Organic Package of Practices Horticultural Crops

Compiled at

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VEGETABLES

CUCURBITACIOUS VEGETABLES

Bittergourd, snakegourd, pumpkin,ashgourd, cucumber, watermelon, bottlegourd, littlegourd and ridgegourd are the important cucurbitacious vegetables. Thedetails of varieties, season, seed rate and spacing of these crops are given in the following table.

Table 01: Varieties, season, seed rate and spacing of different cucurbitaceous vegetables

Crop	*Varieties*	*Season*	*Seed rate (kg /ha)*	*Spacing*
1	2	3	4	5
Bittergourd (*Momordica charantia*)	As per recommen dation of Universitie s and KVKswith respect to climatic conditions	Rainfed- May- August Irrigated- January- March & September- December	5-6	2m x 2m
Snakegourd (*Trichosanthes cucumerina***)**	--	Irrigated- January- March & September- December	3-4	2 m x 2 m
Cucumber	--	Irrigated- January-	0.5-0.75	2m x 1.5m
(*Cucumis*		March & September-		
sativus)	--	December		

Oriental pickling melon (*Cucumis melon var.conomon*)& Culinary melon (*Cucumis melo var.acidulus*)	--			
Water melon (*Citrullus lanatus*	--	December-April	1-1.5	3m x 2m
Bottlegourd *(Lagenaria siceraria)*	--	Rain fed-May-August Irrigated-January- March & September-December	3-4	3m x 3m
Pumpkin *(Cucurbita moschata)*	--	Rainfed-May- August Irrigated-January-March & September-December	1-1.5	4.5m x 2m
Ashgourd *(Benincasahispida)*	--	Rainfed-May-August Irrigated-January- March& September-December	0.75-1	4.5m x 2m
Littlegourd *(Coccinia grandis)*	--	Planting time-May-June & September-October	Stem cuttings with 3-4nodes from female plants @2-3 cuttings/pit	4m x 3m
Ridgegourd (*Luffacutangula)*	--	December-March & May-August	2.5-3	2m x 2m

Sowing/planting

Pits of 60 cm diameter and 30-45 cm depth are taken. Well rotten FYM or other organic manure (12 t/ha) is mixed with topsoil in the pit and seeds are sown at the rate of 4-5 per pit. For Littlegourd plant stem cuttings with 3-4 nodes from female

plants @ 2-3 cuttings/pit. Unhealthy plants are removed after two weeks and only 3 plants are retained per pit.

Manuring

Additional Manurial requirement (apply any one of the following manuresdepending upon the availability)

Nutrient source	Quantity
FYM / Cow dung/	8 t/ha
Compost/	8 t/ha
Vermicompost/	4 t/ha
Greenleaf	8 t/h

Manures are applied in 2 splits at winding and flowering stage. Applyfresh cow dung slurry @ 1 kg/litre of water at fortnightly intervalsstarting from flowering.

For Littlegourd, apply FYM @12.5kg/pit at the time of preparation of pits. Apply another dose of FYM@12.5kg/pit when the plants start vining.

Irrigation

During the initial stages of growth, irrigate at 2-3 days interval and on alternate days during flowering or fruiting. Irrigation at 15 mm CPE (approximately at 3 days interval for sandy loam soils) is more economical than irrigating once in two days especially during summer months for water economy.

After cultivation

For bittergourd, snakegourd, littlegourd and ridgegourd, erect pandals when the plants start vining. For cucumber, watermelon, bottlegourd, pumpkin and ashgourd, spread dried twigs on the ground for trailing. Conduct weeding and raking of the soil along with application of manures. Earthing up is to be done during rainy season. Provide mulch in the field throughout the crop growth period with materials like green leaves, plant residues, decomposed coir pith, coconut husk, straw etc.

Plant protectionPests

Fruit fly *(Bactrocera cucurbitae*)

1. Cover the fruits.
2. Remove and destroy infested fruits.
3. Apply neem cake 250 kg / ha (100g / pit) at planting and onemonth later.
4. Use any of the following fruit fly traps
   i) Fish meal trap – Place 5 g dry fish in coconut shell, moisten andadd 0.5 g Furadan. Put coconut shell inside a polythene cover. Make holes on the cover above shell and hang the cover from 'pandal' (trellis).
   ii) Fruit fly trap can also be made by taking 20 g banana pulp in a coconut shell and beer 3 ml and palm oil 3 drops.
   iii) Trap adult fruit flies using cue lure plywood blocks containing 6:4:1 mixture

of ethyl alcohol: cue lure: Malathion. Re set traps at four months interval. Hang plywood blocks with pheromone @10nos./ha

iv) Trap adult fruit flies using food baits. Make a pulp of 20 g banana,10 g jaggery and 5 g furadan in 100 ml water (jaggery heated to 80 degree Celsius) at 2.5m spacing. Change traps after 3 weeks. Red banana, Robusta, Njalipoovan and Palayankodan fruits can be used.

v) Set yellow painted coconut shell traps containing carbofuran smeared banana pieces (Palayankodan) at 2 m spacing at the start of flowering till final harvest. The traps are to be replenished once in seven days.

5 Apply *Beauveria bassiana* 10% WP and *Paecilomyces lilacinus* 5% WP

6. Spraying of leaf extract of *Ailanthus* 10 % and cashew 10% in combination is effective against fruit fly in bitter gourd.

Aphids, Green Jassid, White fly and Mite

1. Spray 2% neem oil + garlic emulsion spray.
2. Dissolve 60g soap in 150 ml warm water, add soap solution to neem oil and castor oil slowly and mix well. Dilute with 6 litres of water. Add 120 g garlic paste. Take the extract and spray.
3. Apply 1.5% fish oil soap.
4. For preventing mite, plant hoppers and jassids, apply 10% magnesium sulphate on leaves, which will provide strength forplants.

Leaf and flower feeder (*Diaphania* sp.)

Collect and destroy larvae.

Spray, solution containing 1 litre cow's urine + 10 g bird chilli + 9 litres water. Apply *Beauveria bassiana* 10% WP and *Paecilomyces lilacinus* 5% WP

Spraying of 10% leaf extract of *Ailanthus* and cashew is effective against fruit fly in bittergourd.

American Serpentine leaf miner

Spray neem seed kernel emulsion (4%) before 8'O clock in the morning.

Epilachna beetle

1. Remove and destroy egg masses, grubs and adults occurring on leaves.
2. Use predator (*Chrysocaries johnsoni*) of larvae and pupae.
3. Apply *Beauveria bassiana* 10% WP and *Paecilomyces lilacinus* 5%WP
4. Spray leaf extract of ailanthus and cashew (10%).
5. Neem oil + garlic emulsion spray (2%).

Diseases Mosaic

Uprooting and destruction of affected plants and collateral hosts shouldbe done. Spraying neem-based insecticide (2%) to control the vector.

SOLANACEOUS VEGETABLES

Chilli, brinjal and tomato are the important solanaceous fruit vegetables grown in the state. The details of seed rate, time of planting, varieties and spacing are given below.

Table-02: Seed rate, time of planting, varieties and spacing of different solanaceous vegetables

Crop	*Seed rate*	*Time of planting*	*Varieties*	*Spacing*
Chilli (*Capsicum annuum*)	1.0 kg/h a	May-June (before south- west monsoon)/	As per recommendation of Universities and KVKs with respect to climatic conditions	45cm x 45 cm / 75cm x 45-60cm
		Sept.-October (for an irrigated crop). Can be grown throughout the year.		45cm x 45 cm
Brinjal (*Solanum melongena)*	370-500 g/ha	May-June (before south- west monsoon)/	--	60cm x 60 cm / 75-90cm x 60 cm
		Sept.-October (for an irrigated crop). Can be grown throughout the year.		75-90cm x 60 cm
Tomato *(Lycopersicon esculentum*)	400 g/ha	October- November (foran irrigated crop)	--	60cm x 60 cm

Nursery

Solanaceous vegetables are transplanted crops. Seeds are sown in the nursery and one month old seedlings are transplanted to the main field. An area of 21/ cents (0.01 ha) is required for raising seedlings for one hectare. For sowing the seeds, raised seed beds of 90 to 100 cm width and convenient length are prepared in open space with fertile topsoil to which well decomposed organic matter has been incorporated. Care should be taken to prevent incidence of damping off in

the nursery. For this add one kilogram of *Trichoderma* to 100kg of dried farmyard manureand 10 kg of neem cake spread under shade to which water is sprinkled for maintaining moisture. Keep the mixture for fifteen days with

Intermittent turning. To the nursery soil, add 1 kg of PGPR mix 1 at the time of bed preparation. After sowing the seeds, mulch with greenleaves and irrigate with a rose can daily in the morning. At the time ofirrigation, add *Pseudomonas fluorescens* @ 20g/litre at frequentintervals. Remove the mulch immediately after germination of the seeds.Addition of diluted (25g/ litre) cow dung slurry or cow urine (diluted 8times) increases the vigor of the seedlings. Restrict irrigation one weekbefore transplanting and irrigate heavily on the previous day of transplanting.

Land preparation and transplanting

Land is prepared to a fine tilth by thorough ploughing or digging. Well rotten organic manure is incorporated in the soil and seedlings aretransplanted in shallow trenches or on ridges/ levelled lands according to season. Transplanted seedlings may be given temporary shade for 3-4 days during hot days.

Manuring

Apply lime @ 500 kg/ha based on the acidity of soil 15 days before transplanting. Apply FYM or compost @ 25t/ha as basal dose to which *Trichoderma* and PGPR mix 1 each @ 2.5 kg /ha are mixed and kept for

15 days in shade. Apply *Pseudomonas* and AMF at the time of transplanting. Instead of FYM, poultry or powdered goat manure @ 1t/ha can be applied. Dip the roots in 2% Pseudomonas or PGPR mix 1 before transplanting to the field.

Top dressing

Top dressing can be done at 7-10 days interval with any one of the following

1. Soil application of fresh cowdung slurry @ 1 kg/10 litres (50 kg/ha)
2. Soil application of biogas slurry @ 1 kg/10 litres (50 kg/ha)
3. Soil application of cow's urine 500 litres/ha (8 times dilution)
4. Soil application of vermiwash-500 litres/ha (8 times dilution)
5. Soil application of vermicompost / poultry / powdered goat manure-1 t /ha
6. Soil application of groundnut cake1 kg/10 litres (50 kg/ha)

Foliar spray can be given with cowdung slurry/ vermiwash/ cow's urine.

After cultivation

Give pre-transplanting irrigation, if the soil is not moist enough. Irrigate at two or three days interval during summer. Stake the plants if necessary. Weeding followed by organic manure application and earthing up may be done at one and two months after transplanting. Provide mulch in the field throughout the crop growth period with materials like green leaves, plant residues, decomposed coir pith, coconut husk, straw, etc.

Plant Protection

Table-03: Pests and their control

Crop	Pest	Control measures
Chilli	Aphids	Spray tobacco decoction or neem oil - garlic emulsion (2%) or *Nattapoochedi* (*Hyptis suaveolens*) emulsion (10%). Spray *Verticillium lecanae* or *Fusarium pallidoroseum* (1010conidia/litre). Release green lacewing bugs @ 50,000 eggs/ha.
	Jassids	Spray neem oil-garlic emulsion (2%) or lemon grass/ ginger extract (10%)
	Thrips	Spray Kiriyath (*Andrographis paniculata*) extract(10%),
	Mite	Apply neem oil 5% or neem oil + garlic emulsion 2%.Spray diluted rice water once in 10 days against mite.
Chilli tomato	White fly	Spray *Verticillium lecanae* (1010conidia/ litre) or garlic emulsion (2%). Place Sticky yellow traps.
Brinjal fruit borer	Shootand	Protect the seedling in the nursery with net. Mechanical hand picking and destruction of the affected part along with the larvae. Place pheromone traps @ 100nos./ha. Spray neem- garlic emulsion (2%). Spray Bt available as Dipel, Delphin, Halt, Bioasp, Biolep (0.7ml/litre). Use S- NPV (250 LE/ha). Spray leaf extract of ailanthus and cashew (10%).
	Red spider mite	Spray water using sprayer. Spray rice gruel water on under surface of leaves. Spray castor oil-soap emulsion or neem oil- garlic emulsion (2%).
	Hopper	Spray neem-garlic emulsion (2%)or products like Nimbicidin/ Econeem/Uneem (2ml/litre). Spraying of lemongrass/ ginger extract (10%) is also effective.
	Epilachna beetle	Spray soap-garlic-castor oil emulsion (2%). Collect and kill all stages of thepests. Spray Clerodendron plant extract 4-8% or Custard apple seed extract 2-5%
Tomato	Fruit borer	Spray Neem seed kernel extract 5%.Use H-NPV (250 LE/ ha). Spray Bt. Spray Pongamia oil (2%). Apply Pongamia or neem cake 250 kg/ hectare at plantingand repeat 2 or 3 times at 30 to 45 days interval
	Serpentine leaf miner	Spray Neem oil-garlic emulsion (2%) before 8'O clock in the morning. Apply neem cake to soil (250kg/ha). Spray neem oil, marotti oil or illupai oil 2.5% or spray neem seed kernel extract 4%.
Crop	*Pest*	*Control measures*

Crop	Pest	Control measures
Chilli, brinjal & tomato	Nematode	Apply Eupatorium and neem leaves, neem cake, rice husk, wood shavings, and castorcake @ of 100g /m2. Apply VAM, Plant Growth Promoting Rhizobacteria, and Paceilomyces to soil @ 2kg /ha. Seed treatment with *Bacillus macerans* @ 3% w/w (2.5 kg/ha) and drenching *withB.macerans* @ 3% solution 30 days after sowing.

Table-04: Diseases and their control

Crop	Disease	Control measures
Chilli, & tomato	Dampingoff	Sow the seeds in raised beds prepared in brinjal open area during summer months. Pre inoculation of AMF in furrows @ 200g/m2. Apply lime in nursery bed. Use *Trichoderma*, *Pseudomonas fluorescens* and PGPR mix II. Neem cake canbe applied @ 250 kg/hectare to reduce soil innoculant.
	Leaf spot	Spray *Pseudomonas fluorescens* (2%) SprayBordeaux mixture (1%).
	Bacterial	Cultivate resistant varieties (KAU). Use lime in the field. Cultivate wilt marigold in field prior to tomato cultivation. Soil application of*Pseudomonas fluorescens* or PGPR mix II@ 20g/litre at 15 days interval. Seedling root dip and foliar spray of *Pseudomonas fluorescens* 1-2%.
Chilli	Leaf curl virus	Spray neem based insecticides (2ml/litre) to control the vectors. Grow resistant varietieslike Punjab Lal & Pusa Sadabahar.
Tomato		Spray neem based insecticides (2ml/litre) to control the vectors. Grow 5-6 rows of maize around the crop atleast 50 days before transplanting tomato. Keep the plot weed free.

Storage of seeds

Packaging of seeds in polythene cover (700 gauges) increases the storage life upto 7 months. Seeds treated with Trichoderma and Pseudomonas (each @ 6g/kg seed) can be stored upto 5 months.

LEGUMINOUS VEGETABLES

COWPEA

Vegetable cowpea includes bush type (*Vigna unguiculata* subsp*.unguiculata***)** and yard long bean (*Vigna unguiculata* subsp*.sesquipedalis***)** Cowpea can be grown throughout the year under Kerala conditions. It can be grown as a pure crop in single-cropand double-crop rice fallows during *rabi* and summer seasons. Cowpea can be grown in homestead garden throughout the year and in kole lands of Trichur district during summer where rice crop cannot be raised due to water scarcity.

Season

Cowpea can be grown in any season. As a rainfed crop, sowing is done inthe month of June. The most suitable time is after the first week of June. During the second crop season, sowing can be done during September- October. During summer, cowpea can be sown during January- February.

Varieties

a. Bush type: Bhagyalekshmy, Pusa Barsathi, Pusa Komal

b. Semi trailing: Kairali, Anaswara, Varun, Kanakamony, Arka Garima

c. Yard long bean: Sharika, Malika, Vaijayanthi, Lola, Vellayani Jyothika

Sowing / Spacing

Plough the land thoroughly 2-3 times and remove weeds and stubbles. For bush vegetable type, spacing of 30 cm between rows and 15 cm between plants is suitable. For semi-trailing varieties, provide a spacing of 45cm x 30 cm. Trailing varieties can be sown in pits (@ 3plants / pit) at 2m x 2 m spacing for trailing on pandal or in channels at 1.5m x 45cm spacing for trailing on trellis.

Seed inoculation and seed pelleting

Cowpea seeds should be inoculated with Rhizobium and pelleted with lime.

Procedure for Rhizobium inoculation

The content of each packet of Rhizobium inoculum is sufficient for seeds to be sown in the area indicated in the packet (250 to 375 g/ ha). Usethe inoculant only for the specific leguminous crop mentioned on packet before the expiry date.

Do not expose the Rhizobium culture to direct sunlight or heat. Mix the inoculant uniformly with the seeds by using minimum quantity of either 2.5% starch solution or `*kanjivellam* in order to ensure better stickiness of the inoculant with the seed. Take care to avoid damage to the seed coat. Dry the inoculated seed under shadeover a clean paper or gunny bag and sow immediately. The Rhizobium culture or the inoculated seeds should not be mixed with chemical fertilizers. Vermicompost can also be used for coating seeds.

Procedure for lime pelleting

1. Add finely powdered (300 mesh) calcium carbonate to moist fresh Rhizobium treated seeds and mix for 1- 3minutes until each seed is uniformly pelleted. Depending on the seed size, the following quantity of lime will be required.
   a. Small seeds: 1.0 kg/ 10 kg of seed
   b. Medium sized seeds: 0.6 kg/ 10 kg of seed
   c. Large sized seeds: 0.5 kg/ 10 kg of seed
2. Spread out the pelleted seeds on a clean paper to harden. Sow themas soon as possible. However, lime pelleted seeds can be stored up to one week in cool place before sowing.

Note-

i) Lime coating of seeds is required only for seeds that are to be sown inacidic soils.

ii) Ordinary agricultural lime is not good for pelleting because of its large particle size.

iii) Hydrated lime should not be usedfor pelleting.

iv) The dry pellet should be firm enough to resist moderate pressure. It should appear dry without loose lime on the surface or in the container.

v) The lime pelleted seeds can be mixed with the fertilizer and sown. However, the period of contact between the fertilizer and the pelleted seeds should be as short as possible.

vi) Pelleted seeds should not be sown into a dry field.

Manuring

FYM – 20t/ha

Lime – 250 kg/ha or dolomite 400 kg/ha.

Lime may be applied at the time of the first ploughing.

In addition, apply any of the following combination as supplement FYM /Cowdung @ 2 t/ha + Rock phosphate 100 kg/ha Compost @ 4 t/ha + Rock phosphate 70 kg/ ha

Vermicompost @ 2 t/ha + Rock phosphate 110 kg/ha Greenleaf @ 3.5 t/ha + Rock phosphate 100 kg/ha Poultry manure @ 1.5 t/ha + Rock phosphate 50 kg/ha

(Note: The quantity of Rock phosphate can be reduced to 50% bypriming it with the manures and the entire quantity of rock phosphate should be applied as basal dose).

The additional organic manures can be applied in splits at fortnightly interval.

Bio fertilizers: AMF / Phosphorus solubilising micro-organisms @1g per plant at the time of sowing increases the P availability.

Growth promoters: Foliar application of growth promoters like panchgavya or vermiwash at fortnightly intervals increases marketable yield.

After cultivation

Hoeing gives adequate aeration to the soil and help the root system tospread easily. Pruning excessive vegetative growth is advantageous for increased flowering and fruiting. For yard long bean, provide trellis or pandal for trailing as soon as they start vining.

Irrigation

Ensure steady supply of water. Avoid too heavy irrigation as it encourages profuse vegetative growth. Irrigation at the flowering stage induces better flowering and fruit set.

Plant ProtectionPests

1. **Pea aphid (*Aphis craccivora*)**

   This is a major sucking pest. Spray Neemazal T/S 1% @ 2 ml / litre at fortnightly intervals for managing pea aphid in cowpea.

   The fungus *Fusarium pallidoroseum* can be used for controlling peaaphid. Bran based fungus can be applied @ 3 kg per 400 m2 immediatelyafter infestation is observed. Only one application is necessary. *Hyptis suaveolens* extract (1 litre) + 60 g soap (in ½ litre water), dilute the mixture 10 times and spray.

   General measure: Spray leaf extract of *Strychnos nuxvomica* + soap. Dilute with water and spray.

2. **Jassids and white flies**

   Spray neem seed kernel extract 5%.

3. **American Serpentine leaf miner (*Liriomyza trifolii*)**

   This is the major pest of cowpea. Adoption of the following methods willreduce the infestation of the pest.

   Destruction of the weed host plants viz. *Achyranthus aspera, Amaranthusviridis, Cleome viscosa, Heliotropium indicum* and *Physalis minima.*

   Need based application of neem oil, marotti oil or illupai oil @2.5 %. Cultivate tolerant accession (VU-12).

4. **Pod borers**

   Spray diluted cow's urine + asafoetida + bird chilli extract. Apply neemcake

@ 250 kg/ha at flowering.

Apply neem seed kernel extract 5%

5. **Leaf folder**

Collect leaf folds and destroy the larvae.

6. **Pod bugs**

Collect with sweep net and destroy different stages of the bug. Wet thecrop canopy to destroy young ones.

Destroy weed host plants. Spray amruth neem 5ml/ litre.

Spray nimbicidin 2 ml / litre or neemazal 2 ml / litre or neem seed kernelextract 5%.

7. **Pea stem fly**

Increase seed rate in endemic areas.

8. **Red spider mite**

Apply neem oil 5% / neemoil garlic emulsion 2% / garlic emulsion 2% / fish oil soap 2.5%

9. **Root knot nematode and reniform nematode**

Apply neem or *Eupatorium* leaves @ 15 t/ha, two weeks before sowing.

10. **Pulse beetle**

Smear the seeds with coconut oil or ground nut oil 1:100 (W/W) Apply dry, powdered rhizome of *Acorus calamus* @1kg/ 100kg seed.

Diseases

1. **Soil borne diseases and nematodes**

Follow soil solarisation using 150-gauge clear polythene sheets. Coverthe soil with these sheets in sunny summer days after slightly moisteningthe soil. The soil temperature will reach as high as 52oC. Continue the polymulch for 1 week during which the soil temperature will rise and kill the soil borne fungi, bacteria, nematodes and weeds near the soil surfaceand thereby reduce the soil inoculum load. Soil drenching with 1%Bordeaux mixture or 2% Pseudomonas protects the crop form fungal diseases.

2. **Collar rot and web blight (*Rhizoctonia solani)***

- Apply neem cake @ 250 kg/ha Reduce soil moisture
- Use organic manure enriched with *Trichoderma viride* and drench with 2% *Pseudomonas.*

3. **Fusarium wilt (*Fusarium oxysporum*)**

Burn trashes in the pit before sowing. Remove and burn the affected plants along with the root system. Seed treatment with *Trichoderma viride* @2 g/ kg seed + soil application of 2.5 kg/ha at 30 DAS coupled with soil application of

neem cake @150 kg/ ha at the time of land preparation reduce the incidence of *Fusarium* wilt.Drenching with 2 % *Pseudomonas.*

4. Dry root rot

Treat the seeds with *Trichoderma viridae*@ 4g/kg, *Pseudomonas fluorescens* @10g/ kg or soil application of neem cake @ 250kg/ ha. Soil drenching with 2 % (20 g /litre) *Pseudomonas.*

General

Spray 1% Bordeaux mixture to protect the crop form fungal diseases.This will also avoid the entry of white flies which transmit the variousviral diseases.

DOLICHOS BEAN (*Dolichos lablab*)

Dolichos bean is a hardy crop and suitablefor cultivation in homesteads. Pole and bush varieties are available.

Season

The pole types are short day types and sownduring July-August. The bush types can be grown throughout the year.

Varieties

Pole type: Pusa Early Prolific, Hima, Grace Bush type: Arka Jay, ArkaVijay.

Sowing

Pole varieties are sown in pits (three plants / pit) at a spacing of 1.25m x

0.75 m and bush types are sown in ridge and furrow system at a spacing of 60cm x 15 cm. The pole types are trailed over pandals, trellis or stakes.

Manuring

- FYM – 20 t/ha as base.
- In addition, apply any one of the following combinations as supplement.
- FYM / Cowdung @ 4 t / ha + Ash125 kg / ha + Rock phosphate300 kg / ha Compost 8 t / ha + Ash 100 kg / ha +Rock phosphate

  200 kg / ha Vermicompost 4 t / ha + Ash 100 kg / ha + Rock phosphate 300 kg / ha Greenleaf 7 t / ha + Ash 100 kg / ha + Rock phosphate 300 kg / ha
- Poultry manure 3 t / ha + Ash 200 kg / ha + Rock phosphate 150 kg / ha

(**Note:** The additional organic manures may be applied in several splits at 10-14 days interval. Quantity of Rock phosphate can be reduced to 50% by priming it with the manures).

Biofertilizers

Seeds should be inoculated with Rhizobium and pelleted with lime. Application of AMF/ Phosphorus solubilising micro-organisms @1g per plant at the time of sowing increases the P availability.

Growth promoters

Foliar application of growth promoters like panchgavya or vermiwash at fortnightly intervals increases marketable yield.

After cultivation

Hoeing gives adequate aeration to the soil and help the root system to spread easily. Pruning excessive vegetative growth is advantageous for increased flowering and fruiting. For pole types, provide trellis or pandal for trailing as soon as they start vining.

Irrigation

Ensure steady supply of water. Avoid too heavy irrigation as it encourages profuse vegetative growth. Irrigation at the flowering stage induces better flowering and pod set.

Plant protection

The control measures recommended for cowpea are effective in this crop also.

WINGED BEAN (*Psophocarpus tetragonolobus*)

Winged bean is suitable for cultivation inhomesteads.

Season: The winged bean is a short day crop and sown during August - September.

The bush types can be grown throughout theyear.

Varieties

Revathy, PT 62, PT 16, PT 2

Sowing / Spacing

Seed rate: 15- 20 kg/ha

Spacing: 1.25m x 0.50m. They are trailed over pandals, trellis or stakes.

Manuring

- FYM – 20 t/ha.
- In addition, apply any one of the following combinations assupplement.
- FYM / Cowdung @ 4 t / ha + Ash125 kg / ha + Rock phosphate300 kg / ha Compost 8 t / ha + Ash 100 kg / ha +Rock phosphate

  200 kg / ha Vermicompost 4 t / ha + Ash 100 kg / ha + Rock phosphate 300 kg / ha Greenleaf 7 t / ha + Ash 100 kg / ha + Rock phosphate 300 kg / ha.
- Poultry manure 3 t / ha + Ash 200 kg / ha + Rock phosphate 150 kg / ha
- (Note: The additional organic manures may be applied in several splits at 10-14 days interval. Quantity of Rock phosphate can be reduced to 50% by priming it with the manures).

Biofertilizers

AMF / Phosphorus solubilising micro-organisms @1g per plant at the timeof sowing increases the P availability.

Growth promoters

Foliar application of growth promoters like panchgavya or vermiwash atfortnightly intervals increases marketable yield.

After cultivation

Hoeing gives adequate aeration to the soil and helps the root system to spread easily. Pruning excessive vegetative growth is advantageous for increased flowering and fruiting. Provide trellis or pandal for trailing as soon as they start vining.

Irrigation

Ensure steady supply of water. Avoid too heavy irrigation as it encourages profuse vegetative growth. Irrigation at the flowering stage induces better flowering and pod set.

Plant protection

The crop is comparatively free from pests and diseases.

CLUSTER BEAN (*Cyamopsis tetragonoloba*)

Cluster bean is a hardy crop suitable for cultivation under adverse soil and climaticconditions.

Season: The cluster bean seeds are sown during February – March and June – July.

Varieties

Pusa Naubahar and Pusa Sadabahar.

Sowing

Seed rate: 10- 12 kg/ha

Spacing: 45 – 60cm x 20- 30 cm.

Manuring

- FYM – 25t/ha
- In addition, apply any one of the following combinations as supplement FYM / Cow dung 2 t / ha + Ash 750 kg / ha + Rock phosphate 200 kg / ha Compost 4 t / ha + Ash 625 kg / ha + Rock phosphate 140 kg / ha Vermi compost 2 t / ha + Ash500 kg / ha + Rock phosphate 220 kg / ha Greenleaf 3.5 t / ha + Ash500 kg / ha + Rock phosphate 200 kg / ha.
- Poultry manure1.5 t / ha + Ash 825 kg / ha + Rock phosphate 100kg / ha.

(**Note:** The additional organic manures may be applied in several splits at fortnightly interval. Quantity of Rock phosphate can be reduced to 50% by priming it with the manures).

Biofertilizers:

AMF / Phosphorus solubilising micro-organisms @1g per plant at the timeof sowing increases the P availability.

Growth promoters:

Foliar application of growth promoters like panchgavya or vermiwash atfortnightly intervals increases marketable yield.

After cultivation

Hoeing gives adequate aeration to the soil and help the root system tospread easily.

Irrigation

Ensure steady supply of water. Avoid too heavy irrigation as it encourages profuse vegetative growth. Irrigation at the flowering stage induces better flowering and pod set.

Plant protection

The crop is comparatively free from pests and diseases.

PERENNIAL VEGETABLES

DRUMSTICK (*Moringa oleifera* L.)

Drumstick is a traditional multipurposevegetable of Kerala. It thrives in almost all the soils of Kerala. However, it prefers well drained loamy soils. It is better to avoid heavy clayey soils and water stagnated areas.

Varieties / Cultivars

There are two types

a) Propagated by limb cuttings : MO-144, Jaffna, Palmuringa

b) Seed propagated : AD- 4 (TNAU varieties such as PKM 1 and PKM 2 are suited for adjoining dry border regions of Kerala such asErithiyampathi, Chittoor, Menonpara)

Seed rate

Cuttings: 625nos. / ha Seeds: 325 g/ha.

Preparation of planting materials

a) Limb cuttings: One-year-old cutting of 1 to 1.5m length and 15- 20cm girth is ideal for planting. The fresh cuttings are not advised toplant on the same day of cutting from the mother plant. They are kept under shade for one week in a slanting position so that the basal cut end become dry before planting.

b) Seedlings: For getting good establishment in the main field, healthy seedlings have to be raised. The seeds are sown in the polythene bags filled with potting mixture, kept in open area and irrigated daily. The seeds start germination within a week and the seedlings will be ready for planting about three to four weeks after sowing.

Time of planting in the main field

Pre- southwest monsoon period April- May is most ideal for planting both types of drumsticks.

Land preparation and planting

Select the site that receives direct sunlight, as drumstick never tolerates shade. Land is made free of weeds and pits of 60cm x 60cm x 60cm size are made. The pits are partly filled with topsoil and manures and left as such for two weeks before planting. The cuttings/ seedlings are planted in the pits. In the case of seedlings, care should be taken to avoid root damage while removing the polybags. Shade should be given for the seedlings for 3-4 days after planting.

Spacing

Both types of drumsticks can be planted at a spacing of 4m x 4m

Manuring

Apply the following organic manures at the time of planting and repeat the application every year during April – May.

- Powdered cow dung 10 to 15 kg/ pit Neem cake 1.5 to 2 kg/pit
- Rock phosphate 0.50kg/ pit
- Wood ash 1.0kg/ pit.

After cultivation

Irrigate the crop once in a week during summer. Stake the seedlingplants if necessary. As far as possible keep the tree basins free of weeds.Mulching the basins with dry leaves is ideal. Avoid irrigation during the pre-bearing periods. After flowering, irrigation increases fruit set and fruitweight. In the case of seed drumstick, the tip of the seedling has to be pinched off after attaining a height of 1 -1.5 m to enhance the productionof lateral branches.

Plant protection

- Green caterpillar and hairy caterpillar are the common pests which can be controlled by neem based insecticides (2ml/litre) and tobacco decoction.
- Stem borer is a problem in some areas and it can be managed byBt formulations such as Dipel /Delphin / Halt (0.7%).
- For the control of *Fusarium* wilt, soil application of *Trichoderma* (2.5kg/ha) and drenching with 2% *Pseudomonas* are effective.

Yield

High yielding drumstick varieties will bear 250 to 275 fruits /tree/yearrecording 30 to 35 t /ha.

AMARANTH *(Amaranthus spp.)*

Amaranth is the most popular leafy vegetable of Kerala. Though it can be grown throughout the year, summer is found to be the best season.

Varieties

Red : Kannara local, Arun, Krishna SreeGreen : Co-1, Co-2, Co-3 and Mohini Mixed type : RenuSree

Note : Kannara local is a season bound variety, which comes to flowering in November-December.

Seed rate : 1.5 to 2 kg/hectare

Method of planting:

Direct sowing and transplanting.

Nursery

Solarization of the nursery bed before sowing and seed treatment with *Pseudomonas* (10 g/kg seed) can control nursery diseases. Apply FYM 10 kg enriched with Trichoderma, Neemcake 50 g, PGPR mix 1- 100 g and AMF 200 g/m2.

Main field

Prepare the land by ploughing or digging followed by levelling.Shallow trenches of width 30-35cm are made at 30 cm apart. Transplant20-30 days old seedlings in the shallow trenches at a distance of 20 cmin two rows. During rainy season, planting shall be done on raised beds. Before planting, dip the roots of the seedlings in a solution containing*Pseudomonas* 20 g/litre for 20 minutes.

Manuring

Apply FYM or compost @25t/ha as basal dose. *Trichoderma*, PGPR mix 1 @2.5 kg/ha each are mixed with FYM and kept for 10-15 days at cool atmosphere. These are applied to the soil as basal dose. Top dressing can be done with any of the following manures at 7-10 days interval.

1. Soil application of fresh cowdung slurry @ 1 kg/10 litres (50 kg ha)
2. Application of biogas slurry @ 1 kg/10 litres (50 kg/ha)
3. Application of cow's urine 500 litres/ha (8 times dilution)

4. Application of vermiwash-500 litres/ha (8 times dilution)
5. Application of vermicompost - 1 t /ha.
6. Application of groundnut cake-1 kg/10 litres (50 kg/ha)

Foliar spray can be given with cowdung slurry/ vermiwash/ cow's urine after each harvest.

After care

Give presowing irrigation, if the soil is not moist enough. Provide mulch in the field throughout the crop period with materials like green leaves, plant residues, decomposed coirpith, straw etc. During summer, irrigate at intervals of 2 to 3 days. Conduct weeding regularly and earth up rows during rainy season.

Plant protectionPests

Leaf webber and leaf roller can be controlled mechanically by collecting and destroying them. Dipel or Halt (0.7 ml/litre) can be sprayed for controlling leaf webber. Apply 4% leaf extract of neem, thevetia orclerodendron with soap water.

Diseases

Leaf spot is a serious disease in rainy season and it can be controlled to acertain extent through an integrated approach.

1. Grow leafspot resistant varieties like Co-1
2. Seed treatment with *Pseudomonas* 8 g/kg of seed.
3. Soil application of *Trichoderma* as enriched cowdung- neem cake manure.
4. One kg of fresh cowdung is put in 10 litres of water and the clear solution after filtering the supernatant liquid is sprayed at regular intervals.
5. Soil application of green manures like sunnhemp/glyricidia + neemcake (100kg/ ha) + *Trichoderma* (1-2 kg/ha) is found to be effective against leaf spot disease.

OKRA (*Abelmoschus esculentus*)

The three main planting seasons for okra are January-February, May-June and September-October.

Varieties

Green/light green fruited: Pusa Sawani,Kiran, Salkeerthi, Susthira, Arka Anamika

Red fruited: Co-1, Aruna Yellow vein mosaic

resistant /tolerant varieties : Arka Anamika, Arka Abhay, Susthira, P7, Varsha Uphar (all green fruited).

Seed rate

The seed rate is 8.5kg/ha for the summer crop sown in January -February and 7 kg/ha for *kharif* crop.

Storage of seeds

Packaging of okra seeds in polythene cover (700 gauges) increases the storage life upto 7 months. Seeds treated with *Trichoderma* and *Pseudomonas* can be stored upto 5 months.

Sowing

- Sow the seeds at a spacing of 60 cm between rows and 45 cm between plants for *kharif* crop and 60cm X 30cm for summer crop. 45cm x 45cm spacing is also found ideal.
- Seed soaking in double the volume of water (Hydro priming) for 2 hours improved germination and vigour of the seeds. For thesummer crop, soaking time can be prolonged for 16 hours before sowing.
- Seed treatment with *Pseudomonas* (8g/kg of seed) improves germination and vigour of seedling. Ensure sufficient moisture inthe field right from the time of sowing of seeds.

Manuring

Apply lime @500 kg/ha based on the acidity of soil 15 days before sowing. Apply FYM or compost @25t/ha as basal dose. *Trichoderma*, PGPR mix 1 @ 2.5 kg /ha each are mixed with the FYM and keep for 15 days at cool atmosphere. These are applied to the soil as basal alongwith *Pseudomonas* @ 2 kg/ha.

Top dressing

Top dressing can be done at 10-15 days interval with any one of thefollowing

1. Soil application of fresh cowdung slurry @ 1 kg/10 litres (50 kg/ha)
2. Application of biogas slurry @ 1 kg/10litres (50 kg/ha)
3. Application of cow's urine 500 litres/ha (8 times dilution)
4. Application of vermiwash-500 litres/ha (8 times dilution)
5. Application of vermicompost - 1 t /ha
6. Application of groundnut cake1 kg/10 litres (50 kg/ha)

   Foliar spray can be given with supernatant solution of cowdung slurry/ vermiwash/ cow's urine upto flowering.

After care

Give pre-sowing irrigation, if the soil is not moist enough. Provide mulch in the

field throughout the crop period with materials like green leaves, plant residues, decomposed coirpith, straw etc. During summer, irrigate the crop at intervals of 2 to 3 days. Conduct weeding regularly and earth up rows during rainyseason.

Plant protectionPests

The important pests are jassids, fruit and shoot borer and root knotnematode.

Jassids

Use neemoil-garlic mixture (2%) / nimbicidine(2ml/litre) / econeem(2ml/litre) / uneem(2ml/litre).

Lemongrass suspension (10%) can also be used for the control.

Fruit and shoot borer

1. Remove and destroy affected shoots and fruits
2. Spray with neem kernel suspension (5%)/ ginger suspension(10%)/ neem leaf extract (4%)
3. Use *Trichogramma chilonis* and *Trichogramma japonicum* @1 cardeach/5 cents followed by *Bacillus thuringiensis* spray (Delphin/Bioasp/Halt-0.7ml/litre)
4. Apply *Beauveria bassiana* 10% WP

Bhindi leaf roller

1. Collect and destroy the leaf rolls
2. Apply *Beauveria bassiana* 10% WP

Root knot nematode

1. Apply neem leaves or *Eupatorium* leaves @ 250 g/plant in basins one week prior to planting and water daily. The effect of thistreatment persists upto 75 days after sowing in summer season.
2. Apply neem cake/castor cake @ 1 t/ha or growing of marigold (trapcrop) in between okra plants.
3. Seed treatment with *Bacillus macerans* @ 3% w/w (2.5 kg/ha) and in heavily infested area, seed treatment with *B. macerans* @ 3% w/w and drenching *with B. macerans* @ 3% solution 30 days after sowing.

Diseases

Yellow vein mosaic

Vein clearing and vein chlorosis of leaves are the characteristic symptoms. The yellow network of vein is very conspicuous and veins andveinlets are thickened. Fruit become small and yellowish green in colours. Whitefly (*Bemisia tabaci*) and leaf hopper (*Amrasca biguttula*) are the vectors of this virus. Spraying neemoil-garlic mixture (2%)or nimbicidine/ econeem/ uneem (2ml/litre). Use of disease resistant varieties (Arka Anamika, Arka Abhay and Susthira) and destruction of host weeds (*Croton sparsiflora* and *Ageratum sp*.) are also effective.

TUBER CROPS

AMORPHOPHALLUS (*Amorphophallus paeoniifolius*)

Amorphophallus requires fairly long growing season and a rainfall of about 150 cm duringthe crop period. A well-drained soil of medium texture is suited for this crop.

Season

Corm pieces are normally planted during February-March, before the onset of monsoon.

Varieties

Sree Padma: The crop matures in 8-9 months. Cooked tubers are free from acridity.

Land preparation

Dig pits of 60cm x 60cm x 45 cm size at 90 cm apart. Collect the topsoilto a depth of 15-20 cm separately and fill it after the pits are formed. Apply cow dung or compost @ 2-2.5 kg/pit and mix with topsoil.

Preparation of planting material and planting

Corm pieces each weighing about 1 kg are ideal for planting. While cutting the corm, care should be taken to see that each piece contain a portion of the terminal bud. Dip the corm pieces in cow dung slurry enriched with *Trichoderma* and allow to dry under shade before planting. Nematodes associated with amorphophallus can be controlled by seed material treatment with talc based formulation of *Bascillus macerans, Paecilliomyces lilacinus* @ 3 g (10^6 cfu/g) / kg of corms. Plant one corm piece /pit in the upright position. After planting, cover the pits with dried leaves or other mulching materials. About 12,000 corm pieces weighing about 12 t are required for planting one hectare. Most of the seed material will germinate within one month after planting.

Minisett planting

Planting of minisett/cormel transplant gives better yield than traditional method. Cormels/ minisetts each weighing 75-100 g can be planted directly in nursery beds at a spacing of 90cm x 30 cm.

Manuring

Sow green manure seeds (cowpea/ sunnhemp) @30kg/ha at the time ofplanting

setts/ with the receipt of pre monsoon showers. 10 kg P2O5 as Rock phosphate has to be applied for the green manure crop at sowing time. At flowering (45-50 DAS) incorporate the green manure plants, along with 5t FYM / 2t poultry manure/ 2t vermi compost / 2t coirpith compost and 3t of wood ash. If insitu green manuring is not possible it can be substituted with 6t/ha of FYM. One month after incorporation do the one more weeding and earthing up. Application PGPR mix I increases the availability of N, P and K.

Plant protection

Mealy bugs usually attack the corm both in the field and store. Avoid planting corms already infested. As a prophylaxis, dip the planting material in *Clerodendron* decoction of 4% strength for 10 minutes.

Harvesting

The crop will be ready for harvest 8-9 months after planting.

COLOCASIA [TARO] (*Colocasia esculenta*)

Colocasia is a crop of tropical and sub-tropical regions and requires a warm humid climate. Under rainfed conditions, it requires a fairly welldistributed rainfall around 120-150 cm during the growth period. Well-drained soil is suitable for uniform development of tubers.

Season

Rainfed crop: May-June to Oct-Nov Irrigated crop: Throughout the year.

Varieties

Sree Rashmi, Sree Pallavi and Sree Kiran are the improved varieties

Seeds and sowing

- Use side tubers each of 25-35 g for planting. About 37,000 side tubersweighing about 1200 kg are required to plant one hectare.
- Plough or dig the land to a depth of 20-25 cm and bring to a fine tilth. Make ridges 60 cm apart. Plant the side tubers at a spacing of 45 cm on the ridges.

Mulching

Soon after planting, cover the ridges with suitable mulching materials forretention of moisture and to control weeds.

Manuring

Apply cattle manure or compost @ 12 t/ha as basal dressing, while preparing the ridges for planting. Sow green manure seeds (cowpea / sun hemp) @30kg/ha at the time of planting with the receipt of pre monsoon showers. 10 kg P_2O_5 as Rock phosphate has to be applied for the green manure crop at sowing time. At flowering (45-50 DAS) incorporate the plants, along with 4t FYM /2t poultry manure / 2t vermi compost / 2t coirpith compost and 1500kg wood ash. If *insitu* green manuring is not possible, it can be substituted with 5t of FYM + 500kg ash / ha. Biofertlizer PGPR mix I may also apply along with FYM.

After cultivation

Intercultivation is essential in colocasia. Weeding, light hoeing andearthing up are required at 30-45 days and 60-75 days after planting. The leafy parts may be smothered about one month before harvest so as to enhance tuber development.

Irrigation

Ensure sufficient moisture in the soil at the time of planting. For uniformsprouting, irrigate just after planting and one week later. Subsequent irrigation may be given at 12-15 days intervals, depending on the moisture retention capacity of the soil. The irrigation should be stopped 3-4 weeks before harvest. About 9-12 irrigations are required for the crop till harvest. In the case of rainfed crop, if there is prolonged drought, supplementary irrigation is required.

Plant protection

To check the incidence of leaf diseases like blight, give prophylactic spray of *Pseudomonas* 1-2%. For controlling serious infestation of aphids, apply tobacco decoction/ *Lantana* decoction + soap solution. Leaf feederscan be controlled by applying *Clerodendron* decoction (4%).

Harvesting

Colocasia becomes ready for harvest five to six months after planting.

The mother corms and side tubers are separated after harvest.

Storage of seed material

The side tubers for use as planting materials are to be stored properly.

Keep the seed tubers in sand spread over the floor to avoid rotting.

DIOSCOREA (YAMS)
GREATER YAM (*Dioscorea alata*)

Dioscorea alata is predominantly a tropical plant. The crop cannot withstand frost and excessively high temperatures. Temperature around 30ºC and rainfall of 120-200 cmdistributed throughout the growth period areideal. Day length greater than 12 hours during initial stages and shorter day length during the later part of the growing season favour satisfactory tuber formation. Yam requires loose, deep, well-drained, fertile soil. The crop does not come up wellin waterlogged conditions.

Season

Seed tubers are normally planted during the later part of the dry season (March-April) and start sprouting with the onset of pre-monsoon showers. Ifthe planting is delayed, yams start sprouting in storage, which is not desirable for planting.

Varieties

- Sree Keerthi*:* Suitable for intercropping in mature coconut garden and with banana. Sree Roopa: Possesses excellent cooking quality.
- Indu: This is recommended as a pure crop and also as an intercrop of coconut in the reclaimed alluvial soils of Kuttanad.
- Sree Shilpa: This is the first hybrid having good culinary quality. The crop matures early, within 8 months. The tubers have 33-35% dry matter, 17-19% starch, 1.4-2% protein and 0.8-1.2% sugar.
- Sree Karthika: High yield, excellent cooking quality. The crop matures within 9 months.

The tubers have 21.42% starch, 1.14% sugar and 2.47% crude protein.

Seeds and sowing.

D. alata produces mostly a single big tuber in which only one head end of the tuber is available as good seed material. For getting the head end in maximum number of propagation units, the whole tuber is first cut longitudinally and then horizotally. Each piece should weigh at least 250-300

g. Dip the pieces in cowdung slurry and allow to dry under the shade beforeplanting. About 2500-3000 kg of seed material is required to cover one hectare of land.

Preparation of land

Plough or dig the land upto a depth of 15-20 cm. Dig pits of size 45 cm^3at a distance of 1m x 1m. Apply 1-1.25 kg cattle manure or compost /pit, mixwith topsoil and fill up three fourth of the pits. Plant the cut tuber pieces andcompletely cover the pits with leafy materials to conserve soil moisture and maintain optimum temperature.

Manuring

Apply cattle manure or compost @10-12 t/ha or 1-1.25 kg cattle manureor compost / pit as basal dose. Sow green manure seeds (cowpea/ sun hemp) @30kg/ha at the time of planting with the receipt of pre monsoon showers. 10 kg P_2O_5 as Rock phosphate has to be applied for the green manure crop at sowing time. At flowering (45-50 DAS) uproot and incorporate the green manure plants, along with 4t FYM / 2t poultry manure / 2t vermi compost / 2t coirpith compost + Azospirillum & P solublising organisms @ 2 kg/hectare or PGPR mix I. If *insitu* green manuring is not possible it can be substituted with 6t/ha of FYM.

Plant protection

Yam scale and mealy bugs are found to infest the corms both under fieldand storage situations. As a prophylactic measure, dip the planting material in4% *Clerodendron* decoction for 10 minutes.

Trailing

Trailing is essential to expose the leaves to sunlight. Trailing has to be done within 15 days after sprouting by coir rope attached to artificial supports in the open areas or to trees where they are raised as an intercrop.When grown in open areas, trail to a height of 3-4 m. Trail the vines properly as and when side shoots are produced.

Harvesting

The crop becomes ready for harvest within 8-9 months after planting. When the vines are completely dried up, dig out the tubers without causing injur

LESSER YAM (*Dioscorea esculenta*)

It is grown in a similar agro-climatic situation asthat of *D. alata*. Planting season and manuring are also similar.

Varieties

- Sree Latha: This is a selection from Thiruvananthapuram district with a duration

of 8 months. Tubers are oblong to fusiformwith creamy white flesh.

- Sree Kala: This is an early variety with 7.5 months duration. Thetuers have 35-37% dry matter, 23-25% starch and 1-1.3% sugar.

Seeds and sowing

Select medium size tubers weighing about 100-150 g each. Plant the whole tuber, one in each mound and cover completely with soil. Mulch the mounds to maintain optimum temperature and moisture. To plant one hectare, 1800-2700 kg of seed materials are required.

Preparation of land

Plough or dig the land to a depth of 15-20 cm. Prepare mounds at a spacing of 75cm x 75 cm. Incorporate cattle manure @ 1 kg per mound.

Manuring

The manure dose and schedule of application are the same as that of *D. alata*.

Trailing

Trail the vines by fixing small poles attached with coir rope and direct 4-6 plants per pole.

Harvesting

The crop is ready for harvest by about 7-8 months time. Tuber yields of20-25 t/ha can be obtained by following the improved methods of cultivation.

WHITE YAM *(Dioscorea rotundata)*

White yam or African yam is a new crop species ofedible yam introduced from Nigeria.

Varieties

- Sree Subhra: The tuber contains 27-28%dry matter, 21-22% starch and 1.8-2% protein.
- It is drought tolerant with 9-10 monthsduration.
- Sree Priya: The tuber contains 25-27% dry matter, 19-21% starch and2-2.5% protein. It is drought tolerant and duration is 9-10 months. It is suitable for intercropping in mature coconut garden and with banana.
- Sree Dhanya: It is the first dwarf variety. The tubers have 28-30% dry matter,

22-24% protein and 0.3-0.5% sugar.

Cultivation practices are the same as that for greater yam.

Rapid seed yam production (minisett technique)

In this method clean and healthy yam tubers weighing about 1 kg are cut into cylindrical (disc-like) pieces, each about 5 cm thick. From each such piece, 2-4 small pieces (30 g) could be obtained by cutting the disc longitudinally or along the two perpendicular diameters. Such a piece is calleda "minisett". The minisetts are then spread out under light shade for anhour with cut surface facing up before planting them in the nursery seedbeds. The minisett takes 2-3 weeks for sprouting. At this stage, they are transplanted to the main field at a spacing of 50 cm on ridges taken 1 mapart.

SWEET POTATO (*Ipomoea batatas*)

Sweet potato requires a warm humid tropical climate with a mean temperature of about 22 ºC. Though sensitive to frost, it can also be grown in the hills up to an altitude of 1500- 1800 m as a summer crop. Under rainfed conditions the crop requires a fairly well distributed annual rainfall of 75-150 cm. Beinga photosensitive crop, sunny days and cool nights are favourable for better tuber development.

The crop can be grown on a variety of soils having good drainage, but grows best in fertile sandy loam soils. Heavy clayey and very light sandy soils are not suitable for proper tuber development.

Season

Rainfed crop: June-July, September-October

Irrigated crops: October-November (for uplands) and January-February (for low lands)

Varieties

Improved varieties: H-41, H-42, Sree Nandini, Sree Vardhini, Sree Retna, Sree Bhadra, Kanjanghad, Sree Arun, Sree Varun

Local varieties: Badrakali Chuvala, Kottayam Chuvala, Chinavella, Chakaravalli, Anakomban.

Preparation of land

Work the soil to a fine tilth by ploughing or digging to a depth of 15-25cm. Take ridges 25-35 cm high, 60 cm apart for planting vines.

Seeds and sowing

- Sweet potato is propagated by means of vine cuttings. To obtain vine cuttings, raise nurseries from selected tubers using the following method. 80 kg of medium sized weevil free tubers (each of 125-150 g) are required for planting in the primary nursery area (100 m^2 to plant one hectare).
- Plant the tubers at a spacing of 30-45 cm on ridges formed 60 cm apart in the primary nursery and multiply by planting the cuttings after 45 days on ridges in secondary nursery of out 500 m^2 area ata spacing of 25 cm.
- Apply 25 kg of poultry manure /100 m^2 about 15 days after planting in the primary nursery. To ensure better plant growth in the secondary nursery, 80 kg of poultry manure or 40 kg of poultry manure + cow dung slurry has to be applied in two split doses on 15th and 30th day after planting.
- Vines obtained from the freshly harvested crop can also be multiplied by planting in the secondary nursery to obtain sufficientplanting material.
- Cuttings from the apical and near apical portions of the vines are preferred for planting in the main field.
- Sweet potato vine cuttings with intact leaves are bundled, dipped in water, covered with banana leaves and kept under shade for two days prior to planting.
- Irrigate the nursery on every alternate day during the first 10 days and once in 10 days, thereafter.
- Vines will be ready for planting on the 45th day.

In the main field, plant vine cuttings of 20-25 cm length on ridges 60 cm apart and at a spacing of 15-20 cm between the vines. The cuttings can alsobe planted on mounds taken at a spacing of 75cm x 75 cm. On the top of each mound, 3-4 cuttings can be planted. Plant the vine cuttings with the middle portion buried deep in the soil and the two cut ends exposed to the surface. Ensure sufficient moisture in the soil for early establishment of the planted cuttings. Provide adequate drainage and prevent water logging.

Manuring

Apply cattle manure or compost @ 10t / ha at the time of preparation ofridges or mounds and 7.5t FYM / 3t poultry manure / 4t vermi compost / 4t coirpith compost + 1 t ash/ ha along with *Azospirillum* (2kg/ha) and P solublising organisms (2kg/ ha) or PGPR mix I (2.5 kg/ha) in two equal split doses at 2weeks and 5 weeks after planting. Inoculate AMF at the time of planting and dip vines in PGPR mix I before planting.

Irrigation

When grown as irrigated crop, provide irrigation once in 2 days for a period of 10 days after planting and thereafter once in 7-10 days. Stop irrigation 3 weeks before

harvest. But one more irrigation may be given 2 days before harvest.

Aftercultivation

Conduct two operations about 2 weeks and 5 weeks after planting. The top dressing with organic manures (2 t/ha) may be done along with the second weeding and earthing up. Prevent development of small slender tubers at the nodes by turning the vines occasionally during active growth phase.

Rotation and mixed cropping

Under irrigated condition, sweet potato can be rotated with rice and planted during December-January after harvest of the second crop of rice. As a mixed crop, it can be grown along with colocasia, amorphophallus etc. Under rainfed conditions, green manure crops such as kozhinjil and sunnhemp can be grown after the harvest of sweet potato and later incorporated into the soil at the time of land preparation for the succeeding crop.

Plant protection

Sweet potato weevil

1) Remove and destroy the crop residues of the previous crop.
2) Use healthy and weevilfree planting materials.
3) Apply *Eupatorium odoratum* leaves as mulch @ 3 t/ha at 30DAP.
4) Trap adult weevils using sweet potato tuber pieces (of about 6 cm diameter) of 100 g size, kept at 5 m apart during 50 to 80 DAP at 10 days interval. Tubers may be cut and kept inside wire cages to avoid rat damage.
5) Use pheromone traps (3Z Dodecenyl 2E butenoate).

Harvesting

The duration of the crop depends on the variety; but in general, the crop can be harvested in about 3.5-4 months after planting. Harvest the crop when leaves begin to turn yellow and the tubers mature. The maturity of tuber can be ascertained by cutting fresh tubers. The cut surface will dry clear if the tuber is mature and becomes dark green if immature. Harvest the crop by digging out the tubers without causing injury.

TAPIOCA [CASSAVA] (*Manihot esculenta*)

Tapioca grows and produces best under warm humid tropical conditions where rainfall is well distributed and fairly abundant. It can also be grown under irrigation where rainfall is low. Its outstanding characteristic in terms of moisture requirements is the ability to withstand fairly prolonged periods of drought. However, at the time of planting there must be sufficient moisture for the plant to establish itself. The crop cannot withstand cold andis killed by frost.

The crop grows well in well-drained laterite, gravelly and sandy loam soils. Heavy and rocky soils are less suitable because they restrict root development. The crop cannot survive waterlogged conditions and in such areas, it must be planted on mounds or ridges that permit drainage. The cropcan also be gown on hill slopes and on wastelands of low fertility.

Varieties

- M-4*:* This is an erect type with excellent cooking quality having 10months duration.
- The starch content is 29%.
- H-97: This is a semi-branching variety, tolerant to mosaic disease with duration of 10 months. But the harvest can be prolonged even up to 16 months. The starch content is 30%.
- H-165: This is a non-branching type with poor cooking quality having eight months duration. It is tolerant to mosaic but susceptible to wilt disease. The starch content is 24.5%.
- H-226: This is a semi-branching type with medium cooking quality having 10 months duration. It is moderately susceptible to mosaic. Thestarch content is 29%.
- Sree Visakham: This is a semi-branching type with yellow coloursed flesh having 10 months duration. It shows high tolerance to mosaicand low susceptibility to pests like red mites, scale insects, thrips etc. The starch content is 26% and vitamin A 466 IU.
- Sree Sahya: This is a predominantly semi-branching type with 10months duration. It shows high tolerance to mosaic and low susceptibility to pests like red mites, scale insects, thrips etc. The starch content is 30%.
- Sree Prakash: This has seven months duration and the yield potential is30-40 t/ha.
- Kalpaka: This is a non-branching type with six months duration and is suited as an intercrop of coconut in reclaimed alluvial soils of Kuttanad.
- Sree Jaya: This is an early variety with seven months duration and excellent cooking quality. Tuber contains 24-27% starch and is low in cyanogens.
- Sree Vijaya: This is an early variety with 6-7 months duration and excellent cooking quality. Tuber contains 27-30% starch and is low in cyanogens.
- Sree Harsha: This has 10 months duration and good cooking quality. Tuber

contains 34-36% starch. They are non-bitter and ideal for culinary purposes and the high starch content makes it suitable for preparing dried chips.

- Nidhi: This is a high yielding early variety with 5.5-6 months duration. Itis tolerant to mosaic and moisture stress. Tuber contains 26.8% starch and 20 ppm HCN.
- Vellayani Hraswa*:* High yielding early variety with 5-6 months duration.It cannot tolerate drought. The cooking quality is very good. Tubers contain 27.8% starch and 53 ppmcyanogen.
- Sree Rekha: It is a top cross hybrid with 10 months duration. Tubers contain 28.2% starch with excellent cooking quality.
- Sree Prabha: It is a top cross hybrid with 10 months duration. Tubers contain 26.8% starch with good cooking quality.
- Sree Padmanabha: This is a mosaic tolerant variety.

Preparation of land

Plough the field 2-3 times or dig to a depth 25-30 cm depending upon soil type to establish a deep porous field in which the setts are to beplanted.

Planting material

Tapioca is propagated from stem cuttings. Harvested stems of theprevious crop are to be stored vertically under shade in well-aerated places.At the time of planting, select mature healthy stems free from pests and diseases. Discard about 10 cm of the lower mature end and about 30 cm of the upper immature end. Cut the stems into setts of 15-20 cm length using a sharp knife. About 2000 stems are required for planting one hectare.

Season and planting

The main planting seasons are April-May with the onset of southwest monsoon and September-October with the onset of northeast monsoon. Planting can also be done during February-April, provided sufficient moisturecan be made available through irrigation. For maximum tuber production, April-May planting is preferred because the crop can effectively utilize both the monsoons. The second best season is September-October.

Pit, flat, ridge or mound method of planting can be adopted depending upon soil type, topography of land and elevation so that water logging is avoided. Pit followed by mound is found to be the best method of planting. Plant the cuttings vertically after smoothening the lower cut end, at a depth not exceeding 4-6 cm. Adopt square method of planting at a spacing of 90cm x 90 cm @ one cutting per pit / mound. It is preferable to adopt 75cmx 75 cm spacing for non-branching varieties like M-4.

Gap filling should be done within 15 days after planting preferably with longer setts of 40 cm length. Sree Visakham is a variety suitable for as intercropping in coconut gardens.

Manuring

For local varieties, along with cattle manure or compost @12.5t/ha, *Azospirillum* (2kg/ ha) and P solublising organisms (2kg/ha) may be applied at the time of planting the setts.

For high yielding varieties, cattle manure or compost may be applied @ 12.5 t/ha during the preparation of land or while filling up the pits so as to provide about 1 kg of organic manure per plant. *Azospirillum* (2kg/ha) andP solublising organisms (2kg/ha) or PGPR mix I have to be applied along with FYM at the time of planting the setts. In low lands, FYM@ 12.5t/ha can be replaced by poultry manure@ 5t/ha. Sow green manure seeds (cowpea/ sunnhemp) @ 30kg/ha at the time of planting the setts with the receipt of pre monsoon showers. 10 kg rock phosphate/ha has to be applied for the green manure crop at sowing time. At flowering (45-50 DAS) uproot and incorporate the green manure plants, along with 5t FYM / 2t poultry manure /2.5t vermi compost / 2.5t coirpith compost + 500 kg ash. If *insitu* green manuring is not possible it can be substituted with 6.25 t FYM and 500 kg ash per ha. Inoculate AMF at the time of planting.

In laterite soils, rock dust from quarry @ 3t/ha along with 12.5t/ha FYM can meet the full requirement of nutrients for cassava.

After cultivation

Keep the field free of weeds and maintain soil loose by 2-3 shallow diggings or hoeing upto 90 days after planting followed by light earthing up. Retain two shoots on each plant in opposite directions and remove excess shoots about 30 days after planting.

Irrigation

Under conditions of well-distributed rainfall, tapioca grows well as a rainfed crop and irrigation is not necessary. However, the crop has to be irrigated to provide sufficient moisture under conditions of prolonged dry periods after planting. For high yield irrigate the crop.

Intercropping in tapioca.

Tapioca is planted at a spacing of 90cm x 90 cm and it takes about 3-3.5 months to develop enough canopy to cover the land. So it is possible to have an intercrop of groundnut during the early stages of tapioca crop. Bunch varieties of groundnut like TMV-2, TMV-7, TG-3, TG-14 and Spanish Improved are preferred for intercropping in tapioca. The best season for sowing groundnut is May-June. Immediately after planting of tapioca setts, groundnut seeds are sown at a spacing of 30 cm between rows and 20 cm within rows, so that two rows of groundnut can be accommodated in between two rows of cassava. A seed rate of 40-50 kg/ha is recommended for dibbling one seed per hill. Only well-matured and bold seeds are to be selected for sowing. In acid laterite soils of Kerala, apply lime @1000 kg/ha of as basal dressing. Apply cattle manure or compost @12.5 t/ha + *Azospirillum* 2kg/ ha +Phosphorus solubilsing micro organism 2kg/ ha at thetime of planting. One month after sowing of the seed, earthing up may be done. Once pod formation has started (i.e., 40-

45 days after sowing) the soil should not be disturbed, as it will affect the pod development adversely. The groundnut crop matures in 105 to 110 days. After the harvest of pods, the haulms are incorporated in the soil. By adopting this practice, 20-25% additional income can be obtained.

In sandy areas intercropping tapioca with cowpea / groundnut / black gram / green gram may be recommended giving a spacing of 20 cm on both sides of the ridges. The non- trailing grain cowpea variety V-26 is recommended as a companion crop along with tapioca. For a pure crop of tapioca or for a cropping system involving tapioca as the main crop and the pulse crop suggested above, the field may be irrigated once in 36 days to a depth of 5 cm. This recommendation is for shallow water table situations. For deep water table situations, the crop may be irrigated once in 24 days to adepth of 5 cm.

Plant protectionPests

Red spider mite and scale insects

Red spider mites in the field and scale insects under storage areimportant pests of tapioca. Under field conditions light infestation of mites can be controlled effectively by spraying the crop with water at 10 days interval from the onset of mite infestation. In the case of very severe infestation, spray *Clerodendron* decoction of 2% strength at monthly intervals from the time of appearance of mites.

Scale insects

As a prophylactic measure, the stem may be sprayed with *Clerodendron* decoction of 4% strength, before storing.

Termites

In places where termite attack is expected, use neem leaf along with FYM at the time of mound formation. Planting of arrowroot along ridges and mounds is a good repellant.

Rodents

To ward off rodents, plant *Plumbago* (Citraka) cuttings randomly on mounds. Along the borders planting two rows of ginger/turmeric to ward off rodents. Also practice baiting and trapping.

Diseases

Cassava mosaic disease (CMD)

The disease is transmitted by a white fly *Bemisia* sp. Alternate light and green patches are seen on the foilge. The affected leaves become crinkled and distorted. As a rule, only stem cuttings from disease free plants should be used for planting to minimize the spread of the virus disease. For this purpose, tagging of disease free healthy plants for selection as planting materials must be practiced from September to December. All plants showingeven very mild symptoms must be rejected. Mosaic tolerant varieties such as H-97 and Sree Padmanabha may be used to minimize economic loss of tubers.

Production of disease free planting material of tapioca through nursery techniques

Setts with 3 to 4 nodes from apparently disease free plants are collectedand planted in the nursery at a very close spacing of 4cm x 4 cm so that about 500 setts can be accommodated in one square metre land. Daily watering of the setts has to be done for the first 10 days and on alternate days thereafter. Screening of CMD symptoms may be started 10 days after planting. Setts showing even mild symptoms are to be removed and burnt. This must be continued up to 20-25 days, by that time healthy sprouted cuttings can be transplanted to the main field. Supplementary irrigation may be given in the transplanted field till they get established. Screening fordisease symptoms and rouging of infested plants may be continued in field atweekly intervals up to harvest. The selected healthy stems are again cut intominisetts and subjected to nursery and field screening. By adopting this technique it is possible to produce healthy plants.

Leaf spot

Spray 1% Bordeaux mixture for control of leaf spot.

Bacterial blight

Bacterial blight is a disease noted in severe proportion in certain parts ofKerala. Use of resistant or tolerant varieties is the only method of control. Among improved varieties, H- 97, H-226, H-1687 and H-2304 are tolerant tothe disease while H-165 is highly susceptible. Among the local varieties, M-4,Paluvella, Pichivella, Parappilppan, Anamaravan etc. are tolerant to the disease.

Harvesting

Tapioca becomes ready for harvest 9-10 months after planting. Hybrid varieties like H-226, H-97 and H-165, when grown under recommended management practices have recorded yields up to 40-50 t/ha of raw tuber. The local varieties and M-4 yield on an average 12-14 t/ha of tuber.

Management of storage pests of cassava

Treating chips with granular salt (3%), sun drying thoroughly and storingin gunny bags in godown are very effective against *Araecerus fasciculatus* and *Sitophilus oryzae*.

COLEUS (*Solenostemon rotundifolius*)

Coleus thrives well in tropical and subtropical regions. A well –drained medium fertile soil is suitable for its cultivation.

Season

Plant the cuttings in the main field between Julyand October.

Variety

Nidhi and Sreedhara.

Nursery

Raise the nursery approximately one month before planting. An area of 500 to 600 m^2 is sufficient to produce cuttings required for one hectare of main field. Apply 125 to 150 kg FYM in the nursery area. Plant the seed tubers at a spacing of 15 cm on the ridges taken 30 cm apart. About 170 to200 kg of tubers is required to raise the nursery. Take the vine cutting to a length of 10-15 cm from the top portion after three weeks from planting.

Preparation of main field

Plough or dig the land to a depth of 15-20 cm and from ridges at30cm apart or raised beds of 60-90 cm width.

Planting

Plant the vine cuttings collected from the nursery on ridges at a spacingof 30 cm or on raised beds at 30cm x 15 cm spacing.

Manuring

Apply cattle manure or compost @10 t/ha at the time of preparation of ridges and 6t FYM / 2t poultry manure/ 2t vermi compost / 2t coirpith compost + 2 t ash /ha at 45 DAP along with PGPR mix I (2.5 kg).

Application of rock dust 10t/ha along with FYM 10t/ha can be recommended as basal dose for coleus in red soils of Kerala without any additional quantity of manure.

After cultivation

- Conduct weeding and earthing up at 45 days after planting along with topdressing.
- Cover a portion of the vine with soil to promote tuber formation.

Plant protection Root-knot nematode

Plough the field deeply in summer and destroy root residues and other plant parts by burning. Adopt crop rotation with tapioca or sweet potato. Application of neem cake is suited for this crop to reduce the incidence of root knot nematode.

Harvesting

Harvest the crop 5 months after planting.

ARROW ROOT (*Maranta arundinacea*)

Rhizomes are used for the production of starch. Starch grains are small and easily digestible. Hence it can be used as food for infants. It has also medicinal value against dysentery etc.

Propagation

It is propagated vegetatively by rhizomes. Healthy disease free rhizomes with at least one germinated sprout are the planting material. Take small pitsat 50cm x 30 cm spacing on the seed bed and plant seed rhizomes with germinated sprout facing upwards. Cover the rhizomes with farm yard manure and mulch the bed with leaves or straw. Weeding is done 2 or 3 times along with earthing up and mulching.

Planting arrowroot rhizome pieces under partially shaded condition as existing coconut garden during May-June at a spacing of 30cm x 15 cm on raised flat beds results in higher rhizome yield (45.00t/ha) and starch yield (7.00t/ha). Mulching using locally available plant materials like green leaves, dried leaves or coconut fronds immediately after planting improves yield.

Apply cattle manure or compost @ 10 t/ha at the time of land preparation and 5t FYM/ 2t poultry manure / 2t vermi compost / 2t coirpith compost + 1 t ash /ha along with *Azospirillum* and P solublising organisms each @2kg/ha or PGPR mix I.

The crop matures in 7 months. Drying up of leaves is the indication of maturity. Dig out rhizomes without damage. Remove the dry leaves and roots. The cleaned rhizomes are either marketed or dried and stored.

FRUIT CROPS

MANGO (*Mangifera indica L.*)

Mango belonging to Family *Anacardiaceae* is the most important commercially grown fruit crop of the country.

A. Climate

Mango is a tropical fruit, but can be grown upto 1100 m above MSL. The ideal temperature range for successful mango cultivation is between 240 to 270 C . It can be grown best in regions with a rainfall of 25 cm and 250 cm. High humidity, rain or frost during flowering is detrimental to mango cultivation. Higher temperature during fruit development and maturity gives better quality fruits. Regions with bright sunny days and moderate humidity duringflowering are ideal for mango growing.

B. Soil

Mango can grow well in all types of soil from alluvial to lateritic, except the black cotton soils, which are considered as poor. The only prerequisite is a deep (2 to 2.5 m) and well drained soil.

Land preparation

The land is prepared by usual ploughing, harrowing and leveling. A gentle slope is provided to facilitate proper irrigation and prompt drainage to avoid the harmful effects of water stagnation. After marking of the points for the plants, pits of 90X90X90 cm are dug during summer months. This operation is done by utilizing a planting board so that precise location of the plants in the middle of the pit remains undisturbed. While digging of pits, it is essential to keep the topsoil and subsoil separately in two heaps near each pit for two to four weeks.

This helps in exposing the harmful soil organisms to weathering agencies, providing better aeration to the root zone and in making provision for nutritional requirements for healthy development of the soil. The pit is filled with 20 kg of FYM, 5 kg of vermicompost and Biofertlizers (Azospirillum and Phosphobacteria). Green manuring is also done with the onset of SW monsoon in July/August with Daincha and Sun hemp. Growing of leguminous green manuring crops helps in Nitrogen fixing besides providing excellent green cover to entire field, which in turn prevents moisture loss.

Spacing

Spacing varies from 7 m to 10 m either way.

Planting material

Mango is propagated by inarching and veneer grafting, but of late, epicotyl and softwood grafting replacing these two methods. As regards,selection of root stock, research trails shows that polyembroyonic cultivar Vellaikolambam significantly reduces the canopy size by half without reducing production. Planting material is procured from nurseries, which propagate the planting material either by organic or chemical means. However, it is preferable to procure planting material from organic sources.

Varieties

The varieties as recommended for mango for agro climatic conditions byKVKs and Agricultural Universities.

Planting

It is done with the advent of monsoon. The planting season could be July to December, depending upon the monsoon and availability of irrigation facilities.

Water Management

The water requirements mainly depend on the age, soil type and climate. However, young plants upto 2 years should be watered regularly. The newly planted grafts need about 25-30 l of water every day. Irrigating the grown up trees after fruit set at 10-days interval increases their yield.

Mango growers commonly practice drip irrigation so as to control over watering and also to irrigate a larger area with better management practices.

Cultural practicesWeeding

It is preferable to select a site, which is free from serious weed problems. Mulching with straw during the first few years of establishment may be useful in controlling weeds. In older mango orchards, weed management is less problematic due to shading and leaf litter.

Pruning

Pruning mango tree is important for tree size control and to improve the fruit colours. Essentially, tree pruning and canopy management is same for organic or conventional production. Pruning is done to open up the structure to allow good airflow and adequate internal light. It also minimizes disease riskand assists in good fruit coloursation. Internal pruning to remove dead wood can be very important to help reduce the incidence of disease like stem end rot.

Rootstock sprouts and low-lying branches have to be removed. Overlapping, intercrossing, diseased, dried, weak branches are removed toget good sunlight and aeration. For internal branches, pruning may be done during August- September, once in three years. Flowering should not beallowed upto three years. Among the crowded terminal shoots, weak shoots are trimmed to retain two healthy shoots during August- September annually.

Manuring

- Green manuring with the common crops, like sun hemp (*Crotolaria juncea*) and

dhaincha (*Sesbania aculata*), shrubs and trees like glyricidia, karanj, subabool etc.

- Biofertlizer like Rhizobium, Azospirillum, Azatobactor, Phosphate solubilizing bacteria – Phosphobacteria(PSB), Blue Green Algae (BGA) can be used to improve the soil nutrient condition.
- Mulching with materials like bark, nut shells, weeds, grass, wood chips, silage, paddy/wheat straw, rice husk, coir dust, banana, sugarcane leaf trashes etc. improves water holding capacity, Nutrient condition of soil and controls the growth of weeds to certain extent.
- Applying PSB and Azospirillum during the pit preparation and also as soilapplication during the crop growth period.
- Application of Organic manures (10-20 kg/tree) through NADEP, Vermi, Biodynamic Compost (BD) or Microbe Mediated Compost in descending moon period
- Growing of legume for green manuring or as inter/cover crops as per requirement as permoon constellation
- Mulching after application of 100 g Cow Pat Pit (CPP), Spray of cow horn manure (BD 500) and release of earthworms in presence of proper moisture as per calendar.
- Need based foliar spraying of biodyanmic liquid manures/vermin wash/(CPP) in ascending phase.

Plant protectionPests

The important pests are hopper, mealy bug, stem bores, fruit fly. Pest management practices foreach pest are described below:

1. Fruit Fly

Adult and larvae maggots cause fruit damage. Egg laying females puncture the fruits leaving scars and holes on the fruit surface. Larval feeding causes premature fruit drop and destroys the pulp of the fruit. The fruit eventually rots making it unsuitable for harvesting and human consumption. Fruit fly attack is controlled by harvesting the crop early when fruits are mature green. This is the stage of maturity when crops are not susceptible to fruit fly attack. Removal of fruits with dimples and oozing clear sap, collection and destruction of fallen and damaged ripe fruits and practicing field sanitation helps in controlling fruit fly attack.

2. Mango Mealy bugs

The mealy bug affected plant leaves are distorted (rolled or folded), stunted and yellow. Heavy infestation causes drooping of leaves and flowers and reduces fruit setting and attacked fruits drop prematurely. Mealy bugs excrete large quantities of honeydews, which promote sooty mold that causes blackened malformed leaves, stems, and fruits. Infested fruits are unmarketable.

Spraying steady stream of water on the host plant to knock off mealy bugs,

hand picking of the bugs from the affected plants to reduce populations and pruning the affected plant parts to remove mealy bugs, applying chilli and soap sprays are the suggested control measures.

Removal and destruction of heavily infested plant will help in cutting down the infested sites andreducing its future population.

3. Mango leafhopper

Both the nymphs and adults feed on the plant sap of the flowers, leaves,tender shoots and newly formed fruits. They then suck out the liquid contents leaving behind the dead empty cells, which are small white spots. The affected flower heads turn brown and dry up. Leafhoppers produce large amounts of sugary liquid waste called honeydew, on which sooty mould develops. The appearance of sooty mold on plants is an indication of leaf hopper infestation. Spraying garlic oiland neem oil are recommended as control measures.

4. Mango shoot caterpillar

The larvae feed on the growth flushes of nursery stock, young trees, and top-worked trees. Occasionally, the fruit stalks and young fruits are damaged. The sudden death of a part of a branch, cracked branch and falling off a branch are indications of the attack. It is controlled by applying ginger, garlic and chilly extract and neem leaf extract. Pruning the affected plant parts and burning or burying them helps in controlling their population. Central Institute for Subtropical Horticulture (**CISH**) Lucknow, recommends the following practices for controlling pests in mango:

- Spraying of Biodynamic pesticide prepared from cow urine, neem,karanj (*Pongamia glabara*), castor, *Thevtia nerrifolia*, Vitex spp.
- Spraying Nettle leaf extract sprays to control hard pests like mango hoppers, mealy bugs, etc. Nettle spray is prepared by soaking 250 g of nettle leaf powder in 4-5 l of water for 24 hrs. Filter the extract andmix in 20 l of cow urine. Dilute to 200 l in water and spay on foliage to control pests.

Disease management:

The important diseases of mango are Powdery mildew, Anthracnose, Stem-end rot, and Sootymould. Suggested measures are as follows:

1. Powdery mildew

It is a fungal disease caused by *Oidium mangiferae* and can destroy the crop. Its incidence is favoured by high humidity accompanied by cloudyweather and low night temperatures during the period between panicle development and fruit set. It is characterized by the appearance of greyish white powdery bloom on the flower buds and fruits. Need based spraying of Horsetail / Casuarina extract helps in controlling the disease.

2. Anthracnose

It is a fungal disease and occurs especially in humid and high rainfall areas. The characteristic symptom is the appearance of black necrotic areas on the affected parts. The affected young shoots finally show die back symptoms. As

the fungus survives on dead or dried twigs, these should be pruned and burnt at the earliest. Good canopy management and tree nutrition / soil management, close monitoring and application of copper hydroxide & potassium bicarbonate sprays help in controlling the disease.

3. Anthracnose Stem end rot

Removing dead wood, good canopy management and tree nutrition / soil management helps in controlling the disease. It is reported that application of calcium to the soil in the form of gypsum at low rates, 2-4 kg per tree prior to flowering reduces the severity of internal fruit disorder significantly. Farmers are also applying some commercially available bio-pesticides such as *Pseudomonas fluorescens*, *Verticillium lecanii*, *Beauveria bassiana* as foliar sprays, besides neem oil spray in controlling the disease. CISH findings on disease management:

- Two sprays of Cow Horn Silica (BD-501) at flowering and fruitdevelopment stage
- Biodynamic tree paste/cow dung paste for control of gummosis and dieback
- Spraying of Horse tail (*Equisetum arvensis*)/Casuarina leaves extractfor control offungal diseases in ascending moon period.

It is reported that in Uttar Pradesh, application of cow dung paste has almost replaced the spray of Copper Oxychloride for the control of die back in rejuvenated old mango orchards. It is also effective in controlling anthracnose and control of stem borer.

Harvesting

Mango fruits need 12^0 to 14^0 days after fruit set to mature. The fruits should be harvested at the correct stage to obtain the characteristic taste and flavour of the variety. Harvesting is traditionally done when a few semi-ripe fruits fall from the tree. However, it is not a scientific method. The accurate method of finding maturity is by sinking the fruits in water and when fruits fully sink in water, they are considered to have attained full maturity.

Fruits sinking in water have specific gravity of less than 1.02. The fruits will give best taste and flavour when the shoulders outgrow the stem-end and colours is olive green or when the colours become light. Harvesting of fruits should be done before 10 AM or after 04 PM to keep fruits fresh, turgid for longer shelf life. Harvest only matured fruits as frequently as possible in about4-6 rounds. Injury to the fruits during harvesting brings down their quality andmakes them proneto fungal attack.

Harvest fruits with sharp secature keeping 3-5 cm pedicel. It is important that all fruits should have pedicels intact to avoid oozing of latex on fruit surface spoiling appearance, development of black spots and paving way for entry of pathogens. Harvested fruits should be kept in shade and not in open sun and transported to the pack house for post-harvest operations.

Post Harvest treatment

Dip the fruits in 52^0C hot water immediately after harvest for 5 minutes followed by 8% plant wax to reduce anthracnose disease in mango during storage. In general

fruit requiring only short term storage before retail sale areunlikely to suffer from fungal break down and post harvest fungicides may notbe necessary. For longer storage of mangoes a fungicide treatment is usually required. However, effective organic treatment for post-harvest fungal breakdown is yet to be established. The important pre and post-harvestpractices are:

- Produce from a healthy tree in a well managed orchard with goodhygiene
- Grow with adequate calcium and other elements
- Do not subject to excessive N during fruit development and ripening
- Pick at the correct stage of ripeness
- Do not subject to bruising or damage
- Maintain at ideal temperature
- Clean, pack and transport.

Generally grading of fruits is done by farmers manually according to size of the fruits. Grade will vary with variety. The prevailing grading standards for Alphonso are given as an example;

- A + Grade - > 300 gm
- A Grade - 250 –299 gm
- B Grade - 200-249 gm
- C Grade - 150-199 gm
- D Grade - < 150 gm

Yield

Initial yield is reported to be 30 kg per tree and attaining the peak yieldsof 100 kg/ tree in the 10th year afterplanting.

BANANA *(Musa* spp.)

Banana prefers tropical humid low lands and is grown from the sea level to 1000 m above MSL. Itcan also be grown at elevations up to 1200 m, butat higher elevations growth is poor. Optimum temperature is 27°C. Soils with good fertility and assured supply of moisture are best suited.

1. Season

Rainfed crop: April - May

Irrigated crop: August - September

2. **Variety:** As per the university suggestions local variety can be selectedbased on the climatic requirements.

3. **Preparation of land:** Prepare the field by ploughing or digging and dig pitswith pit size 50 cm x 50 cm x 50 cm for planting.

4. **Selection of suckers**

Select 3-4 months old disease free sword suckers from healthy clumps.

The rhizome should be dipped in hot water (50°C) for 20 minutes to prevent nematode infestation. The rhizomes are to be smeared with cow dung solution and ash and dried in the sun for about 3-4 days and stored in shade up to 15 days before planting. Soaking the suckers in *Pseudomonas fluorescens* solution (2%) for 30 minutes before planting is beneficial.

5. **Planting**

Plant suckers upright in the centre of pits with 5 cm pseudostem remaining above soil level. Organic manures and *Trichoderma harzianum* (100:1) should be applied in the pit before planting. Press soil around the sucker to avoid hollow air spaces.

6. **Manuring**

1. FYM or compost or green leaves @ 10 kg/plant at the time of planting.
2. 500 g of lime in the pit and allow to weather.
3. Vermicompost @ 2 kg / pit at the time of planting.
4. Groundnut cake/ neem cake @ 1 kg /pit at the time of planting.
5. N, P and K biofertilizer- PGPR mix I @50-100 gm /pit should be applied at the time of planting. The biofertilizer should be mixed with 5 kg FYM. It should be ensured that there is enough moisture in the soil at the time of application.
6. Panchagavya 3% as foliar spray three times at 3rd, 6th, and 9th months after planting After planting banana, sow sunnhemp /daincha/ cowpea adopting a seed rate of 50 kg/ ha (20gm per plant). Incorporate the crop into the soil 40 days after sowing. Repeat sowing of green manure crop and incorporate into soil 40 days after sowing. Compost made from banana leaves and bunch stalk is rich in potassium content. *Insitu* vermicomposting is a novel technology for organic banana.

Additional nutrient requirement for different varieties

Varieties	Quantity / Plant		
	FYM/Compost (kg)	Rock phosphate (g)	Ash (kg)
Nendran	20	200	1
Palayankodan	10	300	2.0
Other varieties	15	300	1.5

It is preferable to apply organic manures in two equal split doses at 2nd and 4th month after planting.

7. **Irrigation**

1. During summer months, irrigate once in three days.
2. About 6-10 irrigation per crop may be given depending upon soil conditions.
3. Mulching the basin with 3.5 kg paddy straw (waste quality) will considerably improve the bunch yield

8. Weed control

During early stages, complete control of weeds could be obtained by raising cowpea in the inter spaces. Hand weeding by giving 4-5 surface diggings (depending upon weed growth) will give good weed control. Avoid deep digging. Do not disturb soil after plants start producing bunches. If green manure crop is grown, weeding operations can be reduced to 1-2 diggings. Mulching is an effective practice for controlling weeds.

9. Desuckering

Remove side suckers produced till the emergence of bunch. Retain one ortwo suckers producedafter the emergence of the bunch.

10. Inter cropping

Amaranth, colocasia and elephant foot yam can be profitably intercroppedwith banana by adopting organic method of cultivation for all crops in the field.

11. Plant protection

❖ **Pests**

1. Field sanitation - remove all dried leaves over the pseudostem.
2. Remove severely infested plants with rhizome in full and destroy by burning the life stages of the insect.
3. Destroy pseudostem of harvested plants.
4. Remove the loose dry sheaths of the pseudostem of plants from 5^{th} month onwards and followany of the methods.

a) Swab mud slurry around the pseudostem:

If infestation is noticed, then mix neem oil emulsion @ 3 % in the mud slurry (30 ml/ litre) used for swabbing.

b) Spray neemazal (1% EC) on the psuedostem and fill the leaf axils at monthly intervals starting from 5^{th} month onwards:

Spray application on the pseudostem and leaf axil filling with entomopathogens, namely,

Beauveria bassiana or *Metarhizium anisopliae* @ 1×10^7 spores/ml.

c) Spray entomopathogenic nematode (EPN) @ one billion/ha over the pseudostem or place three cadavers containing EPN s in alternate leaf axils at fortnightly intervals.

d) Place split pseudostem pieces of 2 ft long in the ground when plants are 5months old. Collect weevils in the trap and destroy daily.

e) **Banana Rhizome Weevil *(Cosmopolites sordidus):*** Use pheromone trap with Cosmolure / Cosmolure $^+$ (an aggregation pheromone) toattract both sexes of weevil. Keep the trap throughout the year, changing the site when the number of weevils collected is reduced. Change pheromone sachet in every 45 days.

f) **Aphid** acts as a vector for the transmission of viral diseases of banana. The fungal biocontrol agent *Verticillium lecanii* is pathogenic to the aphids. Spray the spores of *V. lecanii* @ 1 x 10^7 spores/ml, whenever aphid population is noticed.

g) **Nematodes:**

- Pare the rhizomes and dip in hot water at 45 -50°C for 20 minutes willcontrol nematodes.
- Apply neem cake @ 1kg/plant at the time of planting.
- Intercrop banana with sun hemp or marigold to reduce nematodepopulation.

❖ **Fungal diseases**

1. Cut and burn all severely affected leaves.
2. Need based sprayings are to be given depending upon the severity of the disease.
   i) Spray 1% Bordeaux mixture soon after the appearance of the initial symptoms of the disease. The disease appears with the commencement of southwest monsoon.
   ii) Power oil (Mineral oil) 1 % emulsion is effective in controlling the disease.
   iii) Bioagents like *Pseudomonas fluorescens* 20g/litre (2%) or *Bacillus subtilis* 5g/ litre is effective against sigatoka leaf spot disease.
3. Grow reistant/less susceptible varieties such as BRS-1, BRS-2 and Dudhsagar. Among Nendran, the selection Manjeri Nendran II is least susceptible.

❖ **Virus disease of banana**

1. Use disease free suckers for planting.
2. Eradicate disease affected plants.
3. Spraying neem based insecticide on the pseudostem to control the vector.
4. The fungal biocontrol agent *Verticillium lecanii* is pathogenic to the aphids. Spray the spores of *V. lecanii* @ 1x10^7 spores per ml whenever aphid population is noticed.
5. Varieties such as Karpooravally, Kanchikela, Njalipoovan and Koompilla kannan are tolerant.
6. Avoid growing cucurbitaceous vegetables as intercrop.

PINEAPPLE (*Ananas comosus*)

Pineapple is mostly grown at low elevations in areas with a temperature range of 15° to 30°

A. Pineapple is tolerant to drought because ofthe special water storage cells. They can be grown with a wide range of rainfall from 600- 2500 mm / annum, the optimum being 1000- 1500mm. Pineapple can be grown in a wide range of soils, but does not tolerate water logging. It can be grown as a pure crop on plantation scale or as an intercropin coconut gardens.

Varieties

Kew - recommended for processing industry Mauritius - recommended forcommercial cultivation for table purpose and distant marketing, due to its shorter duration, better fruit quality, keeping quality and transportability.

Season

Main season of planting is April-May and August-September, but can alsobe planted in all months except during heavy rain of June-July. The best timefor planting is August to get higher yield. During summer months, if there areno summer showers after planting, irrigation should be given three weeks after planting for proper establishment.

Cropping system

Mauritius can be grown as a pure crop in garden land, reclaimed lowlands and wetlands and as an intercrop in coconut and newly planted rubber plantations. In rubber plantation, it can be grown for the first 3-4 years only.

Land preparation pure crop

Prepare the land by digging the area to be planted at 90 cm width in rows/ strips, leaving the interspaces undisturbed. However, ploughing can beadopted in level land. Planting is done in paired rows of 45cm distance between rows and 30cm between suckers. Suckers may be planted in triangular method in the paired rows. Interspace between the paired rows is kept at 120-150cm. Contour planting is ideal in sloppy areas to prevent soil erosion. About 30000 suckers can be planted in one ha.

Intercropping in coconut garden

Land preparation, spacing and planting are the same as described above in pure crop. There can be three-paired rows in between two rows of coconut.Coconut tree basin should be kept free. About 20000-22000 suckers can be planted in one ha.

Intercropping in rubber plantations

System of planting is in paired rows at 45cm x 30cm. Either one or two paired rows can be planted in between two rows of rubber depending on the spacing of the rubber planting. About 20000 suckers can be planted in one ha.

Wetlands / lowlands

Pineapple is highly sensitive to water stagnation and high moisture regimes. Hence it is important to provide good drainage, if grown in wetlands.In paddy lands, pineapple is planted in paired rows at 45cm x 30cm spacing on ridges taken at 60-90cm height, depending on the water table and drainage requirement. The ridges are separated by drainage channels having 60cm width. The width of the ridges varies from 120-150cm. Wherever water stagnation and poor drainage are expected, a wider and deeper channel is given in between ridges. About 25-30000 suckers can be planted in one ha.

Selection of suckers

Suckers are selected from disease and pest free healthy plants. Suckers are to be graded into those having 500-750g and 750-1000g. The graded suckers are planted in different blocks or plots, to get uniformity in growth andflowering. Bigger suckers give early yield.

Planting

After preliminary land preparations, planting is done in small pits of 10- 15cm depth at a spacing of 45cm between rows and 30cm between plants in the rows. There is no need to plant the suckers in trenches.

Manuring

Apply compost / FYM @ 500 g per plant at the time of planting. Also apply rock phosphate @ 20 g per plant and bone meal @ 50 g per plant. It will be ideal to apply the compost/ FYM, rock phosphate and bone meal in the pits taken for planting. Six weeks after planting, apply 250 g cowdung or vermi compost, 50 g neem cake, 50 g groundnut cake, one gm azospirillum and one gm phosphobactor or PGPR mix 1 for each plant and mild earthing up is done. Apply 1.5 g of sulphate of potash in liquid form along with cowdungsolution at an interval of 6, 10, 14, 18, 22 and 30 weeks after planting for each plant.

Irrigation

Wherever irrigation facilities are available, providing irrigation in summer months attwo weeks intervals results in good fruit size and high yield. If thereis no irrigation facility, the crop should be scheduled for harvest before summer months (before March).

Weed control

Hand weeding can be adopted in between plants and spade weeding in interspaces. Intercropping with ginger, coleus, brinjal, bhindi etc. in the earlystages can control weeds in interspaces. It can also be controlled by sowing green manure crops like sunnhemp or daincha which can be used as green manure for pineapple by 2-3 months.

Flower induction

For inducing uniform flowering, 25 ppm ethephon is applied on physiologically mature plants having 39-42 leaves (7-8 months after planting).The solution for application in 1000 plants is prepared by adding 1.25 ml of ethephon (3.2 ml of 39% ethrel or

12.5ml of 10% ethrel) in 50 litres of cowdung solution. Pour 50 ml of the prepared solution to the heart of the plant during dry weather conditions (when there is no rain during the time of application).

Flowering starts by 30 days and completes within 40 days of growth regulator application. Fruits will be ready for harvest by 130-135 days after the application of growth regulator. Harvest over different months / seasons could be obtained by carefully phasing / planning the planting and growth regulator application.

Plant protection Sun burn

During summer months it is necessary to protect the fruits from sun scorching by covering with dried grasses, coconut or arecanut leaves.

Pests

Mealy bugs (*Dysmicoccus brevipes / Pseudococcus bromeliae*)

Mealy bug is a serious problem in pineapple. For its control, sanitary measures are to be adopted. The plot should be kept weed free. Apply *Verticillium* @ 1 g per plant in liquid form for the control of mealy bug.

Diseases

Root rot / heart rot / fruit rot

Caused by *Phytophthora* sp., *Pythium sp*., *Fusarium sp*., etc. The fruits at the soil level rot and emit foul smell. The stem at the soil level also show rotting symptoms. Providing drainage is most essential. The water table should be at least 60 cm below the soil surface. Badly affected plants should be destroyed. To prevent disease problems biocontrol agents can be used. Two weeks after planting, apply *Pseudomonas fluorescens* or PGPR mix II as 2% spray and drenching. Repeat its application if any diseases are observed.

Ratoon cropping

The plant crop after harvest can be retained as ratoon crop for two more years. After the harvest of the plant crop, chopping the side leaves of the mother plant should be done for easy cultural operations. The suckers retained should be limited to one or two per mother plant. Excess suckers if

any should be removed. Earthing up should be done. Other management practices are same as for the plant crop.

Organic Citrus (*Citrus spp.*)

Citrus trees can be grown over a wide rangeof climatic and edaphic conditions butproper site selection remains the key to successful organic production. An important factor for economically viable yields is the availability of good quality

irrigation water, even in the Humid Tropics. Therefore before

selecting a site for organic citrus production, not only soil, but also water analysis is essential.

Most organic growers are in the situation of **converting an already existing plantation** into organic production Thus, the first and most important conversion step is the design of the organic orchard based on the following ecological principle: the higher the diversity of species, the higher the stability of the agro-ecosystem. The high degree of biodiversity creates the habitat for natural enemies of pests. One of the most important tasks on the way to organic production is to find strategies on how to increase bio-diversity:

- Create a diverse mosaic of citrus units and other crops from an existing plantation. In case of narrow planting distances it will be necessary to cut down several rows of citrus trees and instead plant hedges or other fruit trees, creating citrus plots of about 1-2 ha size (or smaller).
- Between the rows (in the alley-way) it might be possible to intercrop with pasture (sheep), beans or other crops. However, this might be difficult in case of older plantations where the trees are adapted to a certain management; in this case, a step-by-step procedure is recommended (introduction of new crops and elements year by year), because the root systems of the citrus trees have to adapt to new competition in the soil.
- The density of existing plantations might be decreased to 8 x 8 m (156 trees per ha) if there is a too high density. High-density plantings reduce ventilation and light interception and thus increase disease pressure. Lower density plantings are better adapted to the organic production system.

Establishing a new organic citrus orchard

As examples in Eastern Cuba or the Mexican peninsula of Yucatan show it is possible to produce organic citrus successfully also in polycultural systems. In agroforestry systems citrus trees are mixed with other fruit trees, leguminous trees, banana, palm trees, coffee and cocoa,

beans and other species covering the soil.

The basic tools of organic soil management are interdependent and influence tree health, tree development, fruit yield and quality. Organic citrus growers therefore combine these three questions. Relevant soil management techniques for organic citrus orchards include:

- Use of cover crops (understorey plants) or mulching,
- Agroforestry and intercropping methods;
- Mechanical techniques for weed control.

Soil cover systems

A permanent soil cover is an important component of the organic orchard cultivation system. Locally adapted leguminous crops for the humid tropics, such as *Teranamus labialis, Arachis pintoi, Neonotonia wightii,* help restore degraded soils very fast, they successfully suppress weed, fix nitrogen and prevent erosion. To avoid strong competition between the cover crop and the citrus suitable management of the cover crop is necessary. Measures are:

- Mulch the cover crops before the dry season to prevent competition e.g. for water.

- Reduce the percentage of living soil coverage to optimally adapt the soil cover system to the soil, the crop and the climate conditions. One possible solution is the sandwich-system (chart 3), which is easy feasible for young plantations and in orchards with deep soils where tree roots are not too close to the soil surface. However, in orchards for-merely established with herbicides and soil erosion ”dug out” citrus roots are sometimes present. In this case it would be too harmful for the trees to change to a cultivation system. In these casessystems with cover crops or organic mulches should be used. In such orchards, the traditional cover crop system is the suitable method.

Organic citrus soil management

Weed Control = Soil Cover + Management of Undesired Plants

Organic citrus growers distinguish between desired and undesired cover plants and speak of cover crop management instead of weed control. They do this by sowing competitive cover crops (legumes and other desired plants) to suppress undesired plants like perennial grasses as *Panicum sp., Paspalum sp., or Amaranthus*. There is a large number of plants, which provide worthful habitats for beneficial insects (especially by bearing flowers) or/and improve soil conditions without competing with citrus trees (e.g.

Centrosema pubescens, Desmodium, Cassina obtusifolia and *Alysicarpus vaginalis*). Such soil cover plants are enhanced in organic citrus production. However soil cover plants can also be habitat for pests and have to be selected carefully. Undesired plants are best suppressed by:

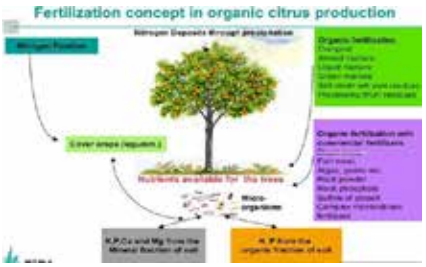
- Regular mowing the (leguminous) cover crops. Different types of mowers are available most of them operated by a power take off from the tractor. Specially constructed mowers for organic orchards permit mowing in the alleyway and under the trees with sensor controlled bat wings.
- Hand weeding if it begins to dominate cover crops or citrus trees.
- Mulching and traditional discing.

Supplying nutrients and organic fertilization

Fertilization in organic citrus growing is based primarily on compost. Only if necessary – on the basis of soil and leaf analysis –additional organic commercial fertilisers are brought in. Suitable strategies have to be planned according to the soil condition e.g. applications have to be applied 2-4 weeks before the expected nitrogen demand of the trees (2-

4 weeks before flowering) because mineralisation of nitrogen from compost is slow. If nitrogen demand is important (> 50 kg /ha) nitrogen supply cannot be given with compost only (chart 4).

Fertilization concept in organic citrus production



Pest and Disease Management

Most mites, insects and nematodes, that attack citrus cause economic damage only occasionally. Many pest problems in conventional citrus production are related to the almost complete elimination of natural enemies by the excessive use of synthetic pesticides. Organic growers make use of natural control agents to a maximum possible. Many pest problems can be controlled effectively with biological control methods. Generally, bio-control methods and agents help to decrease the level of pests rather than to eradicate them. Pest and disease management in organic citrus production relies with priority on indirect control methods.

The pressure of pests and diseases in organic citrus groves depends very much on local conditions and indirect management methods. Favourableconditions are:

- Ideal design of orchard (wide distances for good ventilation; seeabove);
- Mosaic of production units;
- Diversity of crops and diverse habitat;
- Resistant varieties;
- Know how and experience of farmer;
- Local availability of bio-control agents etc.

Water Management and Irrigation

Citrus trees are water-conserving plants and thus capable of withstanding long periods of drought as they have leaves covered with epicuticular wax. However, even in humid subtropical and tropical regions with sufficient total rainfall, irrigation is important during the dry periods to achieve good yields. Regular, moderate irrigation reduces physiological fruit drop, improves flowering, fruit set, fruit size and juice content. On the other hand excessive irrigation can affect fruit quality negatively as the contents of soluble solids and acidity decrease due to a dilution effect.

High water quality (filtered preferably) with absence of chemicals, heavy metals, toxic bacteria and with low salinity levels is essential. Regular water analysis is compulsory for organic certification.

Pruning

As the trees grow, the inner and lower branches become shaded. Most of the fruiting occurs in the outer periphery of the canopy whereas the inner parts suffer from shading having bad or no fruit set and quality. This problem can become especially severe in high-density plantings. Therefore, a yearly pruning is essential to maintain light and air penetration because a good aeration also contributes to the prevention ofpests and diseases. It is advisable to maintain the tree height at no more than twice the planting distance in the row.

PLANTATION CROPS & SPICES

Tea (*Camellia sinensis*)

Importance and relevance of organic tea

The organic tea culture aims at establishing a fundamental organic and sustainable farming system for tea growers by using low cost, readily available and easily adaptable techniques. This will ensure healthier teas as well as improve soil quality in terms of fertility, structure, aeration, infiltration, water retention capacity, cation exchange capacity etc. By following a near natural soil management practice and ensuring a good ground cover, the organic culture will also help in prevention of soil erosion, rejuvenation of degraded soil, provide ample scope for recycling of various organic wastes. This as well as special crop protection measures adopted in organic tea production help reduces environmental pollution and as a consequence maintain biodiversity and reduce pest and disease infestation. By following the organic culture will also help in realizing higher returns from unit quantity of tea exported. Teas in Assam are mostly grown in flatlands with some exception in Cachar and few other areas, while it is mostly grown in hill and mountainous regions in Darjeeling. While flatlands have their unique problem of waterlogging (if drainage is faulty), the mountain areas face other problems of difficult landforms, small and marginal landholdings, but there are some common factors such as climate, soils, vegetation and relief that impact tea production. The recent complexities of climate change triggered by global warming have compounded tea production due to uncertain and abrasive weather. At a micro scale there are some studies which obliquely point out that organically grown crops are more resilient to climate change than conventionally grown crops. However, studies need to be conducted in tea production system to verify such results.

Selection of site

- The area needs to be sufficiently isolated to ensure that there is no possibility of any pollutants or contaminants flowing or drifting into it from any known or unknown sources. There should be a buffer zone of sufficient width on all sides of the field depending on the topography of the area, to ensure the above safety. The minimum width of the buffer zone should be 100 meters.
- Tea requires strongly acidic soil with pH around 5.0 and soil depth of 1.5 meters to 2.0 meters and good drainage. Organic matter status should be medium to high depending on the elevation and rainfall of the area.
- After felling the trees their root system should be removed to the maximum extent possible. Stones should also be removed. The trashes should not be burnt in situ. Ash being alkaline increases the pH of the soil.
- There is heavy crop loss in the initial 4-5 years once conversion of the tradition

area to organic area is started. The rate of loss of productivity is comparatively low in the old tea section. Therefore, more old tea area should be included for conversion to organic area at the beginning.

- Area prone to waterlogging should be avoided.

Choice of planting material

Growth and flushing behavior of the tea bushes vary according to the soil and agro climatic condition of the area, where the plants are grown. Therefore, one has to be choosy and planting material with a proven record of performance, and best suited for specific location, should only be selected. Moreover, a single clone or seed stock should constitute not more than 10% of the total area of a tea garden as an insurance against total debacle due to unforeseen reasons. While selecting the plants, both yield and quality parameters should receive due consideration.

Pre- planting Operations

Tea being a perennial plant, once they are planted in the field, soil could not be disturbed for next fifty or sixty years i.e., throughout the entire life of plants. This necessitates proper soil management before planting which includes land preparation, soil rehabilitation (particularly, in case of uprooted area) followed by stalking and planting

Land Preparation

In land preparation practices one should take adequate care of soil conservation. for that following measures are needed to be adapted.

Virgin area

The tree should be killed once season ahead of proposed planting. The dead trees should be uprooted along with their root system during the winter period. The land should be cleared and leveled during winter. The main drains should be laid and the excavated soils should be thinly sprayed over the depressed ground.

Uprooted area

Ploughing, harrowing and subsoiling

- After uprooting and marking of the drains the land should be ploughed and harrowed in a sequence of Ploughing ---Harrowing----Cross ploughing---Cross harrowing----Sub soiling -------Harrowing ---Levelling.
- The depth of ploughing should not be less than 45 cm for which 75 HP tractors in tandem are required.
- In hills/tillas, where use of tractor is not possible, only leveling should be done followed by planting of rehabilitation crop.
- Sub soiling is to be done employing single blade sub soiler of 75-90 cm depth. The distance between the lines of sub soiling should be within 60 cm taking care not to sub soil the lines of main drain. However, sandy soils may not require sub soiling to such depth.
- To obtain maximum lifting and displacement of that compacted layer, two rounds of sub soiling should be done at right angles.
- Tractors of 90 HP is required to undertake sub soiling upto a depth of 75 cm in moderately heavy soil.

- Improper sub soiling results in restricted growth of roots and movement of water.
- In the case of highly acidic soils, broadcast 2-3 tonnes /ha of finely powdered slaked lime before ploughing *with the prior approval of the inspection body*.
- Field and collector drains can now be provided and the excavated soil should be thoroughly spread.
- All the major natural depressions should be kept undisturbed.
- Direct planting of tea after uprooting and land preparation should be avoided.
- Reconditioning of the soil is required to eliminate the activity of pathogenic soil borne organisms.
- Organic matter from decomposed leaf and also the root residues improve the soil fertility.
- Growing of legume or grass can improve the soil structure. Crops recommended for rehabilitation are
  - Guatemala grass
  - Pusa Giant Hybrid Napier
  - *Mimosa invisa*

  (Preferably as mixture of Guatemala and Mimosa)
- Thereafter the area is kept under rehabilitation for a period of 2 years with crop like Guatemala grass (*Tripsicum laxum*), Pusa Giant Hybrid Napier, Citronella grass (*Cymbopogon Confertiflorus* and *C.nardus*), Crotolaria anagyroides and mimosaa invisa, preferably as mixture. If the growth of the rehabilitation crop is not satisfactory, extent rehabilitation period. The rows of rehabilitation crops planted should serve as the future lines of tea, particularly in heavy soil. In sloppy topography permanent grass line should be established in upper bank of drains and along the sides of plucking paths well ahead of planting tea.

Drainage

- The main drains and the submain drains should be designed with respect to the gradient and slope. While designing the main drains it should be undertaken with respect to the catchment it serves instead of the section which is being uprooted.
- The recipient stream or the hullah that serves as the outfall should be examined properly with respect to its highest flood level and average water level. In case it is not done in the past , it should be undertaken at least wo to three years prior to uprooting.
- The depth of the main and the submain drain should be determined on the basis of the outfall condition.
- The collector and the field drain lines should be marked which will dug as per the designed dimension after completion of land preparation and leveling.
- The collector drain spacing should be 4-5 times of spacing of the field drains. It should be at least 15 cm deeper than the field drains.
- The field drain spacing should be as per the specification given below. The depth of the field drains should vary between 90-105 cm in relation to the outfall.

Soil Type	Spacing of Field Drain (m)
Loamy sand/sandy Sandy Loam Silt Loam/ Silty Clay Loam	20-25 15-18 10-12

Density of Population

Spacing (cm)	No. of plants per hectare
100 x 60	16666
100 x 75	13333
105 x 75	12698
105 x 60	15873
105 x 60 x 70	17316
105 x 65 x 75	15686
110 x 65 x 75	15238

Standard of plants:

- Plants should be 40-50 cm in height and 0.5-0.8 cm in collar diameter with 12-15 leaves.
- Age should be 10-18 months

Time of planting:

- Non droughty area : November to December or April to mid June
- Droughty area: End April to mid June or November to December under irrigation.
- Planting should be avoided during rains when the soil is wet.

Closer spacing is advisable for bushes having compact frame like TV1, TV17, TV27, TV28, TS449, TA 17/1/54 etc, while for bushes having spreading frame like TV 14, TV19, TV 20, TV23,TV 26,TV 29, TV 30,S3A/3,TS 462,TS 462, TS 463 TS 520 etc. wider as spacing should be adopted.

During initial few years, yield will be more in closely planted tea due to linear relationship between yield and plant population. Sustained high yield thereafter will depend on the bush frame and other related factors.

Planting

Size of plant: When the plants attain pencil thickness (5-8mm) and 40-45 cm tall having 10-12 leaves should be selected for planting. Sufficient hardening is required before planting.

Planting pit:

Ideal dimension for planting pit is 45cm diameter and 45-60 cm deep. The dimension should never be reduced, Otherwise root growth will be impaired and ultimately the productivity of the plants will suffer. While excavating soil from the pit, top soil and bottom soil are to be kept separately and during refilling these should be placed in the reverse order(i.e. fill top soil first at the bottom of the pit).

- Recommended pit size is 45-60 cm deep with 45 cm diameter. In Darjeeling diameter should be 30 cm.
- In heavier soil the pit should be loosened further by 15 cm over the recommended depth.

Planting mixtures:

- Cattle manure / compost: Dry well rotten cattle manure to be used @ 3-4 kg per pit. The organic manure should be thoroughly mixed with the excavated soil.
- Rock phosphate @ 60 gm at the bottom of the bheti mixing with excavated soil.
- 10% suspension of Trichoderma is to be mixed with the excavated soil/organic manure/compost @ 30 l/3t
- Best recently developed planting mixture is P and microbial enriched vermicompost @250-300 g/pit

Planting technique:

During planting, sleeves are placed at the centre of the pit without disturbing the sleeve soil. While refilling the soil in to the pit, light ramming is to be done so that no air pocket remains. While planting, care should be taken to flush the top of the sleeve with ground level. After completion of planting, ground leveling should be done to fill the depressions.

Mulching:

A layer of mulch should be minimum 10cm thick and are to be placed 10cm away from the collar of the plant(to save plants from the damage due to heat generation). In case of scarcity of mulching material initially a thin layer of mulching should be provided immediately, which may be topped up gradually. Mulching for moisture conservation must be completed by mid November. Soil rehabilitation crops like Guatemala grass are generally used mulch. To cover one hectare area (with 10cm thick lopping of Guatemala grass) about 15tonns of green matter will be necessary. Any vegetative material like water hyacinth, citronella grass, thatch, paddy, straw etc may be used as mulch, depending on their availability.

Green Cropping:

In young tea till obtaining adequate ground cover green crop can provide cover to the ground besides improving the microclimate required to support growth of young tea. In sloppy topography this can also reduce top soil loss and helps in conserving moisture for young tea. Therefore, green crop in sloppy topography should be established in between tea rows prior to planting tea. Generally, *Crotolaria anagyrioes, Pyrotripis cytisoides, Sesbania rostata* are used as green crop in alternate hedge. Periodic lopping of side branches is required to improve aeration.

A. In Plains

For Non droughty area (winter planting)

YEAR	MONTH	OPERATION	PLUCKING
0	November- December	Plant tea	Allow to grow
+1	End January-early February(soon after establishment) June –July (i.e at tippingtime) End October	Debudding/thumb prune/decentering ataround 20 cm Selectely remove Strong central branches at 25-30 cm Step up by a leaf, if necessary, in autumn	Tip at 65-70 cm groundmeasure
+2		Unprune*	Pluck to janam

+3	Between end January and early February	First frame forming prune at 35- 40cm.Remove /head back thick central branch (es), if necessary.	Tip at 65-70 cm
+4		Unprune	Pluck to janam
+5	Between end January and early February	Final frame forming at 40-45 cm. Remove/ head back thick central branch(es), if necessary.	Tip at 65-70 cm

- In case of vigorous clones, first frame forming prune and subsequent operations should be advanced by a year.

For Droughty area (Spring planted)

YEAR	MONTH	OPERATION	PLUCKING
0	April- June July –August (soon after establishment)	Plant tea Debud/thumb prune/ decentre at around 20 cm.	Allow to grow Tip at 65-70 cm ground measure.
+1	End January- early February	Selectively remove strong central branches within 25-30 cm above ground.	Pluck to janam.
+2	Between end January and early February End October	First frame forming prune at 35-40 cm .Remove /head back thick central branch(es) , if necessary. Step up by a leaf, if necessary.	Tip at 65-70 cm
+3	-	Unprune	Pluck to janam
+4	Between end January and early February	Final frame forming prune at 40 -45 cm . Remove/ head back thick central	Tip at 65-70 cm.
+5	-	branch(es),if necessary. Unprune	Pluck to janam

B. In hills (Low to medium elevation)

YEAR	MONTH	OPERATION	PLUCKING
0	April –June July – August (soon after establishment)	Plant Tea, debud	Allow to grow Tip at 65 cm ground measure.
+1	End January – early February	Thumb prune/ decentre at round 20 cm. Selective removal of strong central branches.	Pluck to janam
+2	Between end January and early February	First frame forming prune at 30-35 cm. Remove/ head back thick central branch (es), if necessary.	Tip at 60-65 cm
+3		Unprune, raise a leaf in July – August	
+4		Unprune	Pluck to janam.
	Between end January and early February	Final frame forming prune at 35-40 cm. Remove/head back thick central branch(es), if necessary.	Tip at 60-65 cm
+5		Unprune	Pluck to janam.

Hills elevation (High elevation)

YEAR	MONTH	OPERATION	PLUCKING
0	April-June July – August (soon after establishment)	Plant tea, debud	Allow to grow Tip at 65 cm ground measure.
+1	End – early January February	Thumb prune/ decentre around at 20 cm.	Pluck to janam.
+2	End early January-February	Selective removal of strong central branches.	
+3	Between end January and early February	First frame forming prune at 35-40 cm. remove / head back thick central branch (es) if necessary.	Tip at 60-65 cm
+4		Unprune , raise a leaf in July – August.	
+5		Unprune	Pluck to janam

	Between end January and early February	Final frame forming prune at 35-40 cm. Remove/ head back thick central branch(es), if necessary.	Tip at 60-65 cm
+6		Unprune	Pluck to janam.

Formative prune

After the plants are established in the field, which is indicated by two new flushes of growth, apical domination is removed by adopting any of the following methods:

(a) Decentering: On ascertaining full establishment of the plants following planting, decentering of the main stem should be done within 18-20cm, provided at least 2- 3 laterals are present below that height. Prior to decentering, assessment of root starch reserve (through starch test) is essential to find out whether the roots posses adequate starch reserve to withstand the shock of pruning.

(b) Lung/Thumb pruning: If the plants are devoid of any laterals up to a height of 20cm from ground level, instead of centering, the main stem of the plant is half broken above that height by using a small knife or holding the plants between thumb and index finger and forcibly bending them in such a way that the tissues on one side are left intact. This will enable the plant to restrict upward movement of water and nutrients (beyond the broken portion), while download translocation of metabolites will continue. This will force lower buds to develop into shoots. The top broken part should be bent southward or westward, depending on the direction of thye row and the broken part must be completely removed after the shoots from below produce new flush of growth. After decentering or lung pruning , any leader primary growing faster and getting thicker (than usual), should be head back 25-30cm above ground level within couple of months time. No starch test is necessary before lung pruning.

(c) Debudding: Debudding is an ideal technique which may better be adopted in the nursery itself about a week before transferring the plants to the field, because it will be then more thorough and economical. Under this method the top two and a bud shoot should initially be tipped to encourage swelling of the buds below within a fortnight. Thereafter the top axillary buds are nipped off by using a sharp blade or bamboo knife at the height of 20cm from ground. No starch test is necessary to undertake this operation.

First frame formation prune (1st FFP)

This pruning is imparted to the 20-26 months old plants during the cold weather at 8-10 cm below the pre-determined height of the permanent frame. Root starch reserve is assessed before imposition of pruning. Thicker branches are head back on merit and any congestion is removed. But care must be taken not to open up the centre too much. This treatment is aimed at uniform distribution of bush vigour to the peripheral branches, which results in ramification of branches of even thickness throughout the total expansion of the bush frame.

Final frame formation prune (2nd FFP)

Depending upon the plant growth as well as thickness of the majority of pruning sticks (more than 8mm diameter), Final frame formation pruning is imparted 2-3

years after 1st FFP, about 8-10cm above last pruning mark. The basic idea behind this pruning lie4s in development of around 30 well grown branches on the permanent frame with a spread of 2700-3200 sq.cm (i.e 60x45 or 65x45 or 65x50 sq.cm). Atleast 70% branches of the permanent frame should be 1.0cm thick and the frame should cover 30-40% ground area with minimum one stick per 100 sq.cm of the frame area.

Tea bushes thus formed comprise a three tier branching system in the proportion of 1:3:7 and each tier of branches having adequatye thickness to support the one above it. A recent survey conducted by Tocklai throughout the entire N.E Indian tea growing region revealed some more information regarding the frame structure of existing high yielding bushes which is mentioned below:

(a) The number of main branches (formed below centering level) of the high yielding bushes are around 5.5-7.0, while at permanent frame level it hovers around 25.0- 30.0.

(b) The thickness of main branches of high yielding bushes are about 3.4 cm and the same for branches at frame level ranges between 1.8cm to 2.0cm. But the current study failed to establish a direct relation between thickness of pruning sticks and yield, although in most case, bushes having thicker pruning sticks were associated with higher yield.

Schedule of operations for bringing-up of young tea

With the escalation in the cost of bringing up of young tea into bearing attempts is now being made to reduce the gestation period of tea through agronomic operations. Attempt to reduce the soil rehabilitation period was discarded after observing the physical and chemical properties of non rehabilitated soil after uprooting of tea. It was futher concluded that initially the plants grown in uprooted soil without rehabilitation may show no apparent adverse effect but afterwards productivity suddenly drops down and plants become uneconomic. Some salient findings emerged from recent experiment are presented below:

- Different planting materials require different management techniques for bringing up of young tea depending upon their growth vigour.
- Plants should be lung pruned immediately after their establishment followed by centering.
- Lung pruned plants exhibit more uniform branch distribution as compared to decenterd plants and number of branches are also more.
- Height of decentering may be increased up to 22cm depending on growth and variety.
- With the adoption of proper planting method followed by lung pruning, first frame formation pruning (FFP) may be advanced to next year itself provided the plants attain recommended thickness at collar and frame level.
- Vigorous plants exhibit better growth and yield when the second FFP is imparted at a higher height(50cm)

Important Agriculture Practices

Nutrition

- Manuring will exclude all inorganic fertilizers except the permitted ones. There will be inclusion of more organic matters and bio agents in the manuring schedule of organic tea.

  Application of AZOVAM, a bio formulation of AM fungi and *Azospirillum spp.* developed by TRA for use in tea nursery. The material may be made available by TRA on request.

  In sleeve: Scope (slightly inclined) about 1.0 - 1.5 cm. diameter and 2.5 - 3.0 cm. deep soil portion from the centre of the filled sleeve and put 10 g of azovam biofertilizer and tighten the soil. Fresh/callused cuttings should be planted in the same position.

  At the time of filling sleeves: A thin layer of azovam biofertilizer may be applied below 2.5 - 3.0 cm soil depth.

  In callusing/rooting bed: 500 g azovam biofertilizer per square meter should be mixed by forking to the rooting zone soil.

- **Planting pit**. The excavated soil is concentrated with 4-5 kg well rotten cattle manure or 100 g - 200 g concentrated organic manure like oil cake. The current recommendation is to use 60 g of rock phosphate (RP) per pit. The rock phosphatge should be mixed evenly with soil at the bottom for gradual availability. Organic manure (vermicompost) should be fortified with tricoderma (30 L/3t).
- The most effective alternate planting pit mixture is P-enriched vermicompost @250-300/pit.
- **Young tea section:** Broadcast 5 t well rotten cattle manure FYM/ vermicompost/ compost in two splits i.e., March-April, September-October. It is to apply to individual bush by placement.
- Inoculation of bulky organic manures with culture of Azospirillum, *Azotobacter* and phosphate solubilising bacteria (consortium) @3g/250-300g of compost (@ 3g/plant) before application into the field is also practiced in some tea estates.
- Apply 5% solution of vermiwash as foliar spray once in a month

Conversion and maintenance of established plantations Conversion period

- Normally three years are considered to be conversion years.
- From the first day of conversion no inorganic chemicals like fertilizers, insecticides, pesticides and herbicides should be applied in the proposed area except the approved one, if any.
- One can start marketing the tea as "in conversion organic tea" only after the lapse of one year from the start of conversion

The tea can be marketed as "organic tea" only after the completion of conversion of three years

Important considerations in pruning and skiffing

Tea is cultivated for succulent vegetative shoots for which the plant needs to be maintained t vegetative phase growth all through. In order to achieve this objective, pruning is imparted to the bushes from time to time. If pruning is delayed the age of the shoot bearing top branches increases for which, the size and weight of growing shoots on plucking surface decreases. More and more buds fail to grow with loss of vigour of the growing apices and there will be preponderance of banjhi shoots on plucking table. The bushes under the circumstances start accumulating excess food in the frame instead of contributing to growing shoots . To restore the vegetative growth phase, at this stage, pruning of tea bushes become essential.

Objective of Pruning

1. To maintain ideal frame height and thereby maintain plucking table at a convenient height for effective plucking.
2. To induce stimulate for vegetative growth.
3. To improve bush hygiene
4. To renew wood.
5. To increase partitioning of metabolites to growing shoots.
6. To regulate crop during the season.
7. To reduce the incidence of pests and diseases.
8. To improve the quality of tea.
9. To facilitate consolidation by infilling of vacancies.

Type of Pruning / Skiffing

The various type of pruning /skiffing imparted to tea bushes to suit the objectives mentioned above are classified below:

Rejuvenation prune

a) Objective

1) To renew the vigour of bush for productivity by removing the unproductive wood from the bush frame.
2) It is a stopgap in the estates having large number of old tea sections due for uprooting and replanting but failed to undertake due to various reasons.

b) Criteria for selection

- The section must not be programmed for uprooting with in next 12- 15years.
- The section should be devoid of primary root disease infection.
- There should have enough scope for improving drainage, if deficient.
- Vacancy in the section must not exceed 25%.
- Not more than 20% of the remaining bushes should be affected by stem disease (like Poria and Agalospora) down to the collar region.

- Health of the bushes should be such that they should be able to withstand severity of cut, and recover satisfactorily from pruning (hybrid jats usually perform better than light leaf Assam jat)

c) Pruning Height

Cambod/Assam type bushes of plains : 40-50 cm from ground level. Assam type bushes in hills: 25-35cm from ground level.

Chinary bushes in hills :15-20 cm from ground level.

Medium Prune

Due to rise in pruning height at the end of each subsequent pruning cycle there will be continuous rise in plucking table height. When the height between 50-60 cm from the ground level with the objective of lowering the frame height which is called as medium prune.

Light Prune or cut Across

Light pruning of tea bushes is required at the end of a pruning cycle. This is done retaining at least 5cm of wood above the last prune.

Deep skiff

With the adoption of 3-4 year pruning cycle to maintain a balance between yield and quality of crop, deep skiff is imparted within each cycle. This is the severest type of skiffing of primaries over the last pruning mark. It is done normally between 12-15 cm above the last light prune mark. When it comes after light prune, this is a cut given midway between the pruning and the plucking levels.At this level, at least a fork on each of the primary is available thereby ensuring higher crop.

Medium skiff:

Medium skiff is given to remove the current years crow 's feet. When it is done on light prune tea tipped at 20 cm or dep skiffed tea tipped at 10 cm, this will be a cut at a height of 15 cm from the pruning mark or 5 cm below the last tipping level .however ,when medium skiffing is done after one or more year/years of unprune/ light skiff/level off skiff, the skiff is given is just below the "crow's feet" formed by last years of plucking.

Light skiff:

Light skiff is a cut given at or upto 1cm above the previous tipping level i.e just deep enough to remove majority of the plucking points and level of the crow's feet. It would be cut througth the green wood above the crow's feet. It is consider as unprunned tea .

Level of skiff:

Level of skiff is trimming operation to level the uneven plucking points and old leaves that protrude above the plucking level at the end of the season. It is a cut about 5cm above the tipping level which retains more green tips of twigs on the plucking table.

Time of Prunning/Skiffing;

Time of pruning should concide with the period when the starch reserve in the root is maximunm and the vegetative growth is ceased. Time of pruning effect of the

total crop has profound influence on ther distribution of crop .It is difficult ot arrive at the exazt timer of pruning in general as it depends upon the various factors like climate, locality, requirement of crop and quality, seasonal distribution of crop , incidence of pest and diseases etc .It has been found that highest total crop Is obtained when pruning/skiffing is done during December and January. The study of the movement of photosynthates also reveal that the downward movement of photosyntates in tea bushes starts from October and reaches its peak in mid – February and then the photosynthates start moving upward. In view of this for the plains of north-east India December and January were found to be the Ideal months for pruning or skiffing of tea bushes. In Darjeeling, pruning can be started as early as November.

EFFECT OF PRUNING/SKIFFING ON CROP AND QUALITY

The total as well as seasonal crop is affected by pruning/skiffing. Quantum of loss/ gain of crop depends upon the severity of cuts. The following percentage of crop loss is normally associated with the type of prune as compared to unpruned:

Type of Prune/Skiff	Percentage loss of Crop
Medium Prune	60-70%
Light Prune	30-35%
Deep Skiff	10-15%

Medium Skiff 5-10%

Leaf from unpruned teas generally gives inferior quality than from LP,Ds or MS tea in plains. Studies made at Tocklai had showed that lighter the skiff, the lower is the price realization but earlier is the flush. But in case of Darjeeling as the second flush crop is more important for its value and the same can be obtained from unpruned teas, quality is considered to be associated with UP teas.

Pre-Pruning Operation Rejuvenation prune

1. Ring barking of old/diseased shade trees 2-3 years before pruning.
2. Steps should be taken in advance to raise nursery for both tea and shade infilling.
3. Vacant patches should be rehabilitated by establishing Guatemala grass or citronella grass two years in advance.
4. In shadeless /inadequately shaded section (s), raise shade 2-3 year pruning.
5. Improve drainage.
6. Rest the bushes for a period of at least 8 weeks before pruning.
7. Prune at a recommended height at which it is possible to get rid of maximum number of Knots and unproductive/dead/diseased wood.
8. Retain healthy "lung/breather" in southwestern direction on each at the time of pruning.
9. Apply additional dose of potash @ 60-120 kg/ha K2O as patenkali, based on soil potash status along with 40kg P2O5as Rock phosphate/ha as broadcast in the year of proposed prune preferably during September.

Medium prune

1. In inadequately shaded section(s), raise temporary shade trees.
2. Rest the bushes for a period of 6-8 weeks before pruning.
3. Apply additional dose of potash and phosphate @ 60 kg K2O as patenkali and 40 kg P2O5 as rock phosphate each as broadcast in the year of prune preferably during September.
4. Retain a healthy "lung/ breather" on each at the time of pruning preferably in south western direction.
5. Prune at a recommended height at which it is possible to get rid of maximum number of knots and unproductive /dead/diseased wood.

Light prune

1. Rest the weak section (s)/weak bushes infected by black rot for a period of 3 weeks before pruning.
2. Retain one "lung/breather" in the centre of each bush to improve the standard of pruning and for better recovery.
3. Prune retaining 4-5 cm of wood from last light prune mark.

Post pruning Operations

1. Spray a round of any approved copper oxychloride formulation at 1:400 dilution on the cut surfaces within 48 hours of pruning.
2. In case of medium pruning, seal the surface of large cuts with a recommended bituminous paint immediately following spraying of coc.
3. In place of COV and protective paint Trichoderma (20)% can be used as a paste on large cut marks .For light prune entire bush frame with 5% solution of trichoderma should be sprayed.
4. Remove all the unproductive "banjhi" shoots dead/diseased wood by round of good knife cleaning.
5. In medium/heavy prune section(s) , remove the left out knots ,individually.
6. Following Knife cleaning of MP bushes alkaline wash with a mixture of quick lime(2 kg),Washing soda (6kg) and 100 litres of water as required to maintain bush hygiene.
7. Remove "lungs"/breathers and indopaste the cut surface when majority of the buds opened.
8. Complete cultural operations like ground leveling, filling up of depression around the collar of the bushes, improvement of drainage system and uprooting of dead shade tree and tea stumps following pruning
9. Control measures against termite should be completed before the bud break starts.
10. Protect all the newly opened buds/shoots from sucking pests by spraying any approved insecticide at recommended dilution.

Pruning Cycle

The period between two successive light pruning is termed as pruning cycle. During

the interim period (in between), lighter forms of cut or unpruned or a combination of both are followed. In a pruning cycle all the forms of pruning/skiffings are introduced sequentially for distribution of crop, renewal of wood and for producing crop/quqlity. A pruning cycle may spread over 3-4 years in the plains and upto 5 years in the hills of Darjeeling depending upon elevation. The duration of pruning cycle should be such that at the end of cycle, the branches attain the desired thickness. Clones behave differently to various forms of pruning/skiffing in a cycle depending upon the duration of the cycle. Pruning sticks would have survived in a shorter circle get generally smothered in a longer circle. This is more pronounced in a light leaf Assam jats than chinary jats. This means that all clones do not responds similarly to longer pruning circle.

Cultural Practices

Soil water conservation measures

Adoption of proper soil and water conservation measures is essential for organic tea cultivation. Trenching and mulching conserve rain water and make the moisture available to the plants on a sustained basis. Tea pruning, leaf litter and compost should be buried in trenches. Mulching can be done with Guatemala grass (*Tripsacum laxum*), weeping love grass (*Eragrostis curvula*), bracken fern, shade tree lopping and other plant materials. Guatemala grass can be planted in large vacant patches with the twin objectives of rehabilitating the soil raising mulch material.

Soil reaction

The soil pH should be maintained at about 5.0 by application of agricultural lime or dolomite lime (IMO certified) once in a pruning cycle after getting permission from certifying agencies. The quantity of liming material should be determined on the basis of soil pH, rainfall and crop yield.

Nutrient Management in mature tea

- Broadcast will rotten cowdung/FYM or any compost @ 15 t/ha or 5 t of Neem cake or 3 t of Castor cake uniformly one month of application of rock phoaphate @30- 50 kg/ha. This should be broadcasted in two splits i.e., pre-monsoon and one post monsoon application. (Neem cake may be mixed at half of the doses with at half doses of vermicompost/FYM in two splits)
- Inoculation of bulky organic manures with culture of Azotobacter (10 kg ha-1) and phosphate solubilising fungi (Aspergillus niger) before application into the field is also practiced in some tea estates.
- For supplementation of potash apply wood ash @ 500kg/ha preferably in dry soil by broadcasting 15 cm away from collar. Wood ash may be applied only in mature tea field except in the pruned year. Under low potash level, patentkali, a naturally occurring mined potash fertilizer (30% K2O, 10% MgO and 17% S) need to be applied a2100-150 kg/ha depending on mean yield of a pruning cycle.
- Vermiwash, prepared preferably from potash rich biowaste viz., Mikania, Ipomia, banana etc, may be applied at 5% dilution (V/V) once in a month. More effective in DS and UP teas.

- Plant extract/weed extract was prepared in 200L capacity. One third of the vassel was filled with weed 1 kg fresh cowdung and water filled. Allowed it to ferment for 2 months. Applly 40 l of extract with 400 l of water/ha
- Cow urine (1L urine in 10 L of water can also be applied once in a month especially between October to March.
- Application of ZnSO4 @10 kg/ha/yr can be applied as foliar in UP and DS teas after getting necessary approval from certifying agency
- Basic slag, natural rock phosphate, limestone, chalk, gypsum etc are used occasionally with the prior approval of the inspection body.
- Retention of pruning litters in situ could add a substantial quantity of major and micronutrient nutrient to the soil besides recycling a huge amount of organic matter (Approx. 5000 kg/ha). Pruning litter may be sufficiently chopped and then evenly spread around the tea bushes (avoid creating heaps of material) leaving 10 cm around collar. They are cut into small pieces, and then shredded fungal cultures of Trichoderma viride, Trichurus spiralis, Paeciliomyces fusiporus etc @ 300 gm mt-1 of material was added. For best results, a 100% moisture level was strictly maintained during the initial period. Nutrient status also improved.
- To discourage the farm workers from using the pruning litter as fuel, they are provided with an alternative easily available fuel source and also made aware of the benefit of the mulch for their future generations.
- A good stand of recommended species of shade trees adds about 2500-5000 kg/ha of organic matter to soil annually by leaf-drop, twigs and pods. During this process a substantial quantity of major and micronutrients are recycled to the soil.
- Cultural practices like mulching, growing leguminous crops (shade trees, cover crops, green crops etc)would be a good source for the supply of nutrients.
- Biofertilizers may possibly be used effectively in the organic tea sections where no chemical fertilizer is used. In shade tree nurseries (using rhizobia), during rehabilitation through grasses (with Azospirillum) and / or legumes (with rhizobia) and Use of VAM in nurseries and young teas singly, or in dual inoculation with diazotrophs. Besides contributing nutritional needs, the diazotrophs can contribute in other ways in promoting plant growth. These include production of plant growth promoting substances, protection from pathogens etc.
- Use of bio-fertilisers fortified with tea suitable bio-inoculants in organic tea fields is approved. Bio-fertiliser are found to have positive impact on growth of young tea and yield of mature tea. Acis tolerant bioformulations approved by the certifying agencies may be used @25 kg/ha.The material may be mixed with soil at 1:5 ratio (viz., 1 part of Azospirilum formulations with five parts of

soil)and apply by shallow placement method in root zone of the tea bushes. Phosphate solubilising biofertilisers viz., Pseudomonas and Bacillus sp. Can also be used @20 kg/ha. Biofertiliser can be applied by mixing with vermicompost/ cattle manure. Application of mixed biofertiliser (consortium) resulted greater positive effect than application of single biofertiliser.

** Compost: (1.00% N, 0.65% P2O5, 0.50% K2O)

Vermicompost: (1.6% N, 0.70% P2O5, 85% K2O)

Neem cake: (4.20% N, 0.35% P2O5, 0.48% K2O)

Castor cake: (4.50% N, 0.34% P2O5 and 0.98% K2O)

Pest and diseases management

Pests and disease management in org. tea is primarily preventive rather than curative. Within a balance ecosystem, the pest and disease are controlled by use of resistant varieties, balance nutrient supply, augmentation of natural predators and parasites, pheromone traps, biopesticides-microbials and plant extracts, Mechanical/ physical practices and correction of faulty cultural practices . Strict and close monitoring is the utmost important.

Pest management through Microbial Bio-agents

Bio-agent	Conc.	Availability	Application against
Neem formulation (5% Azadirachtin)	1:1500	TRA recommended formulatrions	Sucking andchewing pests
Beauveria bassiana (Entomepathogen)	5-10% cfu suspension	TRA recommended formulatrions	Tea mosquito bug
Experimental use *Bacillus thuringiensis* (Bacterial product)	-	-	Caterpillar pests
Metarhizium anisopliae	5-10%	TRA recommended formulatrions	Termite

Pest management through Plant Extract

Botanical names	Concentration	Availability	Application
Cleodendron infortunatum	5-10% Aquous extract	In an around tea growing areas	Tea mosquito bug and Red spider
Polygonum hydropiper	5-10% Aquous extract	In an around tea growing areas	Tea mosquito and Red spider
Acorus calamus	5-10% Aquous extract	In an around tea growing areas	Tea mosquito bug and Red spider
Cassia tora	5-10% Aquous extract	In an around tea growing areas	Tea mosquito bug and Red spider
Xanthium strumerium	5-10% Aquous extract	In an around tea growing areas	Tea mosquito bug and Red spider
Amphineuron opulentum	5-10% Aquous extract	In an around tea growing areas	Tea mosquito bug

Cassia alata	5-10% Aquous extract	In an around tea growing areas	Tea mosquito bug
Helianthus sp.	5-10% Aquous extract	In an around tea growing areas	Tea mosquito bug
Leonurus sibiricus	5-10% Aquous extract	In an around tea growing areas	Tea mosquito bug

Disease management through Microbial Bio-agents

Product	Concentration	Availability	Application
Trichoderma viride/ T. harzianum	Spraying of 10% cfu suspension	TRA recommended formulations and TRA, Tocklai	Soil application- Charcoal stump rot, Brown root rot Application on pruning cuts- Poria branch canker and Thorny stem blight
Trichoderma viride/ T. harzianum	Manual application of 20% suspension (paste)	TRA recommended formulations and TRA, Tocklai	On the pruning cuts to protect against Poria branch canker and Thorny stem blight
Bacillus subtilis (Bacterial bioagent)	10% broth	TRA recommended formulations and TRA, Tocklai	Black rot and Blister blight

Disease management through Plant Extract

Botanical names	Concentration	Availability	Application
Acorus calamus	5-10% Aquous extract	In an around tea growing areas	Blister blight & black rot
Cassia tora	5-10% Aquous extract	In an around tea growing areas	Blister blight & black rot
Cassia alata	5-10% Aquous extract	In an around tea growing areas	Blister blight
Xanthium strumerium	5-10% Aquous extract	In an around tea growing areas	Blister blight & black rot
Leonurus sibiricus	5-10% Aquous extract	In an around tea growing areas	Blister blight

Weed control

- Weed control is the most difficult part in the org concept.
- Weed reduces 12-15% crop annualy
- Obnoxous weed reduces 30-40%
- High infestation causes poor establishment, weak health and mortality
- Chemical control increases 5-8% crop increase.
- Biological control not successful.

- There is no known bio-herbicide with acceptable efficacy
- Sickling of weeds in between the tea rows (gaullies) are the most effective weed control measures and should be done effectively and timely. Weeds around the collar of the plant should be removed by hand.
- Weeds may be controlled by hand pulling during dry period. Uprooted and slashed weeds should be retained in the field.
- One ground cheeling should be done at the end of March or earley April followed by org manure application when there is vigorous growth of weeds. Thereafter frequent slashing of weed monthly needs to be done for 6-7 months up to Dec.

Diversification, livestock farming (Livestock is an integral feature of org farming for cow dung, sheep, goat and poultry manure.)

- For additional income
- Farm wastes will meet the manure needs of the garden as well as provide raw material for biogas production
- The composting process can be enhanced using vermiculture
- Improve the socio-economic condition
- Raising of live stock is a good farm diversification practice. Maintaining a livestock farm and a house garden by each worker will produce considerable additional material like milk, meat, eggs and vegetables for own use and the surplus will bringadditional incom. Farm wastes will meet the manure needs of the garden as well as provide raw material for biogas production. Using vermiculture composting process can be enhanced. Thus atleast a major part of the required input can be generated within the garden

Cold weather practices in tea

In a perennial crop like tea sustainability of bush productivity mainly depends on maintenance of bush health and hygiene. It is observed that under package of sound agriculture practices most of the recommended planting materials can produce more than 3000kg made tea hectare at maturity in N.E. India. However, such areas are smaller and confined to a few sections in different estates. This clearly indicates that a proper planning at estate level is necessary to sustain high level productivity through maintenance of bush hygiene and soil health.

Cold weather being the lean period for crop, majority of the agricultural practices that have impact on crop and health of tea should be done with perfection. The field operations to be carried out during cold weather in regional basis have been highlighted.

Post-harvest and Manufacturing

Manufacturing practices

For manufacturing, only mechanical and physical process are allowed with natural fermentation. It can be manufactured as orthodox, CTC, Oolong or green tea. Tea is manufactured by either CTC (curl, tear, crush) or orthodox methods. Either

methods involve withering (basicaaly air drying to reduce moisture), curling, tearing and crushing the leaves (in case of CTC) or rolling the withered leaves (in orthodox manufacture). The next event is fermenting the processed leaves (about 30 minutes) followed by drying at 212°C. In no single step is there for any use of chemicals. The organic tea should be processed separately from non-organic leaves. The manufacturing machines and other containers should be free from any traces of chemicals including heavy metals.

Isolation of manufacturing facility

Manufacturing of organic tea should be carried out in a separate factory to eliminate all changes and possibilities of coming into contact with the conventional tea. The manufacture of "organic tea in conversion" and "organic tea" should be done on separate days; care should be taken for proper cleaning and washing the factory with water under pressure before the manufacture of "organic tea" and after manufacture of "organic tea in conversion".

Storage and packing

There should be separate store for organic tea where no fumigation, insecticides or fungicides are used. Vacuum, steam or high pressure water cleaning is permitted. Organic tea should be packed in plywood chests or biodegradable packing materials on the same day of production and the organic quality grade should be clearly indicated on each chest or container along with the invoice number of dispatch.

Transportation and shipment

The chests of organic tea should be transported separately and there should not be any chance of it coming into contact with the conventional tea. Before shipment to destination, it should be stored in an isolated place, away from the conventional tea.

COCONUT (*Cocos nucifera*)

Coconut requires an equatorial climate with high humidity. The ideal mean annual temperature is 27ºC with 5-7ºC diurnal variation. The palm does not withstand prolonged spells of extreme variations. A well-distributed rainfall of 1300- 2300 mm per annum is preferred.

Coconut is grown in different soil types such as laterite, coastal sandy, alluvial, and also in

reclaimed soils of the marshy lowlands. It tolerates salinity and a wide range of pH from 5.0-8.0. Organic farming practices have to be adopted to suit the varying climatic and soil conditions.

Selection of site

Select sites with deep (not less than 1.5 m depth) well drained soil. Avoid shallow soils with underlying hard rock, low-lying areas subject to water stagnation and heavy clayey soils.

Cultivars

1. West Coast Tall (WCT)
2. Lakshadweep Ordinary (Chandrakalpa)
3. Philippines Ordinary (Kerachandra)
4. Andaman Ordinary
5. Java
6. Cochin China
7. Kappadam
8. Komadan

Hybrids

1. Lakshaganga (Lakshadweep Ordinary x Gangabondam)
2. Anandaganga (Andaman Ordinary x Gangabondam)
3. Keraganga (West Coast Tall x Gangabondam)
4. Kerasankara (West Coast Tall x Chowghat Orange Dwarf)
5. Chandrasankara (Chowghat Orange Dwarf x West Coast Tall)
6. Kerasree (West Coast Tall x Malayan Yellow Dwarf)
7. Kerasoubaghya (WCT x SSA)
8. Chowghat Green Dwarf x West Coast Tall
9. Chandralaksha (Lakshadweep Ordinary x Chowghat Orange Dwarf)

***Tender nut variety*: Chowghat Orange Dwarf**

Note:

(1) Hybrids Anandaganga, Keraganga and Kerasankara are recommended for general cultivation both under rainfed and irrigated conditions.

(2) Other hybrids especially Chandrasankara are recommended for ideal situations and where good management practices are adopted.

(3) Since the performance of Chandrasankara is markedly superior to that of WCT in root (wilt) affected areas, cultivation of Chandrasankara is preferred in such areas.

(4) Chandralaksha, Lakshaganga and Chandrakalpa are recommended for cultivation under drought prone areas.

Selection of mother palms

Select mother palms having the following characters:

1. Regular bearing habit and yielding not less than 80 nuts / annum.
2. Age 20 years or more (5 years after reaching full bearing capacity).

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

   Avoid palms which

   (i) have long, thin and pendulous inflorescence stalks

   (ii) produce long, narrow, small sized or barren nuts

   (iii) show shedding of immature nuts in large numbers and

   (iv) are grown under favourable environmental conditions.

Collection and storage of seed nuts

Collect mature nuts (above 11 month old) during the period from December to May. Lowering of bunches by means of ropes may be done when the palms are tall and ground is hard. Discard nuts, which show improper development or other undesirable features. Store seeds in shade for a minimum period of 60 days prior to sowing in nursery. For storing, arrange the seed nuts with the stalk-end up over an 8 cm layer of sand in a shed and cover with sand to prevent drying of nut water. Up to five layers of nuts can be arranged one over the other. The nuts can also be stored in plots, provided the soil is sandy and the ground is sufficiently shaded. In the case of nuts harvested in May, heap them in partial shade, till husk is well dried and then sow them in the nursery.

Selection and preparation of site for nursery

Nursery sites should be well drained with light textured soil and with adequate but not too much shade. In open areas, provide shade during summer. Prepare beds of 1.5 m width and of convenient length with 75 cm space between beds. In areas where drainage is poor, prepare raised beds.

Before planting, examine seed nuts and discard those without nut water and rotten kernels. Sow the nuts in the nursery after commencement of southwest monsoon during May-June.

Spacing of nuts

Plant the seed nuts at a spacing of 30 cm (between rows) x 30 cm (between nuts) with four or five rows per bed.

Method of planting seed nuts

Plant the seed nuts in the beds in trenches 25-30 cm deep and cover with soil so that top portion of husk alone is visible. The nuts may be planted either horizontally

with the widest of the segments at the top or vertically with stalk-end up. Vertical planting is preferable on account of convenience in transporting and lesser risk of seedling injury.

Care and management of nursery

Provide protective fencing to the nursery if it is located in open area. If the soil is sandy, provide mulching immediately after the cessation of monsoon rain. Irrigate the nursery once in two days during summer months. Keep the nursery beds free of weeds by periodic weeding. If termite is noticed, remove soil in the affected area up to a depth of about 15 cm and dust soil and nuts with small quantity of sodium chloride. Repeat if attack persists. Periodically spray the plants with 1% Bordeaux mixture to prevent fungal infection.

Selection of seedlings

Remove seed nuts, which do not germinate within 6 months after sowing as well as those with dead sprouts. Select only good quality seedlings (9-12 months old) by a rigorous selection based on the following characteristics.

1. Early germination, rapid growth and seedling vigour.
2. Six to eight leaves for 10-12 month old seedlings and at least four leaves for 9 month old seedlings.
3. Collar girth of 10-12 cm.
4. Early splitting of leaves.

Note: The recovery of quality seedlings will be about 60-65%. Since early germination is one of the criteria for the selection of seedlings, the storing and sowing of seed nuts should be in lots rather than in a staggered manner.

Removal of seedlings

Remove seedlings from the nursery by lifting with spade and cutting the roots. Keep the seedlings in shade and do not expose to sun. Plant seedlings as early as possible after removal from nursery. Never allow lifting the seedlings from the soil by pulling the leaves or stem.

Preparation of land and planting of seedlings

The nature of preparation of land before planting depends upon topography of land, soil type and other environmental factors. On slopes and in areas of undulating terrain, prepare the land by contour terracing or bunding. In low-lying areas and rice fields, form mounds to a height of at least 1m above water level. In reclaimed kayal areas, planting can be done on the field bunds. The size of pits for planting would depend upon soil types and water table. In loamy soils with low water table, pit size of 1m x 1m x 1 m is recommended. In laterite soils with underlying rock, take larger pits of size 1.2m x 1.2m x 1.2 m. In sandy soils, the size of pits may be 0.75m x 0.75m x

0.75 m. The pits may be filled up with topsoil to a height 60 cm below the ground level. In low lying lands, take shallow pits and as the plant grows,

raise the ground level by adding silt and sand so as to cover the entire bole of the palm. The same procedure can be adopted when planting is done on mounds or bunds. Burial of two layers of husks in the floor of the pits will be useful for moisture conservation. The husk is to be buried in layers with concave surface facing upwards. After arranging each layer, sprinkle common salt on the husk to

prevent colonization by termites.

Note: In lateritic areas, common salt at the rate of 2 kg per pit may be applied on the floor of the pit to improve soil conditions. Common salt is to be applied about six months prior to planting.

Spacing

Spacing depends upon the planting system, soil type etc. In general, the following spacings are recommended under different systems in sandy and laterite soils. In lateritic gravelly soils, under rainfed conditions of north Kerala, a closer spacing to accommodate 250 palms per ha is more economical.

Table 10.Spacing for coconut

Planting system	Spacing	Approximate numberplants/ha
Triangular	7.6 m	198
Square	7.6 to 9 m	170-120
Single hedge	5 m in the rows 9 between the rows	220
Double hedge	5m x 5m in rows between pairs of ro	280

In the hedge system of planting, the rows should be aligned in north-south direction and the seedlings planted as in the triangular system.

Time of planting

Planting the seedlings during May, with the onset of pre-monsoon rains is ideal. Under assured irrigation, planting can be done during April also. In low- lying areas, plant the seedlings in September after the cessation of heavy rains.

Shading and irrigation

For the first two years from planting, irrigate @ 45 litres of water per seedling, once in 4 days, during dry summer months. Provide adequate shade to the transplanted seedlings.

Weeding and interculture

Keep the pits free of weeds by periodical weeding. Remove the soil covering the collar of seedlings. As the seedlings grow and form stem, fill up the pits gradually by cutting the sides. Proper intercultivation provides control of weeds and creates soil mulch. Any tillage system (ploughing, digging, raking or forming mounds) that provides soil mulch and control weeds may be followed depending upon local conditions. For laterite, sandy and red sandy

loam soils give two ploughings or diggings in May-June and September- October and one raking in January. In areas where surface run off is more, form mounds in September- October and level them in November-December.

Drought management in coconut gardens

Coconut produces nuts round the year. Therefore, adequate supply of water is essential for its unhindered growth. Soil moisture is essential for the absorption of nutrients by roots. Moisture stress leads to stunted growth, drooping of leaves, immature nut fall and decreased yield. Importance may be given on the following aspects so as to ward off stress.

1. Husk burial for moisture conservation

Burying of fresh or dried coconut husk around the palm is a desirable practice particularly for moisture retention. The husk can be buried either in linear trenches taken 3 m away from the trunk between rows of palms or in circular trenches taken around the palm at a distance of 2 m from the trunk. The trenches may be of 0.5 m width and depth. The husks are to be placed in layers with concave surface facing upwards and covered with soil. The beneficial effect of husk burial will last for about 5-7 years. Instead of husk, coconut pith can be buried @ 25 kg / palm / year.

2. Mulching

Mulching is an effective method of conserving soil moisture. Mulch the coconut basins with green / dry leaves at the close of northeast monsoon (October-November). Mulching also adds organic matter to the soil and reduces the soil temperature. Do not disturb soil in the coconut garden during summer months. In level lands, during rainy seasons excess water may be conserved in small trenches dug out in the plantation. In sloppy areas, land may be terraced and trenches dug across. This will facilitate maximum percolation of rainwater and water storage. For moisture conservation, lowermost 3-5 leaves may be cut and removed. Provide adequate shade for the transplanted seedlings for 1-2 years. To minimize the heat load on the stem, application of lime solution on the trunk up to a height of 2-3 m at the start of the summer season is recommended.

3. Green manure and cover crops

Green manure and cover crops recommended for cultivation in coconut gardens are:

(a) Green manure crops: *Crotalaria juncea* (sunn hemp), *Tephrosia purpurea* (kolinji), *Indigofera hirsuta, Pueraria phaseoloides*.

(b) Cover crops: *Calapagonium muconoides, Mimosa invisa, Stylosanthes gracilis*

(c) Shade-cum-green manure shrub: *Tephrosia candida*

Sow green manure and cover crop seeds during April-May with the onset of pre-monsoon rains. The green manure crops should be ploughed in and incorporated into the soil during August-September. This will increase the water holding capacity of soil. *Calapagonium* can be grown either as green manure or cover crop. *Tephrosia* is especially suited for planting around seedling pits for summer shade and as a source of green manure in the rainy season.

Manuring of adult palms

Apply FYM /cowdung 50kg + ash 5kg + *Azosprillum* 200 g / palm / year or PGPR mix 1.

Note:

1. Under irrigated conditions, manures can be applied in 3-4 equal split doses.
2. In the case of low-lying areas, apply manures in one single dose after water table recedes or in two split doses as conditions permit.
3. The application of organic materials such as forest leaves, cattle manure, coir dust or coconut shredding @ 10 kg per pit along with PGPR mix I (100-200g) in the first three years will be useful to obtain better establishment of coconut palms in sandy soils and in coastal situations.

Time, frequency and method of application

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

Under rainfed conditions, apply manures in two split doses, 1/3 rd at the time of early southwest monsoon showers in April-June and 2/3 rd in September-October.

Under irrigated conditions, apply manures in three or four equal doses in April-May, August-September, December and February-March.

Apply lime or dolomite during April-May, magnesium sulphate during August-September.

For an adult palm 1 kg dolomite or 1 kg lime + 0.5 kg MgSO4 is required per annum.

Apply manures in circular basins at a radius of 2.0 m from the base of the palm and 10 cm deep, opened after the onset of southwest monsoon. Split doses can be applied with irrigation water in summer months.

Recycling of palm waste

Recycling of palm waste is very much beneficial especially for maintaining the availability status of micronutrients and trace elements. Palm wastes like coconut leaves, crown waste,dried spathes, husk etc. may be deposited in a small trench of convenient length, 0.5 m to 0.75 m wide and 0.3 to 0.5 m deep at a distance of 2-2.5 m away from the base of the trunk. Fill up this trench with the palm wastes along one side of the palm (say north) in one year, opposite side (south) in the next year, east in the third year and so

on. This practice of organic recycling of waste has been found to improve the growth and productivity of the palms.

Intercropping and mixed cropping

Schedules for inter/mixed cropping may be drawn up based on the canopy size, age and spacing of palms. In general, palms in the age group of 8-25 years are not suitable for inter and mixed cropping. However, cereals and tapioca are recommended as intercrops in young coconut plantation up to 3-4 years. Since ginger and turmeric are shade tolerant crops with shallow roots, they can be intercropped in coconut garden even in the age group of 15-25 years. It ensures better land utilization, solar energy harvesting, efficient water use, utilization of soil nutrient resources, more returns and an insurance against crop failure. Under conditions of wider spacing i.e. beyond 7.6 m, intercropping is possible irrespective of the age of the palms. The following crops are recommended as intercrops:

Cereals: Rice, maize

Legumes and pulses: Groundnut, horsegram, cowpea

***Tubers*:** Tapioca, sweet potato, yams, colocasia

***Spices*:** Ginger, turmeric, chilly, pepper, nutmeg, cinnamon, clove

***Fruit plants*:** Banana, pineapple, papaya (Banana variety Palayankodan is recommended in the reclaimed soils of Kuttanad. Three suckers per clump have to be retained).

***Beverage crop*:** Cocoa

***Fodder grasses*:** Hybrid Napier, guinea grass

In all cases, separate application of adequate manures to the individual crop is essential.

Crop cafeteria for multiple cropping in coconut garden

Perennials: Cocoa, nutmeg, pepper, clove, lemongrass and cinnamon.

Annuals:

(a) *Kharif*: Rice, maize, groundnut, ginger, turmeric, chilli, yams, colocasia,redgram, vegetables, sweet potato, tapioca, banana, pineapple, papaya and fodder grass.

(b) *Rabi*: Sesame, horsegram, redgram, vegetables, cowpea, sweet potato and banana.

(c) Summer: Vegetables

Irrigation

Irrigate the palms during summer months in basins around palms as shown below:

Table-05: .Irrigation requirement of coconut

Parameters	Soil texture			
	Sandy	Sandy loam	Loam	Silty clay
Available soil moisture (cm/m)	8	12	17	21
Quantity of water / irrigation / palm in litres in a basin of 1.8 m radius	600	900	1300	1600
Frequency of irrigation (days)				
All areas in Kerala except north eastern portion of Thrissur and Palakkad districts	3-4	5	7-8	9
North eastern portion of Thrissur and Palakkad districts	2-3	3-4	5-6	6-7

Note: In coastal sandy soils, seawater can be used for irrigation. In irrigated gardens, interruption of irrigation would lead to serious set back in yield and general condition of palms. Hence, when once started, irrigation should be continued regularly and systematically. In sandy loam soil, irrigating the crop with 500 litres of water through basin taken at 1.5 m radius at an interval of 15 days is most economical. Do not irrigate seedlings and very young palms with seawater.

Drip irrigation

In the traditional system of irrigation followed in coconut gardens such as flood irrigation, basin irrigation etc. irrigation efficiency is only 30 to 50 per cent due to considerable wastage of water. In addition, cost on inputs like labour and energy in adopting these systems are high. Scarcity of water and increasing cost of labour and energy are deterrents in adopting these traditional irrigation systems. Under these circumstances, drip irrigation is the most suitable system of irrigation to coconut. Some of the major advantages of drip irrigation are: it saves water, enhances plant growth and yield, saves energy and labour, most suited for soils having low water holding capacity and undulating terrain, reduces weed growth and improves efficiency of fertilizers. For coconut, generally, three to four drippers are given per palm. The water requirement for an adult palm is 40 to 50 litres per day.

D x T hybrid production

The following guidelines are suggested for large-scale production of D x T hybrid seedlings. Assisted pollination should be done to get maximum hybrid nut production. As far as possible use prepotent palms as parents in the hybridization programmes.

Selection of mother palms

Palms with the following phenotypic character combination may be selected for hybridization work.

1. Nuts without ridges and having yellow, orange or red colours.
2. Palms with overlapping female and male phases.
3. Small crown and canopy compared to that of tall palm.
4. Narrow stem without any bulging at the base with close leaf scars.

Hybridization

1. Use mixed pollen from identified tall palms.
2. Emasculate the inflorescence by cutting the male flowers with scissors and stripping if necessary within 5-7 days of opening the spathe.
3. Cloth bags made of very close mesh should be used for covering the inflorescence.
4. Dusting of pollen-talc mixture in 1:9 proportion using pollen dispensers is recommended.
5. Assisted pollination for at least 3-5 days on each inflorescence till last female flower becomes receptive and fully pollinated.
6. Remove bags after the seventh day of pollination of the last female flower.

Nursery

The nuts should be harvested before it is tree-ripe and sown immediately in the bed without storage. Nursery beds should be mulched or shaded and watered regularly and adequately.

Plant protection 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, waterlogging and lack of aeration.

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

Pests

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.

Prophylactic / control measures

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 250g neem cake or marottti (*Hydnocarpus wightina*) cake mixed with equal volume of sand in the innermost 2-3 leaf axils as a prophylatic measure. This treatment is to be done twice, ie, during April-May before the onset of south-west monsoon and during September- October after the south – west monsoon.
4. Dust manure pit walls with lime powder and plaster with cow dung.
5. Boil castor cake and groundnut cake with a little quantity of water. Keep in earthern pots near light source to attract beetles, which can be collected and killed.
6. Mix sand (250g) and neem seed powder (100g) and fill inner leaf sheaths of youngest leaves.
7. Apply roots, shoots, leaves and flowers of *Clerodendron infortunatum (peruvalam)* with cowdung in manure pits. Fresh plant or shade dried plant mixed with cowdung in the ratio 1:10.
8. Release *Baculovirus oryctes* infected adults @ of 10-15 / ha to bring down the pest population.
9. Inoculation of breeding sites with entomopathogenic fungus *Metarrhizium anisopliaevar. major* (@ 5 x 1011 spores / ml) gives effective control.

Red palm weevil *(Rhyncophorus 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. Clean the crown periodically before and after rain.
6. Mix sand and nerium seed powder and fill the bore holes.
7. 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 insecticides to each trap to kill the weevils trapped.
8. Use of pheromone trap for attracting and killing adult weevils @ one trap per 2 ha.

Leaf eating 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 prophylatic 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. Mix extract of 2 kg neem seed kernel and 200 g soap in 200 litres of water and spray followed by the release of larval pupal parasites.

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. Apply sugar solution in coconut basin near root zone.
4. Leaf loppings of *Anacardium occidentale, tamarindus indica* and *tectona grandis* and drenching with cashew nut shell liquid (CSNL) solution (2% v/v) is effective against root grub.

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

Grow neem as alternate host to attract the bugs and destroy the bugs.

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

Coconut eriophyid mite 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. 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 bunch from top avoiding unpollinated inflorescence. Care should be taken to see that spray fluid reaches the perianth region of third, fourth and fifth bunch 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.

   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 and the nuts never grow to proper size.

Control

Remove and destroy all dried up inflorescence and unproductive buttons. 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. Boil 10kg wheat and two large pieces of Glyricidia bark and broadcast in field as bait.
2. Mix gypsum and sugar and keep in places as bait where rats are frequent.
3. Take 1 part nerium seed powder + 9 parts rice +1 part coconut pulp + a little oil. Mix well and use as a bait.
4. Mix shrimp powder and cement (dry) and keep as bait. Pre baiting with shrimp powder alone will be more effective.
5. Use tin barrier around tree trunk to prevent rat damage.

Diseases

Bud rot *(Phytophthora palmivora)*

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 colours 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.
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 neighbouring palms, as a prophylatic measures. 4.Drench crown with *Pseudomonas fluorescence* 2% suspension or PGPR mix II.
5. Adopt control measures for rhinoceros beetle.
6. Provide adequate drainage in gardens.
7. Adopt proper spacing and avoid over crowding in bud rot prone gardens.

Mahali *(Phytophthora palmivora)*

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 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 ribbing and flaccidity of leaflets. Yellowing of outer whorl of 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 practices for the effective management of root (wilt) disease is given below:

1. Rogue out palms that are affected severely by root (wilt) and that 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. Growing green manure crops like sunn hemp, sesbania, cowpea and calapagonium 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.
3. Apply manures in 10cm deep circular basins at a radius of 2 cm from the bole of the palm.
4. When the crop is grown under the bund and channel system, desilt the channel and strengthen the bunds during summer months.
5. Ensure proper drainage in the field during rainy season.
6. 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. Apply Trichoderma + *Pseudomonas fluoroscence* so as to enhance the soil health. Irrigate the palms in soil month.

Package for severely affected areas

Apply FYM 25kg + coirpith compost 25kg + wood ash 5kg + kayal silt (if available) per coconut basin. Sow 35g of cowpea seeds per basin of 1m width and incorporate the biomass in the soil. Bury coconut husks of 25 coconuts in the basins and apply

water.

Leaf rot *(Colleototrichum gleosporiodes, Exserohilum rostratum and Fusarium* spp.*)*

Symptoms

Appearance of water-soaked brown lesions in the spear leaves of root- wilt affected palms is the initial symptom. 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.

Management

1. Remove the rotten portions from the spear and the two adjacent leaves.
2. Spray crowns and leaves with 1% Bordeaux mixture in January, April- May and September. While spraying, care has to be taken to spray the spindle leaf.
3. Application of *Pseudomonas fluorescence* 2% suspension in the leaf at the initial stage of infection.

Stem bleeding (*Thielaviopsis paradoxa)*

Symptoms

Exudation of the reddish brown liquid through the growth cracks mostly at the basal part of the trunk above one meter from the basin 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.

Control

1. Chisel out the affected tissues completely and paint the wound with Bordeaux paste.
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. Irrigate the palm during summer season and avoid water stagnation during rainy season.
4. Apply *Trichoderma* @ 50g/palm along with FYM.

Grey blight (*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.

Tanjore wilt (*Ganoderma lucidum)*

Symptoms

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 discoloursed 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.
4. Drench the basin with 40 litres of 1% Bordeaux mixture to soak soil up to 15 cm depth at quarterly intervals.
5. Avoid flood irrigation in order to prevent the possible spread of the pathogen through soil.
6. 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.
7. Avoid growing leguminous crops in and around the garden.

Safe storage of copra

Copra obtained from commonly cultivated varieties / cultivars is attacked by various insect pests in store. Among these ham beetle *Necrobia rufipes* and saw toothed grain beetle *Oryzaphilus surinamensis* are of major importance, which can cause more than 15% loss to copra when stored for

more than six months.

Following precautions are to be taken for the safe storage of copra for more than three months:

(1) Dry the produce to four per cent moisture content.

(2) Avoid heap storage, which causes maximum damage.

(3) Store copra in netted polythene bags or gunny bags.

Shell fired copra dryer

A new type of dryer working on indirect heating and natural convection principles using coconut shell as fuel has been designed and developed by CPCRI. The overall dimension of the dryer is 2.25m length, 105m breadth and 1.5m height. The capacity of the dryer is 1000-1200 nuts per batch. The dryer has two heating chambers which are arranged in parallel. Specially developed rolling in type of fuel trays are used for burning the fuel. The dryer consists of a drying chamber, a burning chamber, a plenum chamber and ventilation holes. Each full tray produces heat for 6 hours, with a temperature of about 80-82°C. Generally after 6 hours, when the temperature drops below 600°C, the fuel trays are removed from the dryer, cleaned and reloaded with fuel, refired and replaced into respective burning chambers. About 4 loads of fuel are required with a capacity of 80 shells per tray to dry the copra to about 6.25% moisture content. The total drying time is 24 hours. The cost of the dryer is approx. Rs 35,000/-. Farmers and entrepreneurs interested

to purchase this dryer can contact, Agricultural Technology Information Centre (ATIC), Central Plantation Crops Research Institute, Kasargode for further details.

CASHEW (*Anacardium occidentale*)

Cashew is adapted to warm humid tropical conditions. It can be grown in almost all types of soils from sandy to laterite and up to an elevation of 600-700 m including wastelands of low fertility. It grows and yields best in well-drained red sandy loams and light coastal sands. Heavy clay soils, poor drainage conditions, very low

temperature and frost are unsuitable for the crop.

Selection of site

Organic cashew orchards, whether planted new or converted from existing orchards, should be isolated from the conventional orchards by a minimum distance of 500 m. Being a tree crop, a minimum period of three years is required for converting an existing cashew plantation in to organic. Since newly planted trees take 2-3 years for yielding, the nuts collected from the first harvest itself can be considered as organic.

Varietal choice

High yielding varieties recommended for the region is to be selected for new planting and re-planting. The varieties recommended for cultivation in Kerala are presented Table.By principle, preference is to be given for pest and disease resistant/ tolerant varieties. Unfortunately, none of the improved varieties are found to be resistant to major pests of cashew. However, Damodar is apparently tolerant to Tea Mosquito Bug. Likewise, Goa-11- 6 (Bhaskara), released by National Research Centre for Cashew, Puttur is reported to perform well even under un-sprayed situations. A grouping of released cashew varieties according to their susceptibility to tea mosquito bug is furnished inthe table

Table-06: Varieties according to their susceptibility to tea mosquito bug

Varieties/ hybrid/types	Mean yield(kg/ tree/ year)	Nature of bearing	Susceptibility statusto TMB
Anakkayam-1 (BLA 139-1)	12.00	Early	Susceptible
moMadakkathara-1 (BLA 39-4)	13.80	Early	Moderately susceptible
Vridhachalam-3 (M 26/2)	11.68	Early	Moderately susceptible
Kanaka (H-1598) (BLA 139-1 x\H 3-13)	12.80	Mid	susceptible

Varieties/ hybrid/types	Mean yield(kg/ tree/ year)	Nature of bearing	Susceptibility statusto TMB
Dhana (H-1608) (ALGD 1-1 x K 30-1)	10.66	Mid	Moderately susceptible
K-22-1	13.20	Mid	Moderately susceptible
Dharasree (H-3-17) (T 30 x Brazil 18)	15.02	Mid	Moderately susceptible
Priyanka (H-1591) (BLA 139-1 x K-30-1)	16.90	Mid	susceptible
Amrutha (H-1597) (BLA-139-1 x H 3-13)	18.35	Mid	Moderately susceptible
Anagha (H-8-1) (T 20 x K30-1)	13.73	Mid	Highly susceptible
Akshaya (H 7-6) (H4-7 x K30-1)	11.78	Mid	Moderately susceptible
Madakkathara-2 (NDR 2-1)	17.00	Late	susceptible
Sulabha (K 10-2)	21.90	Late	Moderately susceptible
Damodar (H 1600) (BLA 139-1 x H3-13)	13.36	Mid	Apparently tolerable
Raghav (H 1610) (ALGD-1-1 x K-30-1)	14.65	Mid	Moderately susceptible
Poornima (BLA 139-1 x K 30-1)	14.10	Mid	-

Planting materials

Cashew can be propagated by seedlings, air layers and softwood grafts.

Since it is a cross-pollinated crop, vegetative propagation is recommended to obtain true to type progeny. Field establishment of air layers have been found to be poor. Hence softwood grafts, which give a high rate of establishment and early flowering, are recommended for planting.

1. **Propagation by seedlings**

Selection of mother trees

Select mother trees having the following characteristics:

(1) Good health, vigorous growth and intensive branching habit with panicles having high percentage of hermaphrodite flowers.

(2) Trees of 15-25 years of age.

(3) Bearing nuts of medium size and weight (5-8 g/nut) with an average yield of 15 kg nuts per annum.

(4) Bearing 7-8 nuts per panicle.

Selection of nuts

Select mother trees in February and collect seed nuts in March-April. Select good, mature, medium sized nuts, which sink in water as seeds after drying in sun for two to three days.

Raising seedlings

Raise seedlings in polythene bags during May. Use bags of size 20 cm x 15 cm and fill the bags with garden soil, leaving a gap of 1 to 1.5 cm above. Soak seed nuts in water for 18 to 24 hours to hasten germination. Sow the pre- soaked seed nuts in bags filled with garden soil at a depth of 2-3 cm with the stalk end up. Seeds germinate in seven to ten days.

2. Propagation by air layering

Prepare air layers during February-March, so that they will be ready for planting in June-July. Select 9-12 month old pencil-thick terminal shoots. Remove carefully a strip or ring of bark, 0.6 to 1.2 cm thick by using a sharp knife without injuring the underlying wood. Wind a string around the cut area and cover it with moist moss or wood shavings or sand and saw dust mixture or ordinary potting mixture and wrap round with 150-200 gauge polythene film of size 23 x 15 cm. Secure loose ends of film with jute fiber. When roots emerge from the ringed portion in 40-60 days, give a 'V' cut at lower end of treated shoot. After about 15 days, deepen the cut slightly. Cut and separate rooted shoot about 7 days later. Pot the layers immediately after separation from the tree into containers of size 15cm x 15 cm made from coconut husk and keep them in shade. Avoid excessive watering. Plant the layers along with the container in the prepared pits with the onset of southwest monsoon. Provide shade and mulch with dry leaves to reduce sun-scorch in tender plants. It is advisable to defoliate the layers two weeks before separation from the mother plant.

3. Propagation by grafting / budding

Different methods of grafting viz., epicotyl grafting, softwood grafting, veneer grafting, side grafting, patch budding etc. have been tried in cashew with varying degrees of success. Among them, softwood grafting was found to be the best for commercial multiplication of cashew.

Softwood grafting Selection of seednuts

(1) Seed nuts may be collected during the peak period of harvest (February-March) and sun-dried for 2-3 days.

(2) Fresh seed nuts are to be used for raising rootstock. Seed nuts stored for more than one year may be avoided.

(3) Quality seed nuts may be selected by immersing in water or 10% saline solution. Seeds, which sink in water, may be selected.

(4) Medium sized nuts (7-9 g) may be selected to get vigorously growing seedlings.

Raising of rootstocks

1. Use polythene bags (size 25 cm x 15 cm, 300 gauge thickness) for raising root stocks
2. Make holes in the bags to ensure good drainage.
3. Prepare the potting mixture (1:1:1 ratio of red soil, river sand and compost) mixed with rock phosphate @ 5 g per 2 kg potting mixture. Perfectly solarised soil is to be used for the preparation of potting mixture. For the production of healthy grafts in the organic systems, it is advantageous to use 2 g *Trichoderma viride,* PGPR mix I (5g) and 10 g Mycorrhiza per bag. Combination of sand: soil:

cowdung potting mixture mixed with PGPR mix I or *Azospirillum*+ PSB+AMF @ 10 g per bag is better for production of vigorous root stocks. Fill the bags up to the brim of the bag.

5. Sow the pre-soaked nuts in the centre of the bag with stalk end up, at a depth of 2.0-2.5 cm.
6. Water the bags immediately after sowing and daily thereafter. Avoid excess irrigation.
7. Nuts usually germinate within 15-20 days after sowing during monsoon months and within 8-10 days during dry months.
8. Nuts should be sown at weekly intervals to get continuous supply of rootstocks.
9. During summer, provide partial shade to the seedlings till they change their bronze colours to green and then keep them in the open.
10. The seedlings will be ready for grafting in 50-60 days after germination.
11. Prevent damage to germinating nuts from squirrels, birds etc.

Selection of rootstock

Select 50-60 day old healthy seedlings having single main stem grown in the centre of the bag, as rootstock.

Selection of scions

(1) Select a high yielding variety of cashew as a mother plant to collect adequate number of scions.

(2) Select 3-5 month old non-flowering lateral shoots of current season's growth.

(3) The selected scions should be 10-12 cm long, straight, uniformly round and pencil thick with brown colours having dormant plumpy terminal bud. The top 4-5 leaves should be dark green in colours indicating proper maturity of the scion.

Pre-curing

(1) Pre-cure the selected scions by clipping off three fourth portion of leaf blades.

(2) Scions will be ready for grafting in 7-10 days after leaf removal.

Collection of scions

(1) The pre-cured scions are to be cut early in the morning to avoid desiccation.

(2) The scions should be collected before the terminal buds sprout.

(3) Wrap scions in moist cloth and put in polythene covers as soon as they are cut from the mother tree and bring them to the nursery for grafting. If necessary, they can be stored for 3-4 days and used for grafting.

Preparation of rootstock

(1) Retain two pairs of bottom leaves and remove others from the selected seedlings using a sharp knife.

(2) Give a transverse cut on the main stem, 15 cm above ground level.

(3) A cleft of 4-5 cm deep is made in the middle of the decapitated stem of the seedling by giving a longitudinal cut.

Preparation of scion

(1) Select a matching scion stick (same thickness as that of the rootstock).

(2) The cut end of the scion is shaped to a wedge of 4-5 cm long by chopping the bark and wood from two opposite sides.

Grafting

1. The wedge of the scion is inserted into the cleft of the rootstock, taking care to ensure that the cambium layers of stock and scion are in perfect contact with each other.
2. The graft joint is secured firmly by polythene tape (1.5 cm wide and 30 cm long).
3. The scion of the graft is to be covered with a wet polythene cap (15cm x

12.5 cm, 100 gauge thickness) and tied at the bottom to maintain humidity inside and to protect the apical bud from drying. The polythene cap should not touch the terminal bud.

4. The grafted plants are to be kept under shade for 10-15 days to enable sprouting of the terminal buds.
5. The polythene caps are to be removed and the grafts shifted to open place. The successful grafts show signs of growth within 3-4 weeks after grafting.
6. The grafts will be ready for planting 5-6 months after grafting.
7. The success in softwood grafting is more during the period from March to September under Kerala conditions.

Care in the nursery

1. The grafts are to be watered regularly using a rose can or micro- sprinkler.
2. Remove new sprouts emerging from rootstock at frequent intervals.
3. Panicles, if produced by the grafts, may be removed as and when observed.
4. Shift the grafts frequently from one place to another to prevent them from strikingroots into the ground.
5. Soil application of 100ml of decanted extract of fermented (two days) groundnut cake improves growth and vigour of grafts.

Graft production under polyhouse

Softwood grafts can be prepared almost throughout the year with a mean graft success of about 60-70%. Higher success is achieved during the monsoon season. For this, low cost polyhouses (prepared from casuarina / bamboo poles / areca reapers / GI pipes / PVC pipes and covered with high density polythene sheet of convenient dimensions, preferably 20 m long and 6 m wide) may be utilized for graft production. The height of the polyhouse should be 2.5 m in the middle and 1.0 m on both sides. The plants may be watered using hose. Misting units can also be fitted at appropriate points and switched on for about 5-10 minutes at an interval of two hours from 10 a.m to 6 p.m during summer season. This reduces the temperature build up inside the polyhouse. Raising of rootstock seedlings, grafting of rootstocks and maintenance of grafts can be done inside the polyhouses. These polyhouses give protection to the seedlings and grafts during heavy rains and reduce the mortality. Again during summer months the seedlings / grafts can be

maintained in these polyhouses by covering with HDPE shade nets (35-50% shade).

Planting and management of grafts

The softwood grafts will be ready for planting in 5-6 months after grafting. The pits are filled with topsoil and 5-10 kg of compost or dried cowdung / pit and the grafts are planted after carefully removing the polythene bags. Care should be taken while planting to see that the graft union is 2.5 cm above the ground level. The polythene tape is to be carefully cut and removed subsequently. Staking should be done immediately after planting to protect the grafts from damage.

Planting and management of plantation

Plant softwood grafts in pits of size 50cm x 50 cm during June-July. Planting may be done at a spacing of 7.5 m for poor and 10 m for rich and deep soils and sandy coastal area. On very sloppy lands, the rows may be spaced 10-15 m apart with a spacing of 6-8 m between trees in a row.

Depending upon the weed growth, weeding operation may be done during August-September. Mulch the plant base with dry leaves to reduce sun-scorch to tender plants.

Initial training / shape pruning

The sprouts coming from the rootstock portion of the graft that is from the portion below the graft joint should be removed frequently during the first year of planting. Initial training and pruning of young cashew plants during the first 3-4 years is essential for providing proper shape. Thereafter, little or no pruning is necessary. The plants should be allowed to grow by maintaining a single stem up to 0.75-1.00 m from ground level. This can be achieved by removing the side shoots or side branches gradually as the plants start growing from the second year of planting. Weak and criss-cross branches can also be removed. Branches growing unwieldy may also be cut off. Proper staking of the plants is required to avoid lodging due to wind during the initial years of planting. Initial training and pruning of cashew plants facilitate easy cultural operations such as terrace making, weeding, fertilizer application, nut collection and plant protection. The flower panicles emerging from the grafts during the first and second year of planting should also be removed (deblossoming) in order to allow the plant to put up good vegetative growth. The plants are allowed to flower and fruit only from the third year onwards.

General pruning

In older cashew plantations, removal of dried or dead wood, criss-cross branches, water shoots etc. should be attended to at least once in 2-3 years. This allows proper growth of the canopy and receipt of adequate sunlight on all the branches. Pruning of cashew plants should be done during May / June.

Nutrient management

Cashew is generally grown in soils with low fertility status and water holding capacity. To ensure supply of sufficient nutrients leading to optimum growth and yield in organic cashew, an integrated approach consisting of growing leguminous green manure/ cover crops, recycling of crop residues, application of organic mixtures and bio-fertilizers is to be followed, which is agronomically and economically effective. If all the organic materials available in the orchard are fully utilized, it can meet a major portion of the nitrogen and a part of other macro and micro nutrient needs. The organic materials available in the plantation can be best used through composting, more efficiently through vermi-composting. It was found that the leaf

litter and cashew apple residue could be effectively used for vermicomposting which will be ready in 95 days. Since the pH of the vermicompost is neutral to alkaline, it is ideal as an ameliorant for acidic soils of Kerala.

Growing of leguminous cover/ green manure crops are highly beneficial particularly in young plantations where intercrops are not raised. Apart from its positive effect on soil fertility status, by contributing dry matter to the tune of 2 to 4 tonnes/ha, cover cropping prevents soil erosion and conserves water; also suppresses weed growth in early years.

When organic manures are used, around 25 kg poultry manure, 60 kg FYM or 30 kg vermicompost may be used per adult tree. Apply 1/5th dose of the organic manure during the first year, 2/5th dose during second year and progressively reaching full dose from fifth year onwards.

Combined application of *Azotobacter* and *Azospirillum* each @ 150 g or PGPR mix I per adult tree is beneficial for increased yield.

Weed management

Use of chemical herbicides is prohibited in organic farming. Manual weeding can be done within 2 m radius of the trunk. In large plantations weeding in the interspaces can be done effectively and economically using tractor-mounted rotary weed slashers. The slashed materials and weeds can be used for mulching, which reduces further infestation. Inter- cropping also helps in controlling weeds substantially. Mature trees on attaining full canopy can smother weed growth to an appreciable extent.

Intercropping

Pineapple is the most profitable intercrop in cashew plantation in the early stages of growth. It can be planted between two rows of cashew in trenches opened across the slope. Paired row of pineapple suckers can be planted in each trench at 60 cm between rows and 40 cm between two suckers within the row. These trenches can be opened at 1 m between two rows of cashew. Ginger, lemongrass and tapioca are also suitable as intercrops and the intercrops are also grown organically.

High density planting

High density planting is a recent technique recommended for enhancing the productivity of cashew plantations. This technique involves planting more number of grafts per unit area and thinning at later stages. Instead of the normal planting density of 64 to 177 plants per hectare (spacing ranging from 7.5 to 10 m in the square system of planting) or 74 to 204 plants (spacing ranging from 7.5 to 10 m in the triangular system of planting), 312 to 625 grafts will be planted per hectare, initially. During later years, as the canopy develops, plant population is to be regulated by selective felling to minimize competition.

While adopting a high density planting technique, grafts may be planted initially at a spacing of 4m x 4m or 8m x 4m so that there will be 625 or 312 plants respectively. This population can be retained for a period of seven to nine or ten years depending upon the canopy expansion rate. If the soil is very rich the canopy development rate will be faster. High density planting would be more useful in poor soils where the rate of canopy expansion is slow. Considering the fertility status of the soil, the level of management in terms of manuring, irrigation, the initial plant population etc. is to be decided carefully for every agro-climatic condition. Later, after monitoring the canopy pressure between adjacent plants, the alternate plants are to be removed.

Finally, when the plants attain full growth, the spacing between the plants will be 8m x 8 m.

If uniform management practices are adopted, during early years of yield, the per tree nut yield will be more or less the same with all the trees, in both the conventional system of planting and in high density planting. But the per hectare yield will be more from high- density plantations (due to higher plant populations) compared to the normal density plantations. During later years, when the plant population is equalized to that of normal density plantation, the productivity of both the plantations would be more or less the same. The bonus yield obtained during the early years of yield would be substantial in high-density plantations.

In addition to obtaining higher yields, substantial quantities of firewood can be obtained during thinning, which may fetch additional revenue to the farmer. The weed growth in the interspaces can be effectively checked to a greater extent.

Top working

Top working is a technique evolved to rejuvenate unproductive and senile cashew trees. Top working can successfully rejuvenate poor yielders in the age group of 5-20 years. The unproductive trees are to be beheaded at a height of 0.75 to 1.00 m from ground level. The stem should be cut with a saw to avoid stump splitting. The best season for beheading trees is May- September. Soon after beheading, the stumps and cut portions should be given a swabbing with Bordeaux mixture and neem oil 5%. Sprouts emerge 30-45 days after beheading. Sprouting will be profuse in young trees. New, 20-25 days old shoots should be grafted with scions of high yielding varieties using softwood grafting technique. To ensure at least six or seven successful grafts, 10-15 grafting are to be done on the new shoots of every tree. The best season for grafting is July-November. Thinning of the extra shoots arising from the stumps should be done to obtain better growth of the grafts. Removal of sprouts below the graft joint and removal of polythene strip from the graft joint should be done. Top working is simple and can be done by farmers after getting proper training.

The top worked trees start yielding right from the second year after top working. Thus precocity can be considered as one of the best advantages of this technique. The major disadvantage associated with top working is the huge casualty of trees due to stem borer attack. Intensive care and management to ward off stem borer is essential. As such, adoption of top working on a larger scale would be difficult.

Plant protection Pest management

The following aspects require special emphasis for organic pest management in cashew.

Maintenance of hygiene

Timely pruning can keep the tree in a hygienic manner and thereby avoids the incidence of pests and diseases, particularly in old plantations.

Regular burning of the residues of the plantation at periodic intervals from the flushing time to harvest can systematically eliminate many of the insect pests especially that of caterpillars, thrips, leaf and plant hoppers as well as some of the bug and beetle species. They are positively attracted to light or bonfires and thus get killed.

Prompt monitoring and pest-surveillance

If the pest infestation is detected and located at the correct time, local and limited treatments, which are ecologically safe, can take care of the issues.

Smoking

Smoking the plantation is found repelling many insect species harmful to the crop. Smoking the plantation with organic wastes during flushing, flowering and fruiting phases will keep TMB infestation low.

Mechanical

Mechanical destruction of sluggish and congregating stages of the insect-pest are advisable.

Tea Mosquito Bug (TMB)

This is the most serious pest affecting cashew. The pest usually appears with the emergence of new flushes and panicle. Drying of inflorescence and dieback of shoots are the symptoms.

1. Spray either neem oil (0.5-1%) or *Pongamia* oil (2%) during flushing, flowering and fruiting phases. Add teepol/soap. Repeated sprayings at fortnightly intervals may be required in specific situations such as heavy infestations or young plantations.
2. Trees which harbour large populations of predator ants and spiders being natural enemies of TMB and other pests, can provide protection. So promote predator ant and spider colonies. Since cashew is entomophily, ants can act as pollinators. However, care should be taken while encouraging ants, as they also help in spreading mealy bugs and scales.
3. It is frequently observed that dieback is associated with TMB. To manage the TMB-anthracnose complex, Bordeaux mixture (1 %) may be sprayed as prophylactic along with the control measure for TMB. The affected plant parts are to be removed. The recommendation for combined sprays against tea mosquito bug and anthracnose in endemic areas is given in Table 06.

Cashew stem and root borers

This is a serious pest, which is capable of destroying the cashew tree. Main symptoms of attack are yellowing of leaves, drying of twigs, presence of holes at the base of stem with exuding sap and frass.

Prophylactic measures

1. Phytosanitary measures such as removal of dead and dried branches of trees, dead trees and trees at advanced stages of infestation at least once in six months help in reducing the spread of stem and root borers.
2. Roots should not be left exposed in the field.
3. Swab mud slurry or coal tar and kerosene (1:2) for adult trees or neem oil 5% (50 ml neem oil in 1 litre of water + 5 g of bar soap) on the tree trunk up to 1.0 m height, thrice in a year, from September onwards, at an interval of two months. Commercial formulations may also be used in place of neem oil, after ensuring their quality.
4. Smearing of lime on the bark crevices.
5. Application of wood ash (15-20 kg/tree) and common salt at the base reduces the pest infestation. The wood ash preferably mixed with tea waste is to be applied during July-August while manuring the plants.

Curative measures

Early stage of attack can be detected from the chewed wood observed at the base of the tree. If the infestation is detected early, the grubs should be mechanically removed by carefully examining the bark. While removal, care should be taken not to exceed 50% of the stem girth.

Minor pests

Local and spot treatments are to be taken for mealy bugs, aphids etc. as they often appear in isolated trees/patches. Neem oil garlic emulsion (2%) applied on infested branches checks mealy bug menace.

Dust powdered ash during flushing period to control sucking pests.

Diseases Anthracnose Symptom

The disease affects all young tissues, viz., tender leaves, twigs, inflorescence, shoots, nuts and apples. Appearance of reddish brown, shiny water soaked lesions followed by resin exudation on the affected parts is the initial symptom. On tender leaves, the disease develops as brown circular to irregular spots with dark coloursed margin. In severe cases the lesions coalesce resulting in defoliation. Infection on the tender stem results in the development of reddish brown spots, which later coalesce and spread downwards finally, resulting in die back. On inflorescence, the floral peduncles show blackening and the affected flowers turn black, wither and fall off. The infection on the inflorescence may reach the shoots and finally shows die back.

Control

1. Regular plant sanitation to check the disease spread. Remove and destroy the affected plant parts.
2. Give a prophylactic spray of 1% Bordeaux mixture.
3. Since tea mosquito attack pre-dispose cashew to anthracnose, it is better to have a combined spray of the above fungicides with neem oil (Table 13).
4. Planting wind breaks like *Casuarina* or *Eucalyptus* check the spread of disease from one plantation to another.

Dieback or pink disease Symptom

Appearance of white patches on branches followed by drying of twigs from the tip.

Control

1. Chisel out the affected parts and apply Bordeaux paste.
2. Give prophylactic sprays of 1% Bordeaux during May- June and October.

   In plantations, occurrence of diseases like gummosis, red rust and leaf blight can be combated by application of 1% Bordeaux mixture. Sooty mold (often seen associated with mealy bugs and aphids) can be managed by 1% Bordeaux mixture or 2% starch application.

   Note: For grown up trees, 5 litres of spray fluid is required at high volume discharge rate. For spraying, rocker sprayer with Hi-tree lance is preferable.

   Table-06: Recommendation for the control of tea mosquito bug and anthracnose in endemic areas

Product	Dose (per litre) 50 mlneem oil	Frequency
Neem oil (0.5-1%) +	(5 ml of neem oil in 1 litre of	Fortnightly interval
Copper oxychloride	water with 5 g of barsoap	(depending on
0.2 to 0.3%	or 2 ml Teepol) + 2g	infestation)
	Copper oxychloride	

Diseases affecting cashew nursery

Damping off, seed rot, seedling blight and root rot are the diseases that cause serious damage in the nursery, particularly during rainy season, which can be effectively managed with integrated control measures as given below.

1. The seedling diseases could be prevented by providing proper drainage facilities in the nursery. Provide enough drainage holes on the bags used for raising seedlings.
2. Raise seedlings in solarised potting mixture. Potting mixture has to be solarised for one month using 150 gauge transparent polythene sheets.
3. After filling the potting mixture in the polythene bag, use *Trichoderm*a enriched manure for potting mixture.
4. Incorporate *Mycorrhiza* @ 10g/kg and PGPR mix I 5g/kg potting mixture before sowing the seeds.
5. Remove and destroy the disease affected seedlings.
6. Never re-use contaminated potting mixture.
7. Provide sufficient spacing in the nursery to ward off excess humidity.
8. Never raise cashew nurseries in heavily shaded areas.
9. Drench the nursery bag with 1% Bordeaux mixture or Copper oxychloride (0.2%) or. While drenching, care should be taken to drench sufficient quantity of fungicide to soak the entire potting mixture in the polythene bag. Selection of the above fungicides should be based on the type of the pathogen.
10. Spray the seedlings with 1% Bordeaux mixture as a prophylactic measure to prevent aerial infection.

Utilization of cashew apple

Cashew apple is a valuable source of sugars, minerals and vitamins especially vitamin

C and B2. It can be eaten raw as a fresh fruit. Either whole apples are consumed or they can be cut into small pieces, mixed with table salt and eaten.

Cashew apple can be used for the preparation of various products like squash, syrup, pickle, wine, liquor and vinegar, but commercial production is possible only with the use of chemical preservatives. However, organic processing of cashew apple is possible without the use of chemical preservatives at domestic level, provided refrigerated storage is possible.

COCOA (*Theobroma cacao*)

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.

Varieties

Though three varietal types viz., Criollo, Forastero and Trinitario are recognized, only Forastero types are known to perform well under Indian conditions. 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.

Table-07 . Improved varieties and salient features

Varieties/hybrids	Salient features
CCRP-1	Selection, tolerant to VSD
CCRP-2	Selection, tolerant to VSD
CCRP-3	Selection, tolerant to VSD
CCRP-4	Selection, tolerant to VSD
CCRP-5	Selection, tolerant to VSD
CCRP-6	Selection, tolerant to VSD
CCRP-7	Selection, tolerant to VSD
CCRP-8	Hybrid, tolerant to VSD
CCRP-9	Hybrid, tolerant to VSD
CCRP-10	Hybrid, tolerant to VSD

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.

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 colours 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.

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 method consists of removing a patch of about 2.5 cm length and 0.5 cm width from the rootstocks, preparing a bud patch of 2.5 cm length and 0.5 cm width from the bud wood and inserting it into the rootstock and tying firmly with polythene tape. After three weeks, if there is bud-take, polythene tape is removed; a vertical cut is made half way through the stem above the bud and is snapped back. 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.

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.

Time and method of planting

Raising cocoa as a pure crop is not recommended especially in Kerala due to high pressure on land. 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 50cm x 50cm x 50cm 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. Remove the bag 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.

Manuring

- Upto 4-5 years, growing green manure crops like *Mimosa invisa*, *Calapagonium* and *Pueraria* in open patches and along coconut basins can provide about 5-6 tonnes of green leaf for cocoa. These can be cut at regular intervals and incorporated in the basins. With increasing age, the canopy of cocoa closes, and the quantum of light falling on to the ground becomes so small that raising these cover crops has to be restricted to the coconut basins and some scattered patches reducing the green leaf yield to 2-3 tonnes.
- Border planting of *Glyricidia* for the supply of green leaf manure. Regular pruning of trees and depositing the prunings in the basins.
- *In situ* composting of pod husk (3600 kg/ha) and incorporation into the basin @ 7.2 kg/plant is beneficial.
- Apply farm yard manure @ 40 kg/plant or fresh vermicompost 20 kg per plant in four equal split doses in May, September, December and February under irrigated condition or in two equal splits in April - May and September - October under rainfed condition.
- Apply wood ash @1.0 kg /plant.
- Apply biofertilizer PGPR mix I as enriched organic maure. Inoculate with AMF in the nursery and field at the time of planting.

After cultivation

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.

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 periodicalremoval 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.

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.

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.

Plant protection Pests

Among the pests infesting cocoa, the major ones are the red borer, tea mosquito bug, mealy bug, grey weevil, cock chaffer beetle. These pests are not of very disastrous and these can be effectively controlled by mechanical means.

Rats and squirrels cause considerable damage to ripening pods. Continuous trapping using attractants will be effective to check the squirrel and rat population in the field. As these cause damage to ripe fruits only, damage can be reduced by harvesting regularly and not allowing the ripe pods to remain on the trees for long periods. Adopt rat control measures as in coconut.

Disease

Among the diseases affecting mature plants, black pod caused by *Phytophthoa palmivora* and Vascular Streak Dieback caused by *Oncobasidium theobromae* are important.

The measures recommended to control black pod disease are

1. Periodic removal and destruction of infected pods.
2. Cultural practices like proper pruning and regulating the overhead shade to reduce humidity and to improve aeration.
3. Spraying Bordeaux mixture one per cent at 15 days intervals starting from the onset of monsoon along with periodic removal of infected pods.
4. Extracts of *Allium sativum, Cinnamomum zeylanicum, Lawsonia inermis* and *Adenocalymma allicea* is effective in inhibiting lesion development on detached cocoa pods.
5. Periodical spraying and drenching of 2% *Pseudomonas fluorescensP1* is very effective in checking the disease.
6. Quarantine measures are important in Vascular Streak Dieback since the pathogen is systemic in nature.

   Cocoa nurseries should not be maintained near diseased trees because young plants are easily affected by the disease. Regular pruning of infected branches is recommended to maintain a very low level of infection. During pruning, the branches should be split open to detect the extent of streaking in the wood. The branches are then to be cut 30 cm below the last detectable streak. Eradicative pruning will be more effective if carried out at least one month prior to the wet season. Removal of prunings from the cocoa field is not necessary because the fungus cannot survive or produce spores in the dead wood.

   Genetic resistance offers good prospects of controlling Vascular Streak Dieback. From Kerala Agricultural University, 10 disease resistant clones have been released, the budded plants of which offer a considerable degree of resistance. The hybrid seedlings produced from the clonal gardens of the University are also tolerant to this disease.

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 colours 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.

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 sweatings. 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. 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.

CARDAMOM (*Elettaria cardamomum*)

The habitat of small cardamom is the evergreen forests of Western Ghats. It is grown in areas where the annual rainfall ranges from 1500-4000 mm, temperature ranging from 10-35oC and an altitude ranging from 600-1200 m above MSL.

Cardamom is generally grown in forest loam soils rich in available phosphorous and potassium. These soils are generally acidic in nature, with pH ranging from 4.2 to 6.8. The crop is raised mainly on well drained, deep, good textured soils rich in humus.

Varieties

Table-08: Salient features of improved varieties

Varieties	Salient features
Mudigere 1	Malabar type, for high density planting, tolerant to thrips
Mudigere 2	Malabar type, for high density planting
PV-1	Malabar type
PV-2	Vazhukka type, bold capsules, tolerant to stem borer and thrips, suitablefor 1000 – 1200 m above MSL
ICRI-1	Malabar type
ICRI-2	Mysore type, tolerant to azhukal disease
ICRI-3	Malabar type, tolerant to rhizome rot
IISR-suvasini	Malabar type, suitable for high density planting, tolerant to pests
IISR-Vijetha	Malabar type, field tolerant to thrips, borer and mosaic
IISR-Avinash	Malabar type, tolerant to rhizome rot Njallani greengold Farmers selection, vazhukka type, extra bold capsules, suitable for 1000-1200 m above MSL

Propagation method

Cardamom is propagated through seedlings and suckers, the former is cheaper and the later gives earliness in bearing.

Seed propagation

Seed propagation is favored because the seedlings are free from the viral disease as well as plenty of planting materials are obtained from a small quantity of seed.

Nursery

Ripe capsules of the desired cultivar are collected from high yielding plants during September-October. The seeds are extracted by gently pressing the capsules. The extracted seeds are washed in cold water four times to remove the mucilaginous coating. The washed seeds are drained and mixed with ash and allowed to dry in shade for 2 or 3 days. The seeds should be sown in the nursery within a fortnight. Sowing in September is the best for high germination. Sowing during southwest monsoon and winter should be avoided.

When it becomes necessary to store the seeds, it is advisable to store them in capsule form. It can be preserved in this form for one month, without deterioration of viability. Polythene lined gunny bags can be used for this.

In Kerala and Tamil Nadu, 18 month old seedlings are used for planting. The seeds are sown in primary nursery from where the young seedlings are

transplanted to a secondary nursery and maintained for one year before planting in the main field.

Primary nursery

The nursery site is selected in open, well-drained areas, near a source of water. The land is dug to a depth of 30 cm, cleared of all stubbles and stones; and clods are broken. Beds of size 6m x 1m x 0.3 m are then prepared. Jungle soil is spread in a thin layer over the nursery bed. Seeds are sown on the bed in lines. For an area of 1 m2, 10 g of seed is required. Sixty grams of seeds will be required for a nursery bed of 6 m2. The seeds are covered with a very thin layer of fine soil. The nursery bed is mulched with dry grass. Potha grass (*Grenetia stricta*) commonly seen in high range areas is a suitable material for this purpose. Grass is spread to a thickness of about 2 cm. Paddy straw can also be used for mulching. After sowing, beds have to be watered every day in the morning and evening. The mulch should be removed on commencement of germination. The seedlings have to be protected by providing shade pandals. Regular watering, weeding and protection from pests and diseases are to be attended to. During June-July, seedlings from the primary nursery are transplanted to the secondary nursery.

Secondary nursery

After preparing the site properly, form nursery beds of 6m x 1m x 0.3 m. Mixing of well decomposed cattle manure and wood ash with the top layer of the soil will help the seedlings to establish well and to grow vigorously. During June-July, the seedlings from the primary nursery are transplanted at a spacing of 25-30 cm. Shade pandals should be provided before transplanting. Overhead pandals or individual pandals for each bed may be erected. Mulching the bed with dry leaves will help to conserve soil moisture. Regular watering during dry months, weeding, application of fertilizers, control of pests and diseases and mulching are the essential operations for the maintenance of the secondary nursery. One month before uprooting, the pandal should be removed to encourage better tillering.

Polybag nursery

Polybags can be used for raising secondary seedlings. For such nurseries, seeds are to be sown in beds in primary nurseries in September and transplanted to polybags in December- January. These seedlings would be ready for planting in June-July. In this case, nursery period could be reduced by 6 to 7 months.

Vegetative propagation

Vegetative propagation techniques have become popular among cardamom planters due to earliness in bearing and also resulting in 30-40

percent higher yield than seedlings. For vegetative propagation, a portion of the rhizome with one old and one young sprout contributes a planting unit that is easily separated from the established clumps. This method ensures propagation of high yielding lines.

Planting

Field is cleaned and terraces are made across the slopes at suitable planting distances. Spacing of 2m x 2m is recommended for Malabar, 3m x 3m for Mysore and Vazhukka. Pit size of 45cm x 45cm x 30cm is dug during April-May, filled with a mixture of surface soil and compost or well rotten farm yard manure. This has to be done two months in advance of planting of seedlings for establishment and good growth. Best time for planting is with the commencement of south west monsoon prior to the onset of heavy rains. Cloudy days with slight drizzles would be ideal for planting resulting in early and maximum percentage of establishment. Deep planting should be avoided as it results in suppression of the growth of new shoots that may cause decaying of underground stem. A small mound may be formed inside the pit to cover the rhizome and immediately after planting, mulching should be given and plants should be supported by stakes in order to prevent them from being damaged or blown over by wind. Inoculate AMF at the time of planting and use Trichoderma enriched manure.

Weed management

Cardamom is a surface feeder, therefore two- three rounds of weeding is necessary in a year. The first round of weeding is to be carried in May-June, the second in August- September and third in December-January and weeds can be used as mulch. Normally slash weeding is performed in cardamom plantations.

Trashing

Trashing consists of removing senile and dried shoots of plants once in a year with the onset of monsoon. The trashed leaves and leafy stems may be heaped between the rows and allowed to decay or used for composting. From second year after planting, trashing is to be carried out every year. Trashing facilitates better sunlight penetration and aeration, there by promoting good tiller initiation and growth as well as reduction in thrips and aphids population. It also helps in better pollination by honeybees.

Earthing up

Earthing up of plant base and root zone with top soil is recommended during October- December. While doing this operation, care should be taken to ensure that only top soil is used and it is evenly spread at the base covering only half of the bulb portion of the rhizome.

Water management

Cardamom is generally grown as a rainfed crop, and cardamom tracts of India experience a dry spell of about 5-6 months. Often terrain of cardamom estates is undulating with moderate to steep slopes. Run off from the cardamom watersheds can be collected in farm ponds and small check dams or underground water tapped through dug wells. Effective mulching is also recommended during summer period

so as to protect the root zone microflora from UV radiation and conservation of moisture.

Soil and water conservation

Soil and water resources should be handled in a sustainable manner and appropriate measures are to be adopted for their conservation. In sloppy land the soil may be disturbed to bear minimum in all agricultural operations. Contour bunding may be resorted in sloppy lands to conserve soil and wate **Manuring**

It is estimated that an average of 5-8 tones of dry leaves fall from shade trees annually in a hectare of land in cardamom plantations adding 100-160 kg N, 5-8 kg P, 100-160 kg potassium, 10-16 kg calcium and 25-40 kg magnesium per hectare.

Application of organic manures such as FYM, cowdung or compost @ 5 kg/plant or neem cake @ 1-2 kg/plant and 100 g bonemeal / per plant may be done during June-July and during September/October. Application of *Azospirillum* and phosphate solubilizing bacteria @ 50 g/ plant or PGPR mix I along with 5kg of FYM was found to be effective in enhancing the yield.

Shade

Cardamom is a pseophytic plant that performs very well beneath the forest trees. Cardamom thrives well in moderate shade (50-60% of light intensity-). Trees having distributed branching and small leaves are ideal for cardamom. In newly established plantation where shade is inadequate, fast growing species of *Vernonia arborea* may be planted along with the other trees. Some of the good shade trees suitable are *Vernonia arborea* (Karana), *Cedrella tuna* (Red ceder), *Cassia fistula* (Kanikonna), *Diospyros malabaricum* (Vellakail), *Terminalia tomentosa* (Thempavu), *Hopea parviflora* (Thambakam), *Acrocarpus fraxinifolia* (Balangi), *Mesopsis eminii* (Elangi) and *Artocarpus integrifolia* (Jack). Shade trees like red cedar, which shed their leaves in monsoon, provide natural shade regulation. Protection from sunlight by maintaining an overhead tree shade is essential for cardamom in the initial stages of growth to enhance tillering. In order to provide adequate sunlight during the rainy season, excess shade should be regulated before the onset of monsoon. It is desirable to maintain a mixed population of medium sized shade trees, that facilitate shade regulation, and to maintain more or less optimum conditions throughout the year. Trees that carry crowd crown of canopy are undesirable as shade trees as they hardly allow filtered sunlight.

Bee keeping

The main pollination agent in cardamom is honey bee (*Apis cerana indica*). Maintaining four bee colonies per hectare during flowering season is recommended for increasing fruit set and production of capsules. In some gardens pollination is also effected by rock bee, *Apis dorsata* that occur naturally in the forest ecosystem.

Plant protection Pests

Cardamom thrips (*Sciothrips cardamomi)*

Cardamom thrips are minute fringe winged clawless greyish brown insects that breed on plant parts such as unopened leaf, spindles, leaf sheath, flower bracts and floral tubes persistently. Nymphs and adults puncture the tissues on the ovary and young capsule. The injured tissues form a corky layer on the capsule surface due to host reaction, which appears as scabs. Such capsules appear malformed, shrivelled and cankerous. This condition is known as "Cardamom itch".

The feeding injury by thrips affects the yield by two ways. Firstly, the stunting of panicles and shedding of flowers reduce the number of capsules formed. Secondly, scabbing on capsules lowers their quality, quantity and therefore fetches reduced market price. Thrips population is high during December to May when the temperature is high. With the onset of monsoon, the population of thrips shows a gradual decline and attains minimum coinciding rainy season. Malabar type cardamom with prostrate panicles is more tolerant to infestation by thrips than Mysore and Vazhukka types with erect and semi-erect panicles respectively owing to chemical constituents and disposition of panicle. The extent of damage in terms of quality and quantity of the produce ranges from 30-80%. Cardamom capsules infested by thrips ("Itch") were found not inferior in essential oil content and composition and therefore can be preferred in oil industry.

Management

1) Removal of dry drooping leaves as well as dry leaf sheath (Trashing) during January- February.
2) Destruction of collateral host plants such as *Amomum, Alpinia, Curcuma, Colacasia* in the immediate vicinity of cardamom plantations.
3) Conservation and innundative release of natural enemies such as *Chrysoperla carnea* is very important for enhancing effective predation.
4) Apply fish oil soap (Na) 2.5% plus tobacco extract 2.5%
5) Malabar type cardamom with higher 1, 8-cineole content was preferred in endemic tracts.

Shoot and capsule borer (*Conogethes punctiferalis)*

The caterpillars bore into stem of seedlings, young tillers, panicles and capsules. Early stage larvae bore the panicles leading to drying up of the entire panicle and also bore the immature capsules, feed on the seeds and empty the capsules. The late stage larvae feed on the central core of the stem, affect the xylem vessels interrupting the passage of food materials to the growing parts and lead to the drying of central leaf known as "dead heart" symptom. The conspicuous oozing out of excreted frass at the mouth of the bore holes is an indication of the presence of larvae within.

Management

1) Malabar type having prostrate panicle and lanky stem was found tolerant to borer damage.
2) Removal and destruction of alternate hosts such as castor, ginger, turmeric in the immediate vicinity.
3) Roguing and destruction of infested tillers during September-October.
4) Encouragement of golden backed woodpecker and crow-pheasant in the plantation and installation of bird perches to attract birds of economic importance in biological control.
5) Application of *Steinernematid* entomopathogenic nematodes @ 100IJ/larvae or *Bacillus thuringiensis* when early-instar larvae are found in capsule or panicle or unopened lead buds *ie.,* within 20 days of adult moth emergence.
6) Use of pheromones in the monitoring of the pest and therefore correct timing of application of biorationals shall be recommended.

Root grub (*Basilepta fulvicorne)*

The grubs congregating on the root zone of cardamom clumps feed and cause irregular patch on the roots. As a result, reduction in uptake of nutrients leading to crop loss ranging from 29-66%. As the pest is subterranean, damage on roots may not be known until the symptom is reflected on the foliage (yellowing of leaves) or soil sampling done to assess grub population. Secondary infection by clump rot fungus is also observed in severely infested gardens. The damage is very severe in gardens with inadequate shade. Two peaks of adult emergence were noticed one after the pre-monsoon rains (March-April) and another during September-October.

Management

1) Collection and destruction of adult beetles during their peak period of emergence.
2) Raking the soil and removal of dried leaves before drenching of entomopathogenic nematode (EPN) suspensions.
3) Use entomopathogenic fungi *Metarrhizium anisopliae* and entomopathogenic nematode *Heterorhabditis indica.* Application of entomopathogenic nematode *Heterorhabditis indica* @ 100 IJ/grub.
4) Avoid planting of jack, mango, fig etc as shade trees as these trees are alternate host of the pest.
5) Ensure adequate shade of 65-70% in endemic areas and irrigate the crop before attaining critical period.
6) Control measures against clump rot fungus should be followed immediately after the management of root grub.
7) Proper phosphatic nutrients (readily absorbable compost/vermicompost) are required for rejuvenation of cardamom roots damaged by root grub.
8) Mulching of plant base with leaves of wild *Helianthus* sp. to prevent egg laying of adult beetles.

Whitefly (*Singhiella cardamomi)*

This pest of minor importance has assumed major status owing to unjudicious use of insecticides.

Colonies of nymphs and adults desap the lower surface of the leaves. Chlorotic patches appear initially on leaves, which in turn become yellow and necrotic in the advanced stages. The adult is a soft bodied insect about 2 mm long having two pairs of white wings.

Management

1) Monitoring and trapping the adults using yellow sticky traps coated with viscous castor oil. The traps can be placed between rows of cardamom plants or on the shade trees.
2) Application of 0.5% neem oil on the undersurface of the leaves. Spray fluid need not be applied on the panicles and cardamom stem.

Lace wing bug (*Stephanitis typicus)*

Both nymphs and adult bug with lace like wing desap from undersurface of cardamom leaves gregariously. Greyish yellow spots develop at the feeding site and in severe cases the plant growth is retarded and yield affected.

Management

1) Destruction and removal of alternate hosts such as banana, *Colacasia etc.* from the field

2) Provide adequate shade to the plantation.

Diseases

Capsule rot / *Azhukal* disease (*Phytophthora nicotianae* var. *nicotianae)*

The disease appears during the rainy season. Malabar varieties are more susceptible to *azhukal*. The diseases is more severe on the capsules. On the infected leaves, water soaked lesions appear first followed by rotting and shreding of leaves along the veins. The infected capsules become dull greenish brown and decay. This emits a foul smell and subsequently shed. Infection spreads to the panicles and tillers resulting in their decay. High incidence of the disease is seen during the months of heavy and continuous rain fall and high relative humidity especially during July – August.

Clump rot or rhizome rot (*Pythium vexans*, *Rhizoctonia solani* and *Fusarium* sp)

Symptoms: Decayof the tillers starting from the collar region and toppling of tillers. Affected tillers can be pulled out with little force and the discoloursation of the basal portion of clump can be seen.

Chenthal disease (*Colletotrichum gloeosporioides)*

Symptoms*:* Initially the symptoms appear as small water soaked rectangular lesions on the leaves which, later elongate to form parallelly arranged streaks and turn to yellowish brown to orange red in colours. The central portions become necrotic.

Leaf blotch disease (*Phaeodactylium alpiniae)*

Symptoms*:* The disease is characterized by the appearance of large blotches of irregular lesions with alternating shades of light and dark brown necrotic leaves. This is mainly observed on mature leaves.

Leaf rust (*Phakospora elettariae)*

Symptoms: The symptoms are white or ash coloursed pustules on the undersurface of the leaves and yellowish orange discoloursation on corresponding upper surface of the leaves. This disease is noticed mainly on older leaves.

Stem rot / stem lodging (*Fusarium oxysporum)*

Symptoms: The pathogen attacks middle portion of the tiller and produce pale discoloursed lesions on the tillers leading to dry rotting. The tiller is weakened at this portion and leads to partial breakage. The partially broken tillers bend downwards and hang from the point of infection.

Cercospora* leaf spot (*Cercospora zingiberi)

Symptoms: The symptoms appear on the leaves as water soaked linear lesions, which are rectangular and parallelly arranged along the veins. On the upper leaf surface, lesions turn dark brown with dirty white long patches in the centre. In advanced stages, lesions become greyish brown in colours and later dry off.

Phytophthora* leaf blight (*Phytophthora meadii)

Symptoms: The infection starts on the young middle aged leaves in the form of

elongate or ovoid, large, brown coloursed patches which soon become necrotic and dry. These necrotic dry patches are seen mostly on leaf margins and in severe cases the entire leaf area on one side of the midrib is found affected.

Viral diseases

***Katte* or mosaic**

The virus is transmitted by banana aphid *Pentalonia nigronervosa* and through infected rhizomes.

Symptoms: The first visible symptom appears on the youngest leaf of the affected tiller as slender chlorotic flecks. Later these flecks develop into pale green discontinuous stripes. These stripes run almost parallel to each other from the mid- rib to the margin of the leaves, which form a mosaic pattern symptoms. The infected clumps will be smaller in size with fewer tillers.

Cardamom vein clearing or *Kokke kandu*

Symptoms: Because of its characteristic symptom "hook- like tiller" it is locally called as "*Kokke Kandu*". The affected plants declined rapidly. Yield reduction is to the extent of 62-84 per cent in the plants with different stages of infection. The characteristic symptoms are continuous or discontinuous intraveinal clearing, stunting, rosetting, loosening of leaf sheath, shredding of leaves and clear mottling on stem. Clear light green patches with three shallow grooves are seen on the immature capsules. Cracking of fruits and partial sterility of seeds are other associated symptoms.

Cardamom necrosis / Nilgiri necrosis

Symptoms: The symptoms are seen on young leaves as whitish to yellowish continuous or broken streaks preceeding from the midrib to the leaf margins and later turn reddish brown. Often leaf shredding is noticed. The affected plants are stunted and fail to bear the panicles and capsules.

Management of fungal diseases

1) Expose the area of cultivation to the hot sunlight before planting to destroy the propagules of the pathogens. Apply the Trichoderma enriched organic manure and inoculate AMF at the time of planting.
2) Use of healthy and disease free planting materials.
3) Mulch the basins with green leaves and other organic materials during summer months to protect and conserve the native beneficial microflora and soil moisture. Mulching and application of biocontrol agents can be coupled to protect the cardamom plants against pathogen infection.
4) Destroy the disease caused palnts. Use helathy rhizome for planting. Destroy other host plants of virus like *Amomum connecarpum, Alpinia mutica, Curcuma neilgherrensis.*
5) Prophylactic foliar spray and drenching with 1.0 % Bordeaux mixture before onset of monsoon. Continue the spraying and drenching operations two or three times up to November- December according to the intensity of the disease. Adequate drainage should be provided in the garden.
6) Avoid excess shade during monsoon season to restrict the spread of the disease. Pre- monsoon application of *Trichoderma* enriched organic manure and spraying, drenching with Pseudomonas 2%/ PGPR mix II are effective for the

management of the capsule and clump rot diseases of cardamom.Application of Trichoderma and *Pseudomonas fluorescens* / PGPR mix II during the onset of NE monsoon. Frequency of aplication of Pseudomonas / (Oct-Nov) PGPR mix II may be adjusted with intensity of disease.

Harvesting and processing

Cardamom plants start bearing fruits (capsules) from second year after planting and satisfactory yield are obtained from third year onwards. It takes 110 days from flowering to become mature fruits (brown to black seeded stage). Capsules just before full ripening are harvested to get maximum green colours during curing. Harvesting season is in August- December, peak harvest is during October-November. Capsules are harvested at an interval of 15-20 days at Karnataka and 30 days in Kerala and harvesting completed in about seven- eight rounds.

Post harvest operations consist of washing, curing (drying), cleaning, polishing, sorting, grading and packing. The capsules immediately after harvest are washed in water to remove the adhering soil. After harvest, cardamom capsules are dried in sun and graded according to size and colours. The handpicked fruits are dried in special curing chambers under controlled temperature to retain the delicate flavor and green colours. Heat required for drying is produced by burning firewood in the iron kiln, the heat thus produced is passed through pipes made of galvanized iron sheet. Capsules left for drying are spread thinly on wire net trays and stirred frequently to ensure uniform drying and also helps to retain green colours of capsule. They are initially heated to 50oC for first 4 hours and subsequently reduced to 45- 50oC by opening the ventilators and using exhaust fan. Finally the temperature is raised to 60oC for one hour. The process of drying takes about 36-48 hours

Dried capsule are rubbed with coir mat/gunny cloth/steel mesh and sieved to remove other plant debris. This process is called polishing. The polished capsules are then graded according to size by passing through sieves of size 7, 6, 5 mm. They are sorted according to size and colours. The percentage of recovery is 20-24%. The graded product is packed in polythene lined gunny bags.

GINGER (*Zingiber officinale*)

Ginger is a tropical plant adapted for cultivation even in regions of subtropical climate such as the high ranges. It prefers a rich soil with high humus content. Being an exhausting crop, ginger is not cultivated continuously in the same field but shifting cultivation is practised. The crop cannot withstand water logging and hence soils with good drainage are preferred for its cultivation. It is shade tolerant / loving crop with shallow roots and therefore suitable for intercropping and as a component in the homesteads where low to medium shade is available.

Preparation of land

Clear the field during February-March and burn the weeds, stubbles, roots etc. in situ. Prepare the land by ploughing or digging. Prepare beds of convenient length (across the slope where the land is undulating), 1 m wide, 25 cm high with 40 cm spacing between the beds. Provide drainage channels, one for every 25 beds on flat lands.

Varieties

Table-09: Salient features of high yielding ginger varieties

No.	Variety	Avg. yld t/ha (fresh)	Salient features	Crude fibre (%)	Essen-oil (%)	Oleor-(%)	Dry yield kg/ha
1	IISR Varada	22.6	Bold rhizomes, tolerant todiseases maturity 200 days	3.3-4.5	1.7	6.7	19.5
2	IISR Rejatha	22.4	Plumpy andbold rhizomes, maturity 200 days	20.8	4.0	2.4	6.3
3	IISR Mahima	23.2	Plumpy boldrhizomes resistant tonematode (*M. incognita & M.javanica*), maturity200 days	3.3	1.7	4.5	23.0
4	Supra-bha	16.6	Plumpy rhizomes, maturity 229days, wide adaptability	4.4	1.9	8.9	20.5
5	Suruchi	11.6	Profuse til-lering, bold rhizomes, maturity 218 days	3.8	2.0		25.3

Dry ginger: Maran, Wayanad, Himachal, Kuruppampady, IISR-Varada, IISR- Rejatha and IISR-Mahima

Green ginger: Rio-De-Janeiro and Wayanad Local Rio-De-Janeiro is preferable for extraction of oleoresin.

Planting material

Ginger rhizomes are used for planting. For selection and preservation of seeds,

adopt the following methods:

Mark healthy and disease free plants in the field when the crop is 6-8 months old and still green. Select best rhizomes free from pest and disease from the marked plants. Handle seed rhizomes carefully to avoid damage to buds. Soak the seed rhizomes in a solution containing *Pseudomonas* @ 20g/litre for 30 minutes and dry under shade by spreading on the floor. Store the treated rhizomes in pits dug under shade, the floor of which is lined with sand or saw dust. It is advisable to spread layers of leaves of *Glycosmis pentaphylla* (panal). Cover the pits with coconut fronds.

Examine the stored rhizomes at monthly intervals and remove the rhizomes that show signs of rotting. This will help to arrest further spread of the disease. Provide one or two holes for better aeration.

Season and method of planting

The best time for planting ginger is during the first fortnight of April, after receipt of pre-monsoon showers. For irrigated ginger, the best-suited time for planting is middle of February (for vegetable ginger).

Plant rhizome bits of 15 g weight in small pits at a spacing of 20cm x 20 cm to 25cm x 25 cm and at a depth of 4-5 cm with at least one viable healthy bud facing upwards. Adopt a seed rate of 1500 kg/ha. Before planting soak the seed rhizomes in a solution containing *Pseudomonas* @ 20g/litre for 30minutes and dry under shade.

Manuring

Apply manures and biofertilizers at the following rates.

FYM / compost @ 25 tonnes as basal and 3t/ha each at 60DAP and 120DAP. Apply FYM, *Trichoderma*, neem cake mixture @ 100 g / planting pit at the time of planting. Vermi compost or coir pith compost may also be used at a reduced dose instead of FYM according to availability.

Apply *Azospirillum* @ 2.5 kg /ha / PGPR mix I as basal. Repeat the same doses at 120 DAP. Inoculate with AMF at the time of planting.

Mulching

Immediately after planting, mulch the beds thickly with green leaves @ 15 t/ha. Repeat mulching with green leaves twice @ 7.5 t/ha first 45-60 days and second 90-120 days after planting. Grow green manure crops like dhaincha and sun hemp in the interspaces of beds, along with ginger and harvest the green manure crop during second mulching of ginger beds.

After cultivation

Remove weeds by hand-weeding before each mulching. Repeat weeding according to weed growth during the fifth and sixth month after planting. Removed weeds should be recycled by way of mulching. Earth up the crop during the first mulching and avoid water stagnation.

Plant Protection Pests Nematodes

Apply Neem cake @ 1t/ha at planting. Repeat the same doses at 45 DAP.

Diseases

Rhizome rot and bacterial wilt

- Select sites having proper drainage.
- Dip the seed rhizome with 5% talc formulated (50g/L) suspension *of Pseudomonas fluorescens* P1 for 15 minutes before planting.
- Treat the seed rhizome with AMF.
- Apply organic manure enriched with *Trichoderma* at the time of planting.
- Spray and drench the plant with *Pseudomonas fluorescens* P1 / PGPR mix II at 45 days after planting (onset of monsoon).Repeat spraying and drenching at monthly intervals based on disease incidence and intensity.

Harvesting and processing

For vegetable ginger, the crop can be harvested from sixth month onwards. For dry ginger, harvest the crop between 245-260 days. After harvest, the fibrous roots attached to the rhizomes are trimmed off and soil is

removed by washing. Rhizomes are soaked in water overnight and then cleaned. The skin is removed by scrapping with sharp bamboo splits or such other materials. Never use metallic substances since they will discolours the rhizomes. After scrapping, the rhizomes are sun-dried for a week with frequent turnings. They are again well rubbed by hand to remove any outer skin. This is the unbleached ginger of commerce.

Ginger oil

Ginger oil is prepared commercially by steam distillation of dried powdered ginger. The yield of oil varies from 1.3 to 3.0 per cent. The major use of ginger oil is as a flavouring agent for beverages, both alcoholic and non- alcoholic.

Ginger oleoresin

Oleoresin from ginger is obtained conventionally by extraction of dried powdered ginger with organic solvent, ethanol. Commercial dried ginger yields 3.5-10.0 per cent oleoresin. Ginger oleoresin is a dark brown viscous liquid responsible for the flavour and pungency of the spice.

TURMERIC (*Curcuma longa*)

Turmeric is a tropical herb and can be grown on different types of soil under irrigated and rainfed conditions. Rich loamy soils having good drainage are ideal for the crop. It is a shade tolerant crop with shallow roots suitable for intercropping and also as a component crop in the homesteads where low to medium shade is available.

Preparation of land

Prepare the land to a fine tilth during February-March. On receipt of pre- monsoon showers in April, prepare beds of size 3m x 1.2 m with a spacing of 40 cm between beds.

Seed material

Whole or split mother rhizomes are used for planting. Select well developed, healthy and disease free rhizomes. Store the seeds in cool, dry place or in earthen pits plastered with mud and cowdung.

Varieties

Local varieties: Duggirala, Tekurpetta, Sugantham, Kodur, Armoor, Alleppey, Suvarna, Suguna, Sudarsana.

Table-10: Salient features of high yielding turmeric varieties

S. No.	Variety	Average yield(dry)(t/ ha	Curcumin (%)	Oleoresin (%)	Essetial oil (%)	Dry recovery (%)	Duration	Other features
1	Kanthi	7.34	7.18	12.13	5.15	18.7	240-270	Bigmother rhizome with medium boldfingers and closer inter nodes
2	Sobha	5.74	7.39	15.95	4.24	18.30	240-270	Big motherrhizome with medium boldfingers and closer inter nodes. Inner core of rhizome is dark orange. More tertiary rhizomes.
3	Sona	7.05	7.11	18.00	4.40	18.88	240-270	Orange yellow rhizome medium, bold with no tertiaryfingers. Best suited for central zone ofKerala. Rhizome medium b o l d field tolerant to leaf blotch.
4	Varna	6.37	7.87	13.88	4.56	19.05	240-270	Orange yellow rhizome medium, boldtertiary fingerspresent.Best suited forcentral zone of Kerala. Rhizome medium boldfield tolerant to leaf blotch.
5	IISR Prabha	7.30	6.5	15.00	6.50	19.50	205	-
6	IISR Prathiba	7.23	6.2	16.20	6.20	18.50	225	
7	IISR Alleppy Supreme	6.73	5.55	16.00	-	19.0	210	Tolerant to leaf blotch
8	IISR Kedaram	6.52	5.5	13.60	-	18.90	210	Tolerant to leaf blotch

Season and method of planting

Plant during April with the receipt of pre-monsoon showers. Take small pits in the beds in rows with a spacing of 25cm x 25 cm. Plant finger rhizomes flat with buds facing upwards and cover with soil or dry powdered cattle manure. The seed rate is about 2000- 2500 kg per ha.

Manuring

- Apply FYM / compost as basal dose @ 35 t/ha at the time of land preparation or by spreading over the beds after planting and 3t/ha each at 30DAP and 60DAP. Apply 250 kg ash / ha, half at 30 DAP and the other half at 60 DAP.
- Apply FYM + *Trichoderma* + neem cake mixture @ 100 g / planting pit at the time of planting.
- Vermicompost or coirpith compost may also be used at a reduced dose instead of FYM according to availability.
- Apply *Azospirillum* @ 2.5 kg /ha / PGPR mix I as basal. Repeat the same dose at 60 DAP.

Mulching

Mulch the crop immediately after planting with green leaves @ 15 t/ha. Repeat mulching with green leaves twice @ 7.5 t / ha first 45-60 days and second 90-120 days after planting.

After cultivation

Weed the crop thrice at 60, 120 and 150 days after planting, depending upon weed intensity. Removed weeds should be recycled by way of mulching. Earth up the crop after 60 days.

Plant protection Diseases

Rhizome rot, wilt and leaf spot diseases

- Dip the seed rhizome with 5% suspension *of Pseudomonas fluorescens* P1 for 15 minutes before planting.
- Treat the seed rhizome with AMF
- Apply organic manure enriched with *Trichoderma* at the time of planting.
- Spray and drench the plant with *Pseudomonas fluorescens* P1 / PGPR mix II at 45 days after planting (onset of monsoon). Repeat spraying and drenching at monthly intervals based on disease incidence and intensity.

Harvesting and curing

Time of harvest depends on the variety and it usually extends from January to March. Harvest early varieties at 7-8 months, medium varieties at 8-9 months and long duration varieties at 9-10 months after planting.

Improved method of processing

Cleaning

Harvested turmeric rhizomes are cleaned off mud and other extraneous materials adhering to them and subjected to curing within 2-3 days after harvest so as to ensure the quality of the end product.

Boiling

Fingers and mother rhizomes will have to be boiled separately. Boiling is usually

done in MS pans of suitable size. Cleaned rhizomes (approximately 50 kg) are taken in a perforated trough of size 0.9 m x 0.55 m x 0.4 m made of GI or MS sheet with extended handle. The trough containing the rhizomes is then immersed in MS pan (1 m x 0.62 m x 0.48 m) containing clean water sufficient to immerse the rhizomes. The whole mass is boiled till the rhizomes become soft. The correct stage of cooking can be judged by piercing a wooden needle through the rhizome. If the rhizomes are properly cooked, the needle will pass through the rhizome without resistance. The cooked rhizomes are taken out of the pan by lifting the trough and draining the solution into the pan.

Drying

The fingers are then dried in the sun by spreading them as a thin layer on bamboo mats or drying floor. Artificial drying at a maximum temperature of 65ºC gives a bright coloursed product than that of sun drying especially for sliced turmeric.

Polishing

In order to smoothen the rough and hard outer surface of the boiled dried turmeric and also to improve its colours, it is subjected to polishing. There are two types of polishing, hand polishing and machine polishing.

Hand polishing: The method of hand polishing is simple, which consists of rubbing turmeric fingers on hard surface or trampling them under feet wrapped in gunny bags. 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, 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.

Machine polishing: This method consists of an octagonal or hexagonal wooden drum mounted on a central axis and rotated by power.

Coloursing

Boiled, dried and half polished turmeric fingers (half polished turmeric is more suitable since colours does not stick to the rhizomes that have been polished fully to smooth finish) are taken in bamboo basket and shaken with turmeric powder. For coating 100 kg of half polished turmeric 200 g of turmeric powder is required. When fingers are uniformly coated with turmeric powder, they are dried in the sun.

Turmeric oleoresin

This is obtained by the solvent extraction of the ground spice with organic solvents like acetone, ethylene dichloride and ethanol for 4-5 hours. It is orange red in colours. Oleoresin yield ranges from 7.9 to 10.4 per cent. One kg of oleoresin replaces 8 kg of ground spice.

VANILLA (*Vanilla planifolia*)

Vanilla is a tropical orchid requiring a warm climate with frequent rains, preferring an annual rainfall of 150-300 cm. Uncleared jungle areas are ideal for establishing vanilla plantations. In such locations, it would be necessary to retain the natural shade provided by lofty trees and to leave the soil or the rich humus layer on the top undisturbed. Vanilla is cultivated on varied type

of soils from sandy loam to laterite. It requires filtered sun light. In the absence of natural shade, trees should be grown to provide shade. Dry climate and direct falling of sunlight on to the plants may cause yellowing by sun scorching.

Preparation of land and planting of standards

Clear the land of jungle growth and prepare for planting. Being a creeper, the plant requires support up to a height of about 150 cm. Low branching trees with rough bark and small leaves are preferred as support trees. Cuttings of *Plumaria alba, Erythrina lithosperma, Jatropha carcas* and *Glyricidia maculata* are suitable as live supports. They are to be planted at least six months prior to planting of vanilla for successful establishment. Cuttings of 1.5-2.0m length with 4-5 cm diameter are to be used for planting in pits of about 30cm x 30cm x 30cm at a spacing of 2.5 m between rows and 2m within row. This can accommodate about 1600- 2000 plants in one-hectare area as pure crop. The growth of live standard is to be adjusted to make them branch at a height of 150 cm to facilitate trailing of the vines and artificial hand pollination.

Planting, training and pruning

Vanilla is propagated by planting shoot cuttings *in situ*. Shoot cuttings are to be taken from healthy and vigorously growing plants. Plant rooted cuttings of 60 cm length in pits of 40 cm cube filled with dry leaves and top soil. They are planted close to the base of the support tree. The top end of the cutting is to be tied to the base of the support tree gently so that it will eventually climb on them. If shade is not sufficient from the support tree, palm fronds or other leaves can be used to provide shade to the cuttings. Longer cuttings bear earlier than shorter cuttings.

Plant the cutting with the onset of monsoon rains. Plant the cuttings at a spacing of 2.7 m between plants and 1.8 m between rows. Trail the vines on the live supports and when they attain a height of 150 cm coil on branches of support plants in loops touching the ground. Trailing or coiling is an important cultural operation, which facilitate early induction of flowering.

Manuring

Being a surface rooting plant, manuring should be confined to the surface layer of soil. Provide heavy and frequent mulching to the vines. Apply 10 kg FYM in two split doses in June-July and September-October. Cowdung slurry / biogas slurry / groundnut cake slurry @ 2 litres / plant may be applied around the base of the vine at bimonthly intervals. Vermiwash with 5 times dilution / fresh cattle urine with 10 times dilution may be applied as foliar spray at monthly intervals up to fruit set.

After cultivation

Vanilla cannot withstand even the slightest root disturbance. Hence remove weeds from the plant base by hand-weeding and use them as mulch. Being closely planted, no intercrops are raised in a pure plantation of vanilla. But vanilla can be planted as an intercrop in coffee, coconut, arecanut etc. The vines may be irrigated luxuriantly immediately after flower opening up to harvest of beans. Maintaining high humidity in vanilla plantation by using micro-sprinklers and foggers will help in better growth of vines.

Moisture stress is a pre-requisite for triggering of flowering in vanilla. Therefore, irrigation should be withheld from November -December up to initiation of flower buds ie. January –February.

Judicious lopping of branches of live supports during the onset of southwest and northeast monsoon periods is very important to adjust the shade level to 50 %. All pruned materials can be used as mulch.

Flowering and pollination

Flowering of vine commences usually by about the third year. The inflorescence is produced in the leaf axils during the month of January - February. There is a tendency for some of the vines to maintain only vegetative growth. A light nipping off or pruning of the terminal shoots hasten flowering. Due to the peculiar structure of the flowers, self-pollination is impossible. Hence hand pollination is adopted for fruit set. Best time for

pollinating the flowers is between 6 a.m. and 1 p.m. and a success of 80-85% can be obtained. Successful fertilization is indicated by the retention of calyx and the stigma even after four days of pollination.

Plant protection Pests

Vanilla bug (*Halyomorpha* sp.*)*

Collection of eggs, nymphs and adults and their destruction

Diseases

***Fusarium* wilt*, Phytophthora* rot and fungal leaf spot**

Remove and destroy all disease affected plant parts.

- Dip the vines with 5% suspension of *Pseudomonas fluorescens* P1 for 15 minutes before planting.
- The organic manure used for planting and that applied at different stages of growth shall be enriched with *Trichoderma.*
- After planting, drench and spray *Pseudomonas fluorescens* P1 suspension (2%). *Pseudomonas* application may be adjusted based on disease incidence and intensity. Drenching with copper oxychloride 0.3% for phytophthora and fusarium wilt.

Harvesting and curing

The pods ripen in about 9-11 months time. Before attaining maturity, the fruit is dark green in colours and when ripe yellowing commences from the tip of the pod. Collect the pods at this time, as this is the optimum time for harvesting the pod. If allowed to remain on the vine further, the pods split. Free vanillin is not present in the beans when they are harvested. They also do not have the aroma. Vanillin is developed as a result of enzyme action on a glycoside occurring during the process of curing of beans. Harvested beans are subjected to curing which is characterized by four phases.

1. Killing or wilting beans to arrest the vegetative development in the fresh beans and initiate the enzymatic reactions responsible for the production of aroma and flavour. Killing is indicated by the development of a brown coloursation of the bean.
2. Raising temperature of the killed beans (sweating) to promote the desired enzymatic reactions and to achieve rapid drying so as to prevent harmful fermentation.
3. Slow drying at ambient temperature until the beans have reached about one-third of original weight for the development of various fragrant substances.
4. Conditioning the beans by storing them in closed boxes for three months or longer to permit the full development of desired aroma and flavour. Curing of vanilla involves immersing the beans (2-3 days after harvest) in hot water at a temperature of 63 to 65ºC for three minutes for the cessation of vegetative life. After a rapid drying on woolen blankets, when the beans are still very hot, they are kept in chests lined with blankets. Next day they are spread out in sun on blanket for three to four hours and rolled up to retain the heat. Repeat this for six to eight days during which beans lose their weight, become supple and can be twisted on finger without breaking. This is followed by slow drying in the shade for a period of two to three months.

   Properly dried beans are kept in trunks where the fragrance is fully developed. Finally, they are graded according to size and bundled and placed in iron boxes lined with paraffin paper. The vanillin content of properly cured beans will be about 2.5 per cent.

Yield

The yield of vanilla varies depending on the age of vines and the method of cultivation. Normally it starts flowering from the third year, which gives yield in the fourth year. The yield stabilizes at fifth or sixth year and may decline at about 12th or 13th year. The plants are to be replanted at this stage. Under reasonable level of management, the average yield of a middle-aged plantation will be about 300 kg of cured beans per hectare.

NUTMEG *(Myristica fragrans)*

Nutmeg requires a hot, humid climate without pronounced dry season. The soil should be rich in organic matter and well drained. The tree prefers partial shade. Sheltered valleys are the best suited. It can be grown up to about 900 m above MSL.

Varieties

Select locally available, high yielding and high quality cultivars.

Viswashree is an improved variety from IISR.

Seeds and sowing

Seeds from fully ripened tree-burst fruits are collected directly from the tree for raising seedlings. The fleshy rind and the mace are removed before sowing. Care should be taken to avoid drying of seeds, as dried seeds fail to germinate. Hence immediate sowing of seeds is recommended. Otherwise seeds should be kept in baskets filled with moistened sand till sowing. Seeds of fully mature fruits will be of black colours.

Seed beds of 100 – 120 cm width, 15 cm height and of convenient length may be prepared in cool and shady places. A mixture of garden soil and sand in the ratio 3:1 may be used for preparing nursery beds. Over this, sand is spread to a thickness of 2 -3 cm and the seeds placed 2 cm below the

surface at a spacing of about 12 cm on either side. Seeds germinate within 50 – 80 days after sowing. Young seedlings cannot withstand direct sunlight or heavy moisture. When the plumule produces two elongated opposite leaves, the seedlings are to be transferred from beds to poly bags of size 13cm x 18 cm. Field planting is done six months after germination. Seedlings attain a height of around 23 cm at this stage.

Planting

Nutmeg requires shade for optimum growth. Hence suitable banana varieties can be planted on both sides at a distance of 1m from the pit. This will provide shade in the early stages. Generally nutmeg is cultivated as an intercrop in coconut gardens. Hence the required shade for the growth of plants will be provided by the main crop like coconut. Pits of 90cm x 90cm x

90 cm are dug at a spacing of 8m x 8m with the onset of South West monsoon. The pits are filled with top soil and compost or well decomposed cattle manure and seedlings are planted.

Aftercare

Small rootlets spread very near to top soil. Hence digging should be avoided in the root zone. Therefore hand weeding is generally recommended. Certain rootlets may come above surface soil. Earthing up should be done to protect such rootlets. Dried branches are to be removed. Small branches, which grow erect from the main branches, should also be removed as they do not set fruits.

Manuring

Nutmeg requires heavy manuring. Cow dung or compost is found to be good. Apply 10 kg cattle manure or compost per seedling during the first year and increase the quantity of organic manure to 50 kg gradually till the tree attains an age of 15 years. This can be applied in two or three split doses. Application of poultry manure, vermi compost, neem cake and bone meal is also beneficial to enhance the growth and yield (Table 19).

Table-11: Additional requirement of organic manures

Organic manures	Quantity	
	1st Year	2nd Year
Bone meal	100g/plant	100g/plant
Neem cake	100g/plant	100g/plant
Poultry manure	2kg/plant	4kg/plant
Vermi compost	2kg/plant	4kg/plant

Gradually increase the dose of the manure as the plant grows. Application of biofertilizers such as *Azospirillum* and phosphobacteria / PGPR mix I @10 to

25g/plant in the root zone during the first year and 25 to 50g/plant during subsequent years is also advantageous. Seedling root dip is also beneficial to the plants. Inoculate with AMF in the nursery and field at the time of planting.

Harvesting

Peak period of harvest is from December to May. When fruits are fully ripe, the nuts split open. These are either plucked from the tree or allowed to drop. The two major products are nutmeg and mace. Dried nutmeg and mace are directly used as spice and also for the preparation of their derivatives.

The nuts meant for sowing are kept in moist places and others are dried in the sun for six to eight days till they rattle in their shell. They are stored in warm dry places prior to shelling.

Plant protection Diseases Pests

The hard scale *Saissetia nigra* occurs on the pencil thick branches and desaps the tissues. The infested shoots invariably develop sooty mould cover.

Spray tobacco decoction/neem- garlic suspension (2%).

Leaf spot and shot hole *(Colletotrichum gloeosporioides)*

Syptoms: Sunken spots surrounded by a yellow halo are the initial symptoms. Subsequently the central portion of the necrotic region drops off resulting in shot hole symptoms. Die back symptoms are also observed in some of the mature branches. On young seedlings drying of the leaves and subsequent defoliation are seen.

Control: The disease can be controlled by spraying 1% Bordeaux mixture 2-3 times during rainy season.

Fruit rot *(Colletotrichum gloeosporioides)*

Symptoms: Water soaked lesions are seen on the fruits, the tissues of which become discoloursed and disintegrated. Premature splitting of the pericarp and rotting of mace and seed are the main symptoms of this disease. The internal tissues are found rotten. The fallen fruits become enveloped with the growth of the organism.

The above diseases can be controlled by spraying *Pseudomonas fluorescens* @ 20 g/ litre / PGPR mix II/ spraying 1% Bordeaux mixture.

MEDICINAL & AROMATIC PLANTS

CHETHIKODUVELI (*Pulmbago rosea*)

This is an attractive erect rambling shrub with long tuberous roots and bright red flowers in long terminal spikes. It is also called as Red Flowered Leadwort. Root tubers are the medicinally important parts. This is an esteemed remedy for leucoderma and other skin diseases. The synonyms of fire like 'agnih' 'analah' etc. are attributed to this drug to indicate caustic action of roots causing blisters on skin. The drug is used only after adequate curing and purification. Roots contain plumbagin, which is responsible for the therapeutic action of the drug.

The crop can be grown satisfactorily under open as well as in coconut gardens.

Land preparation, planting and manuring

In mid-May, trenches of 1 m width, 50 cm depth and convenient length may be made. Apply green leaves @ 20 t/ha / FYM @ 10 t/ha and bone meal 2 t/ha and fill the trench with top soil. Alternative to this, combined application of FYM @ 10 t/ha with *Azospirillum* and Phosphate Solubilising Bacteria each @ 2.5 kg/ha or PGPR mix I is also recommended. Vermicompost / coirpith compost can also be applied instead of FYM depending upon the availability in a reduced dose.

During June, beds of 15 cm height may be prepared and three nodded semi hardwood cuttings may be planted at a spacing of 5cm x 5 cm. Shade is provided immediately after planting as high humidity is required for rooting. Inoculate cuttings with AMF to ensure maximum sprouting and early growth in main field.

The crop may be top dressed with pre-composted poultry manure @ 2.5 t/ha or FYM @ 5 t/ha twice at 6 and 12 months after planting and earthed up.

Varieties

Mridhula

Clonal selection. High root yield (2.94 t/ha -dry) and low plumbagin content (0.22%).

Can be used without curing in the preparation of indigenous medicines

Agni

Clonal selection. High root yield (2.65 t/ha -dry) and high plumbagin content (0.80%).Suitable for the extraction of plumbagin.

After cultivation

Keep the field free of weeds by frequent weeding up to 9 months after

planting and irrigate the crop at fortnightly interval by flood irrigation during dry months.

Harvesting

Crop can be harvested in about 18 months after planting. After digging out, root tubers are cleaned by washing in water and marketed fresh or dried.

NEELA AMARI (*Indigofera tinctoria*)

Nili is a reputed drug for promotion of hair growth. Due to antitoxic property it is also a good remedy for poisons. This plant, which is the original source of natural indigo, is an erect shrub. Leaves are important in medicine and form a major ingredient of preparations like 'Nilibhringadi'. Roots are also used in ayurvedic preparations.

Nili grows well in open conditions and coconut gardens above the age of 25 years.

Land preparation

Prepare soil to fine tilth by ploughing two or three times.

Seeds and sowing

Seeds are very small and seed rate is 3-4 kg/ha. Seeds may be sown directly or transplanted from nursery to main field. Seeds require pre- treatment for good germination, as seed coat is hard. Seeds are mixed with sand and ground gently to break seed coat. An alternate method for enhancing germination is dipping the seeds in boiling water for a second. After pre-treatment seeds are broadcasted, preferably by nixing with sand 2-3 times its volume to ensure uniform coverage. Seeds germinate within a week. Transplant seedlings at 40-50 cm spacing when seedlings are 30 days old.

Season

Best time for sowing is September-October.

Manuring

Apply cattle manure @ 10 t/ha as basal dressing and incorporate into soil along with last ploughing. Topdressing may be done with pre-composted poultry manure @ 0.5 t/ha or FYM @1 t/ha incorporated with PGPR mix I (2.5 kg / ha) after each harvest.

After cultivation

Weeding has to be done as when required. Irrigate during summer.

Plant protection Pests

Psyllid, *Arytaina puctipennis* sucks sap from tender shoots and leaves, causing leaf fall and wilting of plants.

Control: The pests can be controlled by spraying, tobacco decoction/ neem- garlic

suspension 2%.

Harvesting

Plants start flowering 2-3 months after sowing. Harvesting is done just before flowering by cutting the plants at a height of about 30 cm from ground level. Irrigate plants after harvest. Subsequent harvests can be made at 1.5-2 months interval. Four to five cuttings can be taken in a year depending on the growth. A crop is retained for 3-4 years for harvest of leaves after which entire plants are dug out and roots are collected.

Seed collection

A few plants per plot are left without cutting to set seeds. Ripe pods are to be harvested in the early morning to prevent loss of seeds by shattering during harvest.

CHENGAZHINIRKIZHANGU (*Kaempferia rotunda*)

Chengazhinirkizhangu is a medicinal herb with aromatic rhizome. Rhizomes are used for treatment of tumours, swellings and wounds. It helps to remove blood clots and other purulent matters in body. It is used in many *ayurvedic* formulations including 'Chyavanaprasam' for improving complexion and curing burning sensation, gastric complaints, mental disorders and insomnia.

Climate and soil

The plant is distributed in the tropics and subtropics of Asia and Africa. It grows wild in wet, humid or shaded forest ecosystems of south India. It is also cultivated as an intercrop with other commercial crops. Moist loamy soil is ideal for the crop. Laterite soil with heavy organic manure application is also well suited.

Propagation

It is propagated through rhizomes.

Varieties

At present, only local types are available for cultivation.

Season

Optimum time of planting is with receipt of pre-monsoon showers.

Land preparation

Plough the field to good tilth. Prepare raised seedbeds of 1 m breadth and of convenient length.

Seed rate

Use rhizome bits of size 10-15 g for planting. About 2500-3000 kg rhizomes are required for planting one hectare. Smoking rhizomes for 2-3 weeks is good for development of healthy sprouts. At times, rhizomes are stored in *Glycosmis pentaphylla* leaves in underground pits covered with coconut fronds.

Planting

Pits are made at 20 cm spacing on the seedbed. Whole or split rhizomes with at least one healthy sprout is planted 5 cm deep with sprout facing upwards and covering pit with FYM.

Mulching

Mulch beds thickly with green leaves or straw @ 15 t/ha immediately after planting and again after two months along with weeding and topdressing. Mulching is absolutely essential for good growth. Mulching suppresses weed growth and provides favourable soil physical, chemical and biological conditions and microclimate for better rhizome production.

Manuring

Compost or FYM @15 t/ha is to be applied in pits at the time of planting. After planting, rhizomes are lightly covered with soil. *Azotobacter* / PGPR mixI 2.5kg / ha and compost/ FYM @ 2.5 t/ha may be applied second and fourth months after planting at the time of weeding and earthing up.

After cultivation

Remove weeds, apply manures and earth up at two and four months after planting, followed by mulching.

Plant protection

During rainy months, rhizome rot is noticed which can be controlled by drenching 1% Bordeaux mixture.

Harvesting and yield

Crop matures in 7-8 months. Drying up of leaves is the indication of maturity. Dig out rhizomes carefully, remove leaves and clean. Rhizomes with attached tubers are usually marketed afresh. Prolonged storage may cause insect and fungus attack. Average yield is 12-15 t/ha and dry rhizome yield 27-30%.

KASTHURIMANJAL (*Curcuma aromatica*)

Curcuma aromatica is a rhizomatous herbaceous medicinal plant. Rhizome is an odoriferous ingredient of cosmetics used for cure of chronic skin diseases caused by impure blood. It is used as appetizer and tonic to women after childbirth. It is also

useful against high fever and worm infestation.

Climate and soil

It is distributed in Southeast Asia. The plant grows wild in the eastern Himalayas and in moist deciduous forests of Kerala and Karnataka. It is grown as a subsistence crop in backyard, kitchen garden and interspaces of other crops in areas with good rainfall. Well- drained rich loamy soils are ideal for the crop. Higher yields of rhizomes are obtained from crop grown under shade.

Propagation

It is propagated vegetatively by rhizomes.

Varieties

At present, only local types are available for cultivation.

Land preparation

Clear the area, remove all the pebbles and stones and plough the field to good tilth. Prepare raised seedbeds of 1.2 m breadth and of convenient length. In sloppy lands the beds should be made along the contours to prevent soil erosion.

Seed rate

A healthy disease free mother rhizome with at least one germinated sprout and weighing not less than 25g is the best planting material. It is required at the rate of 1500 kg/ha.

Planting and manuring

Take small pits at 25cm x 25 cm spacing on seedbed and plant seed rhizomes with germinating sprout facing upwards. Cover the rhizome with FYM @ 10-15 t/ha and mulch the beds with leaves or straw. Combined application of FYM @ 10 t/ha with *Azotobacter* / PGPR mix I @ 2.5 kg/ha is also recommended. At 2 and 4 months after planting, cow dung @ 5 t/ha or pre-composted poultry manure @ 2.5 t/ha may be applied after weeding and the beds may be earthed up.

Aftercultivation

Carry out gap filling if necessary within one month. Remove weeds at two and four months after planting and earth up.

Plant protection

Rhizome rot: Drench with *Pseudomonas fluoroscens* 2% solution.

Harvesting and yield

Crop matures in 7 months. Drying up of leaves is the indication of maturity. Dig out rhizomes without causing damage. Remove dry leaves and roots. Cleaned rhizomes are either marketed or dried and stored. Average yield of fresh rhizome is 28 t/ha which on drying gives 27% recovery.

Processing

Rhizome is thinly sliced and steam distilled for 3-4 hours for extracting essential oil. Oil yield is 90 litres/ha. Oil recovery is 0.33% on fresh weight basis and 1.05% on dry weight basis.

CHITTARATHA (*Alpinia calcarata*)

Alpinia calcarata (galangal) is also known as *rasna* in Sanskrit. It is a perennial herb with non-tuberous pungent rootstock. It grows to a height of 1.5 m and produces around 24 suckers per clump per year. Rhizomes are used in bronchial infections, rheumatoid arthritis and as a carminative.

Climate and soil

Alpinia comes up well in tropical climate. It grows on a wide range of climate and soil. Well-drained hilly areas and places up to 1400 m altitude are good for its cultivation. Fertile red loams to forests soils are suitable.

Propagation

It is propagated vegetatively by rhizomes.

Varieties

At present, only local types are available for cultivation.

Season

Rainfed crop is planted with onset of monsoon in May-June. Irrigated crop can be planted at any time.

Land preparation

Plough the field to good tilth. Remove all pebbles and stones. Prepare raised beds of convenient length and breadth to facilitate drainage.

Seed rate

Fresh healthy disease-free rhizome bits with at least one shoot are the planting material, which is required @ 1000-1500 kg/ha.

Planting

Take small pits on the seedbed and plant 5 cm long rhizome bits. Cover rhizome with FYM and mulch the seedbed with leaves or straw. Optimum spacing is 30cm x 20 cm under good fertility and 40cm x 30 cm under poor fertility conditions.

Manuring

Apply FYM @ 10-15 t/ha as basal in pits. Application of biofertilizer *Azospirillum* / PGPR mixI @ 2.5 kg/ha and *in situ* green manuring with cowpea is beneficial for the crop. At 2 and 4 months after planting, cow dung @ 10 t/ha or pre-composted poultry manure @ 5 t/ha may be applied after weeding and the beds may be earthed up.

Aftercultivation

Carry out gap filling, if required, within one month; remove weeds two months after planting followed by topdressing, earthing up and mulching. Thereafter no weeding is required as the crop smothers the weeds.

Plant protection

Occasionally shoot borers and leaf eating caterpillars are observed which are not serious and controlled by spraying with neem kernel suspension (5%).

Leaf blight disease can be controlled by spraying with 1% Bordeaux mixture / 2% Pseudomonas.

Harvesting and yield

Though the crop can be harvested after 18 months, optimum stage of harvest for obtaining maximum rhizome and oil yield is 36-42 months after planting. Cut and remove shoot portion and carefully dig out rhizomes and roots. Harvesting is very arduous due to strong and extensive root ramification. Separate roots, clean rhizomes and cut into 5 cm long pieces, which are dried in sun for 3-5 days to 10% moisture for marketing. Average yield of rhizomes is about 23 t/ha, which on drying gives 25% recovery.

Processing

Fresh rhizomes on steam distillation for 3-5 hours give 0.22% essential oil. Oil recovery on dry weight basis is 0.93%. Root is also a significant contributor of essential oil.

BLACK MUSLI (*Curculigo orchioides*)

Black Musli or *Nilappana,* one of the ayurvedic *dasapushpas,* is a small geophilous herbaceous plant with cylindrical rhizome. Rhizome is the economic part. It is a rejuvenating and aphrodisiac drug. It improves complexion and is useful in general debility, deafness, cough, asthma, piles, skin diseases, impotence, jaundice, urinary disorders, etc. It is an

ingredient of ayurvedic formulations like *Vidaryadi ghrita, Vidaryadi lehya, Marma gulika, Musalyadi churna etc.*

Climate and soil

The plant is found throughout India from near sea level to 2300m altitude, particularly in rock crevices and laterite soil. It grows well in moist humus-rich soils especially in shady forest areas and rubber plantations. It is a shade loving plant and its growth, yield and quality are optimum under 25 per cent shade. It can be grown as an under

storey crop or intercrop in plantations.

Propagation

The plant is propagated through rhizome. It is slow growing and less competitive.

Varieties

At present, only local varieties are available for cultivation. However, a large variability exists among natural population, which offers wide scope for improvement of the crop by selection and hybridization.

Season

Rainfed crop is planted with the onset of monsoon in May – June.

Irrigated crop can be planted at any time.

Seed rate

Fresh healthy disease free rhizome with at least one shoot is the planting material, which is required @ 750 kg/ha.

Land preparation, planting and manuring

Plough the field to good tilth. Remove all pebbles and stones. Incorporate poultry manure @10t/ha or FYM 20t/ha and PGPR I @ 2.5 kg/ha. Prepare raised beds of convenient length and breadth to facilitate drainage. Fresh rhizome bits of 1.5-2 cm are planted at a spacing of 10cm x 10 cm. 25% shade is required for proper growth. Mulching is not good as it adversely affects crop establishment and yield.

After cultivation

Carry out gap filling, if any, within one month. Soil should be sufficiently moist to get maximum rhizome development. Two to three weedings are essential to control weeds. As the rhizome development is upward, regular earthing up is required for high yield.

Plant protection

Seedling rot is found during rainy season and spraying 1% Bordeaux mixture can control it. Rhizomes are found eaten by rodents and hence proper control measures are to be taken for their control.

Harvesting and yield

Plant grows actively up to 7 months, after which it could be harvested for rhizome yield. During summer months, above ground portion becomes dried up. If it is not harvested during current year, it will put forth new shoots with onset of next monsoon. Harvesting is done by digging out rhizomes. Shoot portion and roots are removed and separated rhizomes are cleaned. Fresh rhizome yield is 3-4 t/ha. Rhizomes are sliced to 1 cm size, dried in sun and marketed or stored in gunny bags. Dry rhizome yield is 1-1.5 t/ha (35-40% dryage). Higher yield is obtained if harvested during second year. Dry rhizome contains 53% starch, 12% protein, 3% fibre, 2% fat, 0.1% curculigoside and 4% ash.

HOLOSTEMMA (*Holostemma adakodien*)

Holostemma or *Adapathiyan* is a large, glabrous, laticiferous twining shrub, much branched, with shining stem and large conspicuous flowers. Root is the economic part. It is useful in ophthalmopathy, orchitis, cough, burning sensation, stomachalgia constipation, fever and *tridoshas*. It is used in preparations of *Vidaryadi ganam, Dhanwandharam thaila,*

Manasa mithra vatakam, Balarishta and Anuthaila. It is also useful in eye diseases and it imparts resistance to diseases.

Climate and soil

It grows on a wide range of climate and soil. Well-drained hilly areas with an underlying hard pan are good for its cultivation. Fertile red loams to forest soils are suitable.

Propagation

The plant is propagated vegetatively by vine cuttings and rot cuttings and by seeds. Seeds are collected from the plant in November-December before being dispersed. Seeds are cleaned, dried and stored for sowing. Stored seeds after soaking in water for 4-5 hours are sown on seedbeds. When seedlings are fully germinated, they are planted in polybags, which are kept in shade and irrigated. About 1-1.5 month old seedlings are ready for transplanting.

Varieties

Jeeva

Clonal selection. Purple cordate plant type with long internodes, high yield of thick, sweet roots 1.50t/ha dry root with high soluble sugar content (8.33%).

Season

Rainfed crop is planted with the onset of monsoon in May – June.

Irrigated crop can be planted any time.

Land preparation

Plough the field to good tilth. Remove all pebbles and stones.

Planting

Pits of 30cm3 size are taken at 1-1.2m distance and filled with 10kg dried cow dung and top soil and formed into a mound. Seedlings are transplanted on mounds.

Manuring

Two months after planting, topdressing may be done with cow dung @ 5 kg/plant or pre-composted poultry manure @ 2 kg/plant.

After cultivation

Carry out gap filling, if any, within one month; remove weeds two months after planting followed by top dressing, earthing up and mulching. Thereafter no weeding is required as the crop smothers the weeds. Since the crop is twining in nature, *pandal* or stakes are to be provided to aid trailing. Regular irrigation is to be given till flowering.

Plant protection

Common pests are aphids and leaf eating caterpillars and can be controlled by spraying tobacco decoction.

Leaf spot and leaf blight diseases can be controlled by spraying 1% Bordeaux mixture.

Harvesting and yield

Flowering and fruiting occurs in November-December. Harvesting can be done at 18 months after planting by digging the soil to collect tubers. Tubers are cut into pieces of 10 cm length and dried in sun before sale. Yield of fresh tubers is about 1-1.5 t/ha which on drying gives 500-600 kg.

LONG PEPPER (*Piper longum*)

Long pepper is a slender aromatic climber whose spike is widely used in ayurvedic and unani systems of medicine particularly for diseases of respiratory tract and in abdominal complaints.

Soil and climate

Long pepper is successfully cultivated in well drained forest soils rich in organic matter. Laterite soils with high organic matter content and moisture holding capacity are also suitable for cultivation. It is a tropical plant adapted to high rainfall areas with high humidity. An elevation of 100-1000 m is ideal. It needs partial shade to the tune of 20-30% for best growth. The natural habitat of the plant is on the borders of streams.

Seeds and sowing

Long pepper is propagated by suckers or rooted vine cuttings collected from female plants.15-20 cm long 3-5 nodded rooted vine cuttings establish very well in polybags. Inoculate cuttings with fluorescent *Pseudomonas,* phosphorus solubilizing bacteria and AMF to improve seedling quality index and early growth in the main field. The best time for raising nursery is March- April. Normal irrigation is given on alternate

days. The rooted cuttings will be ready for transplanting in 2 months time. With the onset of monsoon in June the field is ploughed well and brought to good tilth. 15-20 cm raised beds of convenient length and breadth are taken. On these beds, pits are dug at 60cm x 60 cm spacing and well decomposed organic manure at 100 g/pit is applied and mixed with the soil. Rooted vine cuttings from polybags are transplanted to these pits.

Varieties

Viswam

For open and shaded conditions.

Manuring

The crop needs heavy manuring @10 t FYM / vermicompost @ 6.25 t/ha every year**.** Top dressing with FYM @ 5 t/ha is recommended. Application of

wood ash 2 t/ha enhances crop growth and spike production. Apply PGPR mix I @ 2.5 kg/ha in order to supplement N, P, K nutrition.

Irrigation

The crop needs irrigation once a week. Sprinkler irrigation is ideal. With irrigation the crop continues to produce spikes and off-season produce will be available. However, unirrigated crop after the onset of monsoon grows vigorously and shows much hardiness than the irrigated crop.

After cultivation

Gap filling can be done one month after planting. *P. longum* can also be cultivated as an intercrop in plantations of coconut, subabul and eucalyptus. Weeding has to be resorted to whenever necessary. However, care is to be taken not to break the roots of thippali, as any damage result in damping off.

Plant protection

Mealy bugs and root grubs, attack the plant particularly during summer. Infested plants show yellowing and stunted growth. Adults and nymphs of *Helopeltis theivora* severely feeds on the foliage which can be controlled by 0.25% neem kernel suspension. Rotting of leaves and vines during monsoon season caused by *Colletotrichum gloeosporioides* Necrotic lesions and blights on leaves during summer caused by *Colletotrichum* and *Cercospora spp.* can be controlled by spraying 1% Bordeaux mixture repeatedly / application of *Aspergillus terreus* @ 2 g / kg of potting mixture along with neemcake @ 2 g / kg of potting mixture is effective.

Harvesting and processing

Vines start flowering six months after planting and flowers are produced almost throughout the year. Spikes mature in 2 months time. Optimum stage of harvest is when spikes are blackish green. Pungency is highest at this stage. Spikes are hand picked when they become mature and dried. Yield of dry spike is 400 kg /ha during first year, increases to 1000kg during third year and thereafter it decreases. Therefore, after 3 years the whole plant is harvested. Stem is cut at ground level and roots are dug up. Average yield is 500 kg dry roots/ha.

The harvested spikes are dried in sun for 4-5 days until they are perfectly dry. The green to dry spike ratio is 10:1.5 by weight. The dried spikes have to be stored in moisture proof containers. Stem and roots are cleaned, cut into pieces of 2.5-5 cm length, dried in shade and marketed.

KACHOLAM (*Kaempferia galanga*)

Aromatic essential oil of roots of Kacholam is widely used in perfumery, as a condiment, and as a folk medicine. Asians employ rhizomes and leaves as a perfume in cosmetics, hair washes and powders. It is used to protect clothing against insects. Also used in chewing with betel nut.

Kacholam is a plant adapted for tropical climate. Fertile loamy soil having good drainage is ideal for the crop. Laterite soil with heavy organic manure application is also well suited.

Preparation of land

Prepare the land to a good tilth during March by ploughing or digging. On receipt of pre-monsoon showers in April, prepare beds of 1 m width, 25 cm height and of convenient length with spacing of 40 cm between beds.

Seed materials

Whole or split rhizome with at least one healthy sprout is the planting material in kacholam. Select well developed healthy and disease free rhizomes. Rhizomes can be stored in cool dry place or pits dug under shade, plastered with mud or cowdung. Two weeks before planting, smoking the rhizomes by spreading it on *Glycosmis pentaphylla* (panel) leaves is practised in certain localities.

Varieties

Kasthuri

High yield and high volatile oil with yield potential of more than 2 tonnes dry rhizomes per ha and have good aroma and flavour.

Rajani

High yield and high oleoresin with yield potential of more than 2 tonnes dry rhizomes per ha and have good aroma and flavour.

Season and method of planting

Planting is done during the month of May with receipt of four or five pre- monsoon showers. Take small pits in the beds in rows with a spacing of 20cm x 15cm and at a depth of 4-5 cm and plant rhizomes with at least one viable healthy bud facing upwards. Adopt seed rate of 700-800 kg/ha. Immediately after planting mulch the beds thickly with green leaves @ 15 t/ha. Inoculate seed material with *Azospirillum* + PSB + AMF for enhancing rhizome production and oil yield.

Manuring

After planting, rhizome is lightly covered with soil and FYM or compost at the rate

of 20 t/ha is applied in pits. *Azotobacter* / PGPR mixI along with 2.5kg/ha and compost/FYM @ 2.5 t/ha may be applied second and fourth months after planting at the time of weeding and earthing up. Apply PGPR mix I @ 2.5kg/ha along with organic manure.

Plant protection Pests

Major insect pests damaging the crop are shoot borer and the general management measures for organic cultivation may be adopted to control insect pests.

Diseases:

Rhizome rot and leaf spot.

1. Select sites having proper drainage
2. Select seed rhizomes from disease free areas
3. When incidence of rhizome rot is noticed in the field, dig out the affected plants and drench the beds with 1% Bordeaux mixture
4. Inoculation with native arbuscular mycorrhiza, *Trichoderma* and *Pseudomonas fluorescens* at the time of planting.
5. Spray 1% Bordeaux mixture for controlling leaf spot

Harvesting and curing

The crop can be harvested seven months after planting. Drying of leaves is the indication of crop maturity for harvest. Harvest the crop carefully without cutting rhizomes, remove dried leaves and roots, wash rhizomes in water and dry. With sharp knife, chop rhizomes into circular pieces of uniform size except end portion, which has to be cut separately. Spread cut rhizomes uniformly on clean floor and allow drying for four days. On fourth day, heap the rhizomes and keep it overnight. On the next day it is again spread and dried. Clean the dried produce, bag and store in cool dry place or market it. In case of prolonged storage rhizomes may be dried in sun occasionally to prevent insect and fungus attack.

ASOKA *(Saraca asoca)*

Asoka or *Asokam* is a medium sized handsome evergreen tree growing up to 9m in height with numerous spreading and drooping glabrous branches. It is a sacred tree of Hindus and Buddhists and possesses varied medicinal properties. Bark is useful in dyspepsia, fever, burning sensation, visceromegaly, colic, ulcers, menorrhagia, metropathy, leucorrhoea and

pimples. Flowers are considered to be uterine tonic and are used in vitiated conditions

of *pitta*, syphilis, cervical adinitis, hyperdipsia, burning sensation,

haemorrhoids, dysentery, scabies in children and inflammation. Well-known Ayurvedic preparations are *Ashokarishta* and *Ashokaghrita*. *Ashokarishta* is prescribed in leucorrhoea, haematuria, menorrhagia and other diseases of genitourinary system of females.

Climate and soil

Asoka grows well in areas with well-distributed rainfall and in slightly shady areas. The tree is grown throughout India except in northwestern part of the country upto an elevation of about 750 m. It grows on a wide range of soils.

Propagation

The plant is seed propagated. Seeds are formed usually during February- April. Seeds are collected when they ripen and fall down. They are sown after soaking in water for 12 hours on prepared beds. Seeds germinate within 20 days. Seeds are then planted in polybags. 2-month-old seedlings from the polybags are used for transplanting.

Varieties

At present, only local varieties are available for cultivation.

Season

The crop is planted with onset of monsoon in May – June.

Planting

Square shaped pits of 60cm depth are taken at 3m spacing and filled with topsoil, sand and dried cow dung @ 20 kg/pit. 2 months old seedlings are then transplanted.

After cultivation

The base of the trees is to be cleared of weeds and FYM @ 2 kg/tree/ year may be applied twice; first in May- June and again in October-November. The dose is to be increased gradually to 10 kg from 5th year onwards. The plant responded well to organic manuring and also to biofertilisers like *Azospirillum* and Phosphobacter at 1.0 kg/ha.

Plant protection

No serious pests or diseases are generally noted in this crop.

Harvesting and yield

Asoka can be cut after 20 years for collection of bark, the medicinally useful part. It is cut at a height of 15cm from soil level. If irrigation and fertilizers are given, the stump will produce new shoots and it can be harvested again after 5 years. Alternatively, the bark can be collected without

cutting down the tree. Bark is peeled off first, vertically from one side of the main trunk. The excised area is renewed with fresh bark in 1-2 years. Then, bark on the other side can be peeled off. The process can be continued over years.

STRYCHNINE TREE *(Strychnos nux-vomica)*

Strychnos or *Kanjiram* is a large deciduous tree with a fairly straight and cylindrical bole having dark grey or yellowish grey bark and minute tubercles. *Strychnos* is highly toxic to man and animals producing stiffness of muscles and convulsions, ultimately leading to death. In small doses it can serve as efficacious cure for paralysis and other nervous disorders. The seeds

are used as a remedy in intermittent fever, dyspepsia, chronic dysentery, paralytic and neuralgic affections. It is also useful in impotence, neuralgia of face and heart disease. Leaves are applied as poultice in the treatment of chronic wounds and ulcers and the leaf decoction is useful in paralytic complaints. Root and root bark is used in fever and dysentery.

Climate and soil

The plant is distributed throughout India in deciduous forests up to 1200m. It is also found in Sri Lanka and Malaysia. It prefers tropical and subtropical climate. It is grown in different soil types such as laterite, sandy and alluvial.

Propagation

It is propagated through seeds. Viability of seeds decreases on storage. Fresh and dry seeds of *Strychnos nux-vomica* has poor germination. Germination can be substantially increased by treating the seeds with hot water (50o C) for a period of six to twelve hours prior to sowing.

Season

Seedlings can be planted in main field with the onset of South-West monsoon in May- June.

Planting

Seeds are sown in poly bags. The saplings are later transplanted to the main field in pits of about 60 cm3 size taken at a spacing of 3m x 3m, filled with top soil and 20 kg organic manure.

Manuring and after cultivation

Basins of the trees are cleared of weeds and after application of manures covered with soil. FYM @ 2kg per tree is to be applied during early stages and the dose is gradually increased to 20 kg from 5th year onwards.

Plant protection

No serious pests or diseases are generally noted in this crop.

Harvesting and yield

Flowering is during March-April and fruiting during May-December. Fruits take about 8-9 months to mature. Mature fruits are to be harvested from time to time. Mature pods are collected and seeds are extracted, washed, dried and stored for later use. The yield is 50-75 kg dry seed per tree per year.

EUCALYPTUS (*Eucalyptus citriodora*)

Eucalyptus thrives both in the tropics and subtropics. High humidity and plenty of rainfall are conducive to its luxuriant growth. It can be grown in varied types of soils. The essential oil is used in preparation of cosmetics, hair oil and soap and forms a raw material for menthol manufacture.

Preparation of land

Clear the land of jungle growth. Take pits of size 45cm x 45cm x 45 cm at a spacing 2m x 2 m at least one month prior to planting and allow to weather. 20 kg FYM is applied in each pit, mixed with top soil and fill pits with soil completely so as to prevent water stagnation.

Planting

Seeds can be sown directly or seedlings raised in nursery and 4-5 months old seedlings are transplanted with commencement of southwest monsoon. After planting, press the soil around the seedling and form mound.

Manuring

When organically grown, nutrient requirement should be met by application of *Azotobacter* 2.5 kg/ha and compost or FYM @ 10 tonnes/ha each year with the onset of monsoon.

After cultivation

During first year, cultivate the rows in both directions to prevent weed growth. Hand weeding is done around the seedlings. Fire belts are to be

provided all around.

Intercropping

Eucalyptus can be grown along with coffee, lemongrass and palmarosa. In the first four years, intercropping with pineapple, yam and vegetables can be done.

Harvest and curing

Pruning of side branches may be started from second year onwards. Lopping at a height of 2 m is done during third or fourth year and thereafter lopping is resorted to

at half- yearly intervals leaving only one branch. For extracting oil, steam distillation is resorted to. Optimum time for distillation is two hours and average recovery of oil is 1.5-1.8% of the net weight of leaves. Wilting of cut leaves under shade for 24 hours before distillation will increase oil recovery percentage.

Pests and diseases

Important pests of Eucalyptus are termites, leaf cutting ants, snout beetles and wood borers. Pests can be controlled by spraying tobacco decoction/ neem-garlic suspension. Major diseases are seedling blight, stem end rot and leaf spots and can be controlled by spraying 1% Bordeaux mixture.

LEMONGRASS (*Cymbopogon flexuosus*)

Lemongrass prefers warm climate with a well- distributed rainfall and well-drained soil. Usually it is grown on poor, gravelly soils. Lemongrass is a perennial grass mainly cultivated on hill slopes as a rainfed crop. The crop provides maximum yield from the second to fourth year of planting and economic yield up to the sixth year.

Thereafter, the yield declines considerably. The leaves yield aromatic oil, containing 70-85% citral. This oil is used in soaps, cosmetics and disinfectants and is a raw material for manufacturing ionones and vitamin A.

Varieties

OD-19

High yielding, high oil

Seeds and sowing

The crop is propagated mostly through seeds. It can also be propagated vegetatively through planting of slips.

Seeds can be sown directly in the field or seedlings are raised in a nursery and then transplanted. Transplanted crop is found superior to direct- sown crop in respect of grass yield, oil content and citral content in oil. Seeds are sown in well prepared nursery beds during April-May with the onset of pre-monsoon rains and covered with thin layer of soil. The seed rate is 3 to 4 kg/ha. Seeds collected in the season should be sown latest by August of the same year. Seedlings will be ready for transplanting in 45-60 days (6-7 leaf stage).

Land preparation

Land is prepared by digging. Raised beds of 75-80 cm width and of convenient length are formed with a spacing of 30-35 cm between beds. On sloppy terrain, the beds are formed along the contours. At the early southwest monsoon (June-July), two seedlings or slips per hill are transplanted on beds at a spacing of 30-40 cm in

4-5 rows. Before planting, top leafy portion of seedling is cut off leaving the plant stalk about 15-20 cm length.

Manuring

Basal application of compost made of spent lemongrass (refuse obtained after distillation) @ 2.5 t /ha and wood-ash @ 2t /ha is beneficial. Weeding, manuring with 10 t/ha FYM and earthing up may be done twice a year ie. With the onset of pre-monsoon showers and in July- August after second harvest.

Plant protection

Serious pests or diseases do not generally infest the crop.

Harvesting

Harvesting is done by cutting the grass 10 cm above ground level. During first year of planting, three cuttings are obtained and subsequently five to six cuttings per year are taken subject to weather conditions. Harvesting season begins in May and continues till end of January. The first harvest is taken about 90 days after planting and subsequent harvests at intervals of 40-50 days. Optimum interval between harvests to obtain maximum quantity of oil is 40-45 days for local types of lemon grass. For OD-19, optimum interval was found to be 60-65 days when grown in hill-tops and 45-55 days in valleys and lower areas.

Seed collection

Crop for seed production is left without cutting to get maximum seeds. Crop flowers during November-December and seeds are collected during January-February. Whole panicle is cut and dried for one or two days and then threshed and sieved to collect the seeds.

Distillation

Lemongrass is distilled in copper stills of about 100 kg capacities by steam distillation, or water and steam distillation process. Time required for one distillation is about two hours including time required for charging and discharging, provided firewood is well dried and of good quality. For one distillation, about 40 kg of firewood is required. A light yellow, lemon- scented volatile oil is obtained. Providing a perforated disc just above the water level in the copper still will be helpful to produce oil of better quality. This method is known as water and steam method. When crop area is large enough, steam method is found to be more economical. Coal is used as fuel.

Cut grass is chopped into smaller pieces before feeding to the distillation unit. It can be stored up to 3 days under shade without any adverse effect on yield or quality of oil.

Storage of oil

Lemongrass oil can be stored up to 3 years without affecting the quality of oil, if kept in aluminum containers sealed air-tight using wax. The containers are to be kept in darkness.

Yield

Grass yield during first year will be about 10 t/ha, which gives about 28 kg of oil. From second year onwards, grass yield will be about 25 t/ha giving about 75 kg of oil. Average recovery of oil is 0.30-0.35% with 70% citral for local types of lemongrass while OD-19 variety gives 0.40-0.45% oil recovery and 75-85% citral content.

PALMAROSA (*Cymbopogon martinii* var. *motia*)

Palmarosa (rosha grass) is adapted to marginal areas and poor soils; can be grown under dense canopies of trees and used for soil conservation. Flowering tops and foliage contain sweet smelling oil emitting a rose like odour and is widely used in soaps, cosmetics and perfumery industries. Oil is also used as a raw material for

producing geraniol, which is extensively used in perfumery industry.

Propagation

The crop can be propagated by seeds and slips. Seedlings establish quicker and are better than slips from clones. So seedlings are preferred as planting materials under Kerala conditions. Prepare seedbed in well-ploughed soil after 15th April. Seeds @ 4-5 kg/ha is sown in seed beds and covered with a thin layer of soil. Give frequent watering till the onset of southwest monsoon. Seeds collected in January-February must be sown at the earliest.

Planting

Prepare the main field for planting; form beds and plant the seedling, two on a hill, at a spacing of 30cm x 20 cm. Apply organic manures like compost made of spent grass @ 6 t/ ha and wood ash 2.5 t/ha at the time of formation of beds. Weeding, manuring with FYM @ 4 t/ha and earthing up may be done twice a year ie. With the onset of premonsoon showers and in July- August.

Harvesting

By about 3.5 to 4 months, plants attain a height of 150-200 cm and they start producing inflorescence. Grass is cut one week after flowering. Generally two cuttings are made during first year of planting. From second year onwards, 3 to 4 cuttings are possible.

Distillation

As in the case of lemongrass, extraction of palmarosa oil is done either by hydro distillation or steam distillation. It takes two hours to complete one distillation. Average recovery of oil from Amaravathy variety is 0.40 to 0.45%. Allowing the cut grass to wilt in shade for 24 hours during monsoon seasons and 48 hours during the post-monsoon will increase the oil recovery.

Plant protection

Pink globular root aphids occur on roots and cause withering of the crop in patches due to de-sapping. Dig out and burn affected patches and irrigate with water charged with fish oil soap or emulsion spray oil to control the aphids.

VETIVER (*Vetiveria zizanioides*)

Vetiver is a perennial grass, commonly known as 'khus' plant and mainly cultivated on hill slopes as a rainfed crop. Essential oil is extracted from the roots and known as 'khuskhus oil'.

It prefers a warm climate and grows in areas up to 600 m elevation. Even though vetiver grows almost in all soils, a rich and fairly well

drained sandy loam is the best. An annual rainfall of about 100 to 200 cm, temperature ranging from 25 to 40ºC and moderate humidity are ideal for its growth.

Its root contains fragrant oil, which is a perfume by itself. The dry aromatic roots are made into curtains, mats, fans, etc. to emit scented cool aroma when moistened. The oil is used as a valuable fixative for blending perfumes and cosmetics.

Varieties

Two types of vetiver namely, South Indian and North Indian (khus) are generally under cultivation. South Indian types produce higher root and oil yield, but North Indian types have superior oil quality. Among South Indian types, Nilambur type (ODV-3) on an average produces 5 t/ha of root, yielding 20-30 kg oil/ha.

Planting

Crop is propagated through slips. June-July is the optimum period for planting. Two to three ploughings are given so that soil is well loosened and ridges or beds of convenient length are made. Slips are planted in two rows on 1 m wide beds.

Manuring

Usually 5 t/ha of FYM or compost is applied at the time of bed preparation. Normally, vetiver crop is not manured on fertile soils. On poor soils, application of 4 t/ha FYM as topdressing during second year is found beneficial for increasing root and oil yield.

Harvesting and distillation

Optimum period of harvest of roots to get maximum oil yield is 18 months. Harvesting is done with digging forks. Roots are washed gently to remove the earth and are chopped into bits of 4-5 cm length. Oil is extracted by hydro- distillation. Roots must be distilled for 40-50 hours.

Vetiver as a soil binder

Vetiver has a deep, dense and strong fibrous root system. Perennial and sterile characteristics of the crop with its hardiness and unpalatability to livestock make it an excellent soilconserving crop. It may be planted as a contour hedge on sloppy lands or can be used to protect banks of major irrigation canals.

ORNAMENTAL PLANTS

ANTHURIUM (*Anthurium spp.*)

Anthurium is one of the important economic flowers of export potential. There are more than500 species and several varieties. Few of them are commercially important.

Anthurium andreanum, A. veitchii and *A. scherzerianum* are the economically viable species. Many of them are partially epiphytic in growth habit. Plants prefer to grow under shade.

The tolerable level of light in the tropical region during summer is 20-30 per cent. Excess light causes yellowing and scorching of leaves. Very low light intensity causes excessive vegetative growth and low flowering. It is preferable to grow anthurium in the open, under artificial shade structures for better growth and yield. Plant prefers to grow under a relative humidity of not less than 60 per cent and a temperature of not more than 300 C.

Propagation

Anthurium is multiplied by seed and vegetatively by stem cuttings or by separation of basal sprouts. Propagation by seed is not recommended as a commercial propagation method as it results in high variability. Plants can be multiplied in large number by micro-propagation techniques from the tender leaf bits.

Varieties

Varieties suitable for cut flower production under Kerala conditions are Tropical, Can Can, Flame, Casino, Caesar, Acropolis, Lima White, Akapana, Senator, Cheers, Salasaga, Chichas, Pistache and Midori. Varieties suitable as pot plants are Condor, Excellent, Diabladaand Bonina.

Seed propagation

Seeds are produced by hand pollination. Selfing or crossing can be made. Seeds become mature within a period of 4-6 months after pollination. Mature seeds will have a pulpy coating. The pulp is carefully removed without injuring the soft seed. Seeds are sown immediately after extraction. Sowing is done on a medium of clean fine sand or on a moist cotton pad. Sprouted seeds on cotton pad are shifted to sand medium for further growth. Seedlings are highly variable and will take two years for flowering. Seed propagation is not recommended for commercial production, but only for the production of hybrid varieties.

Vegetative propagation

Plants are propagated vegetatively by cutting the thick main stem into 3-4 cm long discs. If the stem is very thick, the discs can be cut vertically. Each bit should

have minimum two lateral buds. Cut-pieces are treated with fungal formulations of *Verticillium locanii* and planted on a medium of clean river sand. Cuttings will take 1-2 months for sprouting. Suckers from flowering plants can also be separated as and when available and planted in the medium.

Seedlings and sprouted cuttings of 5-10 cm height are transferred to the main field or pots. Planting in pots is preferred in the plains. Cultivation in beds is good at higher altitudes (about 1000 m above MSL). A loose medium above the ground is suitable for anthurium. Old and chopped coconut husk (3 cm size) mixed with brick pieces and charcoal are filled in narrow trenches 10 cm below and above ground level. Pots can also be filled with the same mixture. An ideal pot should be 30 cm diameter at top with 3 large holes at the bottom on sides. One seedling can be planted in a pot. On ground, the spacing is 45 to 60 cm depending upon the variety. Fresh cowdung or neem cake mixed with 10-15 times of water, kept for 4- 5 days, can be sprayed on the plants after filtering. Cow's urine can be sprayed or drenched after mixing with 25 times of water.

Cultivation practices

1. ***Growing medium***

   Coarse sand : Neopeat (3:1)

   Fresh cow dung/ neem cake/ neem cake: groundnut cake(1:1) mixed with 10-15 times of water, kept for 3-4 days, supernatant liquid filtered and sprayed on the plants once in a week.

2. ***Growing medium***

   FYM- 200 g/pot Vermi compost - 100 g/ pot

   Biofertilizers- Azospirillum, VAM and Phosphobacteria each @ 2g /plant /2 months. Trichoderma - 20 g/ pot

   Application of Panchagavya 3% or Vermiwash 3% at 15 days interval as sprays on the plant

3. ***Growing medium***

   Sand : Leaf compost (1:1)

   Application of organic manure mixture with the following composition @ 40 g per plant once in two months Leaf compost- 500 g Coir pith compost - 1.2 kg Bonemeal - 1.5 kg Neem cake- 500 g Poultry manure - 300 g.

Plant Protection

Two major diseases are bacterial blight and anthracnose. Blackening of the stem and decay of leaf axils and drying of leaves and flowers are the symptoms of bacterial blight. Tiny circular black spots appear on leaf and spadix in case of anthracnose.

Management of bacterial blight

- Sanitation, isolation of affected plants
- Cut and burn affected parts, sterilize the instruments used for cutting by flaming before using on another plant.
- Spraying *Pseudomonas* (2%) on the plants / PGPR mix II (2%).
- Application of crude extract of neem cake/ *Tagetes erecta* (2:1), Neem cake

extract 2%, Neem oil 1% or coconut oil 1%.

- Root dip and foliar spray with *Bacillus* sp.(0.07%).
- Application of turmeric powder: sodium bicarbonate (10:1) @ 1.5% at weekly intervals. Application of fresh cowdung as sprays (5%).

Management of anthracnose

- Preventive spraying with broth culture of *Pseudomonas fluorescens* 0.5% / PGPR mix II 2%.
- Spray *Phyllanthus niruri* extract (30%) or neem oil (1%) at fortnightly intervals.
- Pruning of older leaves and flowers, removal or suckers at young stage, cleaning of crown before rains are other operations to be carried out in order to have better growth and flowering.

Harvesting

The flowers are harvested with its long stem when 1/4th to 3/4th flowers on the spadix are open, indicated by the change of colour. Colour varies with the varieties.

ORCHIDS

Orchids are noted for their bewitchingly beautiful, long-lasting flowers, widely differing in shape, size and colour. They belong to the family Orchidaceae, reported to comprise over 600 genera, 30000 species and a lakh man-made hybrids. They have varying habitats but epiphytic orchids dominate the trade. They are also classed as monopodials (stems having a

vertical growth, non-branching, with aerial roots) and sympodials (stems having a horizontal growth, producing pseudobulbs in clusters, no aerial roots).

The ideal location for orchid growing is in the open conditions, under appropriate level of shade nets. In Kerala it is also grown under the shade of coconut trees above 10 years old.

Most attractive orchids belong to the group of epiphytes, which require free

moving air at all times. The orchid plants produce aerial roots, which absorb water and nutrients from the atmosphere. Both terrestrial and epiphytes grow under varying levels of shade. Plants grown under deep shade will have good vegetative growth and poor flowering. Hence shade and light regulations are very important operations for better flowering. This requirement varies with the species and varieties. Some species grow in open sunlight. A humid and warm atmosphere is congenial for the growth of most of the tropical orchids. Better results are obtained when the atmospheric humidity is 50% to 80%. Orchids require proper temperature

for good growth and flowering. Accordingly there are tropical, subtropical and temperate orchids.

Genera / varieties

The popular genera of orchids suitable for growing in Kerala are *Arachnis, Aranthera, Vanda, Phalaenopsis* (monopodials); Aranda, Mokara (inter- generic monopodials); *Dendrobium*, *Cattleya*, *Oncidium* (sympodials).

Dendrobium is the most popular genus of Kerala. Some of the important varieties belonging to this genus are given below, grouped according to colour.

Purple and white: Sonia 17, Sonia 28, Sonia Bom Jo, Earsakul Purple: Renappa, New Wanee, Sabine Red, Jurie Red, Velvet Soft

White: Emma White, Fairy White, Kasem White, Snow White, Lemon Glow Pink: Sakura Pink, New Pink, Deep Blush, Master Delight, Pink Cascade Yellow: Sherifa Fatimah, Kasem Gold, Tongchai Gold.

Propagation and planting

The conventional method of propagation is by vegetative means. Monopodial orchids are propagated by stem cuttings. Terminal cuttings with one or two healthy aerial roots are ideal as planting material. Basal cuttings of 30 cm length with a few roots and leaves are also good. Sympodial orchids are propagated by separation of pseudobulbs. A plant with minimum two or three pseudobulbs with the basal root is ideal for planting. Some of the sympodial varieties produce sprouts at the top of pseudobulb called as keikes. Keikes when fully grown can be separated and planted. Besides, backbulbs or spent canes (shoots that have ceased to produce flowers) before they shrivel can be severed from the mother plant and placed horizontally over the medium to stimulate sprouting of new shoots.

Seed propagation is possible only under aseptic conditions. Seedlings produced by embryo culture will take 2-5 years for flowering, depending on the genus.

Meristem culture is very effective in large scale propagation of orchids.

Terminal cuttings of monopodial orchids are planted loosely on old coconut husks at a spacing of 30 cm between plants and 45 cm between rows in long beds. There can be two or three rows in a bed. Basal cuttings will sprout

within a period of two months.

Partial shade up to 50% is required for sprouting. Basal cuttings are planted close to each other in nursery beds for sprouting. After sprouting they are planted at the recommended spacing. Monopodial orchids can be grown on ground above soil level. A thick bed of 15-20 cm height is loosely arranged. Well- dried coconut husks are better than fresh husks. Sympodial orchids are grown on benches above ground level or suspended from above. Slotted wooden baskets filled with small pieces of dried coconut husk or partially burnt charcoal is good for plant growth. Planting is done above the medium with a support for proper anchorage.

Planting can also be done in pots or other containers. Mud pots of 10-20 cm diameter with several large holes on the side and bottom, filled with tile bits, chopped coconut husk or charcoal are used for planting. Both monopodial and sympodial orchids are to be supported properly since the planting is done above the medium. A clear solution of fresh cowdung can be used for irrigation for a few days. Dipping in fresh cowdung solution before planting also gives good results.

Manuring

Monopodial orchids grown on ground can be given cowdung slurry once in a month. One kg fresh cowdung mixed in 5 litres of water is sufficient for one square metre. Two or three applications can be given in a year. Sympodial orchids are sprayed with the supernatant liquid of cowdung slurry.

Adopt any of the following practices for orchids grown in pots

1. Fresh cow dung/ neem cake/ neem cake: groundnut cake (1:1) mixed with 10-15 times of water, kept for 3-4 days, supernatant liquid filtered and sprayed on the plants once in a week.
2. Fresh cow dung – 500 g and cow urine - 500 ml mixed with 10 litre of water, allow to settle, filter, dilute 3 times with water and spray on the plants once in two weeks
3. Panchagavya, 3% as sprays on the plant at 15 days interval
4. Panchagavya 3% + Vermiwash 3% as sprays on the plant at 15 days interval
5. Spray Pseudomonas/ PGPR mix II at monthly intervals.

Plant Protection Snails and slugs

Sprinkle salt over wetted gunny bags placed in shady places near the orchard.

Thrips

Spray fungal formulations of *Hirsutella thompsonii* (10g of the formulation/litre) /*Verticillium locanii,/ Metarhizium anisopliae/, Beauveria bassiana* (1010conidia/ litre)

Harvesting

The spikes are harvested when all the buds of the spike except two or three are open.

JASMINE (*Jasminum spp.)*

Jasmine is an important flower crop that could be grown on a commercial scale in Kerala. *Jasminum sambac* is the most ideal species for cultivation in Kerala. The flowers are used for preparing garlands. The jasmine oil has great export potential in addition to its use for medicinal purpose.

Jasmine can be planted on a wide range of soils. Well-drained sandy loams and red loams are ideal for its cultivation. In clayey soils, there is increased vegetative growth and reduced flowering. They give good yield in low rainfall conditions.

Important cultivars

There are trailing, climbing, and erect growing species and cultivars.

Three important species and their varieties are given below:

1. *Jasminum sambac*: Gundumalli, Motia, Virupakshi, Sujimalli, Madanabanam, Ramabanam.
2. *Jasminum grandiflorum*: Co-1 Pitchi, Co-2 Pitchi, Thimmapuram, Lucknow.
3. *Jasminum auriculatum*: Co-1 Mulla, Co-2 Mulla, Long Point, Long Round, Short Point, Short Round.

Propagation

Layering and cutting are the main propagation methods. Better rooting of cuttings can be obtained by planting in coarse sand. Simple and compound layering methods are followed during June-July to October-November. Layers will be ready for planting within 90-120 days.

Planting

After ploughing the land, pits of about 40cm x 40cm x 40cm size are taken and filled with top soil and 15 kg well-rotten FYM.

Planting distance depends on the species and also on soil and environmental conditions. Species Planting distance

J. sambac	1.2m x 1.2 m
J. auriculatum	1.8m x 1.8 m
J. grandiflorum	2.0m x 1.5 m Planting is usually done during June- August.

Manuring

Neem cake - 100 g

FYM - 100 g

Groundnut cake - 100 g

Soil application at monthly interval per plant from 2nd month after planting. or Neem cake - 100 g Poultry manure - 100 g Groundnut cake - 100 g

Soil application at monthly interval per plant from 2nd month after planting.

Pruning

Pruning is essential and is done at a height of 45cm from the ground level during mid December-January.

Weed-control

Manual weeding is effective but expensive. Mulching reduces weed population.

Irrigation

Constant and adequate water supply during peak flowering season (March-October) is essential for high yield of flowers. After flowering is over, the water supply can be cut off. During summer, irrigate twice in a week.

Plant protection

Apply neem based insecticides (2ml/litre) for the control of pests like bud and shoot

borer, blossom midge.

Drench the soil with 1% Bordeaux mixture to reduce fusarium wilt Spray panchagavya, 3% at 15 days interval.

Yield

Yield of flowers and jasmine oil vary according to the species and management practices.

Species	Flower yield (t/ha	Oil yield (kg/ha
J. sambac	5	15.44
J. auriculatu	5	28.00
J. grandifloru	6	29.00

TUBEROSE (*Polianthes tuberosa)*

Tuberose occupies a very special position among the ornamental bulbous plants because of its prettiness, elegance and fragrance. It has good economic potential for loose/cut flower trade and essential oil industry.

Porous, well-drained sandy loam soils are the best suited for tuberose cultivation.

Cultivars

There are four groups of cultivars as given below:

1. *Single* : Flower is pure white and has only a single row of corolla segments. Cultivars are Sringar, Culcutta Single, Mexican Single and Suvarna Rekha.
2. *Double*: Flowers are white, tinged with pinkish red. Petals are in several whorls. Cultivars are Suvasini, Culcutta Double and Pearl.
3. *Semi-double*: Similar to double but with only 2 to 3 rows of corolla segments.
4. *Variegated*: This has variegated leaves with yellow margins.

Propagation

Propagation is by bulbs. Boat shaped bulbs of size 2 to 3 cm are preferred for planting.

About 1.25 to 1.50 lakh bulbs (800 to 900 kg) are required for planting one hectare.

Cultural practices

Land is prepared well by ploughing two or three times. FYM at 30 t/ha is mixed well with soil. Best time for planting is May-July. The bulbs preferably those of size 2-5 cm or above are to be planted at a depth of 7-10 cm, with a spacing of 20cm x 25

cm. A heavy irrigation once in 5-10 days is necessary depending upon the weather conditions. The peak flowering is between June and October.

Manuring

Application of poultry manure @ 30 t/ha / FYM @ 60 t/ha at the time of planting. The same quantity is applied for the ratoon crops also.

Ratoon crop

After the harvest of the main crop, the flower stalks are headed back and the plot is manured and irrigated. Three or four ratoon crops can be taken from single planting. If the bulbs are not uprooted and replanted after three or four ratoons, the spikes tend to become smaller and unattractive.

Plant protection

Spray panchagavya, 3% at 15 days interval to reduce the incidence of pests and diseases.

Harvest and yield

Tuberose is harvested by cutting the spikes from the base for table decoration or the individual flower is picked from the spike for making garlands and other floral ornaments. The average yield of flower is as follows.

Plant crop : 5-10 t/ha First ratoon : 9-12 t/ha Second ratoon : 4-6 t/ha.

MARIGOLD (*Tagetes erecta*)

Marigold is a popular annual flower that could be grown on a commercial scale. It has gained popularity on account of its easy cultivation and wide adaptability. Free flowering habit, short duration to produce marketable flowers, wide spectrum of colour, shape, size and good keeping quality make marigold an acceptable commercial crop.

A wide range of soils with good drainage is suitable for cultivation of marigold. Sandy loam soil with pH 5.6 to 6.5 is ideal for its cultivation.

Cultivars

There are two species of marigold, namely, African marigold (*Tagetes erecta*) and French marigold (*Tagetes patula*). Inter-specific hybrids between these two species also have been evolved, which are known as Red and Gold hybrids. Varieties under this group are Nugget, Show Boat and Red Seven Star.

African marigold varieties

Apricot, Primrose, Sun Giant, Guinea Gold, Fiesta, Golden Yellow, Hawai, Crown of

Gold, Honey Comb, Cupid, Pusa Narangi Gaintha and Pusa Basanti Gaintha.

French marigold varieties

Rusty Red, Naughty, Marietta, Flame, Star of India and Hormony.

Propagation

Seeds are used for raising the crop.

Cultural practices

Seedlings are prepared by sowing the seeds in the nursery beds as follows:

Prepare nursery beds of 6 m length, 1.2 m width and 10-20 cm height. Apply 30 kg FYM and mix well in the soil. Sow the seeds in rows 7.5 cm apart. Cover the seeds with fine FYM and irrigate. The seedlings will be ready for transplanting within one month.

For the main-field, the land should be ploughed well and FYM @ 30 t/ha should be incorporated to the soil. Pinching is done to increase the total yield. It consists of removing terminal portion of the plant 30-45 days after transplanting.

Irrigate once in 4-6 days depending upon soil moisture and weather conditions. Weeds have to be removed at monthly intervals.

Harvest and yield

Marigold flowers will be ready for harvest in about 2½ months time from the date of transplanting. The plant continues to bear flowers for another 2-2 ½ months from the date of first harvest. The flowers are harvested when they have attained full size. Harvest the flowers in the evening along with a portion of stalk. Yield of French marigold will be 8-12 t/ha and that of African marigold 11-18 t/ha.

General recommendations for control of pests and diseases in flower crops

Any of the fungal formulations of *Hirsutella thompsonii* (10g of the formulation/ litre)*, Verticillium locanii, Metarhizium anisopliae, Beauveria bassiana* (1010conidia/ litre) is effective in reducing population of thrips in flower crops.

Spraying 3% Dasagavya is effective in controlling pests and diseases.

Ecofriendly management of water hyacinth (*Eichhornia crassipes*) in water bodies

Water hyacinth in water bodies can be managed by spraying 5% Cashew Nut Shell liquid (CNSL) emulsion followed by spraying 40%Wetable Powder formulation (WP) of *Fusarium pallidoroseum* (5%). Spraying may be repeated with WP 5% alone, after 2 weeks if any new sprouts develop.

* A minimum of 30 minutes may be given between the applications of CNSL and *Fusariumpallidoroseum*

** In moving water bodies fencing with rope and coconut leaf is recommended.