

**HOR 211 PRODUCTION TECHNOLOGY OF FRUITS, SPICES AND
PLANTATION CROPS (2+1)**

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Classification of tropical, sub-tropical and acid zone fruit – area and production – scope and importance.

Climate is of fundamental importance in the development of fruit cluster.

Fruit has been a major food for mankind from time immemorial. Primitive man, the food habit was based mainly on fruits and also tubers which were found wild in the forests. In fact Adam who is considered to be the progenitor of man was said to have temptingly given the apple.

In Ramanaya and Mahabaratha the cultivation and consumption of fruits were described.

Tamil literature - Mukkanigal

The importance of anola the nellikani

Tropical region refers to region between the tropic of cancer and capricorn. The average temperature is about 27°C subtropic region summer-hotter and the winter cooler than tropics. Humidity is generally lower.

Based on temperature requirement the fruits crops can be classified as temperate, sub-tropical and tropical fruits.

Tropical fruits – mango, banana, sapota, guava, papaya

Sub tropical fruits – Mangosteen, litchi, acid lime

Temperate fruits – Apple, pear, plum. Based on the tolerance to the relative humidity of the atmosphere the fruit crops can be again classified as arid, semiarid zone crops eg., Ber, anona, datepalm, phalsa.

Arid zone are characterized by sparse and highly variable precipitation, extreme variation of diurnal and on annual temperature and high evaporation. The mean annual

rural rainfall varies from 100 mm – 500 mm. Temperature will be as low as 4.4° C and high as 50°C. Although rainfall is low but atmospheric humidity is fairly high.

Area and production of fruits in India during 1999-2000

S1.No.	Crop	Area (000 ha)	Production (000 MT)
1.	Apple	238.3	1047.4
2.	Banana	490.7	16813.5
3.	Citrus	526.9	4650.6
4.	Grapes	44.3	1137.8
5.	Guava	150.9	1710.5
6.	Mango	1486.9	10503.5
7.	Papaya	60.5	1666.2
8.	Pineapple	75.5	1025.4
9.	Sapota	64.4	800.3

Nutritive value of important fruits

S1.No.	Name	Edible portion (%)	Moisture (g)	Protein (g)	Fat (g)
1.	Mango	74	81	0.6	0.4
2.	Banana	71	70.1	1.2	0.3
3.	Grapes	95	82.2	0.6	0.3
4.	Papaya	75	90.8	0.6	0.1
5.	Guava	100	81.7	0.9	0.3
6.	Jack	30	76.2	1.9	0.1
7.	Orange	67	87.6	0.7	0.2

Minerals (g)	Fibre (g)	Carbohydrate (g)	Energy (K.cal)	Ca (mg)	P (mg)
0.4	0.7	16.9	74	14	16
0.3	-	17.0	74	4	9
0.7	5.2	11.2	51	10	28
0.5	0.8	7.2	32	17	13
0.7	5.2	11.2	51	10	28
0.9	1.1	19.8	88	20	41
0.3	0.3	10.9	48	26	20

Iron (mg)	Carotene (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)
1.3	2743	0.08	0.09	0.9	16
0.9	78	0.05	0.08	0.5	7
0.5	3	0.04	0.03	0.2	1
0.5	666	0.04	0.25	0.2	57
1.4	-	0.03	0.03	0.4	212
0.5	175	0.03	0.13	0.4	7
0.3	1104	-	-	-	30

Scope and importance

In India, fruit crops are cultivated in an area of 3.2 million ha with an annual production of 26 million tonnes. India contributes to 8 per cent of the total world production. Although the per day requirement of fruits has been calculated as 230 gram an individual gets only 160 gram. India is the second largest producer of fruits after China. Although fruit is grown throughout the country, the major fruit growing states are Maharashtra, Tamil Nadu, Karnataka, AP, Bihar, UP & Gujarat.

Fruit crops are capable of giving higher tonnage per unit area .

eg) Rice – 20-25 tonnes/ha

Banana -35-40 tonnes/ha

The average calorific value they produce per unit area two crops of wheat produce 52 lakh calories / ha banana – 370 lakh calories /ha.

Fruits are rich source of minerals and vitamins.

Betacarotene – Vitamin A (Mango, Papaya)

Banana, Pine apple – Vitamin B, Since fruits are consumed without cooking the Vitamins are readily available.

Vitamin C – Amla 600 mg/100g of pulp

West Indian Cherry – 1400 mg/100 g.

Fruit culture encourages horticultural based industries like fruit processing and preserved product like jam, jelly, squash and canned fruits.

Mango – Alphonso, Raisin – export.

MANGO : *Mangifera indica***Anacardiaceae**

Mango is one of the most important tropical fruits of the world and is called the king of fruits. Indo Burma – Siam region and Philippines are considered to be the origin of Mango. It is a leading fruit crop in India. The crop is under cultivation for more than 4000 years in India.

The fully ripe fruits are not only considered as a delicious table fruit but also used for preparations like jam, jelly, squash, syrups etc. raw fruits – pickles, chutneys etc.

There are about 1000 varieties being grown in India. Each variety has its own distinct taste, flavour, pulp consistency and yield potential.

Climate: Mango is essentially a tropical crop and it can also be grown in sub tropical climate, from sea level upto on altitude of about 1400 metres. The crop cannot withstand high humidity, rain and frost during the flowering period. The annual mean temperature ranging from 21° to 27°C is ideal for successful crop, though it can tolerate temperature range of 5 to 44°C. Higher temperature during the fruit development enhances maturity and improves fruit size and quality.

Rainfall : average annual rainfall as low as 250 mm to as high as 2500 mm.

High rainfall prior to flowering induces excessive vegetative growth and arrest the flowering. Frequent rains and high humidity will increase the incidence of pests and diseases. Dry cool winter during flowering followed by hot summer and good rainfall after harvest are highly ideal for better mango cultivation.

Soil

Red loamy soil with good drainage is preferable pH 6.5 to 8.

Season of planting: July to December

Planting material : Approach or soft wood grafts

Field preparation

The field is ploughed twice before taking pits. Pits dug at 1x1x1m filled with top soil mixed with 10 kg FYM and 100 g Lindane 1.3% dust per pit.

Spacing: 7-10 m either way

High density planting 10 x 5m for Alphonso, Banganapalli, Mallika etc. for higher productivity.

Irrigation: Regular watering till establishment. Once in 10 to 15 days interval for better fruit development and yield. However for obtaining good flowering the irrigation must be stopped at least 2 to 3 months before the flowering period.

Manures and fertilizers

Generally chemical fertilizer are applied one year after planting.

Manures and fertilizers (kg/tree)	1 Year old	Annual in crease	6 th year onwards
FYM	10.00	10.00	50
N	0.20	0.20	1.0
P	0.20	0.20	1.0
K	0.30	0.30	1.5

Applied during September – October, 45-90 cm away from the trunk upto the peripheral leaf drip and incorporated.

Intercropping

Inter crops can be grown in the initial years till the main crop establishes. Short lived and quick growing fruit crops like papaya, phalsa and guava can be grown in the inter space. Vegetables like onion, tomato, brinjal, chilli etc. can also be grown in mango plantation.

Mango training pruning

Root stock sprouts and low lying branches have to be removed. Mango is a terminal bearer in the past season growth normally does not require any pruning. But when the trees become very old the bearing capacity decreases. This is due to imbalance

in carbohydrate – nitrogen ratio and imbalance in hormonal status which might be due to excessive vegetative growth and self shading of most of the lower branches. The productivity of old trees can be revived by adopting.

1. Heading back
2. Thinning out

Priming is done during the month of August – September. In heading back process the hefty criss-cross branches are headed so that the centre is opened up. All the dead and dried branches should be completely removed. By this, there will be abundant penetration of sunlight as well as aeration. The dormant buds in the old woods get activated.

In thinning out process the excessive terminal shoots all over the surface of the canopy are thinned out by retaining only one to two shoots for each previous season growth. By this the nutrient and hormonal flow is directed to restricted number of shoots so that the terminal bud is converted into a reproductive bud. Thus the old unproductive trees can be made to bear a good crop.

Growth regulators

Spray NAA @ 20 ppm at flowering to increase the fruit retention. During February 0.5% urea (5 g/lit) or 1% KNO₃ (10g in /lit) may be sprayed to induce flowering, if the trees do not flower by that time. Spray 2% KNO₃ at mustard size to increase fruit set and retention of fruits.

Apply paclobutrazol @ 10 g a.i./full bearing tree during first fortnight of September to get maximum number of fruits and yield during off years.

Alternate / Irregular bearing

It is phenomenon of bearing heavily in one year followed by a lean crop or non crop during next year which is specifically called as alternate bearing. To avoid alternate bearing the following points should be borne in mind.

1. Selection of regular bearing varieties such as Neelum and Banglura – South Indian Condi Rumai – regular under Gujarat
2. Regular ploughing the interspace, manuring and irrigation at appropriate times.

3. Regular plant protection – so no crop failure due to adverse pest incidence.
4. Preventive excessive production by proper thinning so as to prevent the trees from exhaustion of nutrients and assimilates.

Plant protection

Plant hopper – spray two rounds of acephate 75 SP @ 1g/lit.

Stem borer: Padding with monocrotophos 10 ml in 25 cm²/tree plug the hole with carbofuran – 5 g/lit.

Mealy bug: Monocrotophos 1.5 ml/lit

Nut weevil: Fenthion – 1ml/lit during marble stage and second spray 15 days after first spray.

Diseases

1. Powdery mildew : Sulphur dust in early morning
2. Anthracnose : Spray mancozeb – 2g / lit as pre harvest spray 3 times at 15 days interval.
3. Sooty mould: Phosphomidon 40 SL @ 2 ml/lit + Maida 5% (1kg Maida or Starch boiled with 1 lit of water and diluted to 20 lit, avoid, spraying in cloudy weather.

Harvest: March to June

Yield

8-10 t/ha upto 15 years

15-20 t/ha from 13-20 years.

Post harvest treatment: Dip the fruits in 52^o±1^oC hot water immediately after harvest for 3 minutes followed by 8% plant wax (Fruitox or waxol) to reduce anthracnose disease in mango during storage. Two pre harvest spray of 0.2% Mancozeb (2.0 g/lit) will also reduce the incidence.

Physiological disorder

Mango malformation – converting inflorescence to vegetative shoot. This is mainly due to bio-chemical called malformins 70 control antimalformins like glutathione

2200 ppm or ascorbic acid 2100 ppm sprayed 3 times at 10 days interval from the time of panicle emergence.

Black tip

Close to brick kiln small black discoloration appear near the tip of leaves and later spreads to cover entire leaf. Isolated black spots appear in fruits and causes necrosis.

Phanerogamic parasite

Loranthus partial stem parasite. It is glabrous stout, normally grown in group on the twigs of mango. Under ambient storage the fruits can be stored for 5-7 days. The storage life can be extended to 4-7 weeks at 5.6°C to 7.2°C and 85 to 90% RH.

Banana : *Musa sp* Scitaminae Sub family: Musaceae

Banana is one of the oldest fruit known to mankind and also important food for man.

Origin: South East Asia

‘Apple of paradise’

Rich source of energy (137 K. Ca/100g)

It is a good laxative.

Important status: Tamil Nadu, Kerala, Maharashtra, Andrapradesh and Bihar.

Edible bananas are mostly hybrids of the two species.

M. acuminata, *M. balbisiana*. They set fruits by parthenocarpy.

Climate: Humid tropic plant. Temperature range of 10°C to 40°C with an average of 23°C.

Altitude: Upto 1500 mts from MSL.

Wind velocity more than 80 m/hr will damage the crop heavily.

Rainfall : 100 mm/ month is good.

Soil: Deep well – drained soil with abundant organic matter.

Depth – one mete

Soil pH: 5.5 – 8.0 found to be optimum.

Season of planting

Wet land – Feb-April: Poovan, Rasthali, Monthan

April – May : Nendran, Robusta

Garden lands : January – February and November – December

Padugai lands : January – February and August – September

Hill banana : April – May (lower palani hills)

June – Aug (Sirumalai)

Propagation : Sucker

- i. Sword sucker – suckers with a well – developed base and pointed tip having narrow sword shaped leaf bladers in the early stage.
- ii. Water sucker or broad leaved sucker – small, undersized suckers of superficial origin bearing broad leaves.

Sword suckers – more vigorous, grows faster and comes to bearing early.

Average weight of the sucker – 1.5 to 2 kg.

Micropropagation through tissue culture – Rapid multiplication of banana suckers.

Pretreatment of sucker : The roots and decayed portion of the corn are trimmed. Pseudostem is cut leaving 20 cm from the corn.

To avoid wilt disease infected portion of the corn may be pared, dipped for 5 min in carbendazim 0.1% (1 gm in 1 lit of water) for wilt susceptible varieties – Monthan, Neyvannan, Virupahshi etc.

Pralinage – with 40 g of carbofuran 3 G granules per sucker.

(The corn is dipped in slurry solution of 4 parts of clay plus 5 parts water and sprinkled with carbofuran to control nematodes).

Alternatively, dip the corn in 0.75% monocrotophos shade dried for atleast 24 hours and plant. Sow sunhemp on 45th day incorporate it after about a month. This operation reduce nematode build up.

TC banana – plants with 5-6 leaves planting – *Pseudomonas fluorescence* / plant 25 gm.

Field preparation

The land is ploughed deeply and leveled. The pits of size 45 cm³ is dug. The pits are refilled with top soil, mixed with 10 kg of FYM, 250 g of neem cake and 50 g of lindane 1.3%.

Spacing		Plants / ha
Garden land	1.8 x 1.8 m	3086
	1.5 x 1.5 m	4444
Wet land	2.1 x 2.1 m	2267
Hill	3.6 x 3.6 m	750

High density planting – 3 suckers / pit at a spacing of 1.8 x 3.6 m (4600 plants / ha).

Irrigation

Irrigated immediately after planting, life irrigation – 4th day subsequent irrigation once in a week for garden land 10-15 days in wetland after manuring.

Drip irrigation – 15 lit/ plant/ day from planting to 4th month.

20 lit/plant / day from 5th to shooting and 25 lit/plant/day from shooting till 15 days prior to harvest.

Application of fertilizers

	N	P	K
Garden land	(g/plant/year)		
Other than Nendran	110	35	330
Nendran	150	90	300
Wet land			
Nendran	210	35	450
Rasthali	210	50	390
Pooven and Robusta	160	50	390

Hill banana

375 g of 40:30:40 NPK mixture and 130 g MOP/clump per application during October, January and April. Azospirillum and Phosphobacteria – 20 g each at planting and 5th month after planting preceding chemical fertilizer application.

Apply N as neem coated urea.

N & K in 3 splits 3rd, 5th and 7th month P at 3rd month of planting.

For tissue culture banana 50% extra fertilizer at 2nd, 4th and 6th and 8th month after planting.

For maximizing productivity – fertigation.

25 litres of water / day + 200:30:300 g N:P₂O₅:K₂O /plant using water soluble fertilizer. For economizing the cost of fertilizers fertigate using normal fertilizers (urea and MOP) with 30% of the recommended dose along with recommended dose of P as basal at 2nd month of planting.

Fertigation schedule

Weeks after planting	N (%)	P ₂ O ₅ (%)	K ₂ O (%)
9-18 (10 weeks)	30	100	20
19-30 (12 weeks)	50	-	40
31-42 (12 weeks)	20	-	32
43-45 (3 weeks)	-	-	8
Total	100	100	100

Interculture

- Mammutti digging at bi-monthly interval and earth-up
- De sucker – prune the side suckers at monthly interval
- Dry and dead, leaves are removed and burnt.
- Male flower – removed a week after opening of last hand
- Bunch emergence – propping. The trees are supported with bamboos or casurina poles to avoid damage by wind.

Growth regulator

Grade of bunch -2,4-D at 25 ppm (25 mg/lit) may be sprayed after the last hand has opened. This also helps to remove the seediness in poovan variety. Spray CCC 1000 ppm of 4th and 6th month after planting. Spray plantozyme @ 2ml/lit at 6th and 8th month after planting to get higher yield.

Micronutrient

ZnSO₄ (0.5%) FeSO₄ (0.2%) CuSO₄ (0.2%) ad H₃BO₃ (0.1%) at 3, 5 and 7 MAP to increase yield and quality of banana.

Bunch cover

Use transparent polyethylene sleeves with 2% (during cool season)-4% (during summer season) ventilation to cover the bunches immediately after opening of the last hand.

Intercropping

Leguminous vegetables, beet root, elephant foot yam and sunhemp. Avoid growing cucurbitaceous vegetables.

Pest

Banana aphid – vector for bunchy top virus

Systemic insecticide – monocrotophos 1 ml/lit

Spray directed towards crown and pseudostem base at 21 days interval thrice.

Injection of monocrotophos 1 ml/plant (1 ml diluted with 4 ml of water) at 45 days interval from the 3rd month till, flowering.

Nematode

Bunchy top virus – *Pentalonia nigronervosa*.

Crop duration : bunches will be ready for harvest after 12-15 months of planting.

Harvest

Bunches attain maturity from 100-150 days after flowering.

Yield (t/ha/year)

Poovan – 40-50

Monthan – 30-40

Robusta – 50-60

Dwarf Cavendish -50-60

Harvested when the ridges on the skin changes from angular to round.

Ripened artificially by smoking in pits dug and covered by wooden plan form bunches are arranged in air tight chamber ethrel – 5000 ppm and kept in petridish. pellets of Na OH is added and closed ethylene is released.

Grapes : *Vitis vinifera* Vitaceae

Grape is a subtropical fruit but adapted to tropical conditions. It is a vine spreading on a support, native of Armenia, a district near the Caspian Sea in Russia. It was introduced into India by the invaders of Iran and Afghanistan. It is one of the most delicious refreshing and nourishing fruits. Fifty percent of the total production of fruits in the world is contributed by grapes. Cultivation of grapes is called Viticulture. There are about 10,000 varieties in the world.

Climate and soil requirement

It is a fruit of semi arid subtropical regions requiring warm dry summer and a cool rainy winter. During winter the grapes shed off their leaves and take rest. During spring they put forth new leaves and flowers. The fruits mature during summer when there is no rains. A long, warm to hot dry summer is needed for proper maturity and ripening. Grapes do not thrive in the region of humid summer as it causes fungal diseases. The distribution of rains is more important than the total amount of rainfall.

In North India heavy rains during July – September hence low production. The plant takes rest during winter since the winter is very severe and put forth new growth in summer. When the crop reach as ripening stage during June there is heavy rain resulting in poor production.

In Western India grapes do not take rest because of warm winter. Hence the grape put forth new growth twice a year. In Bombay – Deccan region and in Hyderabad the crop produced by the new lush in April maturing during rainy season (July –August) has lower market value due to less sugar content.

The climate in South India such as Bangalore in Karnataka, Dharmapuri and Madurai districts of Tamil Nadu is slightly humid and tropical. Here the maximum temperature goes upto 35°C and the minimum temperature does not fall below 12°C due to warm winter condition there is practically no rest period. Almost rainless period during November – June favours heavy as well as sweet crop. Here the vines are pruned twice. Early December pruning yields a sweet crop during April and summer pruning (May) yields a slightly sour crop during September. The climatic conditions are

favourable is parts of Tamil Nadu so that 5 crops are taken in 2 years by staggered pruning techniques.

Soil

Well – drained rich loamy soil with pH of 6.5-7.0. Soil depth should be almost 1 m.

Propagation

Propagated by hard wood cuttings prepared from matured canes (one year old shoot) of healthy, moderately vigorous, virus free vines. Cuttings of 25-30 cm length are prepared by making the lower cut just below a bud and upper cut slightly above the bud. Cuttings should be tied and stored in moist sand for a month for callusing. The callused cuttings start well in the nursery. While planting only one bud is left above the ground level and remaining portion buried in soil. At the end of winter the sprouted and rooted cuttings can be lifted and planted in the main yield. Grafting and budding is practiced with a particular root stock for specific requirement.

- a. Phylloxera resistant root stock
Vitis riparia, V. rupestris
- b. Nematode resistant root stock
Dogridge, Salt creek
- c. Saline tolerant : Solanis, 1616

Preparation of main field and planting

Trenched of 0.6 m width and 0.6 m depth are dug at a distance of 3 m apart for Muscat. Other varieties 1 m³ pits are dug. Well decomposed FYM or compost or green leaf manure has to be applied in the trenches or pit and then covered with soil. The rooted cuttings are planted during June – July.

Spacing: 3 x 2 m for Muscat
4 x 3 m for other Varieties

Irrigation

Immediately after planting 3rd day and once in a week. Irrigation with held 15 days before pruning and also 15 days before harvest.

Manuring and fertilizer (kg pervine)

Variety	FYM			Green leaves			N			P			K		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Muscat	50	50	100	50	50	100	0.10	0.20	0.20	0.08	0.16	0.16	0.30	0.4	0.60
Thom -pron seedless	50	50	100	50	50	100	0.20	0.30	0.40	0.08	0.16	0.24	0.40	0.80	0.120

The manures should be applied twice after pruning. Apply half the dose of K immediately after pruning and the other half after 60 days of pruning. Foliary spray of 0.1% boric acid + 0.2 % ZnSO₄ + 1.0% urea twice before flowering and 10 days after first spray to overcome nutrient deficiency.

Special practices

Tipping of shoots and tying of clusters in the pandal after the fruit set. Remove tendrils. Nipping the growing shoots of axillary buds and terminal buds at 12 to 15 buds. Thinning the compact bunches by removing 20% of the berries at pea stage.

The clusters are dipped in a solution containing Brassinosteriod 0.5 ppm and GA₃ 25 ppm at 10-12 days after fruit set to maintain vigour, yield and quality parameters.

Pests

Nematode

Carbofuran – 60 g/vine a week before pruning and irrigated profusely. The soil should not be disturbed to atleast 15 days. Application of neem cake 200 g/vine also controls nematode. We can afforded for application of *P. fluorescens*.

Flea beetles

Phosalone – 2ml/lit after pruning and followed with 2 or 3 sprayings.

Thrips: Dimethoate – 2 ml/lit

Mealy bug: Monocrotophus – 2 ml/lit

Diseases

Powdery mildew: Sulphur dusting @ 6-12 kg/ha

Downy mildew: Spray 1% BM

Ripening

To get uniform ripening bunches are sprayed with 0.2% K chloride at 20th and 40th day after berry set and clusters of seedless varieties are dipped in 25 ppm GA (25 mg/lit) at calyptra fall stage and repeated again at pepper stage to increase the size of berries.

Yield

Seed less : 15 t/ha/yr

Muscat : 30 t/ha/yr

Pachadroksha: 40 t/ha/yr

Anab-e-shahi

and Arka hybrids : 20 t/ha/yr

Grapes should be harvested only after ripening. The heat requirement of most of varieties ranges from 2900 to 3600 units.

The grape berries can be kept without spoilage for 7 days at room temperature. Grapes can economically be stored upto 40-45 days in cold storage. The optimum storage temperature recommended is -2 to -1.5°C.

Raisins from grapes form an important by product industry in several grape growing countries in the world. Grapes of 17° brix and above are used for raisin making while 20-23° brix is the standard.

Acid lime: *C. aurantifolia*

It is also called or sour lime. The fruit juice is rich in citric acid and ascorbic acid.

Climate and soil requirement

Tropical and subtropical. Can be grown upto 1000 m above MSL. Deep well drained loamy soils are the best. They are sensitive to frost. The optimum temperature is 20 to 30°C. Soil pH should be 6.5 to 7.0.

Season : December – February and June – September

Planting: Healthy seedlings may be planted during June to December at 5 to 6 m spacing in 75 cm³ pits.

Irrigation: Irrigated copiously after planting. After establishment, irrigation may be given at 7-10 days interval. Avoid water stagnation.

Manures and fertilizers per plant

N to be applied in two doses during March and October. FYM, P₂O₅ and K₂O are to be applied in October.

Manures and fertilizers	1 year (kg)	Annual income (kg)	From 6 th year (kg)
FYM	10.00	5.00	30.00
N	0.200	0.100	0.600
P	0.100	0.025	0.200
K	0.100	0.040	0.300

Spray zinc sulphate at the rate of 0.5% (500 g/ 100 lit of water) thrice in a year (March, July and October) after the emergence of new flushes.

After cultivation

Remove branches of main stem upto 45 cm from ground level. Application of green leaves 30 kg per tree once in 3 months.

Intercropping

Legumes and vegetable crops can be raised during prebearing age.

Growth regulator

To increase fruit set spraying 2,4-D-20 ppm during flowering. Fruit retention spraying-2,4-D@ 20 ppm or NAA 30 ppm after fruit set (marble size).

Plant protection

Leaf mine

2 ml/l dimethoate + neem oil 3%

Leaf caterpillar

Endosulfan – 2 ml/l when infestation is moderate to severe.

Sucking pest

White fly : Spray quinalphos – 2 ml/lit

Nematodes : Carbofuran – 75 g/tree

P. fluroscens – 20 g

Diseases

Twig blight: Dried twigs are pruned and sprayed with 0.3% Cu oxy chloride.

Scab: Spray 1% BM

Tristeza virus : Remove the infected trees and destroy. Spray monocrotophos - @ 1ml/lit to control the aphids which spread the disease. Use pre immunized acid lime seedling for planting.

Harvest: Starts bearing from 3rd year after planting.

Though harvested throughout the year, the main crop is harvested during different periods in different parts of the country. The average yield is 20-25 kg/tree/year.

Post harvest treatment

Treating the fruits with 4% wax emulsion followed by pre-packing in 200 gauge polythene bags with 1% ventilation improves the shelf life for more than 10 days. Limes can be stored at 18°C. At HC & RI, PKM a low cost storage tank has been developed with double layer brickwork, the interspace filled with sand which is kept wet by periodical watering.

Mandarinorange: *C. reticulata*

The group of orange is otherwise called Kamala orange. Nagpur santra of Maharashtra, Coorg of Karnataka and Kodai orange of Tamil Nadu. This group is characterized by the loose skin of fruits.

Soil and climate

Subtropical 500-1500 m MSL elevation. A rainfall of about 150 cm to 250 cm is required. The winter should be mild and there should be no strong or hot wind during summer. A medium or light loam with a pH 5.5 to 6.5 would be ideal to grow.

Season : November – December

Planting: Seedlings and budded plants

Spacing: 6 x 6 m pit size 75 cm³ planting during May-June and September – October.

Though the crop is grown as rainfed one, the young plants should be irrigated whenever there is failure of monsoon as well as during summer season.

Manure and fertilizers

Applied twice in a year during June and October.

For Palani hills

Manures & Fertilizers	1 year	II year	III year	IV year	V year	VI year onwards
FYM	10	15	20	25	25	30
N	0.100	0.200	0.300	0.400	0.500	0.600
P	0.040	0.80	0.120	0.160	0.160	0.200
K	0.050	0.100	0.200	0.300	0.300	0.400

For shervaroyan hills (for trees above 6 years old)

700: 375:600 g/tree NPK along with VAM (*Glomus fasciculatus*) @ 1 kg/tree.

Manures are applied in the basin 70 cm away from the trunk and incorporated. Application of lime or dolomite at 4 kg/tree during January – February once in 2-3 years (not mixed with chemical fertilizer).

Micronutrient

ZnSO ₄ – 600 g	} In 450 lit of water applied during new flush
MnSO ₄ – 600 g	
MgSO ₄ – 600 g	
FeSO ₄ – 600 g	

After cultivation

Removal of water shoots

Rootstock sprouts

Dead and diseased shoots

Removal of laterals of the main stem upto 45 m from ground level

Basins should be provided for each tree with gradient slope.

Growth regulators

To increase the fruit retention spraying the trees at flowering and again at marble stage with 2,4-D at 20 ppm or NAA 30 ppm.

Harvest: Starts bearing from 3-5 year after planting in budded plants. In case of seedlings 5-7 years.

Yield: 15-20 t/ha/yr.

A small crop can be obtained from 4 year old tree and the yield will be higher from 7th year. From flowering to maturity it takes 9 months.

Papaya : *Carica papaya* Caricaceae

Papaya is a native to tropical America and grown in almost all tropical and subtropical regions of the world and mainly in India, Australia, Hawaii, Srilanka, Malaya, Mianmar, Taiwan Puerto Rico, Peru, Florida, Texas, California and South Africa. It is believed to have been introduced into India by Portuguese in the middle of 16th century.

Papaya, a very wholesome fruit with high nutritive and medicinal value is rich in vitamin A (880 µg/100g) unripe fruits are used as vegetable and ripe fruits is used as jam, jelly, nectar, ice cream flavours, tuffy-fruity, crystallized fruits etc. Papaya also yields a valuable proteolytic enzyme papain used in meat tenderization. Manufacturing of chewing gums and cosmetics for degumming natural silk, clarifying beer and in medicine, for digestive ailments, ulcer and diphtheria.

Climate and soil requirement

Papaya thrives well in warm and humid tropical climate from sea level upto 1000 Maltitude. It grows and yields well in regions where summer temperature ranges from 38° to 42°C and winter temperature does not fall below 10°C. It cannot withstand low temperature or frost or strong winds beyond 80 km per hour boar and very heavy rainfall. Low temperature and heavy rainfall reduce fruit quality.

Though papaya prefers a rich fertile soil it can be grown one wide range of soils provided they are well drained, with proper manuring and watering. Papaya can not thrive well in calcareous black and heavy soils. It cannot withstand water logging even for a few hours. Soil pH between 6.5 and 7.0 is ideal for papaya growing.

Propagation

Papaya is mainly propagated by seeds. Since it is a highly cross-pollinated crop. The plants raised from seeds have a mixed inheritance which makes them highly variable in performance. Therefore it is important that genetically pure seeds should be collected from the side-mated or selfed fruits.

About 500 g seed is required for raising crop in one hectare. Seedlings, can be raised in the nursery beds, in germination trays and in polythene bags. Before seeds are treated with captan @ 2g/kg of seeds. Four seeds are dibbled in polythene bags in depth not exceeding 1 cm. Partial shade is provided. The bags are watered with rose can seeds start germination within 15-20 days.

Seedlings will be ready in about 60 days.

Best season for planting is June-September. Planting during rainy season should be avoided.

Preparation of field and planting

The field should be well prepared through repeated ploughing and harrowing. After leveling 45x45x45 m size pits are dug at a spacing of 1.8 m x 1.8 m.

Pits are filled with top soil and FYM in 3:1 ratio.

Seedlings are planted in pits taken along with polythene bag by tearing the bottom of the bag. Not less than 4 seedlings should be maintained per pit till the identification of male and female progenies. Finally only one female plant per pit and one male plant for every 20 female should be retained in dioecious types. In gynodioecious type one hermaphrodite type is kept/pit and the female trees are removed. Normally male trees flower earlier than female and have pendulous hanging inflorescence with branched stalk.

Application of fertilizers

Apply FM – 10 kg/plant as basal.

50 g in each N, P and K has to be applied at bi-monthly intervals from 3rd month of planting. 20 gm of *Azospirillum* and phosphobacteria at planting, again six months after planting.

Irrigation

Papaya needs regular water for its rapid fruit development and yield. Irrigation should be given at weekly interval and water logging should be avoided.

Micronutrients

ZnSO₄ 0.5% H₃BO₃ 0/1% spraying during 4th and 8th month to get more yield and growth is recommended.

Interculture

Intercrops like onion, tomato, cowpea can be grown during the per-bearing period.

Plant protection**Nematode**

To control carbofuran 1 g/polybag is applied in the nursery after germination.

Diseases**Root rot or wilt**

Pruning with BM 1% 2-4 times at 15 days interval is recommended.

Crop duration : 24-30 months

Harvest: Fruits should be picked of colour break stage.

Yield: The average yield

CO₂ : 200 -250 t/ha

CO₃ : 100-120 t/ha

CO₅: 200-250 t/ha

CO₆ : 120-160 t/ha

CO₇ : 200-225 t/ha

Papain extraction

Papain has several industrial uses the important is one being in brewing industries.

It is used as meat tenderizer

In textile and leather industries and durgs.

The latex should be tapped from immature papaya fruits. 75-90 days old fruits incision are made by stainless steel knife. The cut is given from stalk to tip of the fruit. The depth of the cut should not be morethan 0.3 cm. Four such cuts are given spaced equally on the fruit surface. Tap the latex early in the morning and complete the tapping before 100 am. The tapping is repeated four times on the same fruit at an interval of 3 days. The cut should be given on the fruit surface in places not covered by previous cuts. The latex collected from all the trees in a day should be pooled, shade dried in an aluminium pan or tray and passed through a 50 mesh sieve to remove all foreign matter. To this potassium meta-bisulphite at 0.5% is added for better colour and keeping quality.

The latex should be dried very rapidly at temperature of 50 to 55°C. Drying should be stopped when the dried product comes off as flakes having a porous texture. The dried papain is powdered with wooden mallets.

The green fruits after papain extraction can be used for pectin manufacture and tuffy – fruity or they can be allowed to ripen and made into other products. CO₂, CO₅ varieties are ideal for papain production.

Papain yield

CO₂ : 600 kg / ha

CO₅ : 800 kg/ha

Sapota: *Manilkhara achras*

Sapotaceae

Sapota is a delicious fruit introduced from tropical America. It is also known as sapodilla or chiku in India. Sapota fruits are recommended to adult patients ailing from tuber culosis and children from primary complex. This offers a high economic returns even under marginal land and low input management.

Climate and soil requirement

Sapota being a tropical fruit crop can be grown from sea level upto 1200 M. It prefers a warm and moist weather and grows in both dry and humid areas. Coastal climate is the best suited. Areas with an annual rainfall of 1250-2500 mm are highly suitable. The optimum temperature is between 11°C and 34°C.

Sapota being a hardy tree can be grown on a wide range of soils. Soil should be well drained without any hard pan. Deep and porous soils are preferred. The most ideal soils are deep alluvium, sandy loams, red laterites and medium black soil. It can tolerate the presence of salts in the soil and irrigation water to certain extent.

Propagation

Grafted plants on *Manilkhara hexandra* (Pala) root stock.

Season of planting-June to December.

Spacing: 8 x 8 m. High density planting 8 x 4 m.

Planting

Pits of 1m³ in dug. Filled with top soil mixed with 10 kg of FYM, 1 kg of neem cake and 100 g of lindane 1.3%. Grafts are planted in the centre of the pit with ball of earth intact. The graft joint must be atleast 15 cm above the ground level. The plants are staked to avoid bending or damage of graft joint.

Irrigation

Irrigated copiously immediately after planting and on the third day and once in 10 days after words till the graft establishes.

Manures and fertilizers (kg/tree)

M & F	1 year old	Annual increase	6 th year onwards
FYM	10	10	50
N	0.200	0.200	1.000
P	0.200	0.200	1.000
K	0.300	0.300	1.500

Manures and fertilizers may be applied in September – October, 45 cm away from the trunk upto the leaf drip and incorporated.

After cultivation

Removal of the root stock sprouts, water shoots criss cross and lower branches.

Intercropping: Legumes and short duration vegetable crops may be raised as intercrop during pre bearing stage.

Plant protection

Leaf webber: Spraying of phosalone – 2ml / lit

Hairy caterpillars : Spraying of endosulfan – 2 ml/lit of water

Budworm : Spray phosalone – 2ml/lit

Diseases

Sooty mould : 1 kg maida or starch is boiled with 5 lit of water, cooled and diluted to 20 lit (5%) and sprayed.

Harvest: Mature fruits are dull brown in colour. When scratched the colour immediately below the skin will of lighter shade if matured while in the immature fruits it is green. The mature fruits are harvested by hand picking.

Fruits at full maturity develop a dull orange or potato colour.

Season: February – June and September – October. The fruits are ripen by keeping the fruits in a air tight chamber with. 5000 ppm Ethrel + 10 g NaOH pellets.

Yield: 20-25 t/ha/year

Brown scaly materials disappear from the fruit surface as the fruit approaches full maturity. As the fruit matures, the milky latex content is reduced.

The dried spine like stigma at the tip of the fruit falls or drops of easily when touched.

Yield start from 3rd year of planting.

Guava: *Psidium guajava* L. ; Myrtaceae

Varieties : Allahabad, Lucknow 49, Arka Amulya, Arka Mridula, and Banaras.

Soil and climate: Guava grows well both in wet and dry regions but it does better under irrigation in the dry tracts. It can be grown upto 1000 m altitude. Well drained soils are the best. Tolerates salinity and alkalinity. In saline soils add 3 kg gypsum/plant during planting and once in three years after planting.

Planting material: Layers

Season of planting: June – December

Spacing: 5-6 m either way

Planting: Plants the layers with the ball of earth in the centre of pit of 45 cm x 45 cm x 45 cm size filled with FYM 10 kg, neem cake 1 kg and top soil + 50 g Lindane 1.3%.

Irrigation: Irrigate copiously immediately after planting, again on third day and afterwards once in 10 days or as and when necessary.

Manures and fertilizes: FYM 50 kg and one Kg in each of N, P and K per tree in two split doses during March and October. To increase the yield spray urea 1% + Zinc sulphate 0.5% twice a year during March and October. To correct the boron deficiency (reduction in size of leaves and fruit cracking and hardening) spray 0.3% borax during flowering and fruit set stage.

Micronutrients spray for controlling bronzing of leaves

Spraying of a combination spray containing ZnSO₄, MgSO₄ and MnSO₄ @ 0.5% and CuSO₄ and FeSO₄ @ 0.25% plus Teepol @ 1ml per 5 lit of solution on various stages.

1. New flush
2. One month after first spray
3. Flowering
4. Fruit set.

Intercropping: Legumes and short duration vegetable crops may be raised during pre-bearing stage.

After cultivation: Pruning of past season's terminal growth to a length of 10-15 cm is to be done during September – October and February – March to encourage more laterals. The erect growing branches are to be bent by tying on to pegs driven on the ground. Old unproductive but healthy trees may be either pollarded or cut the trunks at 75 cm from ground level or dehorned by cutting the secondary branches at a distance of 75 cm from their origin.

Plant protection: Pests

Tea mosquito bug: Spray endosulfan 35 EC at the rate of 2 ml/lit or fenthion 100 EC @ 1 ml/lit or malathion 50 EC at the rate of 1 ml/lit or monocrotophos 36 WSC @ 2 ml/lit or neem oil 3%. Spraying should be done in early mornings or late evenings, at least four times at 21 days interval during fruiting season.

Aphids: Spray monocrotophos 36 WSC @ 1ml/lit or dimethoate 30 EC @ 2 ml/lit.

Mealy bug: Triazophos @ 2 ml/lit + neem oil 5 ml or phosalone 0.05 % + neem oil 5 ml. Release of *Cryptolaemus montrouzieri* beetles (Coccinellid beetles) @ 10 beetles / tree.

Fruit fly: Remove the fallen fruits and bury them deeply with lindane 1.3% dusted over them. Spray endosulfan 35 EC or malathion 50 EC @ 1ml/lit of four times at 15 days interval. Stir the soil around the tree during pest incidence and dust Lindane 1.3%. Use polythene bags fish meal trap with 5 gm of wet fish meal + 1 ml. dichlorvos in cotton. 50 traps are required / ha, fish meal + dichlorvos soaked cotton are to be renewed once in 20 and 7 days respectively.

Safe waiting period: Monocrotophos 36 WSC-10 days and malathion 50 EC-9 days.

Diseases

Red rust: Spray copper oxy chloride 2.5 g/ lit or Bordeaux mixture 0.5% or Wettable sulphur 2 g per litre.

Harvest: Layers come to bearing in 2- 3 years

First crop : February – July

Second crop : September – January.

Yield : 25 t/ha.

Pineapple: *Ananas sativus*; Bromeliaceae

Varieties : Kew, Mauritius and Queen

Soil and Climate: Mild tropical climate as found in the humid hill slopes is best suited. Can be grown in plains under shade. Elevation from 500 m to 700 m is ideal. A light well drained soil with pH 5.5 to 7.0 is preferable. Heavy soils can also be used if drainage facilities are available.

Spacing: Plant in double rows either in beds or in trenches with the plants into the second rows set in the middle of the plants in the first row.

The spacing between two trenches will be 90 cm. Row to row spacing in the same bed per trench will be 60 cm and plant spacing within the row is 30 cm.

Planting: Use suckers and slips of 300-350 g weight for planting. Give a slanting cut to the suckers before planting and dip in Mancozeb 0.3% or Carbendazim 0.1%.

Season: July – September

Manures and Fertilizers: FYM 40-50 t/ha. N 16 g, P 4 g and K 12 g/plant in two equal splits at 6th and 12th month after planting. Apply as foliar spray 0.5%-1.0% sulphate of Zinc and Ferrous solutions at 15 days interval to overcome the deficiencies in the early crop phase.

Aftercultivation: To have uniform flowering apply the following when the crop attains 35-40 leaf stage. NAA 10 ppm + 2% urea (20 g in 1 lit of water) @ 50 ml / plant poured into crown or 2% urea + 0.04% Sodium carbonate + 20 ppm Ethephon (ethrel) @ 50 ml/ plant poured into the crown. To increase the size of the fruit, 200-300 ppm NAA should be sprayed after fruit formation. To avoid calcium induced Iron chlorosis adequate shade should be given.

Plant protection

Mealy bug: Spray methyl demeton 2 ml/lit or monocrotophos 36 WSC 2 ml/lit

Crop duration: 18-24 months

Harvest: Fruits can be harvested from 18 to 24 months. Slight colour change at the base of the fruit indicates maturity.

Yield: 50 t/ha

A plant crop and two ratoon crops are normally taken and in Mauritius variety upto five crops can be taken.

Amla: *Phyllanthus emblica*; Euphorbiaceae

Varieties: Banarasi, NA 7, Krishna, Kanchan, Chakaiya, BSR 1

Soil and climate: Amla is a subtropical plant and prefers dry climate. Hardy plant it can be grown in variable soil conditions. Tolerates salinity and alkalinity.

Planting material: Seedlings, Grafts, Buddings

Planting: Plant during July-August with a spacing of 6 x 6 m in pits of 1 x 1m or 1.25 x 1.25 m.

Irrigation: Irrigate the plants initially for establishment. No irrigation is required during rainy and winter season. Drip irrigation is appropriate with a water saving of 40-45%.

Manures and fertilizers (per plant/year)

Manures and fertilizers	Bearing tree
FYM	10 kg
N	200 g
P	500 g
K	200 g

Manuring to be given immediately after pruning.

Training and pruning: The main branches should be allowed to appear at a height of 0.75 – 1m above the ground level. Plants should be trained to modified central leader system. Two to four branches with wide crotch angle, appearing in the opposite directions should be encouraged in early years.

During March – April prune and thin the crowded branches to provide maximum fruit bearing area in the tree.

Plant protection: Pest

Gall caterpillar: Young caterpillars bore into the apical portion of the shoot during rainy season and make tunnel. Due to this, apical regrowth is checked, side shoots develop below the gall and subsequent growth in following season is greatly hampered. Cut the infected apices and spray systemic insecticide like dimethoate 0.03% prophylactically.

Bark eating caterpillar

Damage the stem and branches of grown up trees by eating bark. Affected portion should be cleared and a few drops of kerosene should be applied in holes to keep this in control.

Disease

Rust: Rust appear as circular reddish solitary or gregarious pustules on leaves and also on fruits. Spray 0.2 per cent mancozeb at an interval of 7 to 28 days during July to September.

Yield: 100 kg/tree annually.

Pear: *Pyrus communis* L; Rosaceae

Varieties: Common pear, Kieffer, New Pear, William and Jargonelle.

Soil and climate: Red laterite soil with good drainage and high organic matter content. Can be grown at an elevation of above 1200 m. pH 5.8 to 6.2.

Planting material: Plant one year old grafts/rooted cuttings.

Planting season: June to December

Spacing: 5 x 5 m or 6 x 6m in pits of 60 cm x 60 cm x 60 cm size.

Application of fertilizers: Apply FYM 25 kg, N 500 g and 1 kg in each of P and K per bearing tree / year.

Training and pruning: Remove stock sprouts regularly. Train the plants to open centre system and prune every year during November – December. Top working on country pear with choice varieties can be done during December – January with cleft grafting.

Plant protection: No serious pest and disease are noticed. Prophylactic spray with a copper fungicides and methyl demeton after pruning can be given.

Harvest: Early varieties will come to harvest in May – June and late varieties in July – October.

Yield: 100 to 120 kg per tree per year in common pear.

70 to 80 kg per tree per year in Kieffer and New Pear.

30 to 40 kg per tree per year in William and Jargonelle.

**AREA, PRODUCTION, PRODUCTIVITY OF SPICES AND PLANTATION
CROPS**

Spices and plantation crops

Spices are those plants, the products of which are made use of as food adjuvant to add aroma and flavour (Eg. Pepper, cardamom, clove and nutmeg).

Condiments are also plants, products of which are used as food adjuvant to add ‘taste’ only (Eg. Coriander, Cumin etc.)

Plantation crops are plants which are grown in extensive scale like coconut, arecanut, tea, coffee, cocoa and rubber etc., are known as plantation crops.

Spices and condiments

S.No.	Particulars	Area (ha)	Production (t)	Productivity (M.t/ha)
1.	Chillies	80,240	56,168	0.70
2.	Coriander	38,850	15,540	0.40
3.	Tamarind	18,900	66,150	3.50
4.	Turmeric	16,850	1,01,100	6.00
5.	Cardamom	5,520	519	0.09
6.	Pepper	3,550	1,065	0.30
7.	Garlic	1,260	7,560	6.00
8.	Clove	700	700	1.00
9.	Ginger	600	15,000	25.00
10.	Other spices	1,350	2,700	2.00
	Total	1,67,820	2,66,502	1.59

Plantation crops

S.No.	Particulars	Area (ha)	Production (t)	Productivity (M.t/ha)
1.	Cashew	84,200	37,890	0.45
2.	Tea	63,400	5,07,200	8.00
3.	Coffee	32,400	19,440	0.60
4.	Betelvine	3,380	76,050	22.50
5.	Arecanut	2,650	4,505	1.70
	Total	1,86,030	6,45,085	3.67

INTRODUCTION TO SPICES CROPS, CLASSIFICATION AND THEIR IMPORTANCE

Spices are those plants, the products of which are made use as food adjuncts to add aroma and flavour. Condiments are also spices, products of which are used as food adjuncts to add taste only. Both spices and condiments contain essential oils, which provide the flavour and taste. They also stimulate digestion on account of their carminative properties. They are of little nutritive value. They are used whole, ground, paste or liquid form, mainly for flavouring and seasoning food. Most spices increase the shelf life of food, especially the dry varieties. Some are added to improve texture and some to introduce a palatable colour or odour.

Classification of spices

There are about 35 spices and condiments which can be broadly classified into 6 groups, based upon the parts of the plants from which they are obtained:

- a. Rhizomes and root spices:** Ginger, Turmeric, and Garlic.
- b. Seed spices:** Nutmeg, Coriander, Fennel, Cumin, Fenugreek, Dill, Aniseed, Celery and Bishopweed.
- c. Bark spices:** Cinnamon
- d. Fruit spices:** Cardamom, Black pepper, Vanilla, All spice, Cassia, Tamarind, etc.
- e. Leaf spices:** Bay leaf, Curry leaf, etc.
- f. Flower spices:** Clove, Saffron, Asafoetida, etc.

Importance of spices in India

Most of the spices are native of our country and hence India is known as the Land of Spices.

1. India produces spices on 2.0 million ha with an annual production of about 2.3 million tones, contributing nearly 20% of world's production
2. Nearly 90-95% of the total production is consumed locally and the rest exported

3. India is the biggest exporter of spices
4. They are indispensable part of our culinary preparation especially used for flavouring and seasoning of food
5. Most of the spices have potential medicinal values. Besides, the spices and spice products are also indirectly used as flavouring or colouring agents or as preservatives in many pharmaceutical preparations.
6. Spices have been used in cosmetic and perfumery industries. Spices oils are used in the manufacture of soaps, tooth pates, talcum powder, aftershave lotions, vanishing creams, mouth freshners and room fresheners etc.