factors.

Control

1. Chisel out completely the affected tissues and paint the wound with tridemorph 5%. Apply coal tar after 1-2 days.
2. Destroy the chiseled materials by burning. Avoid any mechanical injury to trunk.
3. Apply neem cake @ 5 kg per palm in the basin along with other organics.
4. Root feed with tridemorph 5%, thrice a year during April-May, September-October and January-February to prevent further spread of lesions.
5. Apply tridemorph @ 25 ml in 25 litre of water as soil drenching once in four months.

Grey blight

This is caused by the fungus *Pestalotia palmarum*.

Symptoms

Symptoms appear in the mature leaves of the outer whorl as yellow specks encircled by a greyish band which later become greyish white. The spots coalesce into irregular necrotic patches causing extensive leaf blight. In advanced stages, the tips and margins of the leaflets dry and shrivel giving a burnt appearance.

Control

Remove severely affected older leaves and burn. Spray the trees with 1% Bordeaux mixture or propiconazole 0.3%.

Tanjore wilt (*Ganoderma lucidum*)

Symptoms

This disease is of recent occurrence in many parts of Kerala, especially in the districts of Palakkad, Malappuram, Thrissur, Kollam, Thiruvananthapuram and Wayanad. Middle aged palms were seen fatally affected. The characteristic symptom of the disease is the rotting of the basal portion of the stem. The bark turns brittle and often gets peeled off in flakes, leaving open

cracks and crevices. The internal tissues are discoloured and disintegrated, emitting a bad smell. Mild bleeding occurs on the basal region. The tissues on the bleeding spots are soft to touch. Extensive damage of the root system following root rotting has been observed. Ultimately the palm dies off.

Control

1. Apply organic manure @ 50 kg / palm.
2. Apply neem cake @ 5 kg / palm / year.
3. Reduce fertilizer application to one-fourth of the recommended dose.
4. Drench the basin with 40 litres of 1% Bordeaux mixture or tridemorph 0.1% or any other copper fungicide to soak soil up to 15 cm depth at quarterly intervals.
5. Root feed with tridemorph 2 ml mixed with 100 ml water at quarterly intervals.
6. Avoid flood irrigation in order to prevent the possible spread of the pathogen through soil.
7. Isolate the affected palm from the healthy ones by digging a trench of size 1 m deep and 50 cm wide, 1.5 m away from the bole of the infected palm.
8. Avoid growing leguminous crops in and around the garden.

Button shedding

The shedding of buttons in the coconut is attributed to the following reasons.

1. Pathological conditions
2. Attack of insect pests
3. Nutritional deficiencies
4. Soil and climatic variations
5. Defects in pollination and fertilization
6. Structural defects in the flower
7. Abortion of embryos
8. Limited capacity of the tree to bear fruits
9. Unfavourable conditions such as deficit of moisture, water logging and lack of aeration.

The causes of button shedding may be identified and appropriate remedial measures adopted.

Harvesting

Fully matured nuts, which can be recognized by shaking the nuts, should be alone harvested to get the maximum yield of copra and oil. Frequent to harvest varies from place to place. In any parts of Kerala harvesting done at 45 days interval during summer months and at 60 days interval during rainy seasons. Hence 35% of total nuts obtained during hot months i.e., from March- May and least crop is obtained during rainy months. Harvested is done by climbing the tree.

Yield

It is influenced by the Agro- climatic conditions, cultural practices such as Manuring, irrigation, cropping system and control of pests and diseases etc. on an average, a tall variety yielding 60 – 80 nuts per palm per year is considered ideal.

VALUE ADDED PRODUCTS OF COCONUT

Coconut Products

The coconut products can be broadly classified into two categories, viz food products and commercial products. Some of the important products have been included in the following:

1. Food Products

Wet meat or kernel

The kernel or endosperm of the ripe coconut is an important food material in the coconut growing areas. The gratings of the kernel are an essential ingredient of common household dishes. The milk or cream obtained by squeezing the grated kernel and diluted with water goes into many preparations. It also serves as a base for the preparation of various food products of commercial importance. As nut starts ripening, the moisture, ash, protein and the sugar contents starts decreasing but fat content increases. The bottled coconut milk is used as a substitute for cow's milk and the coconut syrup is prepared out of coconut milk, sugar and citric acid. Coconut milk is a rich source of cytokinin.

Desiccated coconut

It is the dried disintegrated coconut meat of fully matured nuts which have been stored for a month before dehusking. This state facilitates the subsequent dehusking operations because the kernel detaches itself from the shell during the storage period. The dehusked nuts are washed, sterilized, and desiccated at a temperature of 77° to 82° Celsius for 40-45 minutes.

Edible copra

Ball copra is prepared out of fully matured (>12 months old) nuts. The unhusked nuts can be stored for about 8 –12 months and during this period the kernel detaches itself the shell and gives a rattling sound, when it is shaken. In another method, fully –matured nuts are dehusked and cut into two halves to make cup copra. They are then sun or artificially dried and stored.

Coconut water

The liquid endosperm of the tender coconut between the age group of 5-7 months makes a refreshing drink during summer and also in the case of gastroenteritis, diarrhoea and against dehydration of tissues and to eliminate poisonous substances through kidney. Coconut water is also used as a 'culture media in various' microbiological studies.

Toddy products

Toddy is a sugar containing juice, obtained by tapping the unopened spadix. The unopened spathe is bent and its 4-5cm length needs to be beaten everyday in order to rupture the cells and induce the flow of sap. An earthen receptacle is placed for the collection of sap. The flow of sap is slow in the beginning and increases in the course. The shearing of the tip and beating of the inflorescence is continued second till a spadix is also brought into production. By this method on an average about 15 –18 litres of toddy is extracted in one month. The young palms produce little toddy compared to older ones. Dwarf palms are highly suitable for this purpose as it easy to tap them but the yield is lower than the tall palms.

Tapping toddy increases the yield of poor bearers but decreases the copra content and hence low oil content. Fresh toddy if not collected under sterilized condition, rapidly gets fermented and the sugar turns into alcohol (5.8%). On distillation, it yields strong liquor known as arrack.

2. COMMERCIAL PRODUCTS

Milling Copra

Copra with moisture content of less than 6% and free from diseases and pests used for the production of oil referred as milling copra. In conventional industry, the copra production destroys vitamin E and sundried copra develops *Aspergillus flavus* which on consumption damages the liver. Therefore, for oil production, the ball copra which is well cured with less than 6% moisture is used.

Coconut oil

The traditional method of obtaining coconut oil through coconut crushing by expeller's leaves about 7-8% oil in the cake and all the proteins and carbohydrates also go as animal feed. This expelled oil further requires refining to lower free fatty acid (FFA) content for better flavour and colour. Coconut oil is obtained by wet processing has more saturated fatty acids and hence resistant to oxidative rancidity, but retains pleasing flavour when refined easily digestible and stable in flavour. The virgin oil is crystal clear and has full coconut fragrance. It retains vitamin E and develops no aflatoxin due to elimination of intermediate copra drying step. It can directly be used as hair oil or baby skin lotion. Because of lower FFA and moisture contents, no flavour or colour develops and thus no refining is required. The absence of protein and carbohydrate residues and haziness prolong its shelf life. The consumption pattern of the coconut oil indicates that out of the total oil produced, 50% is used as hair and skin oil, 35% for edible purposes and the remaining 15% for industrial purpose.

White fibre or yarn fibre

It is also known as mat fibre and extracted from green husks by bacteriological retting (husks are soaked in water for 6-8 months). Usually 9-10 month old nuts are used for the preparation of longest and finest yarns, which are in turn made into ropes, mats, etc.

Coconut fibre (coir)

It is an important product obtained from the fruit husk. The fully matured (12-month old) nuts yield about 35 to 40 % coir. Nuts of 11 months old have still higher coir content ranging from 50-55% while in 9-12 months old nuts it is high as 70%.

Brown fibre

It is produced from the husk of ripe dry nuts by extracting the fibre by mechanical defibring process. It is of inferior quality.

Coconut water beverage

The water phase of coconut with additives and formulations imparting tender coconut water like taste renders this thirst- quenching hygienically packed beverage suitable for serving. This was otherwise wasted and was effluent nuisance due to BOD value in conventional plants.

Coconut shell

The hard brown cover of the kernel shell is also used for the preparation of charcoal, activated carbon and coconut shell powder. Coconut shell activated carbon is best suited for deodorizing and decolouration of sugar syrup used in soft drinks and coconut shell powder is also used in manufacture of cardboards.

1. The origin of coconut is _____
2. Coconut palms are broadly classified in to _____ groups
3. List out the important varieties of coconut?
4. Important pest & disease in coconut?
5. List out the value added products in coconut?

ARECANUT
(*Areca catechu*, Palmae)

Arecanut palm is cultivated primarily for its kernel obtained from the fruit which is chewed in its tender, ripe or processed form. Though it is native of Malayan Archipelago, Philippines and other East Indian Islands, Commercial cultivation is confined only in India, Bangladesh and Sri Lanka. India has about 2, 00,000 ha under this crop with an annual production of 2, 28, 600 tonnes. Kerala, Karnataka and Assam account for more than 90 per cent of the total area and production in our country.

Arecanut production in India has now almost reached a level of self sufficiency. Uses for arecanut other than chewing are negligible. Its export prospects are also very much limited. Therefore, the present policy is not to expand the area under arecanut, but to adopt intensive cultivation and take up replanting of the aged and unproductive gardens. Inter and mixed cropping in arecanut gardens is advocated to augment the income from the existing arecanut garden.

Botany

It is a monoecious palm and its inflorescence is a spadix produced in the leaf axil and is completely enclosed in a sealed boat shaped spathe. The spadix is having a main rachis divided subsequently into secondary and tertiary rachis. Female flowers are confined to tertiary and distal end of the secondary rachis, while male flowers are produced on filiform branches arising below and beyond the female flowers. Both female and male flowers are sessile, with two whorls of perianth. The fruit is a monolocular, one seeded berry and it consists of a fibrous outer husk, enclosing a single seed. It is a cross pollinated crop and fruit set normally varies from 12.0 to 40.0 percent and the time taken from full bloom to maturity of the fruit ranges from 35 to 47 weeks.

Climate and Soil

The arecanut palm is capable of growing under a variety of climatic and soil conditions. It grows well from almost sea level up to an altitude of 1000 metres in areas receiving abundant and well distributed rainfall or under irrigated conditions. It is grown in soils such as laterite, red loam and alluvial soils. The soil should be deep and well drained.

Varieties

There are few local varieties known by the name of the place where they are grown and are Thirthahalli, South Kanara, Mettupalayam, Mohitnagar. Regional Station, Vittal has released three improved cultivars, they are,

Mangala: An introduction from China early bearing, higher fruit set, higher yield, semi tall variety.

Subamangala: A selection from Indonesia, yield 17.5 kg of nuts/palm at the age of 10 years.

Sreemangala: A selection from Singapore yields 16.5 kg/palm at the 10th year.

SAS-1: Sirsi Arecanut Slection, resealed from UAS, Dharwad.

Raising of planting materials

Collection of seed nuts should be confined to high yielding palms which commence to bear early as well as those which give more than 50 % of fruit set. From these selected mother palms, fully ripe nuts are alone collected. All undersized and malformed nuts must be rejected. Heavier seed nuts within a bunch are alone selected, as they give higher percentage of germination and produce seedlings of better vigour than lighter ones.

The selected seed nuts are sown immediately after harvest, 5cm apart in sand beds under partial shade with their stalk ends pointing upwards. Sand is spread over the nuts just to cover them. The beds may be watered daily. Germination commences in about 40 days after sowing and the sprouts can be transplanted to the second nursery when they are about three months old. At this stage the sprouts might have produced two to three leaves.

The secondary nursery beds of 150 cm width and of convenient length are prepared for transplanting the sprouts. The sprouts are transplanted at a spacing of 30X30 cm with the onset of monsoon. Partial shade to the seedlings can also be provided during summer by pandal or growing banana. Care should be taken to drain the nursery beds during the monsoon and to irrigate them during the dry months. Weeding and mulching should be done periodically. Seed nuts can also be sown in polythene bags (25 X 15 cm size ,150 gauge) after filling the bags with potting mixture containing 7 parts of loam or top soil, 3 parts of dried and powdered farm yard manure and 2 parts of sand.

The seedlings will be ready for transplanting to the main field when they are 12 to 18 months old. Seedlings having 5 or more number of leaves selected. The height of seedlings at the time of planting has a negative correlation with the subsequent yield of the plant. Hence



shorter seedlings with maximum number of leaves are removed with a ball of earth for transplanting. If the seedlings are raised in polythene bags, these can be straightway transported to any distance without much damage.

Planting

The planting is done during May- June with the onset of monsoon. Arecanut palms need adequate protection from exposure to the South Western sun as they are susceptible to sun-scorch. Proper alignment of the palms in the plantation will minimize sun scorching of the stem. In the square system of planting at a spacing of 2.7m X 2.7m, the North South line should be deflected at an angle of 35 degree towards west. The outermost row of plants on the southern and south-western sides can be protected by covering the exposed stem with areca leaves or leaf sheaths or by growing tall and quick growing shade trees.

Pits of 90 X 90 X 90cm are dug and the pits are filled with a mixture of top soil, powdered cow dung and sand to a height of 50 to 60 cm from the bottom. The seedlings are planted in the centre of the pit, covered with soil to the collar level and pressed around. A shade of banana can be raised to give protection to the seedlings from sun scorch.

Manuring

Adequate supplies of plant nutrients in the soil throughout the life of the crop are essential to get high yield. Hence, an annual application of 100: 40: 140 g of NPK per tree in the form of fertilizers and 12 kg each of green leaf and compost or cattle manure per bearing palm is recommended. Under rainfed conditions, half the quantity of fertilizers may be applied in April-May and the remaining quantity in Sep- Oct. Under irrigated condition, the first dose of fertilizer is applied only in Feb. Green leaf and compost can be applied in single dose in Sep- Oct. Irrespective of the age of the plants, full dose of green leaf and compost or cattle manure may be applied from the first year of planting itself while one-third of the recommended quantity of fertilizers in the first year, two-third in the second year and the full dose from the third year onwards. The first dose of fertilizers may be broadcast around the base of each plant after weeding and mixed with the soil by light forking, while the second dose is done in basins around the palm dug to a depth of 15 to 20 cm and at 0.75 to 1m radius. In acidic soils, required quantity of the lime may be applied during the dry months and forked in.

Irrigation and drainage

The palms should be irrigated once in four to seven days depending on the soil type and climatic factors. In Kerala, arecanut gardens are irrigated during dry months once in seven or eight days during November-December., once in six days during March, April and May. Adequate drainage should be provided during monsoon since the palms are unable to withstand

water logging. Drainage channels should be 25 to 30 cm deeper than the bottom of the pits to drain excess water from the plot.

Other operations

A light digging may be required when the monsoon ends to break up any crust formed at the soil surface and also to uproot weeds. Weeding should be done periodically to keep the garden clean.

Cover cropping

Cover crops, such as *Mimosa invisa*, *Stylosanthes gracillis* and *Calapogonium muconoides* have been found to be suitable for arecanut gardens. The cover crops may be sown in the month of April-May and the green matter may be cut and applied to arecanut palms at the time of second dose of fertilizer application.

The crops which can be grown successfully in arecanut gardens without loss of arecanut yields are banana, cocoa, pepper, pineapple, betel vine; elephant foot yam, tapioca, dioscorea, sweet potato, arrow root, ginger, turmeric and guinea grass. Nutmeg and clove can be also grown in between four palms on alternate rows.

Harvesting and processing

The stage of harvesting depends on the type of produce to be prepared for the market.

1. Dried ripe nuts/Chali/Kottapak

The most popular trade type of arecanut is the dried, whole nut known as chali or kottapak. Fully ripe, nine months old fruits having yellow to orange red colour is the best suited for the above purpose. Ripe fruits are dried in the sun for 35 to 40 days on dry leveled ground. For drying and dehusking, sometimes fruits are cut longitudinally into halves and sun dried for about 10 days, then the kernels is scooped out and given a final drying.



2. Kalipak

Another form of processing is by making kalipak. The nuts of 6 to 7 months maturity with dark green colour are dehusked, cut into pieces and boiled with water of dilute extract from previous boiling; a kalli coating is given and dried finally. Kalli is the concentrated extract obtained from boiling 3 to 4 batches of Kalipak.



3. Scented suparis

There are many varieties of scented suparis. Dried arecanuts broken into bits, blended with flavour mixture and packed. Formerly the bits were roasted in ghee or oil, but it is almost fully given up nowadays, owing to development of rancidity. The flavouring of supari varies with region and is a closely guarded secret.

In South India scented supari is made from kalipak like batlu. Spices and synthetic flavours are added. Instead of raw spices, nowadays, essential oils are used for easy blending. Rose essence as well as menthol is very common. Coconut gratings are not added nowadays to check microbial growth. These are usually packed in butter paper.

Scented suparis popular in north and central India are of two types; the one made from chali and the other from kalipak. The former is more popular. At times, saccharin is used for sweetening. Additives like colour and flavour are added. Plastic strips are used for convenient packing. Tin and aluminum pouches are used for bulk packing of scented supari.

Post harvest technology

Dehusking of arecanut is traditionally done by skilled manual labour with the help of a tool, which has a sickle shaped small pointed blade fixed on a plant. A simple device for dehusking arecanut, developed by CPCRI, Kasargod can also be used. The main advantage of this device is that any unskilled person can operate it. The optimum is about 60 kg husked nuts in case of dried nuts and 30 kg in case of green nuts if one person operates the device for a day of 8 hours.



In view of the declining use of arecanut as masticatory, alternate and better uses of arecanut and the other products like spathe, husk are now thought of.

Yield

More than 10 kg of ripe nuts per palm at the 10th year is considered as normal yield in any plantation.

Pest management

Mites (*Raoiella indica*, *Oligonychus indicus*)

Adults and young ones suck the lower surfaces of the leaves, causing them to turn yellow and bronzed appearance. The mites can be controlled by spraying with dimethoate or Dicofol at 0.05 per cent.

Spindle bug (*Carvalhoia arecae*)

The feeding injury is caused on the lamina and petiole. The affected leaves show dry brown patches.

Spray crowns with carbaryl 50 WP. The spray should reach the leaf axils. Repeat spraying after 30-35 days if pest incidence continues. Placement of 2 g phorate 10G sachets on the top most two leaf axils prevents the pest attack.

Inflorescence caterpillar (*Tirathaba mundella*)

Caterpillar feed on the flowers and clamp the inflorescence into a wet mass of frass with silky threads.

Force open the inflorescence out of the enclosing spathe and spray Malathion 50 EC (250 ml in 100 litres of water). Control slugs, which predispose inflorescence to the attack of caterpillar, by using bait of Metaldehyde.

Root grub (*Leucopholis burmeisteri*)

Loosen soil around the base of palms to a depth of 10-15 cm and drench with Chlorpyrifos 0.04% suspension twice, one in May just before the onset of southwest monsoon and again in September-October towards the close of the monsoon. Repeat application for 2 or 3 years consecutively to secure a complete eradication of the pest. Root grubs can also be controlled by soil application of phorate 10G around the palms.

Disease Management

Koleroga (Mahali or fruit rot) (*Phytophthora arecae*)

Water soaked lesions appearing on the nut surface near the perianth and spread over the other parts. Infected nuts shed without perianth.

Spray Bordeaux mixture 1% on all bunches three times in a year, one just before the onset of southwest monsoon and the rest at 40 days intervals. If monsoon season is prolonged give a third spray. Use rosin soda adhesive to ensure tenacity of the spray deposit on treated substrate. Remove and burn all fallen and infected nuts.

Bud rot (*Phytophthora palmivora*)

Affected spindle appear yellow, later changing to brown and finally the whole spindle rots. Remove and destroy affected spindle and leaves. In early stages of infection, scoop out affected rotten tissues by making longitudinal side splits and apply Bordeaux paste on the exposed healthy tissues or drench crown with 1% Bordeaux mixture.

Basal stem rot (Anabe roga) (*Ganoderma lucidum*)

Small brown irregular patches appear on the stem and a brownish exudates oozes out from these patches.

Control

1. Isolate affected palms by digging trenches 60 cm deep and 30 cm wide around, one metre away from the base and drench with Captan (0.3%), Calixin (0.1%) or Copper oxychloride (0.3%)
2. Remove and destroy all severely affected palms and stumps of dead palms.
3. Drench the soil with 1% Bordeaux mixture before planting healthy seedlings.
4. Discourage growing of collateral hosts of fungus such as *Delonix regia* and *Pongamia glabra* in the vicinity of gardens.
5. Apply 2 kg neem cake per palm.
6. Avoid flood irrigation and water flowing from infected palms to healthy palms.

Yellow leaf disease

Leaves become yellow, smaller, stiff and pointed, crown gets reduced, and palm remains stunted with few or no nuts.

Maintain the garden properly to keep affected palms in a healthy condition by adopting recommended manurial, cultural, plant protection and other management practices. Improve drainage conditions in the garden.

Band disease

Improve soil conditions by loosening hard soil strata, if present, by providing good drainage. Adopt adequate control measures against spindle bug, mealy bugs, scales and mites. Where the results of the above treatments are not found satisfactory, apply powdered mixture of copper sulphate and lime in equal quantities @ 225 g/palm twice a year at the base of affected palms. Application of borax @ 25 g/palm has been found to have an ameliorative effect.

Collar rot of seedlings

Improve drainage conditions in nursery beds and gardens. Drench spindle and base of seedlings with 1% Bordeaux mixture in disease affected nursery or garden.

Dieback of inflorescence

Remove affected inflorescence immediately. Spray Zineb (4 g in 1 litre of water) or Mancozeb (3 g/l) twice, once just after female flowers are set and again 15-28 days later. Aureofungin sol at 50 ppm concentration is also effective in controlling the disease.

Stem bleeding

Palms in the age group of 10-15 years are more prone to this disease. Symptoms appear on the basal portion of the stem as small discoloured depression. Later, these spots coalesce and cracks develop on the stem leading to disintegration of the fibrous tissues inside.

With the progress of the disease a brown exudates oozes out from these cracks. High water table predisposes the palm to this disease.

Improvement of drainage and root feeding of 125 ml Tridemorph (1.5%) is suggested as control measure against this disease.

Sun scorch

Protect palms from southwest sun by wrapping stems with areca sheath or white-wash the exposed portion. Provide reinforcement to palms showing stem fissures. Grow tall, quick growing trees on southern and western sides of garden.

Nut splitting

This can be considered as a physiological disorder than a disease. Palms in the age group of 10-25 years are more susceptible. Symptoms are premature yellowing of the nuts when they are half to three-fourth mature. Later splits develop at the tips, which extend longitudinally exposing the kernel. Sometimes kernels also show splitting and malformation. Rarely the kernel inside may exhibit splitting without visual symptoms on the husk, resulting in nut fall. Hyper nutrition or sudden flush of water after a period of drought or insufficient moisture in the soil is the probable cause (s) of the disease.

Improvement of drainage in ill drained gardens and spraying of borax @ 2 g/litre of water are found effective in reducing the disease incidence.

1. Scientific name of arecanut?
2. List out the important varieties of arecanut?
3. What are the important cover crops, suitable for arecanut gardens
4. List out the value added products in coconut?
5. Important pest & diseases in arecanut?

BETEL VINE

(*Piper betle*, Piperaceae)

Betel (*Piper betle* Linn.) leaf is used as a masticatory along with arecanut, lime and catechu. The probable places of origin of betel vine are India, Sri Lanka, Malaysia and Indonesia. In India it is an important commercial crop of Andhra Pradesh, occupying about 3,600 hectares. The vine is a dioecious (male and female plants are different), shade loving perennial root climber.



Botany

- Woody climber with adventitious roots at swollen nodes.
- Leaf simple, alternate, cordate, 8-12 cm wide, 12-16 cm long, with Description odor and spicy taste.
- Inflorescence in axillary spike; flowers unisexual, white.
- Fruit globose berry.

Climate and Soil

Betel vine requires a tropical climate with high atmospheric humidity. It can be cultivated in the uplands as well as in wetlands. In Kerala, it is mainly cultivated in arecanut and coconut gardens as an intercrop. The crop grows best on well-drained fertile soils. Waterlogged, saline and alkali soils are unsuitable for its cultivation. The crop also comes up very well in lateritic soils. Proper shade and irrigation are essential for successful cultivation of this crop. An annual rainfall ranging from 200 to 450 cm is ideal. The crop tolerates a minimum temperature of 10°C and a maximum of 40°C. Extremely low atmospheric temperature leads to leaf fall. Hot dry winds are harmful.

Varieties

There are about 100 varieties of betel vine in the world, of which about 40 are found in India and 30 in West Bengal. There are mainly five cultivars of betelvine viz. Desawari, Bangla, Kapoori, Meetha and Sanchi. While Kapoori and Sanchi are the principal cultivars in the peninsular India, Bangla and Deswari are common in North India. Cv. Meetha is grown on

commercial scale in West Bengal only. Betelvine is cultivated over an area of 40,000 ha in the country. It is a capital and labour intensive cash crop.

The important types grown in Tamil Nadu are Thulasi, Venmani, Arikodi, Kalkodi, Karilanchi, Karpuram, Chelanthikarpuram, Koottakkodinandan, Perumkodi, Amaravila and Pramuttan, Kallarkodi, Revesi, Karpuri, SGM 1, Vellaikodi, Pachaikodi, Sirugamani 1, Anthiyur kodi, Kanyur kodi.

<p>Betelvine varieties Source: Betelvine Research Station, Diwthana, Akola</p>		
		
<p>Karapaku Kapuri</p>	<p>Maghai</p>	<p>Ghanagate Bangla</p>

Season

November - December and January – February are optimum for cultivation.

Preparation of field

The field is prepared to a fine tilth and beds of 2 m wide are formed to a convenient length. Provide drainage trenches of 0.5 m width by 0.5 m depth in between two adjoining beds. Plant the seeds of the live supports i.e. Agathi (*Sesbania grandiflora*) in long rows. About 750 banana suckers are planted at the edges of the beds, which are used, for tying the vines on the live support and for packing the betel leaf. When the Agathi plants reach 4 m height, they are topped off for maintaining the height. The crop is planted in two rows in beds of 180 cm width on Agathi plants with a spacing of 45 cm between plants in the row.

Irrigation

Irrigate the field immediately after planting and afterwards once in a week.

After cultivation

Training of the live standards

Before the establishment of vines, the side branches of Agathi trees up to a height of 2 m are removed for early creeping of the vines.

Trailing of the vines

The cuttings sprout and creep in about a month. At this time, they must be trailed on the standards. Training is done by fixing the vine at intervals of 15 to 20 cm along the live standards loosely with the help of banana fibre. Training is done at every 15 - 20 days interval depending upon the growth of vines.

Instead of live standards sometimes bamboo standards are erected at intervals and linked by tying at heights of 30 cm and 150 cm using coir rope. In the initial stages trailing is done on coir tied for the purpose. Trailing is done further by tying the vines, at intervals of 15-20 cm along the standards loosely with the help of banana fibre.

When vines come in contact with standards, they produce adventitious roots using which they cling to support. Trailing is done every 15-20 days depending on the growth of vines.

Bamboo standard



Live standard



Lowering of vines

Under normal cultivation, the vines grow to height of 3 m in one year period. When they reach this height their vigour to produce normal size leaf are reduced and they need rejuvenation by lowering during March - April. After the vine is lowered, the tillers spring up from

the nodes at the bends of the coiled vines at the ground level and produce many primary vines. Irrigation should be given after each lowering.

Manuring

Apply 150 kg N/ha/year through Neem cake (75 kg N) and Urea (75 kg N) and 100 kg P₂O₅ through Super phosphate and 30 kg Muriate of potash in three split doses first at 15 days after lifting the vines and second and third dose at 40 - 45 days intervals. Apply on beds shade dried neem leaf or *Calotropis* leaves at 2 t/ha and cover it with mud (2 t in 2 split doses).

Time of application	Nutrients (kg/ha)		
	N	P	K
Basal dressing	37.5	100	50
Top dressing @ 3 split doses	112.5	0	0

Pests

Scale insects

Select scale-free seed vines. Spray Chlorpyrifos 20 EC 2 ml/lit when one or two scales are noticed on the basal portion of the stem/leaves. Direct the spray solution to the basal portion of the vines. Spray NSKE 5 % or Malathion 50 EC 1 ml/lit.

Mites

Mites can be controlled by spraying Wettable sulphur 50 WP @ 1 g/lit or Dicofol 18.5 EC 0.5 ml/lit.

Sooty mould (Aphids)

To control aphids spray Chlorpyrifos at 2 ml/lit on Agathi leaves. Clip off excess Agathi leaves.

Mealy bugs

Mealy bugs can be controlled by spraying Chlorpyrifos 20 EC at 2 ml/lit or Dimethoate 30 EC 2ml/lit. Concentrate the spray towards the collar region.

Nematode

Application of Neem cake at 1 t/ha or shade dried *Calotropis* leaves @ 2.5 t/ha can be applied to soil for controlling the nematode populations.

Diseases

Phytophthora Wilt

Integrated disease management of *Phytophthora* wilt

- Select well matured (more than 1 year old) seed vines free from pest and diseases.

- Soak the seed vines for about 30 minutes in Streptocyclin 500 ppm or Bordeaux mixture 0.5 %.
- Apply 150 kg N/ha/year through Neem cake (75 kg N) and Urea (75 kg N) and 100 kg P₂O₅ through Super phosphate and 30 kg Muriate of potash in 3 split doses first at 15 days after lifting the vines and second and third dose at 40 - 45 days intervals. Apply on beds, shade dried neem leaf or *Calotropis* leaves at 2 t/ha and cover it with mud (2 t in 2 split doses).
- Drench Bordeaux mixture 0.25% in basins formed around the vine at monthly intervals starting from October – January, three times soil drench and six times spray from June - July.
- During winter season avoid frequent irrigation.
- Remove the affected vines away from the garden and burn them.
- Application of *Trichoderma viride* @ 5 g/vine.

Bacterial leaf spot, blight and bacterial stem rot

Spray Streptocyclin @ 400 ppm + Bordeaux mixture @ 0.25% at the time of first disease symptoms appear. Continue spraying at 20 days intervals. Always spray the chemical after plucking the leaves.

Anthracnose

Spray 0.5% Bordeaux mixture after plucking the leaves after the first appearance of the symptom. The variety Karpoori is susceptible to the disease.

Powdery mildew

Powdery mildew can be controlled by spraying 0.2% Wettable sulphur after plucking the leaves.

Harvest

In about 3-6 months time, vines grow to a height 150-180 cm. At this stage branching is noticed in the vines. Leaves are removed along with the petiole with the right thumb. Once harvesting is commenced, it is continued almost every day or week. The interval of harvesting varies from 15 days to about a month till the next lowering of vines. After each harvest, manuring has to be done.

Yield

About 75 to 100 lakh leaves/ha/year can be obtained.

1. Betel vine belongs to the family?
2. Propagation methods in Betal vine is _____

3. Major disease of betelvine is _____
4. List out the varieties of betel vine is _____
5. Example for a standard tree species for the cultivation of betel vine is _____

CASHEW

(*Anacardium occidentale*, Anacardiaceae)

Cashew is native of south Eastern Brazil, from where it was introduced to Malabar Coast of India in the sixteenth century to cover barren hills and for soil conservation.

Though India produces only 40 percent of the world production of cashew nuts, it meets 90 percent of the world export of cashew kernels. The export earning from cashew constitutes about 2 percent of the total foreign earning from agricultural produces. Cashew growing area is centered only on the coastal area in India. Kerala followed by Tamilnadu occupy more area under cashew nut.



Botany

The cashew tree is a low spreading, evergreen tree with a very prominent tap root. The leaves are alternative, simple, glabrous, obovate, round and pinnately veined. The inflorescence is an indeterminate panicle of polygamomonoecious type i.e. flowers are either bisexual or staminate but both occur intermixed in the same inflorescence. On the same tree, the perfect flowers are larger in size than the staminate. Pollination is carried out by flies, bees and ants as well as by wind.

The fleshy peduncle, the 'cashew apple', is juicy and sweet when ripe. The apple varies in size, colour, juice content and taste. It is rich source of vitamin c and sugar. The cashew fruit is a kidney shaped drupaceous nut, greenish grey in colour. The nuts vary in size, shape, weight (3-20g) and shelling % (15 –30%).



Climate and Soil

It is hardy tropical plant and does not exact a very specific climate. It can come up in places situated within 35° latitude on either side of the equator and also in the hill ranges up to 700 m MSL. It can grow well in places receiving rainfall from 50 cm to 250cm and tolerates a temperature range of 25°-49°c .It requires a bright weather and does not tolerate excessive shade.

Cashew is cultivated on a wide variety of soils in India like laterite, red and coastal sandy soil. To a limited extent, it is also grown on black soils. It can be also grown in hill slopes in virgin organic matter rich soils. They do not prefer water logged or saline soils.

Varieties: The important characteristics of some of the cultivars of cashew are as follows.

S. No	Variety	Nut yield (Kg/tree)	Nut wt (g)	Shelling (%)	Kernel wt (g)	Grade	State	Year
1	Amrutha	18.5	7.18	31.58	2.10	W210	Kerala	1998
2	Subala	21.90	9.80	29.40	2.88	W210	Kerala	1996
3	Priyanka	17.03	10.8	26.57	2.87	W180	Kerala	1995
4	Madakathara	17.00	7.25	26.00	1.88	W210	Kerala	1990
5	Vengurla-1	19.0	6.2	31.0	1.39	W240	Maharashtra	1974
6	Vengurla-2	24.0	4.30	32.0	1.0	W320	Maharashtra	1979
7	Vengurla-4	17.2	7.70	31.0	1.91	W210	Maharashtra	1981
8	Vengurla-5	16.6	4.5	30.0	1.0	W400	Maharashtra	1984
9	Vengurla-7	18.5	10.0	30.0	2.90	W180	Maharashtra	1997
10	VRI-1	7.20	5.0	28.0	1.40	W240	TamilNadu	1981
11	VRI-2	7.40	5.10	28.3	1.45	W240	TamilNadu	1985
12	VRI-3	11.68	7.18	19.1	2.16	W210	TamilNadu	1992
13	VRI-4	16.60	6.63	28.5	1.70	W320	TamilNadu	2000

Ullal-1:It is a high yielding (19.6 kg nuts/tree) variety released for entire Karnataka. This is an early bearing cultivar with high sex ratio (male: bisexual) and high shelling percentage (30.7%).The size of the nut is medium. The flowering commences from last week of November and extends up to middle of March and harvesting is completed by May thus enabling to escape the monsoon showers which otherwise results in the loss of crop. The variety has 144nuts per kg and medium sized apples with yellow colour.

Ullal-2: This is another high yielding (17.9kg nuts /tree) variety released for entire Karnataka. This variety also possesses desirable characters, such as, early flowering and bearing, high sex ratio and high shelling percentage (30%) and as such highly congenial for cultivation in hill zone. It has 164nuts/kg with medium sized and yellowish red apple.

Ullal-3: This variety flowers from November-January and the flowering period extends for 60-70days. The nuts can be harvested in January – March for nearly 60-90days. The average yield per tree is 14.68kg (at the 10th year) and the shelling percentage is 30.00.

Selections S-2 & S-3: These selections are released from National Cashew Research Centre (South Kanara) for cultivation in Karnataka. They give an average yield of 8-10kg nuts/tree with a shelling percentage of 29.

<p>Cashew Varieties: Source: The Directorate of Cashewnut & Cocoa Development (DCCD), Cochin</p>	 <p>Priyanka</p>	 <p>VRI-3</p>
 <p>Ullal 4</p>	 <p>Vengurla-4</p>	 <p>Vengurla-7</p>
 <p>Un 50</p>	 <p>BPP 8</p>	 <p>Madakathara</p>

BPP-5: It is a selection from the Cashew Research Centre, Bapatla (Andhra Pradesh) and is found to be the highest yielder (42.1kg dry nuts/tree on an average) with a shelling percentage of 26.7.

Salient features of cashew Hybrid:

Hybrids	Parentage	Characters
Vengurla 3	Vengurla 1 × Vetore 56	Cluster bearing
Vengurla 4	Midnapore Red × Vetore 56	Highest yielding
Vengurla 5	Ansur Early × Mysore Kotekar1/61	High yielding
Vengurla 6	Vetore 56 × Vengurla 1	High yielding
Bapatla1	Tree 1 × Tree 273	
Bapatla 2	Tree 1 × Tree 273	
Bapatla 3	Tree 1 × Tree 39	

Propagation

Seed propagation is seldom practiced except to raise the rootstock materials.

Vegetative propagation

I. Selection of seed nuts

1. Collect the nuts during heavy bearing period (Feb-April)
2. Sun dry the nuts for 2-3 days
3. Select the nuts which sinks in the 10 % salt (NaCl) solution
4. Sow the nuts as early as possible, because after 6-8 months the germination of seed nut get reduced. More than one year old seed nut should not be used
5. Very big and very small seed nut should not be selected.
Select only medium sized nuts for sowing (130-150 nuts/kg).



II. Production of root stocks

1. Soak the seed nuts in water or cow dung slurry for 2 days or 10 % Sodium hydroxide solution for one day to get higher germination percentage.
2. Sow the seeds in poly bags filled with potting mixture (25cm length, 13cm width and 250 gauge thickness)
3. Make 30 to 40 holes in each polythene bag for easy drainage of excess water



4. Apply 5g of super phosphate per bag along with potting mixture
5. Fill the poly bags with potting mixture till the margin and put dried leaves or small stones at base for easy drainage of water
6. Place the seeds at 2.0 to 2.5 cm soil depth and keep vertically in which the stalk end of the seed nut facing top
7. Apply water after sowing and daily with rose cane and avoid water stagnation
8. Seeds germinate with 15 to 20 days after sowing
9. Staggered sowing at weekly intervals facilitate to make the stocks available continuously for grafting
10. Provide shade to young root stocks; after greening of leaves keep the stocks under open condition or remove the shade
11. 40 to 50 days old root stocks are suitable for grafting
12. During the germination, the cotyledon comes out of the soil and it is tasty, therefore it will be damaged by birds, monkeys and other animals. So during this period it should be watched carefully
13. During this period, the root stocks will be affected by root rot and bacterial leaf blight disease therefore to prevent the root rot apply 0.2% Thiram or Mancozeb and spray for later apply 250ppm Streptomycin sulphate for bacterial blight.

III. Selection of root stocks

1. Good healthy seedlings, without side shoot, growing straight should be selected
2. Better to use the stocks raised in poly bags
3. Use the stocks age of 25-30 days for grafting

IV. Selection and preparation of scion

1. The scion providing mother trees should be grown with good fertilizer application and better management
2. The shoots from unbear terminal shoots of 3 to 5 month aged should be selected
3. Select the scion of 10-12cm length, uniform pencil thickness with cream coloured bud. The top 4 to 5 leaves of dark green in fully matured should be selected. 90 days old scion only will be used for grafting purpose which gives better graft uptake. The selected scion sticks should be precured by clipping off leaf blades, leaving petiole.





4. The new shoots of September- October month are not need any precuring of scion but during other season retain the petiole of leaves with scion
5. Precurred scion can be used for grafting after 7-10 days. The petioles will shed while touching with the fingers.
6. The scion mother trees should not be allowed for flowering therefore during flowering season panicles should be pruned

V. Collection of scion

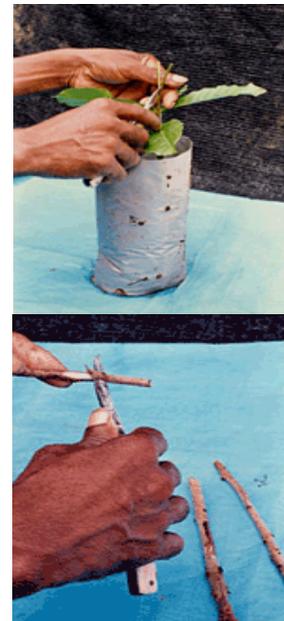
1. Collect the scion from the precurred shoots because it will not dry quickly and gives more graft uptake
2. Collect the scion before the new flush come from the terminal bud
3. Keep the scion separately on variety wise
4. After cutting of scion roll with wet cloth and keep in polythene bag and it can be kept for 1-2 days.

VI. Preparation of stock for grafting

1. In the selected root stock, trim all the leaves except two pairs of basal leaves
2. Decapitated the stocks at 15cm height from the base
3. Make a cleavage in the stock from top to 4.5cm in two equal portion (Figure)

VII. Preparation of scion for grafting

1. Select the scion of uniform thickness related to root stock
2. Make the length of the scion to 10cm if more lengthy
3. Prepare a vedge shape of 4.5cm length in proximal end of the scion after removing bark.



VIII. Grafting

1. Keep the vedge shaped scion on the cleft of root stock
2. Tie the union with polythene sleeves of 200 gauge thickness of 45 cm length and 1.5cm width



3. After tying of grafted stock, cover the top with 25cm x 4cm 200gauge poly bags, it prevents drying of scion
4. Keep the grafted poly bags immediately inside the mist chamber for 15-20 days
5. After 15-20 days remove the poly bags placed over the grafts in inverted position
6. After 20 days remove the grafts from mist chamber and keep it in shade. The grafting success could be seen within 3-4 weeks and scion will be sprouted
7. The grafts will be ready for planting within 5-6 months



IX. Maintenance of grafts

1. Apply water to grafts daily with rose can
2. Prevent the water stagnation during rainy season
3. Remove the polythene film used for joining the stock and scion after 45 days
4. Remove the shoots comes out from stocks whenever emerges
5. 60 days after grafting remove the leaves retained in the root stock.



6. Many of the grafts flower during flowering season. Therefore remove panicle if grafts flowers
7. Change the place of grafts frequently and keep it in polythene lined floor
8. During the summer provide shade to the grafts and during rainy season shade not necessary
9. Frequent spray of pesticide has to be made to prevent the pest and diseases
10. During planting remove the poly bag without damaging the top root.

Planting

Pits of 45 x 45 x 45 cm are dug and filled with a mixture of topsoil, 10 kg of farmyard manure and one kg of neem cake at a distance of 7m x 7m either way during June and planted. In the case of seedling, 45 days old seedlings are transplanted.



After cultivation

The interspaces may be ploughed after the receipt of the rain and intercrops like groundnut or pulses or tapioca rose normally till they reach their bearing stage.

Training and pruning

All the side shoots must be removed up to a height of at least 2m from the ground to cause the branches to form and spread out from the upper section of the trunk. Periodical pruning of dead wood and criss cross branches during the month of July is recommended to minimize the losses through diseases such as dieback and to increase the yield.

Weeding

Clearing the area by manually within 2mtr radius of the trunk and slashing the remainder is essential until the trees shade out most of the trees. Weeding can be done by chemically also. Glyphosate (post emergent) application at 6 to 7 ml per litre of water (0.8 kg a.i./ha) during June – July also effectively controls weeds.

Irrigation

In India cashew is grown mainly under rain fed condition. However protective irrigation especially summer months during January-march at fortnightly intervals @ 200 liters/plant improves fruit set, fruit retention, thereby increasing nut yield.

Mulching

Mulching the tree basins will help in conservation of soil moisture and prevents soil erosion. Mulching with organic matter or residues inhibits weed growth and reduces surface evaporation during summer and also regulates the soil temperature.

Under sloppy areas, soil and water conservation practices can be done by making trenches of 30 cm width, 60 cm depth. And convenient length may be taken in between rows along the contour. This will not only conserve soil and moisture but will also enable to enhance the growth of cashew.

Manuring

Though a regular manurial schedule is not followed by most of the growers, experiments show that application of organic and inorganic manures are essential for higher yield in cashew. The recommended manurial schedule is as follows (per tree per year):

Age of plantation	FYM (kg)	N (g)	P (g)	K (g)
One year old	10	70	40	60
Two year old	20	140	80	120
Three year old	20	210	120	180
Four year old	30	280	180	240
Five years and above	50	500	200	300

In places receiving both South West and North East rainfall, the above quantity can be split into two equal doses and applied and in areas receiving only North-East monsoon, the entire quantity is applied during November. Nitrogen may also be given through foliar spraying (urea 1%) during July and November to get best result.

Plant protection

Tea mosquito, stem borer, thrips, leaf minor and leaf blossom webber are important pests of cashew. Of these, tea mosquito and stem borer causes economical damage in cashew.

Tea mosquito

Tea mosquito bug (*Helopeltis antonii* S.) can cause yield reduction to the tune of 30-40 per cent damaging tender shoots, inflorescence and immature nuts at various stages of development. It attacks the tree in all the seasons during flushing, flowering and fruit setting period but the peak period of infestation is from October to March. To control the pest, spray schedule involving three sprays synchronizing new flushing (October-November), flowering (November-December) and fruit setting (January – February) may be given with the following chemicals:- Quinalphos (25% EC) - 0.05%, Carbaryl (50% WP) - 0.01%, Phosphamidon (85% WSC) - 0.03%

The number of sprays should be limited to three and the same insecticide should be used for the subsequent sprays.

Stem and root borer - Stem and root borer (*Placaederus ferrugineus* L.) is also a dangerous pest and kill the entire plant. It is mostly seen in neglected gardens. The larvae of the beetle tunnel into the tree trunk and eat the bark all around the trunk. Manual removing of grubs and pasting the damaged portion with mixture of Carbaryl 50 gm (50%) and copper Oxchloride (25 gm) in one liter of water give effective control.

Harvesting

The cashew tree commences fruiting in the third or fourth year, attains the full bearing age by the tenth year and lives for 40 to 50 years. Flowering commences in November and extends upto February. The peak months of harvest are March-April and the remaining crop comes to harvest in February and May. The ripened will fall down and nuts from fallen fruits have to be collected.



Yield

The yield starting from 1 kg in 3rd-4th year, yield goes on increasing as the canopy develops and one can expect more than 10 kg of nuts in 8 to 10 years old plant depending on management.

Drying

The nuts collected should be dried immediately under sun by spreading in a thin layer. If the surface is of cement concrete, drying for two full days is sufficient. If the surface is of mud, drying for 3 to 4 days is necessary. While drying, the nuts should be raked quite often. Nuts should not be dried for more than four days since they become brittle and break while processing, causing damage to the kernels.

Top working

As most of the existing cashew plantations are of seedling progenies, the yield level is very low and highly erratic. Hence, top working with improved clones are suggested now. Tree of 20 –25 years old are beheaded at a height of 0.5m from the ground during December – February. A paste, made using 50g each of BHC 50 per cent wettable powder and copper oxchloride in a liter of water, should be applied all over the stump to check any infection by invading pathogens and borer insects. Profuse sprouting normally results in but only 10-15 healthy shoots and properly spaced on the stumps are alone retained. These shoots are grafted at softwood stage (cleft grafting) when they are about 40-50 days old. 7-8 successful grafts may be encouraged to grow vigorously due to the well established root system and they start yielding about 4 kg per tree from the second year of rejuvenation and the yield gradually increase to stabilize at 8 kg from the fourth year of top working.

Cashew processing

Processing of cashew is defined as the recovery of edible meat portion- the kernel from raw nuts, by manual or mechanical means. In India, the processing is by manual means. It consists of;

1. Roasting 2. Shelling 3. Peeling 4. Grading 5. Packing

1. Moisture Conditioning or Humidifying:

A slight under roasting or over roasting adversely affects the quality of the kernels. This is achieved by a moisture step preceding the roasting. The raw nuts are sprinkled with water and allowed to remain in moist condition for about 24-48 hours. This step is known as conditioning. The optimum moisture level at the end of roasting is reported to be 15-20%. Two important points to be taken care of during conditioning are;

- i. The water should not seep through the brown testa.
- ii. The water should be free from iron contaminations.

Iron contamination in the water can interact with polyphenolic materials of testa and the resultant bluish black complex may give patches on white kernel.

2. Roasting

Roasting is designed to make shell brittle.

a. Open Pan Roasting

The earliest process was the pan roasting wherein the nuts are heated on a metal pan over an open fire. Due to the heat and slight charring the shells become brittle. The pan roasting is not followed in organized sectors of industries. The two important methods of processing now adopted are; a. Drum roasting and b. Oil bath roasting

b. Drum roasting

The nuts are fed into a rotating hot drum, which ignites the shell portion of the nut. The drum maintains its temperature because of the oil oozing out of the nuts. The drum is kept in rotation by hand for about 2-4 minutes. The roasted nuts which are still burning are covered with wood ash to absorb the oil on the surface. The rate of shelling and the outturn of whole kernels are very high in this method. However, the main disadvantage is the loss of CSNL which has a very high export potential. In addition there will be considerable heat and acrid fumes in the vicinity of this operation.

c. Oil bath roasting

In this method, the nuts are held in wire trays and are passed through a bath of cashew shell oil maintained at a temperature of 200-202°C for a period of three minutes whereby the shell oil is received from the shells to maximum possible extent. The vessel is

embedded in brick work and heated by a furnace which use spent shell as fuel. During roasting, the shell gets heated and cell wall gets separated releasing oil into bath. As the level rises the oil is recovered by continuous overflow arrangement. The roasted nuts are then converted into a centrifuge. The residual oil adhering to the surface of nuts is removed by centrifuging. The roasted nuts are mixed with wood ash and sent for shelling.

In Panruti (Tamilnadu) the conventional roasting is completely avoided. The raw nuts are exposed to the intense sun that is prevalent in that region. The well dried nuts are hand shelled. Here also the CSNL is completely recovered.

3. Shelling

After roasting, shelling is done by labour. Each nut is placed edgewise and cracked open with a light wooden mallet and the kernel extracted with or without wire prong. Care has to be taken that the inner kernel is intact and not broken into bits. After kernels are removed from the shells they have to be dried to reduce the moisture to loosen the adhering testa.

4. Peeling

Peeling is the removal of testa from the kernels. This is done with help of safety pin or small hand knife. Peeling is made easier when the kernels are subjected to a heat treatment for about 4 hrs in a drying chamber.

5. Sweating

After peeling, the kernels are spread out indoors on cement flooring so that they may absorb some moisture and become less brittle. This prevents the tendency to break easily during grading.

6. Grading

The next stage in the processing is the grading of kernels on the basis of specifications for exportable grades. There are 25 exportable grades of cashew kernels. The kernels are stored into wholes, splits and Broken primarily on the basis of visual characteristics. The wholes are again size-graded on the basis of the number of kernels per 1 lb. The entire grading operation is done manually. However for size-grading mechanical operation is also practiced.

Specification for cashew kernels

Grade designation	Number of kernels per lb	Grade designation	Number of kernels per lb
W 180	375 to 395	W 320	660 to 705
W 210	440 to 465	W 400	770 to 880

W 240	485 to 530	W 450	880 to 990
W 280	575 to 620	W 500	990 to 1100

General Characteristics

Cashew kernels shall have been obtained through shelling and peeling cashew nuts, shall have the characteristic shape, shall be white or pale ivory or light ash in colour, reasonably dry, and free from insect damage, damaged kernels and black or brown spots. They shall be completely free from rancid kernels. The kernels shall be completely free from testa.

Grade designations and their trade names:

Grade designation	Trade names		Trade names
SW	Scorched wholes	SB	Scorched butts
SSW or SW IA	Scorched wholes seconds or scorched wholes IA	SS	Scorched splits
DW		SP	Scorched pieces
B	Desert wholes	SSP	Scorched small pieces
S	Butts	SPS	Scorched pieces
LWP	Splits	DP	second
SWP	Large white pieces	DSP	Desert pieces
BB	Small white pieces	DB	Desert small pieces
	Baby bits	DS	Desert butts
	Cont.		Desert splits

7. Packing

Final operation is packing in 10 kg capacity tins, which are subsequently evacuated and filled with carbon dioxide. In some parts to overcome the possible over-drying a re-humidification step is introduced before packing. The practice of filling with an inert gas is mainly to combat infestation during transit. It may be pointed out that with high quality nut, free from infestation, storing with or without carbon dioxide makes very little difference particularly with reference to rancidity. The importance of inert gas appears to be more for circumventing a possible insect attack from an occasional insect egg entering the tin while packing.

Nitrogen can also do the same function. However, carbon dioxide being a heavier gas is more convenient for handling. Contention that absorption of carbon dioxide makes the kernel

tastier does not have much truth. In any case the processed kernels are rarely consumed without a subsequent heat processing in the form of roasting frying and/or baking.

By products of cashew

After the processing of the shell and other left outs are used making some other products. The major by products of cashew processing are:

1. Cashew Nut Shell Liquid
2. Shell charcoal

1. Cashew Nut shell liquid (CNSL)

The pericarp of the nut consists of a coriaceous epicarp, spongy mesocarp and stony endocarp. The kernel covered with testa membrane is contained in a shell 1/8 inch thick. The mesocarp consists of a honeycomb network of cells containing a viscous liquid called cashew nut shell liquid (CNSL), which provides a natural protection to the kernel against insects.

CNSL is a valuable raw material for a number of polymer based industries like paints and varnishes, resins, industrial and decorative laminates, brake linings and rubber compounding resins. CNSL is traditionally obtained as a byproduct during the isolation of kernel. The major constituent of shell oil is cardanol and anacardic acid of which cardanol is separately extracted and used in many industries. The shell oil was used as a preservative for boats and nets and to protect wood from termites. It is now largely exported and used in the manufacture of plastics, indelible inks, water proofing composition and other industrial products.

Extraction of CNSL

The extraction of CNSL involves various methods viz. hot oil bath, expellers, kiln method, solvent extraction etc, the most common method being hot oil bath. In this method the raw nuts are passed through a bath of CNSL itself by which the CNSL is extracted. This method extracts only 50% of liquid contained in nuts. Then through expellers about 90% of liquid can be extracted.

2. Cashew shell charcoal

The remains of shell after the extraction of CNSL is called shell charcoal. This is used as a fuel. The shell charcoal is used in processing of cashew for drying after shelling.

1. Mode of pollination in cashew?
2. Fermented product of cashew apple?
3. Botanically cashew apple is _____
4. Mode of propagation in cashew _____
5. Export grade of cashew is _____

COCOA

(*Theobroma cacao*, Sterculiaceae)

Cocoa is a beverage crop introduced in India in the early 1965's. It is a native of South America and widely cultivated in Ghana, Nigeria, Sierraleon, Cameroon, Brazil, Equador, West Indies and Malaysia. In India it is cultivated in about 22,000 hectares as a mixed crop in Coconut and arecanut gardens. Kerala accounts for 79 % of the total area and 71% of the total production followed by Karnataka. Cocoa is highly cross pollinated and growing of different varieties adjacent to each other must be encouraged so as to achieve maximum fruit set and yield realization.

Botany

The leaves are alternate, entire, unlobed, 10–40 cm (4–16 in) long and 5–20 cm (2–8 in) broad. The flowers are produced in clusters directly on the trunk and older branches; they are small, 1–2 cm (1/2–1 in) diameter, with pink calyx. The fruit, called a cacao pod, is ovoid, 15–30 cm (6–12 in) long and 8–10 cm (3–4 in) wide, ripening yellow to orange, and weighs about 500 g (1 lb) when ripe. The pod contains 20 to 60 seeds, usually called "beans", embedded in a white pulp. Each seed contains a significant amount of fat (40–50% as cocoa butter). Their most noted active constituent is theobromine, a compound similar to caffeine .A shade-grown cocoa tree can produce fruit for 75 to 100 years or more.



Varieties

There are three broad types of cocoa - Forastero and Crillo, as well as Trinitario, a hybrid of the two. Within these types there are several varieties.

Forastero

Producing the greater part of all cocoa grown; Forastero is hardy and vigorous,

producing beans with the strongest flavour. The Forastero variety most widely grown in West Africa and Brazil is Amelondaro. It has a smooth yellow pod and pale purple beans.

Crillo

With its mild or weak chocolate flavour, Crillo is grown in Indonesia, Central and South America. Crillo trees are not as hardy and produce softer red pods, containing 20-30 white, ivory or very pale purple beans.

Trinitario

Plants are not found in the wild as they are cultivated hybrids of the other two types. Trinitario cocoa trees are grown mainly in the Caribbean, but also in Cameroon and Papua New Guinea. The mostly hard pods contain 30 or more beans of variable colour, though white beans are rare.



Only Forastero types are known to perform well under Indian conditions. Breeding work initiated at the Kerala Agricultural University since 1979 has resulted in the release of seven improved clones of Forastero type. These are CCRP 1, CCRP 2, CCRP 3, CCRP 4, CCRP 5, CCRP 6 and CCRP 7.

These improved clones are suitable for cultivation in different cocoa growing tracts of the country and also in the warm tropical areas especially under the shade of coconut. All these clones are tolerant to vascular streak dieback and have yield potential in the range from 55 to 180 pods per tree per year and mean yield from 38 to 78 pods per tree per year. During 2002, three hybrids viz., CCRP 8, CCRP 9 and CCRP 10 were released. These have mean yields of 90, 105 and 79 pods per tree per year. These are also tolerant to vascular streak dieback disease.

Climate and soil

The cocoa tree flourishes in the dense shade of warm rain forests in its natural habitat and hence can be cultivated in all similar climatic conditions. The tree cannot withstand high winds, drought or sudden fall in temperature.

The crop requires well-distributed rainfall. The minimum requirement of rainfall is about 100-150 cm per annum. Situations where the temperature falls below 10°C or rises above 38°C are unfavourable although minor deviations from the above limit can be adjusted by shade and irrigation. High wind velocity causes considerable mechanical damage to trees.

Cocoa is grown at altitude up to 900 m above MSL though it is possible to grow the crop even in much higher elevations under sheltered conditions.

The best soil for cocoa is forest soil rich in humus. The soil should allow easy penetration of roots and capable of retaining moisture during summer. Clay loams, loams and sandy loams are suitable. Shallow soils should be avoided. Cocoa is grown on soils with a wide range of PH from 6-7.5

Selection criteria for planting materials

Cocoa can be propagated by seed and vegetative means.

Seed propagation

It is desirable to collect seeds from biclonal or polyclonal seed gardens involving superior self-incompatible parents to ensure genetic superiority of planting materials. Polyclonal and biclonal seed gardens have been established at CCRP farm of the Kerala Agricultural University, Vellanikkara and Kidu farm of CPCRI and seeds and seedlings are being supplied to growers. If seeds cannot be procured from such seed gardens, mother plants for collection of seeds may be selected based on the following criteria:

- (1) Trees of Forastero type having medium or large pods of not less than 350 g weight or 400 cc volume, green in colour when immature, having smooth or shallow furrows on the surface without prominent constriction at the neck should be selected. Yield of pods should be not less than 100 per year.
- (2) Husk thickness of pods to be not more than 1 cm.
- 3) Pod value (number of pods to give 1 kg wet beans) to be not more than 12.
- (4) Number of beans per pod to be not less than 35.
- (5) Bean dry weight to be not less than 1 g.

Seeds lose viability within a week of harvest of pods. Seeds are to be sown immediately after extraction from the pods. Viability of the beans can be extended for some more days if freshly extracted seeds are stored in moist charcoal and packed in polybags. Other alternative is extracting beans, removing the testa and packing in polythene bags.

Selection of planting materials

When seedlings are used for planting, select only vigorous and healthy seedlings produced from polyclonal seed garden or selected mother plants as described earlier.

When budded plants are used, select two or more clones for planting as the use of a single clone can lead to poor production due to the existence of self-incompatibility in cocoa.

Seeds and cultivation

Selection of site

Cocoa is usually planted under coconut and arecanut plantations in India. Shade levels under coconut canopy are highly variable depending mainly on the spacing of coconut, extent of canopy development and age of palms. It is estimated that light infiltration through coconut canopy ranges from about 30 to 80 per cent depending upon these factors. Based on this, the general recommendation is as follows:

1. If a choice is possible, a coconut plantation that will let in more light through the canopy may be chosen for raising cocoa.
2. If the light infiltration is over 50 per cent, it may be beneficial to provide additional shade using temporary shade plants like banana.

Preparation of land

The seedlings / budded clones are usually planted in the interspaces of coconut / arecanut. Give a spacing of 3 to 4.5 m. The crop is best grown with 50 per cent light intensity in the early stages. In the early life of the plants, planting of quick growing plants like banana and tapioca can provide temporary shade.

Time of sowing

Though the seeds will germinate at any time of the year, seeds may preferably be sown by December-January, so that 4-6 month old seedlings become available for planting by May-June.

Method of sowing

Seeds are to be sown with hilum-end down or to be sown flat. Sowing is to be as shallow as to just cover the seeds with soil. Removal of pulp may enhance the speed of germination, but the extent of additional advantage is only marginal. Seeds start germination in about a week and germination may continue for another one week. Percentage of germination may be around 90.

Cocoa nursery is to be located in a heavily shaded area, which allows only 25-50 per cent sunlight. Regular watering is necessary to keep the soil moist.

Seedlings are transplanted after 4-6 months. Only vigorous seedlings are to be used and based on height and stem girth, 25% poor seedlings may be rejected. When seedlings are grown under heavy shade, hardening for 10 days by exposing to higher illumination may be necessary before transplanting.

Vegetative propagation

In view of the high variability exhibited by seedling progenies, vegetative propagation is preferred for large scale planting. Though vegetative propagation of cocoa by budding, rooting of cuttings and grafting are feasible, the widely accepted method in India is budding.

Scions for budding are to be collected from high yielding, disease resistant elite plants. Shoots having brown bark and just hardened leaves are selected as bud wood. Scions are preferably procured by cutting off lamina of all the leaves of the selected scion shoot to a distance of about 30 cm from the tip. After 10 days when the petioles have fallen off, these scion shoots are cut and used for budding immediately. Bud wood can be stored by dipping in benzyl chloride followed by washing in water and then sealing the cut ends using molten wax. Bud wood is then wrapped in moist cotton wool and in turn in wet tissue paper or blotting paper and packed in boxes with wet packing material. The packet is then covered using polythene sheets. Storage life of the bud wood can be extended up to 10 days by this method. As far as possible, bud wood is to be collected from chupons as those produced from fans may develop into bushy plants with spreading habit. Rootstock, six to twelve months old may be selected in such a way that scion and rootstock are of the same thickness. Different successful methods include T, inverted T, patch, and modified Forkert methods. Patch budding is adopted in the Kerala Agricultural University.

Patch budding

1. A patch of about 2.5 cm length and 0.5 cm width is removed from the rootstocks.



2. A bud patch of 2.5 cm length and 0.5 cm width from the bud wood is prepared and inserted into the rootstock and tied firmly with polythene tape.



3. After three weeks, if there is bud-take, polythene tape is removed.



4. A vertical cut is made half way through the stem above the bud and is snapped back.



5. The snapped root stock portion is cut back after the bud has grown to a shoot and at least two leaves have hardened.



It is then allowed to grow for a further period of three to six months after which they are transplanted. Under normal conditions, success can be around 70-90 per cent.

Time and method of planting

Cocoa is planted as a pure, mixed crop or intercrop. When planted as a pure crop, Dadap (*Erythrina lithosperma*) is planted at 3x 3m spacing to provide shade. Dadap needs pruning every year. For more permanent shade, *Albizia stipulate* can be planted adopting 9x9

or 12x12m spacings. This requires 4 to 6 years to develop proper canopy to provide sufficient shade.

Cocoa is planted as an intercrop in coconut and arecanut gardens. In coconut, depending upon the spacing adopted, one or two rows of cocoa can be planted in between two rows of coconut i.e., two rows where the spacing is more than 8 m and one row otherwise, the plant distance for cocoa being 2.7 to 3 m. When two-row system is adopted, the seedlings may be planted in zigzag or triangular manner.

In arecanut where the normal spacing is 2.7 m, cocoa is planted at the centre of four areca palms along alternate rows of interspaces only. Pits of 50 x 50 x 50 cm are dug, allowed to weather for one month and refilled with topsoil and 15-20 kg of compost or farm yard manure to ground level. The planting hole should be sufficient to hold the soil ball of the polybag. Tear off the polybags carefully, place the soil ball with the seedlings in the planting hole with minimum disturbance and press the soil around firmly. Planting should coincide with the onset of monsoon, but in places where irrigation is resorted to, flexibility in the time of planting is possible.

Shaping of clonal plants derived from fan shoots

Budded plants from fan shoots have diffuse branching system and bushy growth habit. This type of growth causes difficulties in carrying out cultural operations and harvesting. If a better shape of the plant is desired, appropriate formation pruning may be necessary. This involves identification of a chupon arising from a fan shoot, allowing it to grow and removing the original, lower fan-like shoots in stages. This, however, has to be done slowly as an early drastic pruning will inhibit growth.

Pruning and training

Cocoa grows in a series of storeys, the chupon or vertical growth of the seedling terminating at the jorquette from where four to five fan branches develop. Further vertical growth is continued through a side chupon that arises from a point just below the jorquette which again jorquettes after growing to some height. Left for it, the plant will grow to a height of 8-10 m repeating this process of jorquetting and chupon formation 3-5 times. When cocoa is grown as an intercrop in coconut and arecanut plantation, it is desirable to restrict the growth to one tier formed at a convenient height preferably above the head level of the workers. When jorquetting takes place at lower levels this can be raised by nipping off all the fan branches and allowing one chupon to develop and grow further to jorquette at the desired height. After this is achieved, further vertical growth is arrested through periodical removal of chupons.

The intensity of pruning is to be decided by the nature of growth of individual trees, shade intensity, growth of the companion crops etc. In the early stages, pruning is done to give a particular shape to the tree. After the establishment of the trees in the garden, prune them to the extent of retaining only the required number of leaves (20-30 leaves per developing pod). Removal of secondary branches from the centre should be restricted only to those trees growing in excess shade.

Top working

This technique is useful to rejuvenate old and unproductive cocoa plants and also to convert genetically poor yielders to high yielders. This consists of snapping back the desired trees below the jorquette after cutting half way. The snapped canopy continues to have contact with the trunk. A number of chupons would arise below the point of snapping and this is triggered by the breakage of apical dominance and continued connection with the snapped canopy. Patch budding as described earlier may be done on three to four vigorous and healthy shoots using scions from high yielding, disease resistant clones and the remaining chupons are removed. The polythene tape is removed three weeks after budding and the stock portion above the bud union is snapped back. The snapped portion is removed after two hardened leaves develop from the bud. When sufficient shoots are hardened, canopy of the mother tree can be completely removed. Because of the presence of an established root system and the trunk with reserve food, the top worked trees grow much faster and give prolific yield one year after the operation. Though top working can be done in all seasons, it is preferable to do it in rain-free period in irrigated gardens. For rainfed situations, it may preferably be done after the receipt of pre-monsoon showers.

Top worked trees start yielding heavily from the second year onwards. About 50 per cent improved yield is obtained in the second year and about 100 per cent improved yield in the third year. Loss of crop for one year during the operation is compensated by bumper crop in the coming years. The main stem will continue to belong to the older plant and fruits borne on this area belong to the poor yielder. Better yields are however obtained from the fan branches of the high yielding clone used for top working.

Irrigation

Cocoa grows well as a rainfed crop under conditions of well-distributed rainfall and irrigation is not necessary. If sufficient moisture is not present in the soil due to prolonged drought or failure of rains, irrigation is to be given once in five days. Irrigation, however, helps in better growth of plants and precocity in bearing.

Manuring

Apply N:P₂O₅:K₂O in two equal split doses in April-May and September-October, @ 100:40: 140 g / tree / year. N:P₂O₅:K₂O may be applied @ 200:80:280 g / plant / year, in trees yielding more than 50 fruits per year. Dolomite @ 100 g / plant / year may be applied to plants from the third year onwards.

Under irrigated conditions, the yearly dose may be split into four and applied during April-May, September-October, December and February-March.

Apply 1/3 of adult dose during the first year of planting, 2/3 during second year and full dose from the third year onwards.

Apply fertilizers in circular basins with a radius of 25 cm during the first year. Gradually increase the radius of the basin to 120 cm by the third year. Apply fertilizers in the entire area of 1.5 m radius around the tree followed by forking in.

Plants showing zinc deficiency symptoms (narrowing of leaves, sickle leaf formation, green vein banding, and chlorosis in the interveinal areas) should be sprayed with 0.5 to 1.5% ZnSO₄ three times a year.

Weed management

During the first three or four years after planting, it is essential to keep the field free from weeds. Maintenance and regulation of shade should be carried out promptly. During the establishment phase of the crop particularly in summer, provide mulching with materials like chopped banana sheath, coconut husk, cocoa husk etc. to conserve moisture in conditions of direct insolation. A mature cocoa plantation should form a proper canopy, which will be dense enough to prevent weed growth. Operations such as pruning and regulation of shade should be attended to in time.

Pest management

Stem borer (*Zeuzera coffeae*)

Larvae burrow into the main stem of young plants and fan shoots of older trees, causing drying up.

Control

Prune off and burn affected fan shoots. Spray carbaryl 0.1% on the main stems of young plants as a prophylactic measure.

Striped squirrel (*Funambulus sp.*)

The squirrels gnaw the bronzing pods and extract the beans along with mucilaginous pulp.

Control

Harvest the crop just when bronzing is visible in the pod furrows. Mechanical protection of the pods can be ensured by covering them with punched polybags (150 gauge) smeared with bitumen-kerosene mixture.

Rats (*Rattus rattus*)

Rats are serious pests in densely planted coconut gardens with cocoa as an intercrop. They inhabit the coconut palm crowns and descend during night and cause damage to pods. Nature of damage is similar to that caused by squirrels.

Control

Baiting with anticoagulant rodenticides in the garden is recommended. Rain-proof preparations are to be used. Tie fumarin bars (rain-proof) on the base of an inner frond of coconut. Set up bamboo traps with bow attachment on the crown of palms.

Myllocer weevils (*Myllocer viridanus*)

Adults skeletonise the foliage and this is serious in young plants during July-September. Spray undersurfaces of the foliage with Fenitrothion 0.05%, Quinalphos 0.025% or Fenthion 0.05%.

Mealy bugs (*Planococcus citri* and *Rastrococcus* sp.)

The bugs occur in cherelles, developing pods and shoots and de-sap the tissues. This can be controlled by spot application of Quinalphos 0.025% or Phosalone 0.1%.

Aphids (*Toxoptera aurantii*)

Colonies of pink aphids occur ventrally on the leaves of chupon shoot. Tender shoots are also damaged.

Control

Nip off the flaccid leaves along with the shoots and destroy the colonies.

Cockchafer beetle (*Popillia* sp. and *Leucopholis* sp.)

Grubs feed on the roots of freshly planted seedlings causing wilting. Apply Carbaryl 10% DP at 10 g per pit around freshly planted seedlings.

The pods are damaged by *Helopeltis* sp. The pest can be controlled by spraying Endosulfan 0.05%.

Disease management

Seedling blight (*Phytophthora palmivora*)

The symptoms develop on the leaves and stem of the seedlings or budded plants. On leaves, small water-soaked lesions appear which later coalesce resulting in the blighting of leaves. On stem, water-soaked linear lesions develop initially and later turn to black colour.

Stem infection develops at any point on the stem causing the death of seedlings / budded plants.

Control

Remove and destroy severely affected seedlings. Improve drainage and adjust shade. Spray with 1% Bordeaux mixture or 0.3% copper oxychloride or 0.3% potassium phosphonate just before the onset of monsoon and thereafter at frequent intervals.

Phytophthora pod rot / black pod (*Phytophthora palmivora*, *P. citrophthora*, *P. capsici*)

Fruits at all stages of maturity may be attacked by *P. palmivora*. The first visible symptom is the appearance of a circular brown spot, which enlarges concentrically, and evenly to involve the whole pod surface. Ultimately the colour of the affected pod becomes dark brown or black. In immature pods, the discolouration spreads internally with rotting of the beans. The beans in mature pods may remain partly or wholly unaffected.



Control

Periodically remove and destroy all dried up and infected pods. Spray 1% Bordeaux mixture with adhesive (rosin washing soda preparation) with the onset of monsoon and also at frequent intervals. Provide proper drainage and regulate shade to increase aeration.

Lasiodiplodia pod rot / charcoal pod rot (*Lasiodiplodia theobromae*)

The disease occurs more frequently during dry season. Pods of all stages are affected. The symptoms appear as pale yellow spots from the stalk-end or tip of the pod. Later, the lesions enlarge and cover the entire pod having chocolate brown colour. In due course, the whole pod develops a black sooty appearance due to formation of spores of the fungus.



Control

Since the disease is more common on pods of plants under stress, better management practices will reduce the incidence of the disease. Remove all affected pods and spray 1% Bordeaux mixture.

Colletotrichum pod rot (*Colletotrichum gloeosporioides*)

The disease causes rotting of immature pods. Infection starts from the stalk-end of the pod and spreads towards tip as dark brown discolouration with a diffused yellow halo. Internal tissues of the pod also show discolouration. The whole pod turns to black and remains on the

tree in a mummified form. Sometimes, infection may start from parts other than the stalk region as dark brown sunken lesion.

Control

Remove all infected pods and spray with 1% Bordeaux mixture or 0.3% copper oxychloride or mancozeb.

Phytophthora canker (*Phytophthora palmivora*)

The earliest symptom is the appearance of greyish brown water-soaked lesion with dark brown to black margin anywhere on the stem. A reddish brown liquid oozes out from the lesions, which later dry up to form a rusty deposit. The internal tissues beneath the outer greyish brown lesion appear as reddish brown. The wood shows greyish brown discolouration with black streaks. Wilting occurs, when canker girdles the affected stem / branches.

Control

If the disease is detected early, remove and destroy the affected tissues completely and apply Bordeaux paste. Wilted branches should be cut and removed. Since canker mainly develops from pod rot caused by *Phytophthora*, proper control measures of *Phytophthora* pod rot will help in reducing incidence of the disease.

Pink disease (*Corticium salmonicolor*)

The disease appears as a pinkish powdery coating on the stem of affected plants. The pink colour represents profuse conidial production by the fungus. The fungal growth may rapidly spread and girdle the stem, so that the distal parts are affected. The extent to which the leaf may wilt, turn brown and fall depends on the part of the tree, which is affected. The disease mainly affects the forking region and the damage is localized. Splitting of the bark on the affected region is also noticed. Sometimes, the fungus produces pustules (Necator stage), which are orange red in colour and are arranged in rows along the stem.

Control

Remove all the infected and dried branches. Apply Bordeaux paste at the fork region and at the cut ends of the twigs and spray with 1% Bordeaux mixture before the onset of monsoon. Repeat spraying again once or twice during the monsoon season according to the intensity of the disease.

Vascular streak dieback (VSD) (*Oncobasidium theobromae*)

The first indication of the disease is the characteristic chlorosis of one or two leaves on the second or third growth flush behind the tip. Tip leaves show symptoms first only in very young seedlings or in slowly growing seedlings or branches. The patterns on the diseased leaf develop into small sharply defined green spots scattered over a yellow background. Diseased

leaves fall within a few days after turning yellow. Leaves above and below the first diseased leaf soon begin to show yellowing with green patches and these also fall off finally resulting in dieback of the infected branches.

Leaf scars from the fall of chlorotic leaves are sometimes covered by a white, loosely adherent fruiting body of the fungus. These fruiting bodies have been found only on leaf scars and adjacent bark in the diseased region of cocoa stems. If the diseased stem is split longitudinally, the xylem is found to be discoloured by brown streaks.

Control

Cut and remove all infected twigs. Prune off all affected branches 30 cm below the last point of visible vascular streak of the stem to prevent further spread within the plant. Grow VSD tolerant cocoa types.

White thread blight (*Marasmius scandens*)

The white mycelial threads of the fungus spread longitudinally and irregularly along the surface of the stem of young branches and enter the leaf along the petioles. On the leaf lamina it spreads extensively and forms a much-branched system of fine threads. The affected leaves turn dark brown and such dead leaves eventually get detached from the stem, but are found suspended by the mycelial thread. Extensive death of the young branches and suspended leaves in rows are the common field symptoms.

Control

Remove and destroy the affected plant parts. Avoid heavy shade. Spray 1% Bordeaux mixture.

Harvesting

It takes about 170 days for a cocoa pod to develop from formation to maturity. During the period from 70-140 days after pollination, the size of pods and their fat and sugar content increase rapidly. Ripening takes about 25 days, during which, the pods change colour depending on the variety. Pods remain suitable for harvesting for fairly long time after they have ripened. Hence, it is possible to have harvest of sufficient number of pods at a time by either delaying the harvest of early-ripened pods or harvest of pods, which are fully ripened.



Harvesting should be done at regular intervals rather than daily, once in 7-10 days. Avoid over-ripening of pods. The discards at the harvest can be left in the garden either in the open during summer or in pits at different sites in the rainy season, or they can be incorporated in the

compost. Pod husks from the fermentary can also be used similarly as a good source of organic manure.

Pods are removed by cutting with a sickle-sharp knife, without damaging the cushion from which it is developed. After 2-3 days, they are split by banging them against some hard objects. Opening the pods with a knife damages the beans. During the period between harvesting and splitting, pre-fermentation activity inside the pod is hastened, which improves later fermentation. Beans from the split pods are scraped out with fingers. Portions of placenta and broken, germinated, caked, parthenocarpic and undeveloped beans are removed. On an average, 10-12 pods give 1 kg of wet beans and 3 kg of wet beans (from 30-36 pods) give 1 kg of fermented and dried beans.

Processing

Fermentation

During fermentation, the pulp or mucilage covering the fresh beans is removed and characteristic chocolate flavour is imparted to the final produce. The process is simple but must be carried out properly in order to get beans of good quality. Heat is produced by keeping the fresh beans compactly and this heat must be conserved so that chemical changes inside the bean can be completed. The four methods of fermentation usually employed involve the use of baskets, heaps, boxes and trays for filling up the wet beans.

Tray method

The best method suitable for small quantities of beans is the tray fermentation. Wooden trays, 10 cm deep with slatted / split cane bottoms are divided into a number of sections by means of wooden partitions that fit into appropriate grooves at required distances. The capacity of the tray can be adjusted depending upon the availability of beans by keeping the wooden plank in the appropriate grooves. A convenient tray can be 25 cm wide and 60 cm long. Wet beans are filled in the tray and levelled. About 10 kg of wet beans may be required to load one tray fully.

A single tray of beans will not ferment properly and at least four or five trays are needed for successful fermentation. The trays are stacked one over the other in such a manner that the cocoa filled portions are in a single row one above the other. The top tray is covered with plantain leaves. After 24 hours, a close fitting sack is put to cover the stack to keep the beans warm. Mixing or stirring of beans is not necessary and fermentation gets completed in 4 to 5 days, whereas 6 to 7 days are required for other methods of fermentation.

Basket method

In this method, bean lots ranging from 2-6 kg can be fermented successfully. Mini baskets may be made of bamboo matting, closely woven and should have a diameter of 20 cm and height of 15 cm for a capacity of 2 kg. For slightly larger lots, proportionately deeper baskets may be used (e.g., for 6 kg, the depth may be about 40 cm). The baskets are lined with one or two layers of torn banana leaves to facilitate drainage of sweating. Wet beans are then filled, compacted and covered with banana leaves. The baskets are placed on a raised platform to allow the flow of drippings. After 24 hours, it is covered with gunny-sack and applied weights (bricks). The beans are to be taken out and stirred well 48 hours and 96 hours after the initial setting. Fermentation will be completed in six days and the beans can be taken for drying on the seventh day.

A number of factors influence the duration of fermentation. Weather changes and season are important through their influence on temperature and atmospheric moisture. Ripening also affects fermentation. Beans from unripe pods cannot be fermented. Beans of Criollo ferment more quickly than those of Forastero. During the early stages of fermentation, heat is produced by the action of anaerobic microorganisms. The beans are killed by the combined effect of heat and acetic acid and the cocoa aroma and flavour potential are developed.

Judging the end point of fermentation

Well-fermented beans will be plumpy and filled with a reddish brown exudate. The testa becomes loosened from the cotyledons. When cut open, the cotyledons will have a bleached appearance in the centre with a brownish ring in the periphery. When above 50% of beans in a lot show the above signs, it can be considered as properly fermented.

Drying

On completion of fermentation, beans are dried either in the sun or by artificial means. Sun drying can be done in thin layers 2-3 cm deep and stirring from time to time. Under normal sunny weather, drying can be completed in four to five days. While drying in mechanical driers, care must be taken to avoid exposure of the beans to smoke, fumes etc. The most common method of determining bean dryness is to take a sample and compress this in the palm of the hand and listen for the characteristic sound, which is associated with correctly dried cocoa. The more scientific method is to use a moisture meter.

Storage

The dried beans with moisture content of 6-8% may be packed in polythene bags or polythene lined gunny bags. Some special conditions have to be provided in storage in order to

maintain the quality of the cured beans. Properly dried beans can be kept in 200-300 gauge polythene covers if only small quantities are involved or in polythene lined gunny bags in the case of larger stocks. Beans should be cleaned of flat, broken and other defective beans before storing. The store should be sufficiently ventilated and the bags should be kept on a wooden platform with air space of about 15-20 cm below the wooden planks set over the floor. The humidity should not exceed 80% so as to prevent mould development and pest incidence in the beans. Before storing cocoa, the store can be made clean and insect free by application of pesticides well in advance, but pesticides should neither be applied nor be kept with the beans inside the store. As cocoa beans can absorb and retain permanently any odour from its surroundings, other food-stuffs should not be kept with cocoa. So also, smoke or kerosene fumes should be prevented from entry.

1. Scientific name of cocoa is _____
2. Two types of cocoa are _____
3. Mode of propagation in cocoa is _____
4. _____ type of flowering is seen in cocoa
5. Major pest of cocoa is _____

COFFEE

(*Coffea arabica* and *C.canephora*, Rubiaceae)

Coffee, native of Ethiopia, was introduced into India sometime during 1600 AD by a Muslim pilgrim, Baba Budan on the hills near Chikmangalur. Coffee seedlings were then planted in the backyards and it was not until the late 1820 s that commercial plantations were started in South India by British entrepreneurs. Now coffee cultivation is mainly confined to the States of Karnataka, Kerala, Tamilnadu ND Andhra Pradesh and on a limited scale to Arunachala Pradesh, Assam, Madhya Pradesh, Manipur, Meghalayaa, Mizoram, Nagaland, Orissa, Sikkim, Tirupura and West Bengal. The present area under coffee is 2,43,117 hectares of which arabica accounts



for 49.41 % and robusta 50.59 % with a total production of about 1,75,000 tonnes . About 60 % is exported annually earning around Rs. 300 crores and rest consumed internally. There are 99,000 registered growers of whom 97.13% are small growers with 10 hectares and below. This plantation employs about 3, 71,655 workers.

Botany:

Though the genus coffea consists of about 70 species, only 3 species are of economic importance. They are 1) *C. arabica* (Arabica coffee), 2) *C. canephora* (Robusta coffee) and 3) *C. liberica* (Tree coffee). The first two species are extensively cultivated. The important differences among these two species are:

CHARACTER	<i>C. arabica</i>	<i>C. canephora</i>
1. Ploidy	Tetraploid (2n=44)	Diploid (2n=22)
2. Adaptability	Higher elevation	lower elevation
3. Plant status	A small tree, a shrub or a bush under training.	A bigger tree than arabica.
4. Leaves	Dark green	Pale green
5. Blossoming	Bloom in 9-10 days after the receipt of blossom showers.	Bloom in 7 days after the receipt of blossom showers.

6. Flowers	Scaly, small bracts, per axil 4-5 inflorescence of 1-4 flowers per inflorescence.	Leafy and expanded bracts with 5 to 6 flowers per inflorescence.
7. Berries	10-20 per node oblong to round in shape.	40-60 or more per node, small.
8. Fruit development	8-9 months	10-11months
9. Root system	Small but deep.	Large but shallow
10. Pollination & fertilization	Self pollinated & Self fertile.	Cross pollinated & Self –sterile.

The coffee plant has a prominent vertical stem with horizontal primary branches arising from it in pairs opposite to each other. Another upright shoot, sucker, arises from the main stem especially in a matured coffee plant in between the primary lateral branch and the leaf or its suar. It grows vertically like the main stem. These primary branches give rise to laterals which in turn produce tertiary and quartenary branches. The secondary and tertiary types arise towards the distal end of the branch just above the axil and the other type known as axillary bud which grows in the leaf axil and is capable of growing into a flower cluster or a lateral shoot. The axillary bud provides the main cropping wood for the plant.

Coffee is a short day plant and is South India, flower initiation takes place between September to March. The flower buds grow into a definite size under fairly cold winter conditions and undergo a period of dormancy due to the onset of drought coupled with high temperature, long day and high light intensity conditions prevailing in dry months (November



to march) depending upon the places. There is practically no vegetative growth during these dry months. Immediately after the blossom showers, growth changes are conspicuous in flower buds on the third day following rains due to the moistening of the flower buds, soil wetness and low temperature that follows immediately after rain. This causes the plants to blossom within 7 to 10 days. This imposed dormancy is a necessary event, as it enable single harvest , otherwise, coffee will be blooming through out the year resulting

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in staggered harvesting concomitant with increased cost of picking, etc. The fruit is a drupe and normally contains two seeds. Abortion of one ovule due to non-fertilization leads to the formation of a single seeded fruit, called pea berry. Sometimes, 3 or more seeds may be present due to trilobular ovaries or false polyembryony and is often called triangular seeds. Occasionally, formation of more than one ovule per locule is seen and such seeds are known as elephant bean.

Climate and Soil

Climatological factors like rainfall, temperature, elevation and aspect can influence economic production of coffee much more than soil factors. Soil should be deep, well drained, slightly acidic in reaction and rich in organic matter content.

The optimum soil and climate requirements for arabica and robusta under south Indian conditions are as follows.

Particulars	Arabica	Robusta
1. Elevation	1000-1500m MSL	500-1000 m MSL
2. Annualrainfall	1600-2500mm	1000-2000mm
3. Bloosom rain	March-April	February - March
4. Backing rain	April- May	April- May
5. Shade	Needs medium to light shade depending on elevations & aspects.	Needs uniform thin shade.
6. Temperature	15- 25°C	20-30 C
7. Relative humidity	70-80%	80-90%
8. Soil	Deep friable, porous, rich in organic matter moisture retentive, slightly acidic Ph 6-6.5	Same as for Arabica.
9. Aspect.	Northern, Eastern and N. Eastern aspects are ideal	Flat to gentle slopes
10. Slope of the field	A gentle to moderate slope is ideal.	Gentle slopes to fairly level are to be preferred

Varieties

Variety	Parentage	Special Chraceters
S.795 (Sln. 3)	S.288 x Kent	Resistant to leaf rust race 1 and 11

Sln.7 (San Ramon hybrids)	San Ramon short internode arabica spotted in Costa Rica	Dwarf in nature, but segregates to tall by 30%
Sln. 8 (Hibrido-de-timor)	A spontaneous hybrid of robusta– arabica, spotted in portugese timor island	Highest vertical resistant to leaf rust
Sln.9	Sln. 8 x Tafarikelela	Drought hardy, suitable to different coffee zones
Sln.10 (Catura crosses)	Catura x S.795 or Sln.8	Drought hardy, suitable to different coffee zones

Nursery

Healthy and mature fruits of normal sizes and appearance, three squatters to fully ripe are harvested from specially selected and marked coffee plants for uses as seed bearers. Floats are discarded, the sound fruits are pulped, the beans drained and sieved to remove defective beans. The beans are then mixed with sieved wood – ash , evenly spread out to a thickness of about 5 cm and allowed to dry to facilitate uniform drying. Excess ash is rubbed - off after five days of drying.

Germination beds raised to a height of about 15 cm, one metre width and of convenient length are prepared, Four baskets of fully mature cattle manure or compost, about 2 kg of finely sieved agricultural lime and 400 g of rock phosphate are incorporated in a bed measuring 1mX 6m.

Seeds should be sown with the flat side facing the soil at a distance of 1.5 to 2.5 cm from one another in regular rows. A thin layer of fine soil is then spread. The bed is covered with a layer of about 5 cm of paddy straw. The beds are watered daily and protected from direct sunlight by and overhead pandal constructed for this purpose. The seeds germinate in about 45 days. The seedlings are then transplanted to secondary nursery beds or raising polybag plants.



Coffee seedlings are transplanted to polythene bags of 23 cm X 5 cm with 150 gauge thick in February or March when they are at the bottom or topee stage. The bags are filled with a prepared mixture of 6 parts of jungle soil, 2 parts of well rotten sieved cattle manure and 1 part of fine sand.



At the time of transplanting it is preferable to slightly nip the tap root of the seedling. Transplanting is done preferably in the early morning hours or late in the afternoon.

Regular watering and after-care of the seedlings should follow. Seedlings may be manured once in 2 months with urea dissolved in water, 20 g urea in 4.5 litres of water is sufficient for an area of 1 square metre. Adequate protection is given against nursery diseases and pests. Overhead shade in the nursery has to be thinned and finally removed after the onsets of monsoon.

Preparation of land

Clean felling is not advocated. Selective retention of desired species of wild shade trees is essential. The land should be divided into blocks of convenient sizes with foot path and roads laid out in between. In steepy area, terracing and contour planting may also be adopted.

Spacing for arabica and robusta coffee is 1.5 to 2.0m and 2.5m either way respectively and 1mX1m for dwarf variety Sanraman. A close planting at 1-1.5 m either way and reduce the population by half after one or two harvests is good. Pits of 45 cm, are usually opened after the first few summer shower and seedlings of 16 to 18 months old are planted during June or September – October. A hole is made in the center of the pit after leveling the soil. The seedlings is placed in the hole with its tap root and lateral roots spread out in proper position. The hole is then filled. The soil around the seedling is packed firmly and evenly in such a way that 3 cm high above the ground to prevent stagnation of water around the collar. The seedlings are provided with cross stakes to prevent wind damage.

Training and pruning

Training of the bush is necessary to have a strong frame work which promotes production of bearing wood.

Coffee is trained in two systems viz

1. Single stem system

When the plant reaches a height of 75 cm in Arabica or 110 to 120 cm in robusta, it is topped. This helps to restrict vertical growth, facilitate lateral spreading and increase the bearing area. In this system, a second tier is also allowed sometimes depending upon the soil fertility and plant's vigour.

2. Multiple stem system

It is common in Kenya, Tanzania, is not practiced in India. Pruning in coffee is generally done immediately after harvest and till the onset of monsoon. It is essentially a thinning process and is done mainly to divert the vigour of the plants to certain parts by pruning the other parts. Pruning involves a) Centering b) Desuckering c) Handling

Soil Management

Soil management practices aim at conserving soil and water and in general to make the soil perform its functions satisfactorily. It includes the following practices in coffee.

a) **Digging:** In the new clearing, the field is given a thorough digging to a depth of about 35-45 cm towards the end of the monsoon. All weeds and vegetative debris are completely turned under and buried in the soil while the stumps are removed. Once the coffee plants have closed in, annual digging is not done.

b) **Scuffling or Soil stirring:** In established coffee fields, scuffling or soil stirring is done towards the beginning of the dry period. It controls weeds and also conserves soil moisture.

c) **Mulching:** Mulching young coffee clearings helps to maintain optimum soil temperature and conserve soil moisture and acts as an effective erosion control measure. Mulching also adds to fertility of the soil.

d) **Trenching:** Trenches and pits are dug or renovated in a staggered manner between rows of coffee along the contour during August-October when the soil is fairly easy to work. These are 50 cm wide and 25 cm deep and can be of any convenient length.

e) **Weed control:** New clearings are hand – weeded three to four times a year and established coffee two to three times. During the monsoon, the weeds are slashed back. Another weeding is done towards the end of the monsoon. Clean weeding is generally done during the post monsoon period. Chemical weedicides have gained popularity in larger plantations.

Grammaxone at 1.25 lit in 450 lit of water per hectare has been found to be the best. This should follow weeded plots after 10-15 days.

f) Irrigation: Springer irrigation is mainly used as an insurance against failure of good blossom or backing showers.

g) Soil acidity and liming: The heavy rainfall in coffee growing zones of South India brings about leaching in calcium and magnesium leading to soil acidity. Besides, continuous use of acid forming fertilizers like ammonium sulphate also makes the soil acidic. Agricultural lime and dolomite lime are the most commonly used liming materials.

Shade and its management

❖ Under the climatic conditions existing in India. Coffee is being cultivated under shade. It comprises of two canopies lower or temporary and upper or permanent.

❖ Dadap is used as a lower canopy shade in India. Next to dadap, silver oak is the most commonly used tree for temporary shade.

❖ The most popular permanent shade trees found in south India. *Albizzia lebbec*,



A.odoratissima, *A.moluccana*, *Artocarpus integrifolia*, etc., Permanent shade trees are generally planted about 12 to 14 m apart. The most convenient time to regulate shade is after pruning and liming.

Manuring

Coffee plants produce every year fresh wood for the succeeding crop concomitant with the function of maturing the current berries. Hence, they require a regular supply of nutrients. Besides, being grown in heavy rainfall area, the losses of nutrients due to leaching and fixation are to be offset by regular application of adequate quantities of fertilizers.

As a supplement to soil applications of fertilizers, foliar spraying with (Urea 0.5 kg, Ammophos (20:20) 0.5 kg and muriate of potash 350 g dissolved in 200 lit of water or Bordeaux mixture may be given) during periods of slow growth, flowering and fruit setting. However, Bordeaux mixture should be neutralized properly before dissolving the nutrients.

Manurial recommendation for coffee:

	Pre blossom (March)	Post blossom, Pre monsoon (May)	Mid monsoon (August)	Post monsoon (October)	Total

Arabica					
1st year	15:10:15	15:10:15	--	15:10:15	45:30:45
2nd and 3rd year	20:15:20	20:15:20	--	20:15:20	60:45:60
4th year	30:20:30	30:20:30	--	30:20:30	80:60:80
Bearing coffee 5 years and above: for less than 1 t/ha crop	40:30:40	40:30:40	20:0:0	40:30:40	140:90:120
For 1 t/ha and above	40:30:40	40:30:40	40:30:40	40:30:40	160:120:160
Robusta					
For less than 1t/ha crop	40:30:40	--	--	40:30:40	80:60:80
For 1 t/ha and above	40:30:40	40:30:40	--	40:30:40	120:90:120

Pest Management

Coffee berry borer (*Hypothenemus hampei*)

Coffee berry borer is the most serious pest of coffee world over. The female beetle bores into the berries through the navel region and makes tunnels in the hard bean and lays about 15 eggs. The larvae feed on the beans, making small tunnels. A typical pinhole at the tip of the berries indicates the presence of the pest, and it damages young as well as ripe berries. In case of severe infestation, 30 to 80% berries may be affected resulting in heavy crop loss. The coffee berry borer can be controlled by the following methods.



a. Cultural

Timely and complete harvest, collection of gleanings, burying the infested berries and maintaining optimum shade and good drainage can control the pest.

b. Chemical

Spraying endosulfan 35 EC 340 ml in 200 litres of water along with 200 ml of wetting agent 120-150 days after flowering (Aug-Sept, for arabica and Sept-Oct. for robusta) can control the pest.

White stem borer (*Xylotrechus quadripes*)

Plants show unhealthy symptoms like wilting and yellowing of leaves. As the beetles are active and females lay eggs in the crevices on the main stem of coffee, major efforts to control initial laying of eggs itself is aimed at by swabbing the main stem and the thick primaries with carbaryl 50 WP @ 4 kg in 200 litres of water once or twice (depending upon the severity of the incidence) in April-May or October to December. Apart from this, it is necessary to build up good shade and regularly trace, uproot stump and burn the infested plants. Storing of cut stems is not advisable, as it will advance the flight period.



Shot hole borer (*Xylosandrus compactus*)

Attacked plants dry up, extensive tunneling within the branches seen. This is a major pest in robusta coffee affecting the secondary and tertiary branches causing considerable damage. Injury to the coffee plants is primarily by the extensive tunneling within the branches, which limits the flow of sap. The affected branches dry up. The presence of withering and dead branches with shot holes is the symptom of attack.

Control

1. Prune the affected twigs 5-8 cm beyond the shot hole and burn. This operation should commence from September onwards, as soon as the first symptom of attack like dropping of leaves is noticed, and continued as a routine measure at regular intervals.
2. The pest prefers to breed in the suckers during dry period. So remove and destroy all the unwanted / infested suckers during summer.

Mealy bugs (*Planococcus sp.*)

Mealy bugs damage coffee plants by sucking the sap from the tender branches, nodes, leaves, spikes, berries and roots leading to the debilitation of the plant. In case of root infestation, plants (especially young) become weak, leading to death.

Control

The mealy bug can be controlled by spraying any of the following three insecticides viz. Quinalphos, Fenthion or Fenitrothion. In addition to the above method, the biological control agents like *Cryptolaemus montrouzieri* (ladybird beetle) and the parasitoid *Leptomastix dactylopii* have been found effective. Indirect control of the disease can be made by controlling the ants, which spread the infestation.

Green scale (*Coccus viridis*)

The green scale is a serious sucking pest of coffee particularly arabica.

Control

The chemical control measures include spraying the affected patches with any one of the following insecticides viz. Cythion 50 EC @ 200 ml, Quinalphos 25 EC @ 120 ml, Fenitrothion 50 EC @ 100 ml, Fenthion 1000 @ 80 ml, Methyl parathion 50 EC @ 120 ml or Dimethoate 30 EC @ 170 ml. (Source: Central Coffee Research Institute, Balehonnur, Chikmagalur Dt., Karnataka)



Disease Management

Leaf rust (*Hemileia vastatrix*)

This is an important disease causing economic loss particularly in arabica coffee. On the lower surface of the infected leaves, small pale yellowish spots appear early after the first rains in the season. These spots soon increase in size and number, and many such spots coalesce at severity causing premature defoliation. Severe defoliation leads to debilitation of the bushes and results in poor cropping in the succeeding seasons.



Control

Spray susceptible coffee with 0.5% Bordeaux mixture or 0.03% ai Plantvax 20 EC 3-4 times a year: Bordeaux mixture 0.5% in February-March as pre- or post-blossom spray, Plantvax 20 EC 0.03% ai in May-June as pre-monsoon spray, Plantvax 20 EC 0.03% ai or Bordeaux mixture 0.5% in July-August in mid-monsoon spray (if incidence of leaf rust is severe), and Plantvax 20 EC 0.03% ai or Bordeaux mixture 0.5% in September-October as post-monsoon spray.

Black rot (*Koleroga noxia*)

A disease more in occurrence in endemic areas with heavy rainfall, saturated atmosphere with 95-100% RH, thick overhead shade, low over-hanging branches, sheltered from sunlight and wind in valleys or continuous mist during monsoon. The affected bushes have blackening and rotting of leaves, twig and developing berries. There will be defoliation and berry drop in the affected branches. The entire block affected looks totally debilitated with heavy damage to crop.

Control

Centering and handling of the bushes prior to the onset of monsoon and protecting endemic patches with spraying Bordeaux mixture 1%. If incidence is observed during the monsoon, remove the affected twigs and burn them. Spray with Bordeaux mixture 1% during break in the monsoon.

Brown blight, twig blight dieback (*Colletotrichum glosporioides*)

Small water soaked lesions on margins of leaves and slowly extended causing drying of margins with shedding of berries. Prune badly affected plants during dry months, spray 0.5% Bordeaux mixture.

Harvesting

Coffee fruits should be picked as and when they become ripe to get better quality. Arabica comes for harvesting earlier since they take 8-9 months for fruit development from flowering while robusta takes 10-11 months. Picking is done by hand. The first picking consists of selective picking of ripe berries often seen in the outer portion of the node and is called fly picking. Thereafter, there will be 4-6 main pickings at 10-15 days intervals and final harvest. Stripping consists of picking of still remaining green berries on the plant.



Processing of Coffee

Coffee is processed in two ways a) wet processing to prepare plantation or parchment coffee and b) dry method by which cherry coffee is prepared.

I. Preparation of parchment coffee:

1). Pulping

This method requires equipment and adequate supply of clean water. Fruits should be pulped on the same day to avoid fermentation before pulping. Fruits may be fed to the pulper through siphon arrangement to ensure uniform feeding and to separate lights and floats from

sound fruits. The pulped parchment should be sieved to eliminate any unpulped fruits and fruits skin. The skins are separated by pulping should be let away from the vats into collection pits so that microbial decomposition of the skin will not affect the bean quality when it gets mixed up with the bean.

2) Demucilaging and washing

The mucilage on the parchment skin can be removed by

A) Natural fermentation

The mucilage breaks down in the process of fermentation and it takes 24-36 hours for arabica and 72 hours for robusta. Cool weather delays the process of fermentation. Under fermented or over fermented beans affect quality. When correctly fermented the mucilage comes off easily and the parchment does not stick to the hand after washing and the beans feel rough and gritty when squeezed by hand. When the mucilage breakdown is complete, clean water is let in and the parchment washed pebble clean with three to four changes of water.

B) Treatment with alkali

Removal of mucilage by treatment with alkali takes about one hour for arabica and one and a half to two hours for robusta. The beans obtained after pulping are drained off excess water and spread out in the wax uniformly and furrowed with wooden ladles with a long handles. A 10% solution of caustic soda (NaOH) is evenly applied into the furrows using a water can. 10 litres of alkali is sufficient to treat 25-30 forlits (1 forlit = 40 litres) of parchment. The parchment is agitated thoroughly by the ladles so as to make the alkali to come into contact with the parchment and trampled by feet for about half an hour. When the parchment is no longer slimy and makes a rattling noise, clean water is let in and the parchment washed clean with 3 or 4 changes of water.

C) Removal of mucilage by friction

There are machines, which pulp and demucilage the beans in one operation. However, a number of naked and bruised beans may result in the parchment. It is, therefore, necessary to adjust the machines carefully to obtain uniform pulping and demucilaging. Cup-test results have indicated that there is no difference in cup quality coffee processed by different method.

3. Drying

The next stage is drying the parchment in the sun until the moisture content is sufficiently reduced to permit storage of beans till they are dispatched to curing works. Proper drying contributes to the healthy colour of the bean and other quality factors. Under dried parchment turns mouldy and gets bleached storage and subsequent curing operations.

The parchment is spread on clean tiled or concrete drying floor to be dried slowly by spreading to a thickness of about 7 to 10 cm. Stirring and turning over coffee, at least once an hour, is necessary to facilitate uniform drying. The parchment should be heaped up and covered in the evening until next morning. Sun drying may take about 7 to 10 days under bright weather conditions. At the right stage of dryness the parchment becomes crumbly and the beans split clean without a white fracture when bitten between the teeth. Drying is complete when a sample forlit of coffee records the same weight for two days consecutively. At this stage, coffee is shifted to the stores and bagged in clean, new gunnies. When coffee is being a dried, all naked bean, pulper nipped and bruised beans, blacks, greens and other defective beans are sorted out and dispatched to curing works separately.

II. Preparation of cherry

For preparation of cherry coffee fruits should be picked, as and when they ripe. Green and under-ripe should be sorted out and dried separately. The fruits should be spread evenly to a thickness of about 8 cm on clean drying ground in which the cherries are stirred and ridged atleast once every hour. The cherry is dry when a fistful of the drying cherry produces a rattling sound when shaken and a sample forlit records the same weight on two consecutive days. The cherry should be fully dry at the end of 12 to 15 days under bright weather conditions.

1. Coffee was introduced to India by _____
2. Ploidy level of coffee Arabica is _____
3. Scientific name of tree coffee is _____
4. What is elephant bean?
5. Botanically coffee fruit is called as _____

OIL PALM

(*Elaeis guineensis*, Palmae)

The oil palm tree is a tropical plant which commonly grows in warm climates at altitudes of less than 1,600 feet above sea level. The species, *Elaeis oleifera* (H.B.K) Cortes is native of America; and the species *Elaeis guineensis* Jacq. which originated in the Gulf of Guinea in West Africa (hence its scientific name) is better known as the African oil palm.



This tree produces one of the most popular edible oils in the world - a versatile oil of superb nutritional value. It is the most prolific of all oil plants and in commercial terms the one which offers major prospects of development.

Botany

Plant

Oil palm can reach 60-80 ft in height in nature, but is rarely more than 20 or 30 ft in cultivation. Leaf bases are persistent for years, and prominent leaf scars are arranged spirally on the trunk of mature palms where bases have fallen. Leaves are up to 25 ft in length, with leaflets numbering 200-300 per leaf, about 3-4 ft long and 1.5 - 2.0" wide, with entire margins. Leaflets cover the distal 2/3 of the leaf, and the lower 1/3 is spined with spines increasing in length acropetally.

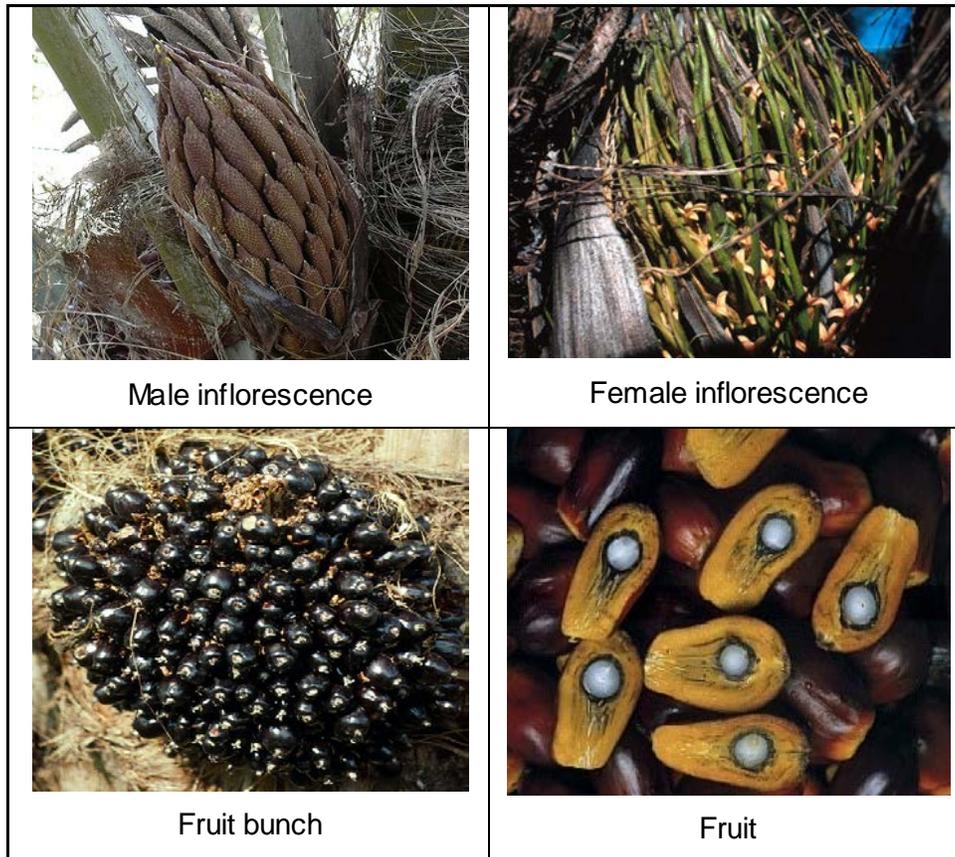
Flowers

Oil palms are monoecious, producing male and female inflorescences in leaf axils. The inflorescence of both sexes is a compound spadix with 100-200 branches, initially enclosed in a spathe or bract that splits 2 weeks prior to anthesis.

Fruit

As in many palms, fruits are drupes. The mesocarp and endocarp vary in thickness, with Dura types having thick endocarps and less mesocarp, and Tenera types the opposite. The exocarp color is green changing to orange at maturity in virescens types, and orange with brown or black cheek colors in the Nigrescens types. Fruit range in size from <1" to 2", and are obovoid in shape. The mesocarp, from which palm oil is derived, is fibrous and oily, and the seed is opaque white, encased in a brown endocarp; palm kernel oil is derived from seeds. The

female inflorescence contains 200-300 fruit, and fruit set is 50-70%. Fruit ripen about 5-6 months after pollination.



Climate and Soil

Oil palm grows best in areas with a mean maximum temperature of 30-32 °C and on an average of at least five hours of sunlight. It can be grown in areas, which receive well-distributed annual rainfall of 200 cm or more. However, it can tolerate two to four months of dry spell.

Soil - wide range of soil types provided good drainage and pH between 4 and 7; tolerates periodic flooding or a high water table; many soils are alluvial in nature. The adult palms can withstand occasional water logging, but frequently waterlogged, extremely sandy and hard lateritic soils should be avoided. Irrigation is generally not practiced.

Varieties

There are three naturally occurring forms of the oil palm fruit, termed *Dura*, *Tenera*, and *Pisifera*. Most cultivars are the *Tenera* form which produces fruit with higher oil content. The only variety recommended for commercial cultivation is *Tenera*, which is a hybrid between *Dura* and *Pisifera*.

Nursery practices

The fruits are separated from the bunch and seeds are extracted by scraping off the exocarp and mesocarp with a knife, or by retting in water. The seeds are then dried by spreading them on concrete or wooden floors under shade for two days. Such seeds can be stored for 3-9 months at about 27 °C without much reduction in viability.

Seeds are soaked in water for five days, changing the water daily. Thereafter, the seeds are spread out to dry for 24 hours. The dried seeds are put in polythene bags and placed in germinator maintained at a temperature of 40 °C. After 80 days, the seeds are removed from polythene bags, soaked in water for 5 days changing the water daily and dried in the shade for two hours. The seeds are then put back into bags and kept in a cool place in order to maintain the moisture content. Germination commences in about 10-12 days. The percentage of germination obtainable by this method is 90-95.

Raising nursery

Polybags (preferably black) of 400-500 gauge measuring 40 x 35 cm are used. The bags are filled with topsoil and compost and are arranged at a spacing of 45 x 45 cm and one sprouted seed is dibbled per bag. A good mulching during summer is desirable.



Watering the seedlings weekly thrice is recommended. A fertilizer mixture containing 15 g N, 15 g P₂O₅ and 6 g K₂O at the rate of 8 g in five litres of water for 100 seedlings may be applied when the seedlings are two month and eight month old.

Planting

Oil palm is planted in the main field in triangular system at spacing of 9 m accommodating 140 palms per ha. Planting is preferably done at the onset of monsoon during

May-June. The polythene bag is torn open and the entire ball of earth is buried in the pit (50 x 50 cm) and levelled.

Leaf pruning

Dead and diseased leaves and all inflorescences should be cut off regularly up to three years after planting. When the palms are yielding, judicious pruning to retain about 40 leaves on the crown is advocated. It is necessary to remove some of the leaves while harvesting. In such cases, care should be taken to avoid over pruning. In addition, all dead and excess leaves should be cut off and crown cleaned at least once in a year, usually during the dry season.

Pollination

Oil palm is a cross-pollinated crop. Assisted pollination is done to ensure fertilization of all female flowers. However, this is not necessary if the pollination weevil *Elaeodobius kamerunicus* is introduced in the plantation. They congregate and multiply on male inflorescence during flower opening. The weevils also visit the female flowers and pollinate them effectively.

Manuring

The following fertilizer schedule is considered satisfactory for oil palm.

N:P ₂ O ₅ :K ₂ O	g/palm/year
First year	400:200:400
Second year	800:400:800
Third year onwards	1200:600:1200

Mg application is necessary only if deficiency symptoms are noticed. Fertilizers are preferably applied in two equal split doses (May and September), within 2 m diameter around the palm and forked in. Supply of sufficient quantities of green leaf or compost is advantageous, especially where the soil is poor in organic matter.

Weed management

The field has to be regularly maintained to allow access for harvesting and palm inspection. The weeded circle should be sufficiently kept clear of vegetation for loose fruit collection. It is also extremely important to reduce direct weed competition in young palms. This can be controlled manually or chemically using herbicide.

Pruning and Training

Old leaves are pruned off to facilitate access to the bunch at harvest. When palms reach heights of 20-30 ft, they become difficult to harvest, and are often injected with an herbicide to kill them or bulldozed down. New trees are planted among the dead and rotting trunks.

Pest management

Rhinoceros beetle

The pest causes severe damage to emerging fronds and spindle. The adult beetle feeds on the softer tissue of the rachis, resulting in snapping off of the fronds and spears at the feeding sites. Field sanitation and elimination of breeding sites are essential components of the pest management operation. This pest can be suppressed by using the virus Baculovirus oryctes.

Red palm weevil

This is a major pest of oil palm in India. These weevils lay their eggs at the cut end of petioles or other wounds. The emerging larvae tunnel into the crown and feed on the growing tissues. Palms infested by red palm weevil start wilting and leaves show gradually increasing chlorosis and fracture in strong winds. If detected early, treatment of affected palm with 0.2% solution of endosulfan or 1% carbaryl would save the palms.

Birds

Many birds such as the forest crow, the house crow and the common Indian myna cause severe damage to oil palm fruit bunches. These birds feed on the mesocarp of the oil palm fruits. The damage can be minimized by scaring the birds and covering the ripe bunch with wire net, 150 days after fruit set.

Disease management

Anthraco nose

This disease occurs in the nursery. It is recognized by regular or irregular brown to black leaf blotches surrounded by yellow haloes, which develop along the margin, centre or tip of the leaves. It causes heavy seedling loss. The disease can be controlled by spraying mancozeb or captan at the rate of 200 g/100 litres of water. Copper fungicides should not be used because of the extreme susceptibility of oil palm seedlings to copper burn (scorching).

Spear rot

This is noticed to affect oil palms of all ages. The incidence is less than one per cent. Yellowing starts from tip of the innermost whorl of leaves. Small lesions occur at the distal portions of spear and rotting extends downwards. As the disease advances, new leaves become rudimentary and show rotting. General decline in vigour and production is then noticed.

Occurrence of spear rot without yellowing has also been noticed. Distinguishable marginal yellowing of leaflets and sudden drying of leaves showing yellowing are other symptoms. Rouging of all the affected palms may be adopted to prevent further spread of the disease. In early stages of the disease, the affected portions of leaves may be removed and burnt.

Bunch failure

Sparse or no fruit set followed by complete drying or rotting of the affected bunches are the typical symptoms. The extent of incidence can be up to 20%. This malady is generally attributed to excess pruning, mutual shading, under pollination, moisture stress and unhygienic conditions. The situation can be improved by assisted pollination as well as by adopting hygienic measures like removal of infected bunches and dry male inflorescence.

Harvesting

As fruit ripen, they change from black (or green in *virescens* types) to orange, but have varying degrees of black cheek color depending on light exposure and cultivar. However, fruit abscission is the best index of bunch ripeness.

First harvest can be taken 3.5 to 4 years after planting. When a few ripe fruits are loose / fall off, the bunch is ready for harvesting. Processing over-ripe fruits reduces quantity and quality of oil.

A chisel is used for harvesting bunches from young palms. The stalk of the bunch is struck hard with the chisel to cut off and push the bunch out. When the palms become taller (from 10 year onwards) a harvesting hook has to be used. When the palms are too tall, it is necessary to climb the palms for harvesting. Each tree must be visited every 10-15 days as bunches ripen throughout the year.

Processing

Oil extraction is a complex process, carried out by large mills that may process up to 60 tons of fruit per hour, or by small scale mills in rural villages that produce only about 1 ton of oil in an 8 hour shift. Oil extraction from fruit follows the same basic steps in either case:

1. Steam sterilization of bunches (inactivates lipase enzymes and kills microorganisms that produce free fatty acids, reducing oil quality)

2. Stripping fruit from bunches

3. Crushing, digestion, and heating of the fruit

4. Oil extraction from macerated fruit (hydraulic pressing)

5. Palm oil clarification

6. Separating fiber from the endocarp

7. Drying, grading, and cracking of the endocarp

8. Separating the endocarp from the kernel
9. Kernel drying and packing

The product of step 5 is termed crude palm oil, which must be refined to remove pigments, free fatty acids, and phospholipids, and to deodorize it. The final product, termed "refined, bleached, deodorized" palm oil is produced.

Dietary value, per 100 gram edible portion

	Oil palm fruit	Palm oil
Water (%)	26	0.5
Calories	540	878
Protein (%)	1.9	0
Fat (%)	58.4	99.1
Carbohydrates (%)	12.5	0.4
Crude Fiber (%)	3.2	0
	% of US RDA*	
Vitamin A	3.5	2.3
Thiamin, B1	13.3	2.0
Riboflavin, B2	5.6	Trace
Niacin	7.0	---
Vitamin C	26.7	---
Calcium	10.3	0.9
Phosphorus	5.9	1.0
Iron	45	55
Sodium	2.4	---
Potassium	5.3	---

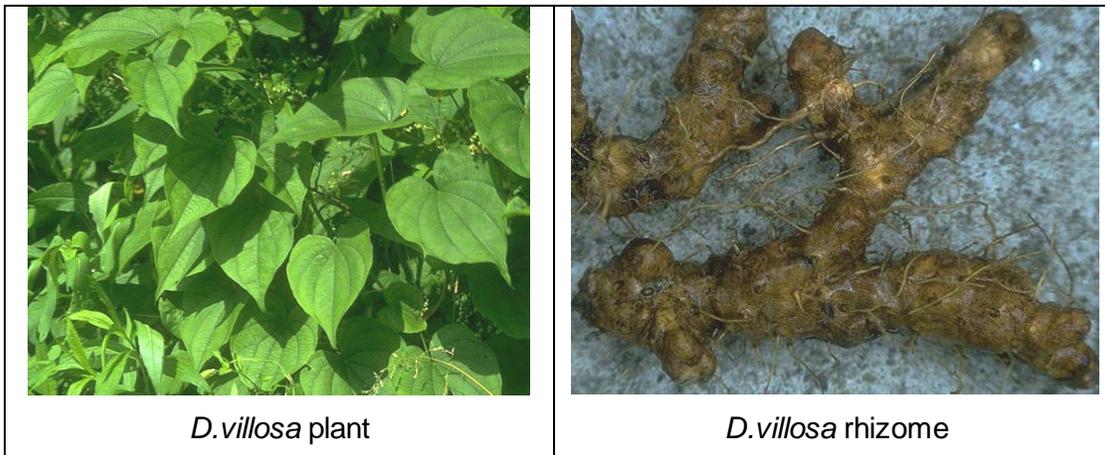
1. Pollination of oil palm is aided by _____
2. Botanical name of oil palm is _____
3. Propagation materials for oil palm is _____
4. Type of seed in oil palm is _____
5. Fruit is botanically called as _____

MEDICINAL YAM

(*Dioscorea sp.*, Dioscoreaceae)

Diosgenin, obtained from *Dioscorea* tubers, is the major base chemical for several steroid hormones including sex hormones, cortisone, and other corticosteroids and is the active ingredient in the oral contraceptive pill. The growing need for steroidal drugs and the high cost of obtaining them from animal sources led to a widespread search for plant sources of steroidal sapogenins; which ultimately led to the identification of the genus *Dioscorea* as the most promising one.

This genus *Dioscorea* belonging to family Dioscoreaceae with over 600 species is widely distributed in tropical world. Some of the species like *D.alata* and *D.esculenta* are under cultivation for long time for their edible tubers. There are about 15 species of this genus containing diosgenin. Among this, *D.floribunda*, *D.villosa*, *D.composita* etc. are widely grown for diosgenin production.



The major *Dioscorea* producing countries are Mexico, Guatemala, Costa Rica, India and China. The estimated world consumption of diosgenin is somewhere between 800 to 1000 tonnes per year. India produces only 25 tonnes of diosgenin annually mainly from the natural source and to be self sufficient, India has to step up its production to the tune of about 200 tonnes of Diosgenin per year. The cultivation hints for *D. floribunda* is discussed here.

The best adapted species in Karnataka, Assam, Meghalaya, Tamil Nadu, Goa, & Andaman is *D.floribunda*, an introduction from Mexico. It produces compact tubers at a shallow depth. The diosgenin content varies from 2 to 7 per cent depending on the age of the tubers.

Climate and soil

It is a tropical species preferring a tropical climate without extremity in temperature. It is adapted to moderate to heavy rainfall areas. Dioscorea plants can be grown in a wide variety of soils, but light soil is good as harvesting of tubers is easier in such soils. Extremely heavy clay soils are, in general not recommended, as they restrict tuber growth and make harvesting difficult. Dioscorea tolerates fairly wide variation in soil pH, though very acid soils should be avoided, the ideal soil pH being 5.5 to 6.5.

Varieties

The Indian Institute of Horticultural Research, Bangalore has released so far two improved varieties.

1. FB(c)-I: This is a composite strain of *D. floribunda*, which has been released for commercial cultivation. This is a vigorous growing strain relatively free from diseases: This has a diosgenin content of 3 to 3.5 per cent. It is suitable for cultivation around Bangalore and Coorg (Karnataka), Goa, Assam, Maghalaya, Tamilnadu, Maharashtra and Andaman.

2. Arka Upkar: This is a high yielding clone released recently. The plants are very vigorous with a stout, robust vine, bearing broad dark green leaves: The tuber branches are thick, broad and deep. It has a higher diosgenin content of 3.5 to 4.0 per cent.

Propagation

Dioscorea floribunda can be propagated by tuber pieces, single node stem cuttings or seed. Commercial planting is normally established by tuber pieces only. Propagation through seed progeny is variable and it may take longer time to obtain tuber yields.

Propagation from tuber pieces is accomplished by cutting the tubers into pieces weighing about 50-70 g each. Three types of tuber pieces can be distinguished for propagation purpose. viz (1) Crown, (2) Median and (3) Tip. Crowns produce new shoots within 30 days after planting, since they have preformed buds. Medians and tips may take up to 100 days to sprout. Crowns are therefore preferred for commercial planting. However, if there is a shortage of material, median and tip portions can be used for planting. Dipping of tuber pieces for 5 minutes in 0.3% solution of Benlate followed by dusting the cut ends with 0.3% Benlate in talcum powder before planting or storage in moist sand beds effectively checks the tuber rot. This treatment is very essential for obtaining uniform stand of the crop. The best time for planting is by the end of April so that the new sprouts will grow vigorously during the rainy season commencing in June in India.

For rapid multiplication of the elite materials in the initial stages, single leaf node cuttings can be adopted. The cutting consists of a single leaf with petiole and about 0.8 cm of the stem.

Such cuttings are prepared from non-flowering plants. They are pre treated with 500ppm of IBA solution by quick dipping and are planted in the mist chamber in sand beds. Within 8-10 weeks, these cuttings are transferred to plastic bags containing equal mixtures of sand, soil and farm yard manure. They will be ready for transplanting in the main field in six months time. This method is not recommended for commercial planting as the growth is very slow but useful to initially multiply the elite materials in larger number.

For raising a crop from seed, fresh seed should be sown in 8 cm x 12 cm plastic bags in the month of February. Polythene bags may be filled up with a pot mixture containing equal parts of sand, soil and farm yard manure. Vermiculite should be used on the top. Atleast two well filled seeds may be sown in each plastic bag at a depth of 0.5 to 1.0 cm. The nursery may be protected from drying by light shade. The bags may be watered with care, lightly and frequently. The germination process completes within four weeks. The seedlings being a vine, it should be supported promptly with thin twigs.

The best season for transplanting the/seedlings in the fields is June-July. Vigorous seedlings may be alone transplanted and others may be discarded. The bottom and sides of bag may be cut before transplanting so as to transplant the seedlings without disturbing the root system. As the progenies raised from seeds are highly variable and their growth is slow, this method is not recommended for commercial plantations.

Planting

Land should be prepared thoroughly till a fine tilth is obtained. Deep furrows should be made at 60 cm distance with plough. The stored tuber pieces are ready for planting, seedlings or single node stem cuttings should be planted in furrows with 30 cm between the plants for one year crop and 45 cm for two year crop. The tuber pieces are planted at about 0.5 cm below the soil level. The new sprouts should be staked immediately. After sprouting is complete, the plants could be earthed up. Soil from the ridges may be used for earthing up so that the original furrows will become ridges and vice verse.

After care

Dioscorea vines need support for their optimum growth and hence the vines are trained over pandal system or trellis.

Weeding

Initially, the vines are weak and tender and can not compete efficiently with the surrounding weeds. Periodic hand weeding, as and when necessary, is essential for the first few months. Experience has shown that once the plants have climbed up on the pandal, the weed populations considerably reduced due to shading. The plants by this stage can also compete

more successfully with weeds.

Manures and Fertilizers

D.floribunda requires high organic matter for good tuber formation. Besides a basal dose of 18 to 20 tonnes of per ha, a complete fertilizer dose of 300 Kg nitrogen, 150 Kg phosphorous and 150 Kg of potassium should be applied per hectare. Phosphorous and potassium should be applied in two equal doses one after the establishment of the crop during May-June and the other during vigorous growth period of the crop (August- September).

Irrigation

Irrigation may be given at weekly intervals in the initial stage and afterwards at about 10 day's interval. However during rainy season no irrigation is needed. In Anamalais, it is raised under pure rainfed conditions.

Interopping

Intercropping with legumes like cowpea, horse gram, duster bean and French bean has been found to smother weeds and also provide an extra income without adversely affecting the tuber yield and diosgenin content.

Duration

The diosgenin content tends to increase with age (2.5 to 3.0 per cent during the first year and 3.0 to 3.5 percent in the second year) and also the tuber yield and hence a two year crop is found to be more economical.

Harvesting

The tubers grow to about 25 to 30 cm depth and hence harvesting is done by manual labour. The best season for harvesting is Feb- March, coinciding with the dry period. On an average 50 to 60 tonnes of fresh tubers can be obtained from one hectare in two years duration.

Plant Protection

The major pests of *Dioscorea* are the aphids and Red spider mites. Aphids occur more commonly on young seedlings and vines. They feed on the young leaves and stem. Young leaves and vine tips eventually die if aphids are not controlled. Older growth is seldom affected. Red spider mites attack the underside of the leaves at the base near the petiole. Severe infestations result in necrotic areas, which are often attacked by fungi. Both aphids and spider mites can be very easily controlled by 0.5 a.i. Kelthane. No serious disease is reported to infect this crop.

Production Technology of Spices, Aromatic, Medicinal Plant Crops

1. Alkaloid content present in medicinal yam is _____
2. Which species of Dioscorea contain higher amount of Diosgenin?
3. Example of a variety in Medicinal yam.
4. Propagation of medicinal yam is _____
5. Economic part of medicinal yam _____

SARPAGANDHA

(*Rauvolfia serpentina*, Apocynaceae)

Rauvolfia root or Serpentine root is one of the important crude drugs used in modern medicine. Its leaves are simple, 7.5 -10 cm long and 3.5 -5 cm broad. Root is prominent, tuberous, usually branched, 0.5 to 2.6 cm diameter, goes 40 to 60 cm deep into soil. The root bark, which constitutes 40-60% of the whole root, is rich in alkaloids known for their efficacy in reducing high blood pressure and as a sedative or tranquilizing agent. The fresh



roots emit a characteristic acrid aroma and are very bitter in taste. The roots possess high alkaloid concentration. Reserpine is the compound / active principle used for hypertension as a life saving drug in allopathic system of medicine. Roots are mainly collected from forests.

Habitat

It is an erect under shrubs (woody herb) and occasionally in scrub jungles and forest clearings growing for a height of 60-90 cm growing wild in North East region up to an altitude of 500 m.

Soil and Climate

The plant grows in a wide variety of soils, from sandy alluvial loam to red lateritic loam with large percentage of humus and acidic in reaction. The ideal pH for this crop is from 4.6 – 6.5. It prefers hot humid climate, humus rich sandy loam soil. A climate with a temperature range of 10 – 30°C seems to be well suited for this plant. The areas with high rainfall and properly drained soil are best.

Variety

(i) Local collection from wild

(ii) Jawahar Lal Neheru Krishi Viswa Vidyalaya has developed one improved variety-R.S-1. The seed viability remains upto 50-60 % after 7 months of storage and yield about 2.5 t/dry roots/ha. In this variety the alkaloid content has been found 1.64 – 2.94 % at 18 months growth.

Propagation

Rauvolfia can be propagated by seed and also by vegetative means like root cutting, root stumps, and stem cutting. Seed propagation is best method for commercial plantation. A healthy mother stock should be raised before hand for collection of seeds.

A) Seed propagation

Seed germination is highly variable. Germination of heavy seeds during April-June after soaking them in water for 24 hours is about 20-40 % while freshly collected heavy seeds germination is highest (up to 60 %). April-May is found to be suitable for sowing seeds in nursery. The nursery is prepared by raised beds mixing with one-third of well matured FYM and leaf mould two-third- amount medium silt-loam soil under partial shade.

Seeds are sown 2-3 cm apart in rows in shallow furrows by April. The furrows are then covered with a fine mixture of soil and FYM. The bed should be kept moist by light watering. Germination starts after 15-20 days and continues up to 40-50 days. The nursery should be kept moist throughout the germination period. Seedlings are ready by mid June- July for transplantation. Seedlings may be raised in poly bags also. About 6 kg seed sown during April-May in a 500-m² bed will be sufficient for one-hectare area.

B) By stem cutting

As collection of seeds is both laborious and costly, vegetative propagation by root or shoot cuttings has been advocated for raising plantation to collect the seeds, as well as to quickly multiply the genetically superior clones. Hard wooded stem cutting measuring 15-20 cm are loosely planted during June in the nursery beds where continuous moisture is maintained. After sprouting and giving out roots, these plants are transplanted in the main field at given spacing. Nearly 75-95 % success is obtained if treated with rooting hormone β - indole acetic acid @ 30 ppm for 12 hours. Treated cuttings root within 15 days.

C) By root cutting

Large taproots with a few filiform lateral secondary rootlets are used. They are cut at 2.5-5 cm in length and planted on moist sand bed. Root cuttings of about 0.25 cm diameter planted in March-June give about 80 % or more success in about 1-1.5 months time. About 100 kg of root cuttings are required to plant 1 ha.

D) By root-stump

This is prepared by cutting about 5 cm root with a portion of the stem above the collar and gives about 90-95 % success. Such plants are transplanted in May-July. Limitation is only one plant can be raised from a single stump.

However, a best result for commercial cultivation is obtained from seed propagation only. To establish initial mother stock the above methods may be used.

Planting

Transplanting the nursery grown seedlings of 40-50 days old which have 4-6 leaves (10-12 cm tall, naked rooted or in poly bags), are planted at spacing of 30 x 30 cm is optimum. Seedlings are carefully dugout and the taproot is cut. They are then dipped in a 0.1 % solution of fungicide before planting to protect them against soil borne fungus causing damping off disease. Sarpagandha takes a long duration (18 months onwards) as it is slow growing crop particularly in the initial stage. About 80,000 – 1, 00,000 number of seedlings are required/ha as a sole crop.

Manures and fertilizers

FYM @ 20-25 MT/ha should be applied during land preparation. After planting N,P & K at the rate 10:60:30 kg/ha is applied as basal dose. Later two equal doses of N each of 10 kg /ha in moist soil may be applied at 50 days and 170 days after planting.

Irrigation

Rauvolfia is cultivated as a rainfed crop. However, if available, 4 irrigations in summer and 2 in winter at one month interval may be applied for higher yield.

Inter cropping

It is possible to grow inter crop in Rauvolfia plantation, like patchouli in the first year particularly where good irrigation facilities are available. Since Rauvolfia is shade loving it can be planted as intercrop in orchards or some other plantation crops.

Weeding

Weeding, cleaning, and hoeing twice during rains and after rains.

Defloration

Flowering and fruiting starts from 6 months onward after transplanting which is irrelevant, unless there is need to collect sufficient seeds for sale or for mass multiplication. If the plant is allowed to flower and bear fruits, these markedly depress both shoot and root growth, because a significant amount of photosynthates is utilized for the production of flowers and fruits by the plants. Therefore, defloration is recommended for better root growth and yield. For seed collection an area may ear marked.

Pests and Diseases

Insect pests

1. Root knots appear as galls caused by nematode causes stunted growth, etiolation and decrease in the leaf size are the symptoms in the aerial portion. Application of 25 kg of 3 G

Carbofuran or 20 of 10 G Phorate granules /ha will control them. *Tagetes* may be intercropped as trap crop against nematode.

2. A pyralid caterpillar (*Glyphodes vertumnalis*) cause appreciable damage to the leaves. Some other caterpillars roll the leaf and feed on the green matter of tender leaves causing defoliation. They can be controlled by spraying 0.2 % Rogor.

3. Cockchafer grubs (*Anomala polita*) attack the seedlings about 2 cm below the hypocotyls, resulting in their drying up. To control the attack of grubs, mix phorate granules with the soil at the time of nursery preparation.

Diseases

1. Leaf spot caused by *Cercospora rauvolfiae* manifests as dark-brown coloured spots on the upper surface of the leaf and yellowish – brown on the lower surface. The affected leaves turn yellow, become dry, and subsequently fall off, resulting in defoliation. To control this Dithane M-45 @ 0.2% is to be sprayed before the monsoon and repeated at monthly intervals until November.

2. *Alternaria tenuis* attacks the leaves, resulting in minute, brownish or dark coloured circular spots with a yellowish margin on the ventral side of the leaves. The fungus also affects the flowers and fruits. The crop should be sprayed with 30 g Blitox in 10 litre water, whenever the symptoms are seen.

Collection of seeds

For collection of seeds, plants in small portion of plantation are allowed to flower and bear fruits.

The fruits start maturing from middle of July and continue till February. Mature seeds bear a purplish black fleshy covering. Since all the seeds do not mature at a time, these are picked periodically, otherwise ripe seeds drop off. After the collection, fleshy covering should be removed by washing the



seeds in water. After washing, the seeds are dried in shade and are stored in airtight containers.

Harvesting & processing

The marketable roots are generally collected 2-3 years after plantation preferably after 30 months of planting. When transplanting is done during June-July harvesting period coincides with shedding of leaves during early autumn. At this stage root contains maximum concentration of total alkaloids. During harvest the roots may be found to go up to 40 cm deep in the soil. During root harvesting the thin roots are also collected. Care should be taken to keep the root

bark intact as the bark constitutes 40-56 % of the whole root and has a higher alkaloid content. In general during winter months plants remain dormant, is considered ideal for harvesting.

Application of a light irrigation if possible will make digging easier. After digging, the roots are cleaned, washed and cut into 12-15 cm pieces for drying and storage. The dry root possesses up to 10-12 % moisture. The dried roots are stored in polythene lined gunny bags in cool dry place to protect them from mould.

Yield

Though Rauwolfia can be propagated by various methods; maximum yield of root is obtained when the propagation is done by seeds that varies from 0.1 to 0.4 kg per plant.. The average yield of Rauwolfia dry root is approximately 2000-2500 kg/ha under average management when harvested at 30 months.

1. Botanical name of sarpagantha _____
2. Economic part of sarpagantha _____
3. Alkaloid content present in sarpagantha _____
4. Propagation of sarpagantha is through _____
5. Alkaloid in sarpagantha has _____ properties

OPIUM

(*Papaver somniferum* L., Papaveraceae)

The opium poppy *Papaver somniferum* is an outstanding medicinal plant, the products of which viz opium and codeine are important medicines used for their analgesic and hypnotic effects. A semi-synthetic derivative of this drug from morphine known as heroin has led to world-wide social problems. But attempts to find a synthetic drug which would replace morphine and codeine have not



been fruitful so far. Its cultivation in India is confined to states of Madhya Pradesh, Rajasthan and Uttar Pradesh.

Papaver somniferum is an erect, rarely branched, glaucous annual, growing to a height of 60 to 120 cm. The leaves are ovate, oblong or linear oblong; flowers are large usually bluish with a purplish base or white, purple or variegated. It produces capsular type of fruits from which the latex known as opium is obtained on lancing. The fruits are about 2.5 cm in diameter, globose in shape. Seeds are reniform with white or black in colour. Though nearly all parts of the poppy plant contain a white milky latex, the unripe capsules contain large amount.

Climate and Soil

It is a crop of temperate climate but can be grown successfully during winter in subtropical regions. Cool climate favours higher yield, while higher day/night temperature generally affects the yield. Frosty or desiccating temperature, cloudy or rainy weather tends to reduce not only the quantity but also the quality of opium.

Opium poppy prefers a well drained, highly fertile light black or loam soil with an optimum pH around 7.0.

Varieties

The most popular varieties grown in the country remain in the field from 140 to 160 days. The following are some of the important varieties of which Talia, Ranghatak and Dhola Chota Gothia are popular varieties recommended for heavy black soils.

(i) Talia

It is sown early and it remains in the field for 140 days. Its flowers are pink and have large petals. The capsule is oblong, ovate, light-green and shiny (waxy).

(ii) Ranghatak

It is a medium-tall variety, maturing for lancing in 125-130 days after sowing. It bears white and light-pink flowers. It produces medium-sized capsules (7.6 cm x 5.0 cm), which are slightly flattened on the top. It yields opium of a comparatively thin consistency that change to a dark-brown colour on exposure.

(iii) Dhola Chota Gotia

It is a dwarf cultivar (85-90 cm), bearing pure white flowers and light green capsules which are oblong-ovate in shape. It is ready for lancing after 105-115 days of sowing and matures for seed in 140 days.

(iv) MOP-3

This variety has been developed at the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Mandsaur, recently. It bears pinkish-white flowers comprising of large non-serrated petals. Its capsules are ready for lancing 120 days after sowing and the variety is recommended where adequate irrigation facilities exist in the later part of the season.

(v) MOP-16

This is another promising selection made at the Jawaharlal Nehru Krishi Vishwa Vidyalay, Mandsaur. The plant bears *white* flowers with serrated petals and round, flat-topped capsules. This is comparatively drought tolerant and is ready for lancing 105-110 days after sowing. It is recommended where an early maturing crop is preferred.

(vi) Shama

This variety was released by the CIMAp, Lucknow during the year 1983. The main alkaloids like Morphine (14.51-16.75%), Codeine (2.05-3/24%), Thebaine (1.84-2.16%), Papaverine (0.82%) and Narcotine (5.89-6.32%) in this variety are reported to be on higher side than the existing commercially cultivated variety. It yields 39.5 kg of *latex* and 8.8 kg/ha of seeds.

(vii) Shweta

This variety was also released by the CIMAp, Lucknow, along with Shama. However, it is reported to be superior to Shama in the content of the main alkaloids-morphine (15.75-22.38%), codeine (2.15-2.76%), thebaine (2.04-2.5%), papaverine (0.94-1.1%) and Narcotine (5.94-6.5%). It gives an average yield of 42.5 kg of latex and 7.8 kg/ha of seeds.

(viii) BROP 1 (Botanical Research Opium Poppy-I) (NBRI-3)

It is a *synthetic* variety developed at the National Botanical Research Institute, Lucknow, by crossing selections from Kali Dandi, Suyapankhi and Safaid Dandi. This variety is highly adaptable to varied agroclimatic conditions and gives a higher yield than national checks. It is moderately resistant to diseases. It yields about 54 kg/ha of opium and 10-13 q/ha of seeds. The morphine content is 13% and above pose a problem, since they remain wet during the rains and are too difficult to cultivate in the dry period.

(ix) Kirtiman (NOP-4)

It was developed at the Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, through selection from local races. The variety is moderately resistant to downy mildew. It yields 35-45 kg/ha of latex and 9-10 q/ha of seeds. The morphine content is up to 12%.

(x) Chetak (U.O.285)

This variety was developed at the Rajasthan Agriculture University, Udaipur. It is moderately resistant to diseases. The opium yield is up to 54 kg/ha and the seed-yield is 10-12 q/ha and contains up to 12% morphine.

In general, the crop needs long cold season (20°C) with adequate sunshine in the early season for a healthy vegetative growth; heavy rains after sowing cause loss in seed germination. Warm, dry weather with a temperature of 30-35°C is required during the reproductive period. Cloudy weather, frost, hailstorms and high gusty winds, particularly during lancing, causes immense damage to the growing crop. Dry, warm weather conditions in February-March favour a good flow of latex and results in higher yields.

(xii) Jawahar Aphim 16 (JA-16)

It is a pureline selection of 10 Callandraces developed at the Jawaharlal Nehru Krishi Vishwa Vidyalay College of Agriculture, Mandsaur (Madhya Pradesh). It is moderately resistant to downy mildew. It gives 45-54 kg/ha of latex, 8-10 q/ha of seeds and contains up to 12% morphine.

Recently, another three varieties: 'NBRI-3' of opium, 'Sujatha' an opium-free poppy for the production of oil and seed and 'Shubhra' for high morphine and seed yield have been released from the NBRI, Lucknow, RRL, Jammu and CIMAP, Lucknow.

Preparation of land

The field should be ploughed 3 or 4 times to produce well pulverised soil. The field is then prepared into beds of convenient size.

Sowing

The seed is either sown broadcast or in lines. Before sowing, the seeds may be treated

with fungicides like Dithane M.45 @ 4 g per Kg of seeds. Seed is usually mixed with fine sand before broadcasting to ensure uniform spread in the bed. Line sowing is preferred to broadcasting as the latter method has many drawbacks like higher seed rate, poor crop stand and difficulty in carrying out inter cultural operations. The best time for sowing is late October or early November. Seed rate is 7-8 Kg/ha for broadcast method and 4-5 Kg/ha for line sowing. A spacing of 30 cm between lines and 30 cm between plants is normally adopted.



After cultivation

Germination takes five to ten days depending upon the moisture content of the soil. Thinning is an important cultural practice to ensure uniform plant growth and better development. This is normally done when the plants are 5-6 cm high, having 3-4 leaves. Thinning is continued until the plants are about 14 to 15 cm height within a period of 3-4 weeks after sowing.

Manures and manuring

Opium poppy responds remarkably to the application of manures and fertilizers which increase both the yield and quality of opium.

Farm yard manure @ 20-30 t/ha is generally applied by broadcasting while the field is prepared for sowing. Besides, 60- 80 Kg of N and 40-50 Kg of P₂O₅ per hectare is recommended. No potash is applied. Half of N and entire P are applied at sowing time through placement and remaining half of N placed at rosette stage.

Irrigation

A careful irrigation management schedule is essential to get a good crop of poppy. A light irrigation is given immediately after sowing followed by another light irrigation after 7 days when the seeds start germinating. Three irrigations at an interval of 12-15 days are given till pre flowering stage and then irrigation frequency is reduced at 8-10 days during flowering and capsule formation stage. Normally, 12-15 irrigations are given during the entire crop period. Any moisture stress during the stage of fruiting and latex extracting may reduce the yield considerably.

Lancing and latex collection

Opium starts flowering in 95-115 days after sowing. The petals start shedding after 3-4 days of flowering. The capsules mature after 15-20 days of flowering.



Lancing of the capsules exudes maximum latex at this stage. This stage can be visually judged by the compactness and a change in the colour from greenish to light green coloured ring in the capsule. The stage is called as industrial maturity.

Lancing may be done with a knife having three or four equispaced pointed ends which does not penetrate more than 1-2 mm in the capsule. Too deep or too shallow incision is not advisable. Lancing may be done early in the morning before 8.00 a.m. at two days interval in each capsule. The length of the incision should be 1/3 or less than the full length of capsule.

Harvesting and threshing

The crop is left for drying for about 20-25 days when the last lancing on the capsules stops exudation of latex. The capsules are then picked up and the plant is removed with sickles. Harvested capsules are dried in open yard and seeds are collected by beating with a wooden rod.



The yield of raw opium varies from 50 to 60 kg/ha.

1. Family of opium poppy is _____
2. Morphine is obtained from _____
3. Opium is extracted from which plant part _____
4. Give two varieties of opium poppy
5. Harvesting of opium poppy is called as _____

OCIMUM

Plant Profile

Family	: Lamiaceae: Labiatae
English name	: Sacred Basi, Holy Basil
Indian name	: Ajaka, Manjari (Sanskrit), Tulsi (Hindi), Thulasi (Tamil)
Species and	: <i>Ocimum sanctum</i> Linn
Varieties	: Sri Tulsi, Krishna Tulsi
Distribution	: India, Andaman and Nicobar Islands
Uses	: Culinary purposes, Drugs, Flavoring Insecticide, Perfumery.

The 'Sacred basil' or 'Holy basil', *Ocimum sanctum* Linn. ($2n=32$) a biennial or triennial shrub belonging to the family *Lamiaceae*, is commonly cultivated in gardens: it is frequently found as an escape. The species is worshipped by the Hindus of India and traditionally grown in courtyards and temples. The leaves of this basil, on steam-distillation, yield a bright yellow, volatile oil possessing a pleasant odour characteristic of the plant, with an appreciable note of cloves.



The plant contains mainly phenols, aldehydes, tannins, saponin and fats. The essential oil components are eugenol (about 71%), eugenol methyl ether (20%), nerol, caryophyllene, selinene, α -pinene, β -pinene, camphor, cineole, linalool and carvacrol (3%). A terpenoid saponin acid possessing anticancer properties has also been isolated. The seeds of this plant give a greenish-yellow fixed oil and also contain **antistaphylocoagulase** which can be extracted with water and alcohol.

The plant is also used as a pot herb: its leaves are used as a condiment in salads, and other dishes. The leaves, seed and root are medicinally useful. The leaves also contain ascorbic acid (82 mg/100 g) and carotene (2.5 mg/100 g). The juice of the leaves possesses diaphoretic, antiperiodic, stimulating, expectorant and antipyretic properties: it is used in catarrh and bronchitis, applied to the skin in ringworm and other cutaneous diseases and as drops to relieve earache. An infusion of the leaves is used as a stomachic in gastric disorders of children. If

taken internally, it strengthens the liver and heart and is a good appetizer. It cures amenorrhea and promotes the secretion of milk in lactating women. The leaves, if chewed, give relief from toothache. The leaf-juice is applied to reduce inflammations. A decoction of the root is given as a diaphoretic in malarial fevers. The dried and powdered root, if taken twice daily for seven days, cures spermatorrhoea.

The seeds are mucilaginous and demulcent and are given in disorders of the genitor-urinary system. The seeds rubbed in water are given for irritation coughs, gonorrhoea, labour pains and dysentery. The seeds rubbed with cow's milk are given for vomiting and diarrhea. The juice of the fresh leaves, flower-tops and the slender roots are considered to be good antidotes for snakebite and scorpion sting. Tribes (Sandals) use the plant in cholera, cough postnatal complaints, hemorrhagic septicemia and dog bite. The volatile oil is reported to possess antibacterial and insecticidal properties. It inhibits the in vitro growth of *Mycobacterium tuberculosis* and *Micrococcus pyrogenes* var. *aureus*. It has marked insecticidal activity against mosquitoes.

Origin and Distribution

O. Sanctum has wide distributions, covering the entire Indian subcontinent, ascending up to 1,800 m in the Himalayas and as far as the Andaman and Nicobar Islands. This plant-occupies a wide range of habitats.

Description of the Plant

It is an erect, herbaceous, much-branched softly hairy, biennial or triennial plant, 30-75 cm high. The leaves are elliptic-oblong, acute or obtuse, entire or serrate, pubescent on both sides, minutely gland dotted. The flowers are purplish or crimson, in racemes, close-whorled. The nutlets are subglobose or broadly ellipsoid, slightly compressed, nearly smooth, pale-brown or reddish with small, black markings.



Types and Varieties

In India, two types of *O.sanctum* are under cultivation: the green type (Sri Tulsi) is the most common, the second type (Krishna Tulsi) bears purple leaves and is preferred in the trade for its higher potency of the drug.

Green Type



Purple type



Soil

It thrives well on a variety of soils. Rich loam to poor laterite, saline and alkaline to moderately acidic soils are all well suited for its cultivation. Well-drained soils aid in better vegetative growth. Water-logged conditions can cause root-rot and result in stunted growth.

Climate

The plant can be grown under partially shaded conditions but it yields less oil. It flourishes well under fairly high rainfall and humid conditions. Long days and high temperatures have been found favourable for the plant growth and oil production. Tropical and subtropical climate (at altitudes up to 900 m) are suited for its cultivation. The plant is moderately tolerant to drought and frost.

Season

The nursery can be raised in the third week of February and transplanting is generally started in the middle of April. This can be undertaken in the month of March, if the seedlings are raised in beds.

Land Preparation

The land is brought to a fine tilth and laid out into plots of convenient sizes for irrigation. It is preferable to add 15t/ha of FYM during the preparation of the land.

Cultivation

Propagation

The plant is propagated by seeds. The seeds are likely to deteriorate in future generations on account of the highly cross-pollinated nature of the crop. Hence, for fresh plantings, the growers have to take fresh seeds from the pedigree stock.

Nursery raising

Raised seed-beds of 15'x4'x9' size should be thoroughly prepared, by the addition on FYM. About 200-300 g seeds are enough to raise seedlings for planting one hectare of land. The seeds should be sown 2 cm deep in the nursery beds. After sowing the seeds in the nursery, a mixture of FYM and soil is thinly spread over the seeds and irrigated with a sprinkler hose. The seeds germinate in 8-12 days and the seedlings are ready for transplanting in about 6 weeks time, at the 4-5 leaf stage. A spray of 2% urea solution on the nursery plants 15 to 20 days before transplanting helps in raising very healthy plants for transplanting.

Transplanting

It is recommended to plant the seedlings at a distance of 40 cmx40 cm, 40 cmx50 cm and 50 cmx30 cm to get high herbage and oil-yield per hectare at Lucknow, New Delhi and Indore, respectively. The plots are irrigated immediately after transplanting. The seedlings will establish well by the time of the second irrigation. At the stage gap planting and replacement of the poor plants is done so that a uniform stand is achieved.

Field View



Fertilizer Application

The application of 120 kg/ha each of P_2O_5 and K_2O is recommended for saline and alkaline soils at Lucknow. The optimum fertilizer dose recommended for this crop is 120 kg N

and 60 kg P₂O₅/ha. Half the dose of N and the entire dose of P₂O₅ are given as a basal dose. Whereas, the remaining N is applied in two split doses, after the first and second cuttings. The application of the micronutrients Co and Mn at 50 and 100 ppm concentrations, respectively, is reported to increase the oil-yield significantly.

Irrigation

Irrigation depends upon the moisture content of the soil. In summer, 3 irrigations per month are necessary whereas, during the remaining period, it should be done as and when required, except in the rainy season when no irrigation is necessary. Altogether, about 12-15 irrigations years are sufficient.

Weeding

The first weeding is done one month after planting, and the second 4 weeks after the first. After this, no further weeding is required as the plants become bushy, thereby naturally suppressing the weeds.

Interculture

One hoeing, two months after planting, is sufficient. The crop may also be earthed-up at this stage.

Diseases and Pests

The plant is susceptible to powdery mildew caused by *Oidium* spp., seedling blight caused by *Rhizoctonia solani* and roor-rot caused by *Rhizoctonia bataticola*. Powdery mildew can be controlled by spraying wet table sulphur (4 g/l of water), and the latter two diseases are managed by improved phytosanitary measures and by drenching the nursery-beds with a solution of mercurial fungicide.

Among the insects, the larvae of leaf-rollers sticking to the under surface of the leaves fold them backwards lengthwise, thus webbing them. Malathion (0.2%) may be sprayed to control this insect.

Harvesting and Yield

The crop is harvested when it is in full bloom. The first harvest is obtained 90-95 days after planting. Afterwards, it may be harvested at every 65-75 days, intervals. Harvesting should be done on bright, sunny days in order to obtain good quality oil-yield. It is not desirable to harvest the crop if it has rained the previous day.

The crop should be cut 15-20 cm above ground-level. The harvested produce may be allowed to wilt in the field itself for 4-5 hours, to reduce the moisture content and the bulkiness.

About 5 t/ha of fresh herbage can be obtained twice or thrice a year.

Distillation of Oil

The harvested produce is usually distilled in its fresh form. However, the oil quality and yield do not diminish up to 6-8 hours after harvest, but any further delay may cause considerable loss in yield and quality of oil. Steam-distillation is found to be superior to water distillation. The whole herb contains 0.1 to 0.23% essential oil. The yield of oil varies with the type, season and place of origin. The oil-yield will be approximately 10-23 kg/ha.

1. What are the major constituents in ocimum oils?
2. Genus ocimum contains _____ species
3. Genus ocimum can be broadly divided into 2 groups _____
4. What is the oil recovery percentage in ocimum sp.
5. Seed rate for ocimum sp is _____

PERIWINKLE

Periwinkle (*Catharanthus roseus* (L) G. Don), belonging to the family Apocynaceae, is one of the few medicinal plants which has found mention in the folks medicinal literature as early as 2nd BC. The plant has been widely used as an abortifient, purgative, antidiabetic, diuretic, hemorrhagic antimalarial, antidysentric and against skin diseases by the ancient people.



Modern investigation have shown that periwinkle contains more than 100 alkaloids distributed through all the parts of the plant like ajmalicine (raubasin), serpentine and reserpine which are well known for their hypotensive and antispasmodic properties Periwinkle gained further importance after the isolation of vincrisine and vinblastine alkaloids which have importance in cancer, therapy. Vincristine sulphate is being marketed under the trade name ONCOVIN, which is used against acute leukemia, and vinblastine sulphate as VELNR to cure Hodgkin's disease and other lymphomas and **chonocarcinomas**. In addition to the above, the alkaloids leurosidine, leurosovine and rovidine also possess anticancer properties, but they are not used clinically.

Origin and Distribution

The plant is a native of Madagascar and from there it has spread to India, Indonesia, Indo-China, Philippines, South Africa, Israel, USA and other parts of the world. In India, it is being grown in Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat and Assam in an area of about 3000 ha. Farmers prefer it because of its wide adaptability and its ability to grow on marginal lands and drought-tolerance that rules out crop failure. The presence of alkaloids all over the plant body confers immunity to cattle browsing and the crop loss due to pilferage.

USA is the world's largest user of this plant's raw material. A single firm which has the patent to manufacture Vinblastine and Vincristine sulphate have been consuming more than 100 t of leaves of the plant annually. Most of it has been imported from Malagasy and the

remaining from India and Mozambique. Hungary is also been one of the major consumer of its leaves followed by West Germany, Italy, Netherlands (raubasin), serpentine, etc. The total demand for these countries is more than 100 t of roots annually.

Soil

The crop is quite hardy and grows well on a wide variety of soils, except those which are alkaline or water-logged. Deep sandy loam to loam soils of medium fertility are preferred for its large-scale cultivation. Because, in this soil there is not only a better development of roots, but it is also easy to take them out at harvest time.

Climate

The distribution of the plant shows that there is no specificity in its climatic requirements. It comes up well in tropical and subtropical areas. However, the growth in tropical areas is better than in the subtropical areas, where its growth is slow due to the low temperatures in winter. It can be successfully grown up to an elevation of 1300 m above sea level. A well distributed rainfall of 100 cm or more is ideal for raising this crop on a commercial scale under rainfed conditions.

Manures and Fertilizers

In areas where FYM is available, it is applied at the rate of 10-15 t/ha to obtain good growth and yield from periwinkle plants. If irrigation is available it is recommended to grow leguminous crops like sun hemp or horse gram and when they reach the flowering stage bury them inside the soil before sowing or transplanting periwinkle. Green manure will act as a substitute for FYM and is useful in the areas where it is either difficult to procure or it is very expensive. The seeds of the green manure crop should preferably be treated with bacterial inoculants prior to sowing, to increase the development of root nodules which absorb atmospheric nitrogen and fix it in the soil. In case organic manure is not applied, it is advisable to apply a basal dose of 25 kg N, 50 kg P₂O₅ and 75 kg K₂O per hectare per year.

Irrigation

In places where rainfall is distributed throughout the year, the plants do not require any irrigation. However, in areas where rainfall is restricted to a few months in a particular period approximately 4-5 irrigation will help the plants

Weed Control

This crop requires two weedings in the initial stages of its growth. The first weeding may be done about 60 days of sowing and the second at 120 days at again. Mulching the paid with cut grass or rice-straw will also minimize the weed growth.

Application of the chemical weedicide Sinhar at 4-5 kg/ha as a pre-emergent spray is highly effective against oil mount weeds similarly, the application of a mixture of 2-4-D and Grammaxone at the rate of 25 kg/ha to the soil before sowing keeps the weeds under control.

Insect Pests and Diseases

The plant is sufficiently hardy and practically free from the attack of insect pests and diseases. However, the oleander hawk moth is reported on this crop. Occasionally, some plants have been found to suffer from the little leaf disease, due to infection by mycoplasma resulting in stunted growth and resetting of the leaves of the plant. The disease can be effectively checked by uprooting and destroying the affected plants.

Recently, another disease 'dieback' or twig blight or top rot caused by *Pythium butleri*, *Phytophthora nicotianae*, *P.debaryanum*, *Alternaria tenuissima* and *Colletotrichum demothum* has been found to affect the crop during the monsoon in some parts of the country. The disease can be controlled by spraying Dithane Z-78 at an interval of 10-15 days. The other fungal diseases reported on this crop are Fusarium wilt caused by *Fusarium solani* and *Sclerotium rolfsi* blight caused by *Phthium aphanidermatum* as well as leaf-sport caused by *Myrathesium raridum*. *A. tenuissima*, *A. oltemata*, *Rhizoctonia solani*, *Ophiobolus catharanthicala*, *Hoplosporella marahwadenis* and *Glomerella cingulata*.

Harvesting

i) Roots

The crops are harvested after 12 months of sowing. The plants are cut about 7.5 cm above the ground level and dried for the stems leaves and seeds. The field is then copiously irrigated and when a reaches the proper condition for digging, it is ploughed and the root are collector. The roots are later washed well and dried in the shade.

ii) Leaves, Stem and Seeds

If there is a demand for leaves, two leaf stripping, the first after 6 months and the second after 9 months of sowing – can be taken. A third leaf stripping is also obtained when whole plant is harvested. After the plant is harvested it is dried in the shade. Its second nodes dehisce and release the seeds with a light threshing which can be used for the next sowing. The leaves and stems are also collected



separately. It may be mentioned here; that the seeds collected in this way will have poor germination because they have been collected from pods in different degrees of maturity. Therefore, in order to obtain good seeds it is advisable to collect them from mature pods two to three months before the harvest of the crop. The aerial part of the plant between 7.5 cm and about 25 cm above the ground level is taken as the stem for the purpose of marketing.

The total alkaloid content in the leaf varies from 0.15 to 1.34%, of which the average content of vinblastine is 0.002%, while that of vincristine is 0.005%.

Yield

Under irrigated conditions, about 4 t/ha of leaves, 1.5 t/ha of stem, and 1.5 t/ha of roots on an air-dried basis may be obtained. Whereas, under rainfed conditions, about 2 t/ha of leaves and 0.75 t/ha each of stem and roots on an air-dried basis may be obtained.

1. Anti cancerous principles present in periwinkle _____
2. Periwinkle belongs to the family _____
3. Vincristine sulphate is being marketing under the trade name of _____
4. Medicinal use of periwinkle is _____
5. Hypotensive alkaloid present in periwinkle is _____

ALOE VERA

Aloe species, perennial succulents belonging to the family *Liaceae*, are the source of the drug aloe. Of the 275 species, there are three commercially important species which are the main sources of the drug. They are: *A. barbadensis*, Mill. ($2n = 14$), (*A. vera* Linn) which yields Curacao aloe or Indian aloe or Jaffarabad aloe or Barbados aloe, which is produced in the West Indies (Curacao, Aruba, Bonaire)



and *A. ferox* and its hybrids which yield Cape aloe, produced in South Africa and *A. perryi* which yields the socotrine aloe. Other aloe species (*A. africana* and *A. spicata*) yield aloes of lesser importance.

Aloe is obtained by cutting the leaves at their base and letting the yellow, bitter juice drain out. The water is evaporated off from the juice by heat, and the resulting light to dark-brown mass is the drug aloe. Of the two major products derived from the leaves, the yellow, bitter juice present in specialized cells beneath the thick epidermis yields the drug aloe and the parenchymatous tissue in the centre of the leaf contains a mucilaginous gel which yields aloe gel or aloe vera gel; it is currently obtained from *A. barbadensis*.

Aloe contains cathartic anthraglycosides as its active principles; these are mostly C-glucosides, notably barbaloin, which is a glucoside of aloe emodin. The concentrations of these glucosides vary with the types of aloe ranging from 4.5 to 25% of aloin. Other constituents present include aloesin and its aglycone aloesone (a chromone), free anthraquinones (e.g. aloe-emodin) and resins.

Aloe vera gel contains a glucomannan which is a polysaccharide similar to guar and locust bean-gums and is believed to be the active constituent. Other constituents reported, or otherwise claimed to be present, include other polysaccharides (containing galactose, xylose and arabinose), steroids, organic acids, enzymes, antibiotic principles, amino acids, biogenic stimulators, wound-healing hormones, saponins, minerals, and so forth.

Fresh aloe gel is well known for its domestic medicinal value. For this reason, *Aloe vera* is also called burn, first-aid or medicine plant. When freshly obtained, the gel has the property of relieving thermal burns and sunburn, as well as promoting wound healing; it also has

moisturizing and emollient properties. The plant is used as a home remedy for these purposes. The only officially recognized use of aloe is its beneficial effect on the skin.

Aloe and aloin are extensively used as active ingredients in laxative preparations, often with other cathartics such as buckthorn, cascara and senna; belladonna extracts are often included to lessen griping. Aloin is also used in anti-obesity preparations. Aloe gel and sometimes the drug aloe are used as moisturizer, emollient or wound-healer in various cosmetic and pharmaceutical formulations. Extracts of aloe or aloin are used in sunscreens, X-ray / burns, dermatitis, cutaneous leishmaniasis and other cosmetic preparations. As a food, aloe extracts are used as a flavouring ingredient primarily in alcoholic and nonalcoholic beverages and in candy to impart a bitter note.

Origin and Distribution

Plants of the genus *Aloe* belong to the old world and are indigenous to Eastern and Southern Africa, the Canary Islands and Spain. The species spread to the Mediterranean basin and reached the West Indies, India, China and other countries in the 16th century; and certain species are now cultivated for commercial purposes, especially in some of the West Indian islands of the north coast of South America. It is also cultivated throughout India.

Description of the Plant

Species and Varieties

Soil

Aloe is a hardy plant and grows on a variety of soils. It does well in the sandy coastal to loamy soils of the plains with a pH of up to 8.5. However, water-logged conditions and problematic soils do not suit its cultivation.

Climate

Aloe is usually cultivated between March and June. The plant has a wide adaptability and can be seen growing throughout the length and breadth of the country. It is found growing in warm, humid or dry climate with even 150-200 cm to about 35-40 cm of yearly rainfall during the growing period. However, in dry regions, the crop should be provided with protective irrigation.

Land Preparation

Before cultivation, the land should be ploughed twice and the field should be cleaned thoroughly of weeds. If required, small canals may be prepared for drainage. About 25 t/ha of cow dung manure is also added.

Cultivation

Propagation

The plants are generally propagated by root-suckers or rhizome cuttings.

Planting

The plants are planted at a spacing of 60 x 30 cm or 60 x 45 cm. About 15-18 cm-long root-suckers or rhizome-cuttings are planted in such a way that two-thirds portion of the root-sucker or rhizome cutting should be under the ground.



Root suckers



Manuring

It is a newly domesticated crop and its full production technology including manurial requirement is yet to be worked out. An *ad hoc* basis application of a mixture of 150 kg/ha of nitrogen (N), potassium (K) and phosphorus (P) is recommended. The fertilizers are applied in the soil near the root-system, after the plants are established. 30 kg of N and 120kg gypsum is recommended for Tamil Nadu.

Irrigation

Soon after planting, the land should be irrigated. During the crop period, irrigation must be provided according to the moisture content of the soil. Generally, 4 to 5 irrigations per year are sufficient. However, water should not be allowed to stagnate near the plant.

Weeding

Weeding may be done twice a year and the land should be kept weed-free.

Pests and Diseases

Normally, the plant is not affected by any pests or diseases of a serious nature. But recently, the leaf-spot disease caused by *Alternaria alternata* and *Fusarium solani* has been reported from India.

Harvesting and Yield

The plants are harvested eight months after planting. While harvesting, the plants can be removed manually or with the help of a tractor-drawn disc harrow or cultivator. The broken rhizome part left in the soil throws out new sprouts in spring for raising the succeeding crop. An aloe plantation gives a commercial yield from the second year up to the age of five years, after which it needs replanting.

The yield of the crop on a fresh-weight basis will be around 10,000-12,000 kg/ha.

1. *Aloe vera* belongs to the family _____
2. Edible wax coating of fruits is obtained from _____
3. Propagule of *Aloe vera* is _____
4. Active principle of *Aloe vera*?
5. Aloin having -----properties

GUGGAL

Commiphora wightii (Arn.) Bhandari syn. *Commiphora mukul*

Family – Burseraceae

It is a shrub or small tree reaching upto 3 to 4 m. high. Leaves sessile, alternate, 1-3 foliate. Plants are dimorphic, Flowers small in fascicles. Fruits are ovoid, drupe.

Regional Names

English	Indian Bedellium
Bengali	Guggul
Gujarati	Indian Gugguru
Hindi	Guggulu, Guggal
Malayalam	Gulgulu, Guggalu
Marathi	Guggala
Kannada	Guggal
Tamil	Maishakshi, Gukkal
Telugu	Guggal



Distribution: Found in Karnataka, Rajasthan, Deccan and Gujarat.

Part Used: Olio gum resin

Properties & Uses

The gum is bitter, acrid, astringent, thermogenic, aromatic, expectorant, digestive, anthelmintic, anti-inflammatory, anodyne, antiseptic, nervine tonic, aphrodisiac, alterative, stimulant, liver tonic, antispasmodic, emmenagogue, haemostatic, diuretic, rejuvenating, general tonic, and is useful in gout, scrofula, sciatica, facial paralysis diplegia, cough, asthma, bronchitis, pectoral and hepatic, disorders, otorrhoea, epilepsy, fever, stangury, hemorrhoids, dysmenorrhoea, amenorrhoea, wounds and ulcers, cardiac disorders, coronary thrombosis, anemia, stomatopathy, pharyngopathy, spermatorrhoea, diabetes, skin diseases etc.

Cultivation & Propagation

Soil and Climate

It can be cultivated in sandy to silt-loam or rocky soils, poor in inorganic matter but rich in several other minerals. The growth is vigorous in the soils, which have moisture-retaining capacity.

Nursery Raising and Planting

The plants are best raised from stem cuttings of semi-wood (old) branch. Woody stem of one meter in length and 110mm thickness is selected and the cut end is planted in a well-manure nursery bed during June-July. The bed should be given light irrigation periodically. The cuttings initiate sprouting in 10-15 days and grow into green sprout in next 10-12 months. These rooted plants are suitable for planting in the field during next rainy season. The cuttings give 80-94 % sprouting.

Seed germination is very poor (5%) but seedlings produce healthier plants, which withstand high velocity wind.

Thinning and Weeding

The plantation does not require much weeding and hoeing. But soil around the bushes should be pulverised twice in a year to increase the growth.

Manure/Fertilizer

Application of 5 kg FYM per plant per year is sufficient.

Irrigation

Requires moderate irrigation. Even limited irrigation during summer, enhances the rate of growth.

Harvesting/Post Harvesting Operation

Plants attain normal height and girth after 8-10 years of growth when they are ready for tapping of the gum by shallow incision on the bark between December and March.

Chemical Constituents

Guggulsterol, Myricyl alcohol, cembrene etc.

Active Constituents

Gum resin shows different pharmacological properties and clinical applications: Astringent, expectorant, aphrodisiac, demulcent, carminative, alterative, antispasmodic, emmenagogue, to enrich blood, against snake bite and scorpion sting. Anti fertility effect. Plant has use in Arthritis also.

Yield

Approximately 500-800 g gums are obtained per plant.

Substitutes/Adulterants

Guggal is often adulterated with the ologum resin of *Boswellia serrata* or sometimes with resin of *pinus* sp. However *Boswellia* gum can be identified with its whitish colour and



powdery appearance externally. Pinus resin is stickier and is generally in the form of paste at normal temperature.

1. Scientific name of guggal is _____
2. Guggal belongs to the family _____
3. Economic part of guggal _____
4. Chemical constituent of guggal _____
5. Common adulterant used in guggal is _____

BELLADONNA

(*Atropa belladonna* L.) Family: Solanaceae

Belladonna (*Atropa belladonna* C.B. Clarke.) belongs to the family Solanaceae. Atrops is commonly called as 'Deadly nighShade'. The commercial drug is obtained from the leaves, flowering tops and roots of *A.belladonna*. Leaves and roots of belladonna contain tropane alkaloids whose concentration varies from 0.13 to 0.70 per cent (average 0.45%). Belladonna leaves are widely used for the manufacture of tinctures and plasters. The drug serves as an anodyne, sedative, stimulant, antidiuretic, antiasthmatic, antispasmodic, anti-inflammatory. It is also used in the treatment of renal and biliary colic, stomach disorders and to stop sweating. The roots are primarily used in the external treatment of gout, rheumatism and other affiliations.



Soil

Belladonna grows well in deep fertile soils of medium texture, which are rich in humus. Heavy clay soils which are water-logged should be avoided to cultivate this crop.

Climate

It is a temperate crop. It behaves as a perennial in temperate climates and gives maximum herbage and alkaloid yield. In sub-tropical areas, it can be grown as a winter crop. However, the plant behaves as an annual as it dies during the summer months and hence the yield is poor.

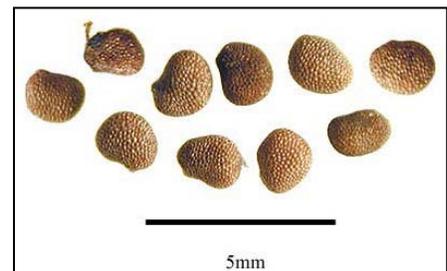
Varieties

There are no named varieties in this crop.

Cultivation

Propagation

The crop is propagated through seeds extracted from berries collected usually from September-November. Seeds may be treated with 80 per cent sulphuric acid at the time of sowing for 2 minutes to improve the germination.



Nursery raising

It can be cultivated by direct sowing, but raising nursery gives best results. The nursery may be raised from the second week of May to the end of autumn (September to October) under sufficient shade. The land should be ploughed well so as to give a fine tilth. Raised beds of size 3m x 1m surrounded by drainage and irrigation channels to be made and apply well decomposed FYM to the soil. Seeds pretreated with fungicides like Dithane M-45 or Agallol (10 g per kg of seeds) may be mixed with fine soil (1:4 ratios) and broadcasting in the nursery beds. Cover the seed beds with a layer of FYM and then with straw. Watering of beds should be done immediately after sowing with a rose can.

The seeds germinate in 3 weeks time. Seedlings will be ready for planting in the field when they attain a height of 15-20 cm after 8-12 weeks.

Transplanting

The ideal time for planting in the field is March-April or October-November. Before planting, the seedlings are treated with fungicide like Agallol. Seedlings are planted at a spacing of 50-60 cm in rows kept 60-70 cm apart. It is always safer to plant the seedlings on raised beds with 1 m wide strips or ridges as it avoids water logging and facilitates irrigation. The field may be irrigated immediately after transplanting.

Harvesting, Processing and Yield

The first harvest of the leaves is available three month after planting. Harvesting should be done as soon as the plants start flowering, as it is the period when alkaloid content is higher. The leaves are cut with the help of pruning scissors.

Leaves are dried immediately after the harvest under shade or sun or artificial heat with or without fans for air circulation. Leaves should be turned over frequently while drying.

The roots are also harvested after 3 years. After the harvest, they are washed, cut into 4 inches length, split length wise if thick and shade or sun dried.

During the first year an average of 1000 kg of dry herb is obtained. The yield increases to 1500 kg per hectare during 2nd and 3rd year. The yield of dry roots will vary from 170 to 335 kg per hectare.

1. Atropin is obtained from _____
2. Belaclona belongs to the family _____
3. Economic part of Beladona is _____
4. Beladona is a _____ crop
5. Tropane alkaloids have medicinal properties of _____

NUX VOMICA

Botanical Name: *Strychnos nux-vomica* Linn.

Family: Strychnaceae (Loganiaceae)

Common Names: Nux-vomica, Poison Nut, Snake-wood, Strychnine Tree, Quaker Buttons, Yetti (Tamil), Kanjiram (Malayalm)



Therapeutic uses

Its dried seeds or beans, and sometimes its bark (called *nux vomica*) are used in herbal remedies. The seeds contain organic substances, strychnine and brucine, that are used in herbal remedies. Dried seeds of kuchila are nervine, stomachic, and cardio-tonic, aphrodisiac, and respiratory stimulant. It is used as a remedy in chronic dysentery, paralytic and neuralgic disorders, epilepsy, rheumatic arthritis, and hydrophobia. In excessive doses, *Strychnos* is a virulent poison, producing stiffness of muscles and convulsions, ultimately leading to death. It is an important drug in all systems of medicine.

Morphological characteristics

Strychnos species is a medium-sized, deciduous tree, with fairly straight and cylindrical bole and dark-grey or yellowish-grey bark with minute tubercles. The nux vomica grows as tall as 49.2 ft (15 m). The nux vomica has roundish, opposite leaves and attractive white flowers. Leaves are simple, opposite, orbicular to ovate, 6–12 cm long and 6–10 cm broad, coriaceous, glabrous, and five-nerved.

Floral characteristics

Flowers of kuchila are white or greenish white and fragrant. They occur in many flowered terminal cymes. Calyx is five lobed, pubescent, and small, about 2 mm in size, while corolla is salver shaped and has five lobes. Corolla tube is cylindrical, greenish white inside and slightly hairy near the base. Stamens are five in number and have short filaments. The roughly spherical fruits of the nux vomica are large hard-rinded berries that contain three to eight round, flattened, grayish seeds. These seeds are covered with silky hairs, are known as strychnine nuts, and are hard and extremely bitter in taste. The seeds of the nux vomica contain several alkaloids that are useful for some purposes, particularly strychnine, and to a lesser extent brucine. Fruit is an indehiscent berry, 5–6 cm in diameter, thick shelled, orange-red when ripe with fleshy pulp. Seeds are discoid, compressed, and coin like, concave on one side and convex on the other, and covered with fine grey silky hairs. Flowering occurs from March to May and fruits mature up to December.

Distribution

Strychnos nux-vomica is the name of an evergreen tree native to south East Asia, especially India and Myanmar, and cultivated elsewhere. The range of the nux vomica in cultivation extends from Sri Lanka, southern China, southeast Asia, and northern Australia. The species is indigenous to India and is distributed in moist deciduous forests throughout the tropical India



Climate and soil

The plant can grow well in dry or humid tropical areas of the country. It grows over laterite, sandy, and alluvial soil

Propagation material

Seeds are the best material for propagation of kuchila plant. The collected seeds are dried in the sun after removing the pulp. Preferably, fresh seeds should be used. The plant can also be propagated through cuttings.

Nursery technique

Raising propagules

A nursery of the plant is raised in December or January in climatic conditions of South India. Seeds are sown in polybags of size 25 cm × 20 cm, filled with soil, sand, and FYM (farmyard manure) mixture. Seeds are directly sown in the polybags after appropriate pretreatment. The polybags are watered regularly so as to keep them moist. The seeds germinate in about 20–30 days. Sometimes the germination may continue up to 45 days. The seedling growth is very slow but roots grow very fast. For vegetative propagation, semi-hardwood cuttings can be prepared in early summer and kept under moist conditions after

treating with commercially available rooting hormones. Rooting percentage is quite low, often less than 25%.

Propagule rate and pretreatment

About 1 kg seeds are required to raise 1 hectare of plantation. Seeds have low germination rate and fresh seeds of *Strychnos nux-vomica* lose viability early. Germination can be increased by treating the seeds with hot water (50 °C) for 6–12 hours prior to sowing.

Planting in the field

Land preparation and fertilizer application

The land is ploughed with disc harrow and tillers to achieve a fine tilth and make it weed-free and arable. Pits of size 45 cm × 45 cm × 45 cm are dug at a spacing of 5 m × 5 m and refilled with mixture of soil and manure in 1:1 ratio. Appropriate quantities of sand may be added if the soil is heavy. About 10 kg of well-rotten FYM is applied in each pit at the time of its refilling.



Transplanting and optimum spacing

In South India, the seedlings are transplanted with the onset of South-west monsoon in May or early June. An optimum spacing of 5 m × 5 m is recommended, which gives a stand of 400 trees per hectare. *P Intercropping system* The plant can be grown as a pure crop or herbaceous crops can be grown with it as intercrops after the first year.

Interculture and maintenance practices

About 10 kg of well-rotten FYM is mixed in the soil during refilling of pits before planting. Additional 10 kg manure may again be applied to the soil around the plants during October–November at the time of weeding. A total of 20 kg FYM/plant/year in subsequent years results in best growth of plants. This is to be applied in two split doses in June–July and September–October. Supplementary doses of inorganic fertilizers (NPK [nitrogen, phosphorus, and potassium]) do not lead to any significant additional growth in the young plantations. The area around the basin of the plant should be kept weed-free by frequent weeding. The interspaces can be kept weed-free by hand weeding or spraying of herbicides like 0.8% paraquat or 0.4% Glyphosate.

Irrigation practices

The crop needs no irrigation during the rainy season and in dry weather; saplings may be irrigated on alternate days, especially in the early years of growth. For matured trees,

irrigation by ring method around tree base at a distance of 30 cm during summer months is beneficial.

Disease and pest control

No significant pest or disease is observed on the crop.

Harvest management

Crop maturity and harvesting

The tree has a long span of life, that is, 50–60 years. It takes about 15–20 years for the tree to initiate flowering. The seeds are collected December onwards when they mature. Fruits can be harvested periodically for many years.

Post-harvest management

Mature fruits are manually collected and seeds from them are extracted, washed, dried in shade, and stored for trade.

Chemical constituents

Strychnine and brucine are two most important and toxic alkaloids present in the seeds (0.4% and 0.6%, respectively). Other parts of tree have varying percentages of these two alkaloids— 1.7% and 2.8% in root bark, 0.3% and 0.4% in root-wood, 0.9% and 2.1% in stem-bark, 0.5% and 0.01% in stem-wood, and 0.2% and 0.5% in leaves, respectively.

Yield and cost of cultivation

Considering a crop stand of 400 plants per hectare and average produce range of 50–75 kg of dry seeds per tree per year, a yield of 12–20 tonnes/hectare is estimated from a 20-yearold plantation annually. The estimated cost of raising 1 hectare plantation in the first year is Rs. 100 000 only, while an amount of approximately Rs. 6500 per hectare is incurred per year in subsequent years.

Use

In herbal medicine, *Strychnos nux-vomica* is recommended for liver cancer, upset stomach, vomiting, abdominal pain, constipation, intestinal irritation, hangovers, heartburn, insomnia, certain heart diseases, circulatory problems, eye diseases, depression, migraine headaches, nervous conditions, problems related to menopause, and respiratory diseases in the elderly. What does it involve?

The seeds of the *Strychnos nux-vomica* tree are removed from the ripened berries of the tree and dried in the sun. Sometimes they are heated or further processed, which may reduce the amount of poison in the seeds. Various herbal preparations are made from the dried seeds, including tablets, liquid extracts, and tinctures.

Production Technology of Spices, Aromatic, Medicinal Plant Crops

1. Nux vomica belongs to the family _____
2. Alkaloid present in Nux vomica is _____
3. Nux vomica can be used against _____
4. Economic part of nux vomica _____
5. Botanical name of nux vomica is _____

MEDICINAL SOLANUM

(*Solanum khasianum* (Clarke), Solanaceae)

Among the various plants which are being used as raw materials for the production of steroidal drugs, steroid-bearing solanum holds an important place due to its quick growth and low initial investment in its commercial cultivation. It yields a glyco-alkaloid, solasodine, a nitrogen analogue of diosgenine. Solasodine through 16-dehydro-pregnenolone (16 DPA) is converted to a group of compounds like testosterone and methyl testosterone and corticosteroids like prednisolone and hydrocortisone. These steroidal compounds have anti-inflammatory, anabolic and antifertility properties, due to which they find large-scale use in health and family planning programmes all over the world.

Distribution

It is widely distributed in the subcontinent, extending from sea-level up to 2 000 m and is reported from Khasi, Jaintia and the Naga Hills of Assam and Manipur. It occurs in Sikkim, West Bengal, Orissa, the Upper Gangetic Plains and in the Nilgiris, ascending to an altitude of 1 600 m. It is reported from North-east, North-west, southern as well as Central India, and extends into Burma and China. Its commercial cultivation is mainly confined to the Akola-Jalgaon tract of Maharashtra in an area of about 3 000 ha.

Description of the Plant

Solanum khasianum synonym(s): *Solanum viarum* Dunal ($2n = 24$), belonging to the family *Solanaceae*, is a stout, branched, woody shrub attaining a height of 0.75 to 1.5 m. The stem has spines, the leaves are ovate to lobed with spines on both the surfaces, the flowers are hermaphrodite, borne on axillary clusters, white; the berries are yellowish when ripe or greenish; the seeds are small, brown in colour and abundant, embedded in a sticky mucilage.



Varieties

Some of the promising, less spiny strains developed in this crop are the Galxo strain, BARC Strain, Pusa-1, RRL 20-2 and RRL-G, L-6 which is said to be completely spineless. 'Arka Sanjeevini' and 'Arka Mahima' are the two diploid and tetraploid varieties of this crop developed at the Indian Institute of Horticultural Research, Hessarghatta, Bangalore and released for cultivation.

Soil

Solanum is a hardy plant and can be cultivated on a wide range of soils under various agro climatic conditions, but it cannot withstand water-logging. Though it can be grown in all types of soils, the best soil for its successful cultivation is red lateritic soil with a moderate quantity of organic matter. The plant does not perform well in very clayey soils. It is sown in lines of 1 to 1.5 cm-deep furrows, 10 cm apart and covered with a thin layer of soil. About 1.25 kg seeds sown in 5 nursery beds of the above size will provide enough seedlings for planting 1 ha of land. Their germination is completed in 7-10 days. Within 4-5 weeks, when the seedlings are 10-12 cm high and develop 6 leaves, they are ready for transplanting into the main field.

Climate

It is found growing under different kinds of climates throughout the length and breadth of the country, but prefers a moderate climate for its successful growth. The growth as well as development of the plants and finally, the yield of fruits depends significantly on the climatic conditions. Depending upon the temperate, dry period length, rainfall and irrigation facilities, the sowing time may vary from June to September or October. The plants sown in late October to February are more susceptible to virus diseases, and sowing in March is not practicable as harvesting and drying will be hindered by the rainy season. Under rainfed conditions, the crop should be sown from mid-June to the first week of July. Under irrigated conditions, the sowing in September results in profuse flowering and berry formation during the winter months.

Manures and Fertilizers

Solanum viarum responds well to the application of manures and fertilizers. Green manuring before planting has been found to increase the yield by 20%. For better yields, an application of 100:60: 40 kg of N, P and K /ha, depending upon the soil condition, is recommended. The entire quantity of phosphorus, potassium and half of the nitrogen are applied at the time of land preparation. While the remaining half of the nitrogen is applied when the plants start flowering. A fertilizer dose of 65: 40: 40 kg of N, P and K has been recommended under Bangalore conditions.

Land Preparation and Planting

In the absence of sufficient moisture in the soil, the field should be immediately irrigated after transplanting. The crop is further irrigated at weekly intervals during the first month and then the interval is increased to once in fortnight, and later as and when required. Well before the time of transplanting, the field is thoroughly prepared about 25 t/ha FYM is incorporated into the soil, it is divided into blocks of convenient sizes, and ridges are opened at a distance of 60 cm.

At the time of transplanting, the seedlings uprooted from the beds are thoroughly cleaned of soil and dipped in 0.1 % Bavistin solution for at least 5 minutes to overcome the wilt problem and, thereafter, transplanted at a distance of 45 cm within the row. Spacing of 50 x 50 cm, 75 x 75 cm and 90 x 120 cm are also recommended for this crop for different locations.

Interculture

After 2-3 weeks of transplanting the first weeding is done, and later when the crop is 2-3 months old. Afterwards, the crop puts on enough canopy to smother the surface and, hence, no growth of weeds takes place.

Pests and Diseases

Insect Pests

The plant is sufficiently hardy and, therefore, free from any of the serious pests. However, it is sometimes attacked by leaf-eating caterpillars and wingless hoppers. In case of severe attack, the crop may be sprayed with Endosulphan (3 ml/l) to control them. The fruit borer (*Leucinodes orbonalis*) and root-eating grubs are the other pests reported. Ekalux (2 ml/l) can be sprayed to control the fruit borer. Chloropyriphos may used to control grubs.

Diseases

1. Powdery mildew will be noticed during prolonged dry and warm period, Bavistin (1 g/l) may be sprayed to control this disease.
2. Collar rot or *Fusarium* wilt can be overcome by keeping the field clean and planting the crop in a well drained soil. Dipping the roots of the seedlings in a 0.1 % solution of Bavistin for 1 hour and drenching the seed-beds with 0.25% of copper oxychloride or 0.1 % of Bavistin solution can control the disease.
3. Sometimes the plants are attacked by mosaic, caused by three different viruses, which leads to stunted growth and chlorotic leaves. Such plants are better removed and destroyed.
4. Bacterial blight is not a serious disease on this crop. However, under severe incidence, a treatment with the solution of 30 g of Streptocyclin and 30 g of Copper sulphate dissolved in 500 l of water per hectare controls this disease.

5. Leaf-blight is caused by *Pythium butleri* and is not a serious problem in this crop.

Seedlings may also be attacked by damping-off disease while growing in the nursery-beds. To control this, the seeds are treated with Bavistin @ 3g /kg of seeds. Drenching the seed-beds 2-3 days after sowing and again when 50% of the seeds have germinated, with 0.1% of Bavistin or 0.25% of copper oxychloride solution, helps to check the further spread of the disease.

6. The occurrence of the chlorotic stunt disease and its association with the root-knot nematode (*Meloidogyne javanica*), and the wilting of plants due to *M. incognita* have also been reported.

Harvesting and Processing of the Berries

Generally, the accumulation of glyco-alkaloid increases with the physiological age of the fruit and attains its peak value in the fruits of 50-60 days. This state of fruit growth coincides with the change in fruit colour from green to just yellow with streaks of green still present, after which the glyco-alkaloid content falls gradually with the maturity of fruits. The alkaloid is distributed throughout the fruit. It is, however, established that about 60% of this is present in, the seeds and the remaining 40% in the pericarp.



The crop takes about 6 months to be ready for harvesting. Harvesting is one of the labour-intensive operations in the cultivation of *S. viarum*. The spiny nature of the plant hampers plucking the berries at the right stage of maturity, which is very important. During the first part of the harvesting season, when the fruit is big, on an average, one person with gloves can pluck about 50 kg of berries, while working 8 hours a day. However, some good workers in the peak season when most of the berries are ready for harvest can pick even 80 kg of berries per day. The figure is reduced to 40 kg towards the closing season when the fruits become smaller in size. The picking operation spreads over 3 months, because the fruits mature at different times. The processing of berries for marketing requires a lot of care. Fresh fruits contain about 80% moisture. The pharmaceutical firms need berries containing about 10% moisture. Hence, the berries must be dried in the sun.

Yield

When the crop is grown by adopting proper cultivation practices, it may yield nearly 10,000 kg/ha of fresh berries which, in turn, will give about 2 500 kg/ha of dried berries.

1. Scientific name of medicinal solanum is _____
2. Steroidal raw material obtained from _____
3. Salosoidin used in the manufacture of _____
4. Origin of medicinal solanum _____
5. Variety of medicinal solanum _____

AONLA

(*Embllica officinalis* Gaertn., Syn. *Phyllanthus emblica*, Euphorbiaceae)

A small to medium sized deciduous tree, 8-18m in height with crooked trunk and spreading branches. Leaves simple, sub sessile; flower greenish yellow; fruit nearly spherical pale yellow with 6 vertical furrows.

Regional Names

English	Indian Gooseberry
Bengali	Amlaki
Gujarati	Ambala, Amala
Hindi	Amla, Aonla
Malayalam	Nelhi
Marathi	Avala
Kannada	Amalaka, Nelhi
Tamil	Nelhi
Telugu	Usirikai, Usirika



Distribution

Wild or planted throughout the deciduous forests of tropical India and on hill slopes up to 1800M.

Part used

Fruit, seed, leaves, root, bark and flowers.

Medicinal properties and uses

Amla is an antioxidant with the free radical scavenging properties, which may be due to the presence of high levels of super oxide dismutase. It is effective in the treatment of peptic ulcer, dyspepsia, diabetes etc. The fruits exhibit hypolipidaemic and antiathero-sclerotic effects in rabbits and rats. Further reported are hepatoprotective, antioxidant, antimutagenic, cytoprotective, anti tumour & antimicrobial.

Soil

A light as well as medium heavy soil except purely sandy soil is ideal for amla cultivation. The tree is well adapted to dry regions and can also be grown in moderate alkaline soil.

Climate

It is a tropical plant. Annual rainfall of 630-800 mm is ideal for its growth. The young plant up to the age of 3 years should be protected from hot wind during may-June and from frost

during winter months. The mature plants can tolerate freezing temperature as well as high temperature up to 46°C

Varieties

The varieties recommended for cultivation are Banarasi, Chakaiya, Francis, NA-4 (Krishna), NA 5 (Kanchan), NA-6, NA-7, NA-10 and BSR-1 (Bhavanisagar).

Cultivation

Propagation

Amla is generally propagated by shield budding. Budding is done on one year old seedlings with buds collected from superior varieties yielding big sized fruits. Older trees or poor yielder can be changed into superior types by top working.

Planting

The pits of 1 m² are to be dug during May-June at a distance of 4.5 m spacing and should be left for 15-20 days exposing to sunlight. Each pit should be filled with surface soil mixed with 15 kg farm yard manure and 0.5 kg of phosphorus before planting the budded seedling.

Irrigation

Young plants require watering during summer months at 15 days interval till they are fully established. Watering of bearing plants is advised during summer months at bi-weekly interval. After the monsoon rains, during October-December about 25-30 litres of water per day per tree through drip irrigation should be given.

Training and pruning

Leaving only 4-5 well shaped branches with wide angle at about 0.75 m from the ground level, other dead, diseased weak crisscrossing branches and suckers should be pruned off at the end of December.

Mulching and Intercropping

During summer, the crop should be mulched with paddy straw or wheat straw at the base of the tree up to 15-20 cm from the trunk. Inter crops like green gram, black gram, cow pea and horse gram can be grown up to 8 years.

Plant Protection

Major insect: Bark Eating caterpillar (*Inderbella tetronis*)

Major disease: Rust (*Ravenellia emblicae*)

Harvesting and yield

Amla tree starts bearing after about 4-5 years of planting. The fruits are harvested during February when they become dull



greenish yellow from light green. The mature fruits are hard and they do not fall at gentle touch and therefore vigorous shaking is required. Fruits can also be harvested using long bamboo poles attached with hooks.

A mature tree of about 10 years will yield 50-70 kg of fruit. The average weight of the fruit is 60-70 g and 1 kg contains about 15-20 fruits. A well maintained tree yields up to an age of 70 years.

1. Amla belongs to the family _____
2. Antioxidant present in Amla _____
3. Give two varieties of Amla _____
4. Major disease of Amla is _____
5. Propagation method of Amla _____

SENNA

Senna (Cassia angustifolia Vahl.)

Senna is a small perennial under shrub, a native of Yemen, South Arabia. The leaves and pods contain Sennosides used for their laxative properties. It was introduced into Tamil Nadu in the eighteenth century where it is grown as an annual crop of 5 to 7 months duration in 8 000 to 10 000 ha both under rainfed and irrigated conditions. Successful cultivations have also been demonstrated in Karnataka (Bangalore) Gujarat (Anand),



Rajasthan (Jodhpur) and Delhi with comparable yield and quality of the produce, but it is yet to establish itself as a cash crop there due to the lack of organized marketing. A major part of the produce is exported in the form of leaves, pods and sennoside concentrates, though several pharmaceutical houses utilize it for the manufacture of calcium sennoside granules, tablets and syrups for marketing within the country as well. Germany, Hungary, Japan, Netherlands and the USA are the main markets. The export of leaves and pods from India is of the value of Rs. 20 million annually. In addition, the erstwhile USSR countries buy sennosides (concentrates) and the current annual export of the sennoside concentrate is around Rs. 20 million.

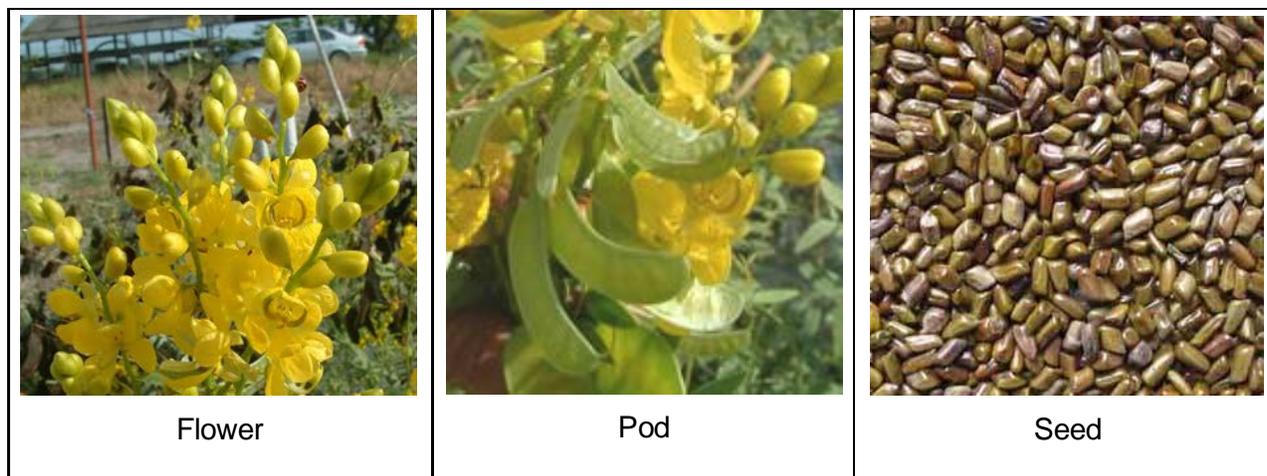
Senna is used in medicine as a cathartic. It is especially useful in habitual constipation. It increases the peristaltic movement of the colon. The pods have the tendency to gripe caused by senna may be obtained by combining it with an aromatic or a saline laxative. The laxative principles of senna are two glycosides, viz., sennoside A and sennoside B. The plant also contains sennosides C & D. A number of other glycosides have also been reported. It also contains beta-sterol (0.33%) and flavanols-kaemferol, kaempferin and isorhamnetin. They are used in the form of decoctions, powders; confections and many other household preparations. Senna extracts, on storage, lose biological activity more rapidly than is revealed by chemical estimation. The leaves/pods as such or in powder form do not lose potency easily. The quantity administered in the form of infusion ranges from 0.6 to 2 g of leaves or pods soaked in 125 ml of warm water for about 12 hours, whereas, it is usually 30 mg of sennosides per tablet.

Origin and Distribution

Cassia is a pantropic genus comprising of 500 species, of which 20 are found in the native flora of India. There are two sources of the Senna drug, namely, *Cassia angustifolia* Vahl, and *C. acutifolia*. Del. *C. angustifolia*, commonly called Tirunelvely senna, is indigenous to Somalia, Southern Arabia, part of Sindh (Pakistan) and the Kutch area of Gujarat. In India, it is cultivated in Gujarat, Rajasthan and Tamil Nadu. In Tamil Nadu it is cultivated in the districts of Thirunelveli, Ramanathapuram, Madurai, Salem and Tiruchirapalli in an area of about 10000 hectares. *C. acutifolia* known as Alexandrian senna is indigenous to Sudan and Sinai. It is cultivated on a small scale in Sudan and Egypt, and is mainly collected from wild plants of *C. acutifolia*, whereas the Indian produce comes entirely from the cultivated crop of *C. angustifolia* and their pods contain about 2.4-4.5 and 1.25 to 2.5% sennosides, respectively.

Description of the Plant

Cassia angustifolia ($2n=28$), belonging to the family Leguminales, is a small perennial under shrub, below 1 m in height with ascending branches. The leaves are large, compound and pinnate. The full grown leaflets are bluish-green to pale-green in colour and emit a characteristic fetid smell when crushed. The flowers are bright yellow in colour, arranged in axillary, (on subterminal) erect, many-flowered racemes. The flowers are not season bound and are borne between, 35 to 70 days of age, depending upon the time of sowing, and its season of cultivation. The pods appear immediately after flowering, are slightly curved, 3.5 to 6.5 cm long and up to 1.5 cm broad, green in the beginning changing to greenish-brown to dark brown on maturity and drying. Each pod has 5 to 7 ovate, compressed, smooth, dark-brown seeds.



The other species is very similar to *C. angustifolia* in morphology and growth, except in the dimension of its leaflets and pods. The leaflets are shorter and narrow. The pods are distinctly short, flat and broad, oblong but slightly curved upwards and are broadly rounded at

the two ends. -Further, surface making on the testa (seed) and stomatal index (leaves) are, remarkably, considered to distinguish between the two species. It has been found that *Cassia obouata* and *C. italica* also possess a fair to good percentage of anthraquinone compounds; *C. obouata* is common all over India. *C. italica* grows on sandy, saline soils in west Rajasthan and Saurashtra (Gujarat) and is a potential new source of the senna drug.

Varieties

KKM-1: It is a selection from Thenkalam local type. 135-140 days. It contains 2.34 % sennoside. It is suitable for Thirunelveli and Tuticorin districts.

The Gujarat Agriculture University, under the All India Co-ordinated Project on Medicinal and Aromatic Plants at Anand, has released a late flowering type as 'ALFf -2' through selection, which remains in a vegetative stage till 100 days and is suitable for growing exclusively as a leaf-crop. The CIMAP, Lucknow, has also released a high-yielding variety named 'Sona'.

Soil

The crop can thrive on a variety of soils, but is largely grown on red loam, alluvial loam and the rich clayey rice-fields. The texture of the soils which account for the major hectrage under senna crop varies from sandy loam to loam, while the black cotton soils are heavier and more fertile. In general, these soils are more friable but less moisture retentive and of low fertility, usually, nitrogen and phosphoric acid are deficient throughout these soils. The average pH ranges from 7-8.5. It is very sensitive to water-logging and, hence, it is grown only on well drained soils.

Climate

Senna is a sun-loving crop and requires bright sunshine for its successful growth. The trials at Bangalore have shown that it can be grown as an early summer (Feb-March) or a winter (Oct-Nov) crop. However, sowing in the rainy season is not good, as the crop on harvest cannot be dried easily. Whereas, under North Indian conditions like Delhi and Gujarat, where the rainy season is short, it is reported to be the ideal time as the plants put on luxuriant growth. Heavy rains and cloudy weather during growth are harmful to the crop. An average rainfall of 25-40 cm, distributed from June to October is sufficient to yield good harvests.

Land Preparation

The land is prepared deep and exposed to the sun for 110-115 days to dry out the roots of perennial weeds, followed by two cross ploughings, harrowing and leveling. FYM is incorporated into the soil at the time of the final cross-ploughing. Then the land is laid out into plots of convenient sizes with irrigation channels.

Cultivation

Propagation

The crop is raised from seeds. Since the seeds have a hard and tough seed-coat, a certain amount of abrading of its surface is necessary to induce quick germination. This is achieved by pounding the seeds lightly with coarse sand in a mortar.

Soaking the seeds for 10-12 hours before sowing is reported not only to give 100% germination, but also the stand of the plants grown is even. About 20 kg of seeds are required to cover a hectare of land.

Sowing

The seeds are broadcast or, more preferably, drilled at a distance of 30 cm in lines made at 30 cm apart at 1.5 to 2.5 cm depth on well prepared land. The germination commences on the third day and is completed within a fortnight. Before sowing, the field should be perfectly levelled, lest it hamper uniform seed germination. It is found that treating the seeds with Thiram, Captan or Agrosan G.N. at 2.5 g/kg protects the seedlings from damping-off and seedling blight diseases which are common occurrences. The seeds can also be dibbled on the inner sides of the ridges opened at 45 cm distance, maintaining a plant-to-plant spacing of 30 cm. Only about 5 kg of seeds are required for this method of sowing.

Manures and Fertilizers

Farmers in Tamil Nadu use 4-5 cartloads (5-10 t/ha) of well-rotted FYM at the time of sowing. In most cases, it fully utilizes any leftover nutrient from the previous crop and, therefore, the nutrient requirement of senna is variable. However, trials in India have shown that the crop in all, takes 50-100 kg of N, 20-50 kg of P and about 30 kg of K /ha in a growing period of 130-150 days, depending upon the growth and number of pickings. In general, where specific soil nutrient status of the field is not readily found, 80 kg of N and 40 kg each of P and K/ha may be applied for the optimum production of leaf, pod and total alkaloids. Of these, the entire dose of P and K and 50% of N should be applied at the time of sowing, and the remaining 50% of N is to be applied 90 days after sowing.

Crop Rotation and Inter cropping

In Tamil Nadu, senna is grown after the paddy and intercrop cultivation in between rows of cotton, sesamum, chillies, brinjal, okra and tomatoes is popular. Studies conducted at Delhi showed that senna-mustard and senna-coriander rotations gave higher profits and these rotations have proved superior.

Irrigation

Senna can be economically grown under rainfed conditions. In most years, the crop needs no irrigations except during prolonged drought. However, when it is grown as a semi irrigated crop the yield, increases considerably. About, 5-8 light irrigations are enough to raise a good crop of senna as heavy irrigations are injurious to the crop.

Weeding and Interculture

When the plants begin to grow, once or twice inter culturing is given after which the rows close up. The first weeding-cum-hoeing is done at 25-30 days, a second at 75-80 days and a third at 110 days, to keep the soil free from weeds. The use of Teeflan herbicide as a pre-emergent sprays at the rate of 4 kg/ha has been reported not only to increase the yield, but also the anthraquinone content.

Pests and Diseases

Pests

The larvae of several leaf-eating caterpillars feed on the green senna leaves. Usually, the spraying of Carbaryl (4 g/l) periodically in the growing season controls the infestation. The white butterfly (*Catopsilia pyranthae*) attack on this crop can be minimized by sowing the crop in March-April, instead of June-July in North India.

Another pest, a pod borer is also reported to attack the pods and can be controlled by spraying Endosulphan (0.05%) or Carbaryl (0.25%) at an interval of 10-15 days.

Diseases

The leaf-spot disease is the most serious disease and causes severe damage to the crop. The infested leaves drop off, resulting in poor yield. The disease is caused by *Alternaria alternata* (Fr.) Keisel. *Phyllosticta* spp. and *Cercospora* spp. The sennoside content in the leaves is inversely proportional to the intensity of the disease. The spraying of 0.15% Dithane M-45 at fortnight intervals, 3 times in a period of 5-6 weeks, has been found to control the disease effectively.

Damping-off of seedlings is the most devastating disease, which is caused by *Rhizoctonia bataticola*. The disease spreads rapidly if the fields are affected by stagnating moisture at this stage. Treatment with Thiram or Captan at 2.5 g/kg of seeds protects the growing seedlings. At a later stage its other physiological form, called *Macrophomina phaseoli* develops; it causes dry rot in the crop and kills the plant. The fields can be drenched with 0.2% Brassicol or 0.5 to 01. %. Rhizoctol, but this only gives partial control.

The leaf-blight disease is caused by *Phyllosticta* spp. usually occurring at the later stages of growth, in September-October. Cloudy days and humid weather conditions favour the spread of the disease.

The leaf-spot disease initially appears as small, brown, irregularly scattered lesions on leaves which grow bigger in size and turn black in colour at a later stage. The spraying of 0.15% Diahane M-45 at fortnightly intervals can control the diseases.

Harvesting, Processing and Storage

It has been found that young senna leaves and pods contain a high sennoside content but since the produce is sold on the basis of weight, a balance between weight and content has to be made, to choose the right stage for harvest. It is also found that senna plants produce foliage



containing higher sennosides between 50-90 days of sowing. The first picking of the foliage crop should be done at 50-70 days' age, depending upon the total plant growth. The picking of leaves is done by hand so that most of the growing tops are removed at harvest; this also induces more branching which, otherwise, reduces the foliage growth considerably. A second picking is taken at 90-100 days and the third picking between 130-150 days, when the entire plants are removed, so that the harvested material includes both leaves and pods together.

The harvested crop should be spread in a thin layer in an open field to reduce its moisture. Further drying of the produce is done in well-ventilated drying sheds. It takes 10-12 days to dry completely. The dry leaves and pods should have a light-green to greenish-yellow colour. Improper and delayed drying changes the colour to black or brown which lowers the sennoside content and it fetches a lower price. A rapid mechanical drying at 40°C could also be attempted. The seeds contain no sennosides and only add weight to the produce. The pods are threshed during drying to remove the seeds. The produce is baled under hydraulic pressure and wrapped in gunny bags for export.

Yield

A good crop of senna can give 15 q/ha of dry leaves and 7 q/ha of pods, under irrigated and good management conditions. The yield, under rainfed conditions is about 10 q/ha of leaves and 4 q/ha of pods.



Estimation of Sennosides

To 0.5 g (40 mesh) of accurately weighed powder in a 100 ml flask add 50 ml of water, swirl to mix, attach a reflux condenser and, immerse the flask in a boiling water-bath with the water-level in the bath just above that of the liquid in the flask, for 15 minutes. Allow the mixture to cool. Decant and filter the extract into a volumetric flask (100 ml). Add 50 ml water to the residue and extract again in the boiling water-bath as above. The final volume in the flask is made up to 100 ml.

Transfer 20 ml of the clear, supernatant liquid from the volumetric flask to a separating funnel, add 0.05 ml of hydrochloric acid and extract with two successive 15 ml portions of chloroform. Discard the chloroform extracts.

Transfer 20 ml of aqueous extract from the separating funnel to a 100 ml flask. Adjust the pH to 7-8 (with pH paper) with 5% w/v solution of sodium carbonate in water. Add 20 ml of 6.3% w/v freshly-prepared solution of ferric chloride (FeCl_3) in a water-mix, attach a reflux condenser to the flask and heat on a boiling water bath for 20 minutes and without cooling the liquid, add 2 ml of HCl. Continue the heating for a further 20 minutes, swirling the liquid in the flask frequently, to dissolve the precipitate and allow it to cool.

Transfer the liquid into a separating funnel, extract with three 25 ml portions of solvent ether, having used each portion to rinse the flask first. Wash the combined etherel extracts with two 15 ml portions of water and dilute to 100 ml with solvent ether. Evaporate 10 ml (extract) of the etherel solution to just-dryness on a water-bath and dissolve the residue in 10 ml of 1N KOH. Then, immediately measure the extinction of 1 cm layer to 500 nm using water as a blank.

Production Technology of Spices, Aromatic, Medicinal Plant Crops

1. Scientific name of Senna is _____
2. Active ingredient of Senna is _____
3. Medicinal properties of Senna is _____
4. Economic part of Senna _____
5. Senna belongs to the family _____

ISUBGOL

(*Plantago ovata* Forsk., Plantaginaceae)

Isubgol or Psyllium (*Plantago ovata*) is important for its seed and husk which have been used in the indigenous medicine for many countries. It has the property of absorbing and retaining water (40-90%) and therefore it works as an anti-diarrhoea drug. It is beneficial in chronic dysenteries of amoebic and bacillary origin. The seed has also Cooling and demulcent effect and is used in Ayurvedic, Unani and Allopathic medicines. The husk yields a colloidal mucilage consisting mainly of xylose, arabinose and galacturonic acid. In India it is grown in about 16,000 to 20,000 hectare in North Gujarat and it is also recently cultivated in small areas in Rajasthan, Haryana and Bihar. The husk and peel are exported largely to USA, West Germany, the UK and France, fetching a foreign exchange of more than crores annually.

It is a stemless annual herb often attaining a height of 30 to 40 cm, with rosette leaves. The plant bears erect ovoid or cylindrical spike with minute white flowers about 45-68, protogynous. Fruit is capsule, each seed is encased in a thin, white, translucent membrane, the husk, which is odourless and tasteless.

Climate and Soil

It requires cool and dry weather and hence in India, the crop is grown in winter i.e. from November - December to March - April. Humid weather, at maturity results in shattering of seeds. A light well drained sandy loam to rich loamy soil with a pH of 7-8 is ideal.

Varieties

Gujarat Agricultural University has released two improved varieties viz. Gujarat Isabgol-1 and Isabgol - 2 which have a yield potential of 800 - 900kg and 1000 kg/ha. respectively.

Preparation of land

Field must be free of weeds and clods and should have fine tilth for good germination. The land is laid into flat beds of convenient size i.e. 1.0m x 3.0 m or 2.5 m or 2.5 m.



Sowing

Fresh seeds from the preceding crop season should be sown for getting high percent germination. The seed rate varies from 4 - 6 kg and is sown after pretreatment with thiram @ 3 g/kg of seed to protect the seedlings from the possible damage of damping off. The seeds, being small and light are mixed with sufficient quantity of fine sand before sowing. The seeds are sown broadcast and are swept lightly with a broom in one direction to cover them with some soil.

After cultivation

Timely weeding is important to encourage good growth of the plants. After 20-25 days of sowing, first weeding is done and 2-3 weedings are required within 2 months of sowing. It responds to manuring. 25 Kg N/ha and 25 Kg P/ha are applied as basal dose at the last ploughing and another dose of 25 Kg N/ha is top dressed 30 days after sowing.

Immediately after sowing light irrigation is essential. First irrigation should be given with light flow of water. The seeds normally germinate in 6 -7 days. If the germination is poor, second irrigation may be given. Later on irrigations are given as and when necessary. Last irrigation should be given at the time when maximum number of spikes has reached the milk stage.

Harvesting and processing

The crop will be ready in about 110-130 days after sowing. When mature, the crop turns yellowish and the spike turns brownish. The seeds shed when the spikes are pressed even slightly. At the time of harvest the atmosphere must be dry and there should not be any moisture on the plant.

The plants are normally cut at the ground level or uprooted if the soil is loose textured. The harvested plants are threshed and winnowed, and the seeds repeatedly sifted until clean. The seeds may be marketed whole or the husk may be sold separately. Seeds are fed to a series of shellers; in each sheller the grinding pressure is so adjusted to remove only the husk. This is separated by fans and sieves at each sheller and the ungrounded material is sent to the next sheller. The husk: seed ratio is 25:75 by weight.



The average yield is about one tonne of seeds per hectare.



Husk



Seed

Plant protection

Downy mildew caused by *Peronospora plantaginia* is the serious disease at the time of spike initiation. Spraying of copper oxy chloride or Dithane Z.78 @ 2.0 g/litre of water is recommended as a prophylactic measure on 30th day from sowing and repeated twice, at an interval of 15 – 20 days.

1. Isabgol belongs to the family _____
2. Scientific name of Isabgol is _____
3. Economic part of Isabgol is _____
4. Two improved varieties of Isabgol _____
5. Mention the stage of harvest in Isabgol _____

STEVIA

(*Stevia rebaudiana*, Asteraceae)

Stevia is a subtropical perennial that produces sweet steviol glycosides in the leaves for which it also known as 'Cheeni Tulsi' or 'Mou Tulsi'. Plants grown at higher latitudes actually have a higher percentage of sweet glycosides. The plant can be utilized as a source for the production of natural sweetener (food), as a source of chlorophyll, phytosterols (non-food: medicine). The sweetener can be converted into gibberellins by fermentation (Non-food — Agrochemicals), the vegetative residue can be used as animal feed and the stalks can be used as a source of cellulose (Non-food: Cellulose industry).



Its medicinal uses include regulating blood sugar, preventing hypertension, treatment of skin disorders, and prevention of tooth decay. The compound obtained from stevia is considered to be the best alternate source for diabetes sufferer. The added value for this new crop can go up to a considerable extent.

Market potential

Market opportunity appears great. Statistics indicate that in some countries up to 30 % of their needed sugar is replaced by stevioside-like sweetness products.

Soil

Stevia prefers a well-drained fertile sandy loam or loam soil, high in organic matter with ample supply of water. It prefers acidic to neutral (pH 6-7) soil for better growth. It requires a consistent supply of moisture, but not waterlogged. Too much soil moisture can cause rot.

Climate

It is a semi-humid subtropical plant that shows higher leaf production under high light intensity and warm temperature. Day length is more critical than light intensity. Long spring and summer days favour leaf growth. Short days trigger blossoming. Stevia prefers partial shade during considerable summer sunshine.

Variety

There are 3 named varieties developed by Sun Fruits Pvt Ltd, Pune viz,

- 1) **S.R.B-123:** It can be harvested 5 times in year. The glycoside content is in between 9-12% found suitable for South.
- 2) **S.R.B-512:** It is suitable for Northern India and the Glycoside content is in between 9-12%.
- 3) **S.R.B-128:** Highest stevioside content up to 21%. Found suitable for Northern India.
- 4) Material that yields Stevioside in the range of 9 – 12% or above can be used as good material for commercial cultivation and should be maintained by vegetative propagation only.

Propagation

Stevia is usually propagated by stem cuttings, which root easily. Sweetness in leaves varies with varieties. Therefore, for propagation cutting should be obtained from a source, which is high in stevioside and low in associated bitterness. Rooting can be enhanced by using commercial rooting hormones. Cutting should be 2-4 inches long, from leaf axils of current year growth with atleast two leaf buds above ground. All the lower leaves are removed keeping 2 or 3 small leaves. Treatment with Paclobutrazol @ 100 ppm has been found to induce the root initiation in short time. Effective outcome of this treatment can be obtained when the cuttings are planted during the month of February-March. Propagation can be done in other period also with varying success.

Land Preparation

Land is either disced and /or harrowed twice to prepare a fairly smooth, firm-planting surface. Around 50 MT of FYM / ha has to be applied as a basal dressing during the last ploughing to incorporate the manure with the soil. With proper drainage and irrigation channels the field is divided into plots of convenient size.

Raised bed preparation

Forming raised beds is the most economical way to grow Stevia. The raised bed should be of 15 cm in height and 60 cm in width. The distance between two rows should be 40 cm and that between each plant 23 cm. This would give a plant population of around 75,000 per hectare.

Planting

March to mid May gives better results. Immediate after planting one irrigation is necessary. The concentration of stevioside in the leaves increases when the plants are grown under long day condition where vegetative period is longer and steviol glycoside yields will be higher.

Irrigation

It needs irrigation, as Stevia cannot stand drought. Sprinkler irrigation (micro sprinklers) is found to be advantageous since the herb is highly sensitive to water stress and requires frequent light irrigation. During summer irrigation at 3-5 days interval gives best results.

Mulching

In order to reduce the impact of drought and high temperature, addition of mulches around the plant is recommended.

Nutrient uptake

Study revealed that at the point of maximum dry matter accumulation, stevia plants consist of 1.4 % N, 0.3% P and 2.4 % K. When biomass production is 7500 kg/ha, it is constituted by 26 % roots, 35 % stems and 39 % leaves. Such biomass would require about 105 kg N, 23 kg P and 180 kg K from both soil and fertilizer. Therefore, the actual rate of application will vary according to soil type and production environment, and need to be optimized for each specific situation.

Manuring and fertilization

Under average condition application of FYM @ 50 t/ha and fertilizers N-60 kg, P₂O₅ 30 kg and K₂O 45 kg/ha is recommended. N is applied in three splits once at basal and remaining two applications after first and second cutting. Stevia plants prefer low nitrogen, but high level of phosphorus and potassium. Slow release nitrogen sources are better due to requirement of low level of N and steady release of N from source. Sometimes stevia shows the symptoms of boron deficiency, which leads to leaf spot and that can be rectified by spraying Borax 6 %. Since the feeder roots tend to be quite near the surface, addition of compost for extra nutrients is beneficial.

Plant protection

No serious pest and diseases have been observed. Neem oil diluted in water may be sprayed against aphids if appear. Deer and rabbits are fond of Stevia due to sweet taste. Fencing is necessary.

Harvesting

Time of harvesting depends on land type, variety and growing season. The first harvest of the crop can be had in four months after planting and subsequent harvest once every 3 months. Generally it can be scheduled for mid to late September when plants are 50-70 cm in height. Short days induce flowering. Optimum yield (biomass) and stevioside quality and quantity is best obtained just before flowering. The easiest harvesting technique is to cut the branches off with pruning shears before stripping the leaves. The tips of the stems can be

clipped off and added to harvest yield, as they contain as much stevioside as do the leaves. On an average three commercial harvests can be obtained per year. It is better to cut the plants leaving about 10 cm stem portion from the ground. This will facilitate new flushes to emerge, which can be harvested as the next crop. For domestic use leaves may be used fresh for tea or may be combined with mint leaves.

Drying

Immediately after harvest the herb is dried. This can be accomplished on a screen or net. The freshly harvested plants can be hung upside down and dried in shade. It can also be dried using simple drying racks inside transparent poly house or transparent glass roofing or by passing dry air just above room temperature. Drying of the stem and soft green leaf material is completed immediately after harvesting utilizing a drying wagon or a kiln or done naturally in case of large-scale production. Depending on weather conditions and density of loading, it generally takes 24 to 48 hours to dry stevia at 400 to 500 C. The drying process does not require excessive heat; more important is good air circulation. On a moderately warm fall day, stevia can be quick dried in the full sun in about 12 hours. (Longer drying time will lower the stevioside content of the final product). A home dehydrator can also be used, although sun drying is the preferred method. After adequate drying, the leaves are stripped of the stems / twigs and packed and stored in cool, dry place. For large-scale commercial production artificial drying and threshing of the dry herbs to separate leaves may be employed.

Yield

About 15,000kg/ha of green herb is obtained which on drying gives about 4166-kg/ha. After separating stems this yields about 3000 kg/ha in the first year. Yield goes on decreasing from 3rd year of planting and hence terminated.

Packaging

Dry leaves are stored in plastic lined cardboard boxes, sealed, strapped and labeled for further processing. After powdering it is to be packed and leveled properly.

Replacement and replanting

From the subsequent years some plants will die off due to various reasons, these gaps should immediately be filled up by well-developed seedlings raised in large size poly bags. Depending on soil type and management the productivity will decline after 2-3 years and this should be replaced with new plantation.

Growing Stevia in home garden

Stevia can be grown either in pots on balcony or any sunny spot. It does well in "container gardens". A 10 to 12 inches diameter container filled with a lightweight growing mix is

an ideal size for each plant. A little mulch on the top will help retain the moisture in the shallow root zone.

1. Stevia belongs to the family _____
2. Scientific name of stevia is _____
3. Economic part of stevia is _____
4. Propagation of stevia is _____
5. Season of planting in stevia _____

COLEUS

Coleus forskohlii Syn: *Coleus barbatus* Brig.,

It belongs to the family Lamiaceae, is one of the most significant potential medicinal crops of the future as its pharmaceutical properties have been discovered only recently. The tuberous roots are found to be rich source of forskolin (syn.Coleonol) which is being developed as a drug for hypertension, glaucoma, asthma, congestive heart failures and certain types of cancers. The plant is well known throughout the country. In Egypt and Africa the leaves of *C.barbatus* are used as an expectorant, emmenagogue and diuretic while its foliage is employed in treating intestinal disorders, and it has been used as a condiment in India for a long time. The tuberous roots of this plant resembling a carrot in shape and brown in color are the commercial parts.

Orgin and Distribution

The crop has been distributed all over the tropical and subtropical regions of India, Pakistan, Srilanka, Brazil and Ethiopia. In India, it is found to be in the subtropical Himalayan regions from Kumaon to Nepal, Bihar and the Decan Plateau of Southern India. It is cultivated in parts of Rajashan, Maharashtra, Karnataka and Tamilnadu in an area of about 2500ha.

Description of the plant

Coleus barbatus ($2n = 30$) is an aromatic perennial plant 0.5 m tall with thick tubers and with very showy bluish to pale lavender coloured flowers, arranged in whorls on a long spike like recemes. The entire plant is aromatic (whether fresh or dried).The leaves and tubers have quite different odours, the latter being reminiscent of but quite different from, ginger.



Members of the genus *Coleus*, have square stems, branched, the nodes are often hairy. The leaves are usually pubescent, narrowed into petioles. The flowers borne on recemes are perfect; the calyx is fine toothed and deflexed in the front. The pale-blue corolla is bilabiate, the lower lobes are elongated and concave. The ovary is four parted and the stigma is bilobed. *Coleus* flowers are cross-pollinated by means of wind or insects. The species has four didynamus, with declinate stamens where filaments unite as a sheath at the base. The roots are tuberous, fasciculated, Up to 20 cm long and 0.5-2.5 cm thick, they are conical, fusiform, straight, orangish and strongly aromatic.

Varieties

1. Manganiperu: It is cultivated in and around Belgaum districts of Karnataka. The tubers are big, 30.00cm length. It is also commercially cultivated in Tamil Nadu.

2. Garmai: It is cultivated in Gujarat state. The tubers are in medium size.

3. Maimul

Soil

It thrives best in porous and well-drained soils with a pH ranging from 5.5-7. It does not require very fertile soils and can be grown on soils with marginal fertility. The red, sandy loam soils of Karnataka are ideal for the cultivation of the crop.

Climate

Coleus is a crop of the tropics and is found growing well on barren hills at an attitude of about 2400 m, under tropical conditions. In India it is grown mainly in Belgaum and in Gujarat. The climate here is humid with RH ranging from 83 to 95% and a temperature of 10 -25C. The annual rainfall is 100-160cm, mainly between June to September. It is also found to perform well in less humid and warmer regions of South India like Coimbatore, where it is grown as an irrigated crop.

Seed and seed rate

The crop is propagated through terminal cuttings (10 cm) or rooted cuttings.

Season

Planting is done during June – July.

Planting

Planting is done at 60 x 45 cm spacing (37,030 plants/ha). In low fertile soils, planting is done at 60 x 30 cm which requires 55, 500 plants/ha.



Before planting the field is ploughed deep soon after the pre monsoon showers and brought to a fine tilth.

Manures and fertilizers

Studies conducted at TNAU, Coimbatore, to standardize the nutritional requirement of this crop have shown that it response well to the application of FYM 15t/ha, 30kg N, 60kg P₂O₅ and 50kg K₂O/ha and dry (3.982t/ha) tuber yield from this crop. Half the dose of N, the whole P and whole K may be applied as the basal dose followed by the remaining half N, 30 days after planting as top-dressing. Apply 10 kg ZnSo₄/ha to avoid micronutrient deficiency.

Irrigation

The first irrigation is given immediately after transplanting, if there are no rains. During the first 2 weeks after planting, the crop is irrigated once in 3 days and thereafter weekly irrigation is enough to obtain good growth and yield.

Weeding

Due to the frequent irrigations during the initial stages, there is a lot of competition from weeds. In order to obtain economic yields, frequent weeding during the early growth period is desirable.

Pest and diseases

Pests

The leaf –eating caterpillars, mealy bugs and root-knot nematodes are the important pests that attack this crop. These insects can be controlled by spraying the plants and drenching their roots with 0.1% methyl parathion, while nematodes can be controlled by the application of carbofuran granules @ 20kg/ha.

Plant protection

Among diseases, bacterial wilt is he major one.

Nematode

1. Crop rotation with Sorghum and Maize can be maintained
2. Planting of marigold along the sides of channels control nematode population
3. Apply 200 kg/ha of neem cake before planting
4. Apply 15 – 20 kg/ha of Carbofuran to control the infestation

Root rot

Trichoderma viridi @ 5 kg/ha is mixed with well rottened FYM and applied twice at 20 days interval.

Bacterial wilt

Drench 300 ppm of Streptomycin to control the wilt. Also apply *Pseudomonas fluorescence* 5 kg/ha by mixing it with well rotted FYM.

Harvesting

Flowers if any should be nipped off during the growing period to obtain more biomass of roots. The crop is ready for harvest 4.5 to 5 months after planting. The plants are loosened, uprooted, the tubers separated, cleaned and sun dried for the extraction of "forskolin".



Yield

Fresh tubers : 15 – 20 t/ha
Dry tubers : 2000 – 2200 kg/ha

1. Economic part of coleus is _____
2. Active ingredients present in coleus is _____
3. Propagation of coleus is _____
4. Coleus can be used as drug for _____
5. Mode of pollination in coleus is _____

ACORUS

Botanical Name: *Acorus calamus*

Family: Acoraceae (Araceae)

Common Names: Sweet flag, Vacha, Acorus, sweet calomel

Distribution

Acorus calamus plant is found near swamps and banks in Asia, Europe, and North America.

Introduction

Acorus calamus is commonly known as sweet flag in India. The leaves of *Acorus calamus* have a lemony scent as well as the roots have a sweet fragrance. *Acorus calamus* has long been known for its medicinal value, and has been cultivated in Asia for this reason.

Plant Description

Acorus calamus is a perennial, semi-aquatic and smelly plant, found in both temperate and subtemperate zones. It is up to 6 feet tall, aromatic, sword-shaped leaves and small, yellow/green flowers with branched rhizome.

Parts Used

Rhizome or the Root

Chemistry

Acorus calamus contains monoterpene hydrocarbons, sequestrine ketones, (trans- or Alpha) Asarone (2, 4, 5-trimethoxy-1-propenylbenzene) and Beta-asarone (cis- isomer).

History

Acorus calamus plant has a long history of usage in both Native and non-Native folk medicine traditions. Aromatic roots used medicinally and ritually by Algonquins, Cree and other NE tribes. *Acorus calamus*, a sterile triploid, was introduced to India and North America by early European settlers, who grew it for medicinal uses. Rhizomes propagate easily, and the species has spread throughout India and northeast and central United States.

Action & Uses of *Acorus calamus*

- *Acorus calamus* is slightly tonic but forms a useful adjunct to other tonics and stimulants.
- *Acorus calamus* is very popular for the remedies of cough and cold and also the other respiratory disorders like bronchitis. In raw form it is also used as cough lozenge.



- *Acorus calamus* provides aid to the digestive system and acts against flatulent colic, Dyspepsia, and vomiting.
- *Acorus calamus* depresses central nervous system, and a well known ingredient in formulation for psycho-somatic disorders like epilepsy.
- The vapours of *Acorus calamus* from the roots do repel some insects.

Cultivation details

Soil and Climate

Prefers, growing in shallow water or in a very moist loamy soil. Requires a sunny position. Prefers a pH range of 5.5 to 7.5. Plants are hardy to about -25°C.

Propagation

This plant is propagated through roots/rhizomes and seeds. Roots of 5-6 cm, firm, and free from any damage or infection is used.

How to Grow *Acorus calamus*

Seed should be planted during the fall or winter in a greenhouse. Fill a 2-inch deep tray with an organic soil mix, scatter seed sparsely on the surface and press firmly into the soil. Do not bury further than 1/8 inch deep. Keep the soil from moist to saturate.

Seed does not require stratification and germinates in less than 2 weeks. When plants reach 3 to 4 inches, transplant them into individual 4-inch pots. Pots can be placed in shallow water or irrigated frequently to maintain very moist to saturated conditions.

Transplant outdoors 1 foot apart in the spring. With adequate moisture seed can also be planted outdoors spring through early summer or in a cold frame late summer through fall. Keep soil very moist to saturated, sweet flag does not tolerate droughty conditions. It should be planted where it will be in full sun to partial shade.

Calamus grows well under seasonal shallow inundation. However, avoid flooding of newly established plants or seeded areas. Starter fertilizers may be used indoors to improve early growth but are unnecessary once transplanted outdoors into a rich soil.

The spadix will turn brown as the seed ripens in late summer or early fall. Seed can be planted immediately or stored in low humidity refrigeration.

The flowering head, produced from the side of the stalk, consists of a fleshy spike sometimes three and half inches long and about 1/2 inch in thickness, closely covered with very small, greenish yellow flowers, which appear from May to July.

The rhizome should be gathered in early spring or



in October and November. Dirt and bitter rootlets should be removed and the rhizome should be dried quickly in a warmed room. The leaves also possess the aromatic properties of the rhizome, but to a lesser extent. Leaves are not employed as a medicine.

Harvest and yield

Rhizomes should be harvested for medicinal use in early spring before new growth, or late autumn. Collect when large and firm, generally after 2 to 3 years of growth, before becoming hollow.

The crop produces 1-1.5 tons of dry rhizome per acre.

1. Botanical name of Acorus _____
2. Acorus is commonly called us _____
3. Economic part used in Acorus _____
4. Active principles present in Acorus _____
5. Propagation of Acorus is _____



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