FRT 4.4: Tropical and Subtropical Fruits 3 (2+1)

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Horticultural Classification of Fruits

Classification refers to the grouping of individuals with similar identities, related in genetic makeup, evolution or climatic requirements. The major units of classification are order, family, genus, sub-family, species, variety/cultivar/sub-species and clone or strain. All fruit crops bear flower and seed (spermatophyte) and belong to class Angiosperm except-chilgoza *(Pinus gerordiono)* of Gymnosperm. Most of the fruits are covered under the dicotyledonous monocotylednous families.

Nomenclature

Linnaeus is considered the father of plant taxonomy while **De Candolle** is the father of systematic pomology. In binomial system of nomenclature each scientific name consists of two components i.e., generic name and species name. It is customary to put the name of pioneer author as third component in trinomial system of nomenclature. All botanical names are written in Latin. According to the rules of binomial nomenclature, generic name always *siorfs* with capital letter and species with small letter. It is mandatory to underline the generic and species name or written in italics.

Knowledge of classification of fruits is very useful to the horticulturists because it serves:

1. To identify and name them,
2. To afford at least some idea of the closeness of their relationship i.e., line of descent to other kinds,
3. To suggest with what other kind they possibly may or may not be interbred or crossed,
4. To suggest the kinds with which they possibly may or may not be integrated, and
5. Often to suggest certain soil and the cultural requirements, climatic adaptations, etc.

Basis of Classification

1. Botanical Classification

In botanical method of classification the fruits are grouped according to their botanical relationship (viz., the morphological and cytological similarities and dissimilarities, their place of origin, cross ability, floral biology etc.), the degree to which they trace back to a common ancestory and they have evolved into their present form.

A list of fruit crops belonging to class, family, genus, species along with common English names are given below:

Sr, No. Family	*Common Name*	*Botanical name*	*Chromosome No. (2n)*
(a) Monocotyledoneae			
1. Arecaceae	1. Coconut	*Cocus nucifera* L.	32
	2. Arecanut	*Areca catechu* L.	32
	3. Oil palm	*Elaeis guineensis*	32
	4. Palmyra palm	*Borassus flabellifer*	32
	5. Date palm	*Phoenix dactylifera* L.	36
2. Bromeliaceae	6. Pineapple	*Annanas comosus* (L.) Merr.	50
3. Musaceae	7. Banana	*Musa paradisiaca*	22,33,44

	(b) Dicotyledoneae		
1. Anacardiaceae	8. Mango	*Mangifera indica* L.	40
	9. Cashew	*Anacardium occidentale* L.	42
	10. Pistachio nut	*Pistachia vera* L.	30
2. Annonaceare	11. Custard apple (Sitaphal)	*Annona squamosa* L.	14
	12. Bullock's heart(Ramphal)	*Annona reticulata* L.	14
	13. Soursop	*Annona muricata* L.	
	14. Cherimoya (Hanumanphal)	*Annona cherimoya* L.	
	15. Atemoya (Lakshmanphal)	*Annona atemoya* L.	
3. Apocyanaceae	16. Karonda	*Carrisa carandas* L.	22
4. Caricaceae	17. Papaya	*Carica papaya* L.	18
5. Ebenaceae	18. Persimmon	*Diospyros kaki*	90
6. Euphorbiaceae	19. Aonla	*Emblica officinalis* L.	28
7. Guttiferae	20. Mangosteen	*Garcinia mangosteena* L.	24
8. Juglandaceae	21. Walnut	*Juglans regia*	32
	22. Pecannut	*Carya illieonsis*	36
9. Lauraceae	23. Avocado	*Persia Americana* Mill.	24
10. Leguminoceae	24. Tamarind	*Tamarindus indica*	24
11. Moraceae	25. Jack fruit	*Artocarpus heterophyllus* L.	56
	26. Fig	*Ficus carica* L.	56
	27. Mulberry	*Morus alba* L.	
12. Myrtaceae	28. Guava	*Psidium guajava* L.	22
	29. Jamun	*Syzygium cuminii* Skeel.	40
13. Oxalidaceae	30. Carambola	*Averrhoa carambola*	24
14 Passifloraceae	31. Passion fruit	*Passiflora edulis*	18
Smallest family of fruit crops			
15. Punaicaceae	1. Pomegranate	*Punica granatum* L.	18
16. Proteaceae	2. Macadamia nut	*Macadamia ternifolia*	48
17. Rhamnaceae	3. Ber	*Zizyphus mauritiana*	48(4x)
18. Rosaceae	4. Loquat	*Eriobotrya japonica*	34
	5. Apple	*Malus domestica*	34
	6. Almond	*Prunus amygdalus*	16
	7. Apricot	*Prunus armeniaca*	16
	8. Sweet cherry	*Prunus avium*	16
	9. Plum	*Prunus domestica*	16, 48
	10. Strawberry	*Fragaria ananassa*	56
	11. Pear	*Pyrus communis*	34
	12. Peach	*Prunus persica*	16
19. Rutaceae	13. Bael	*Aegle marmelos*	18
	14. Mandarin	*C. reticulata* L.	18
	15. Sweet orange	*C. Sinensis* L.	18
	16. Kagzi lime	*C. aurantifolia* L.	18
	17. Grape fruit	*C. paradisi* L.	18
	18. Wood apple	*Feronia limonica* L.	18
	19. Lemon	*C. limon* L.	18
20. Sapindaceae	20. Litchi	*Litchi chinensis*	30
21. Sapotaceae	21. Sapota	*Achrus zapota/ Manilkara*	26

		achras	
22. Tilliaceae	22. Phalsa	*Grewia subinequalis* L.	36
23. Vitaceae	23. Grape	*Vitis vinifera* Michx.	38
24. Sterculiaceae	24. Cocao	*Theobroma cocoa*	20
25. Rubiaceae	25. Coffee	*Coffea robusta*	22
26. Theaceae or Camaliaceae	26. Tea	*Camelia sinensis*	30
27. Actinidaceae	27. Kiwi fruit	*Actinidia deliciosa*	58

2. ECOLOGICAL

The fruit plants are also classified on the basis of tolerance to temperature extremes or hardiness. This type of classification is very important from horticultural stand point. The basic distinction on climatic tolerance helps the growers to select the fruit plants for a particular region. A large number of fruits are grown in India. The commercial cultivation is limited to a very few fruits. India is bestowed with diverse edaphic and climatic conditions. The fruits suitable for various climatic conditions are given in the Table.

Based on Climatic adaptability					
(A) Tropical	1.Cashew 2. Banana 3. Papaya 4. Pineapple 5. Guava	6. 7. 8. 9. 10.	Sapota Custard Apple Jackfruit Carambola Persimon	11.Coconut	
(B) Subtropical	1. Mango 2. Sweet orange 3. Ber 4. Fig 5. Litchi 6. Phalsa	7. 8. 9. 10. 11. 12.	Jamun Karonda Grape Annona Bael Date palm	13. 14. 15. 16. 17.	Pomegranate Aonla Avocado Loquat Mandarin
(C) Temperate	1. Apple 2. Pear 3. Plum 10. Walnut	4. 5. 6.	Peach Apricot Almond	7. 8. 9.	Cherry Strawberry Pecanut

3. Respiration Rate

In some fruits the rate of respiration will undergo a sharp rise and fall during ripening. This phenomenon is called climacteric rise and the fruits are called ***climacteric fruit.*** Whereas some fruits maintain a steady respiration or show only a decline in respiration during ripening are termed as ***non-climacteric fruits.*** This classification is useful for fruit processing, storage and post harvest operation of fruits.

Based on Rate of Respiration

(A) Climacteric (B) Non- climacteric

* Sharp rise in respiration after harvesting		* Steady respiration at the time of harvesting	
1. Mango	7. Fig	1. Citrus	7. Jamun
2. Banana	8. Peach	2. Grape	8. Cashew
3. Sapota	9. Pear	3. Pineapple	9. Cherry
4. Guava	10.Plum	4. Pomegranate	10. Strawberry
5. Papaya	11. Annona	5. Litchi	
6. Apple		6. Ber	

*Climacteric fruits produce much larger amount of ethylene than non climacteric fruits.

*Highest ethylene production : (i) Apple (ii) Passion fruit

4. Fruit Morphology

Depending on number of ovaries involved in fruit formation, fruits are classified into three groups, viz. simple, aggregate and multiple (composite) fruits.

Simple fruits

Fruits developed from single or syncarpous pistil of a single flower with or without accessory organ.

Aggregate fruits

Fruits developing from apocarpous pistil (free carpels) of flowers. It refers to the aggregation of simple fruits borne by single flower (etaerid).

Multiple or Composite fruits

Multiple or composite fruits are produced from the ripened ovaries of several flowers crowded on the same inflorescence.

(C)Based on Fruit morphology

(a) Simple fruit	1	Dehiscent	No fruit crop
	2	Indehiscent	(a)Nuts:- Cashewnut, Hazelnut, Pecanut and Chestnut
	3	Schizocarpic	(a)Lomentum :-Tamarind
	4	Fleshy	
		(a) Berry or Bacca	: Banana, Papaya, Grape, Sapota, Gooseberry, Guava, Date
		(b) Modified berry	(i) **Balausta** - Pomegranate
			(ii) **Amphisarca** : Wood apple, Bael
			(iii) **Pepo** : Water melon
			(iv) **Hesperidium** : Citrus
			(v) **Capsule** : Aonla, Carambola
		(c) Drupe (Stone)	: Mango, Peach, Plum, Ber, Coconut, Cherry , Cocoa, Coffee
		(d) Pome	: Apple, Pear, Quince, Loquat

(b) Aggregate fruits : Etaerio of berries – Custard apple, Annona group.
Etaerio of drupes – Raspberry, Blackberry, Longanberry
Etaerio of achenes - Stawberry

(c) Multiple Fruit : (i) Syconus – Fig

(ii) Sorosis – Jack fruit, Pineapple, Mulberry, Breadfruit

5. Photoperiodism

Fruit crops can also be classfied into three groups according to their photoperiodic responses. This classification is quite different from that **earlier** on the basis of flowering habit where the plants responded to photothermal reactions.

(E) Based on Photoperiodic responces		
1. Long day plant	**2. Short day plant**	**3. Day neutral plant**
Passion fruit Banana, Apple	Strawberry Pineapple, Coffee	Papaya, Guava Banana

5. Bearing Habit

Different bearing habits are noticed in the plants. Fruit trees also have varied bearing habits. On the basis of bearing habit, fruit trees are classified into six categories to facilitate cultural operation like pruning, skiffing, heading back etc.

Classification based on bearing habit

Bearing habits		Fruit crops
I	Fruit buds borne terminally and giving rise to inflorescence without leaves.	Mango, cherry
II	Fruit buds borne terminally and unfolding to produce leafy shoots which terminate in flower clusters.	Apple
III	Fruit buds borne terminally and unfolding to produce leafy shoots with flower or flower clusters	Guava
IV	Fruit bud borne laterally containing flower parts only and giving rise to inflorescence without leaves or leaves present, they are reduced in size.	Citrus
V	Fruit buds borne laterally and unfolding to produce leafy shoots, terminally in flower clusters.	Grapes, Cashewnut
VI	Fruit buds borne laterally and unfolding to produce leafy shoots with flower clusters in leafy axils.	Fig

6. Soil Reaction (pH)

The fruit crops are seen to have tolerance or affinity to specific soil pH and according to soil reaction these may be divided into following groups. This classification gives an idea about tolerance of the fruit crops to various soil reactions and gives an opportunity to select suitable fruit crop for particular soil reaction to raise successful orchard.

Classification of fruit crops according to soil reaction

Slightly tolerant to acid soil pH 6.0-6.8	Moderately tolerant to acid soil pH 5.5-6.8	Highly tolerant to acid soil pH 5.5 and less	Tolerant to alkaline soil pH 7.2-8.0 and above
Mango	Pineapple	Strawberry	Custard apple
Citrus	Orange	Gooseberry	Guava
Banana	Litchi	Raspberry	Date
Guava	Longan	Blueberry	Coconut
Papaya	Avacado	Fig	Aonla
Cashew	Passion fruit	Bael	Olive
Carambola	Chestnut	Elephant apple	Phalsa
Apple	Cranberry	Plum	
Peach	Loquat		
Almond	Jack fruit		

7. Drought Tolerance

Fruits show their varying response to moisture stress. Some of them are characterized by the morphological features like spines, pallishade tissue, thicker cuticle, etc. to guard against moisture stress while others do not have any such mechanism. This classification is useful to the horticulturist to select the fruit crops under specific moisture supply in a particular region provided other climatic factors are not limiting. Further, the classification on the basis of moisture stress tolerance of the fruit crops helps in adjudging the spacing to be provided to them under a given moisture supply.

Classification based on drought tolerance

Drought tolerant/Sensitive	**Fruit crops**
Highly tolerant	Ber, bael, wood apple, karonda, custard apple, datepalm, cashewnut, pomegranate, fig, persimmon.
Moderately tolerant	Mango, jamun, tamarind, grape fruit, lemon, guava, grape (few cultivars)
Sensitive	Banana, orange, rambutan, plum, sapota, litchi, coconut, avocado, jackfruit, apple, pummelo, carambola, papaya, pineapple

8. Salt Tolerance

It is found that the fruit crops tolerate different salinity when grown in coastal or other areas having various natural salt deposits. This classification is especially important to the orchardists who plan to develop orchard in saline areas. Accordingly, fruit crops may be classified based on their relative tolerance towards salt. This is particularly useful to select the type of fruit crops to be grown on diverse salinity level of soil and water.

(F) Relative salt tolerance		
Highly tolerant	Medium tolerant	Highly sensitive

Date palm, Ber Aonla, Guava Coconut, Khirni	Pomegranate, Cashew, Fig Jamun, Phalsa	Mango, Apple Citrus, Pear Strawberry

Climatic Zones of Horticultural crops :-

Fruit growing zones of India: -

CLIMATE

It denotes average condition of weather prevailing over a large area. Temperature, humidity, rainfall, solar radiation and wind are the principal constituent of climate. A rhythmic change in constituent factors brings about change in the climate. Depending upon the prevalence of various constituents the climate is broadly classified into temperate, tropical and sub-tropical types.

(1) **Temperate zone:** Kashmir, HP, hills of UP & some high altitude regions of central India (Nilgiri & Palni Hills). This climate is characterized by the fall of temperature below freezing point in winter. The plants shed their leaves during winter as a survival mechanism. Consequent to fulfillment of chilling hours, the plants again resume their growth. There is snowfall in this type of climate. The ground remains covered with snow for 3 to 5 months in a year. Temperature falls & plants drop down their leaves and enters into rest. For breaking rest, a definite chilling period is required. During summer the temperature varies between 10°C to 14°C and relative humidity between 80% to 100%. This type of climate is observed at 1800 m to 3500 m height from ground level. Apple, pear, peach, plum, walnut, apricot etc grow in this type of climate.

(2) **Tropical zone:** Southern regions of MP & Bengal, States of Gujarat, MS, MP, Orissa, Karnataka, TN & Kerala. There is no distinct summer and winter in this type of climate. Hot and humid summer and mild winter is hallmark of tropical climate. There is no fluctuation in day and night temperature. This type of climate receives high rainfall and humidity. The temperature ranges from 32°C to 37°C and above. It is experienced at 300 m to 900 m height from ground level. Tropical climate prevails along with coastal belt of the country. Fruits like mango, banana, papaya, pineapple, sapota, cashew, jackfruits grow in this climate.

(3) **Sub -Tropical zone:** It is in between temperate & tropical zones. Plains of Punjab & UP. Northern regians of Bihar, MP & W. Bengal & States of Rajasthan & Assam. The temperature occasionally goes below freezing. Climate is hot & comparatively dry. Winter is comparatively less cold. The temperature ranges from 25°C to 30°C and humidity almost 100% during monsoon. It is found at 900 m to 1800 m height from ground level. Fruits are named as subtropical fruits. Lime, lemon, orange, grape, guava, date, fig, pomegranate, phalsa etc. Some tropical fruits like mango, banana, jack fruit, can also be grown in this region.

DIFFERENT TYPES OF HORTICULTURALLY POTENTIAL ZONES OF THE COUNTRY

1. Temperate zone

Jammu and Kashmir, Himachal Pradesh, Parts of Uttranchal, Arunachal Pradesh and Nagaland, Nilgiris and Palni Hills of Tamil Nadu experience temperate climate.

2. North-western sub-tropical zone

Rajasthan, Punjab, Haryana, Parts of Uttar Pradesh, West Bengal, Madhya Pradesh and

Vananchal are counted under this zone.

3.North-eastern sub-tropical zone

Bihar, Jharkhand, Assam, Meghalaya, Tripura, Parts of Arunachal Pradesh and parts of West Bengal experience this type of climate.

4. Central tropical zone

Parts of Madhya Pradesh, Maharashtra, Gujarat, Orissa, West Bengal, Andhra Pradesh and Karnataka are counted under this zone.

5. Southern tropical zone

Parts of Karnataka, Andhra Pradesh, Tamil Nadu and Kerala are counted under this zone.

6. Coastalitropical zone

Coastal part of Maharashtra, Kerala, Andhra Pradesh, Orissa, Tamil Nadu, West Bengal, Tripura, Mizoram, part of Gujarat along sea side, Andaman and Nicobar islands experience such type of climate.

Agro-Climatic zones of Gujarat State :-

I. South Gujarat Heavy Rainfall Zone.
II. South Gujarat Zone.
III. Central Gujarat Zone.
IV. North Gujarat Zone.
V. North-West Gujarat Zone.
VI. North Saurashtra Zone.
VII. South Saurashtra Zone.
VIII. Bhal And Coastal Zone.

1. Mango

B.N.:- ***Mangifera indica*** **L. Family:- Anacardaceae Origin :-** ***Indo-Burma region***

Introduction:

It is national fruit of India. No other fruits can compete with mango in respect to area, production, nutritive value and popularity. For this reason mango is known as king of fruits.

In India mango cultivation is 4000-6000 yrs old. Area in India-9,42,560 hectares. Growing states are U.P. followed by Bihar and A. P., and to some extent in all the rest states. It is also grown in Pakistan, Bangladesh, Burma, Malaya, Philipines, Srilanka, Egypt, Africa, Florida, Hawaii, Brazil, Mexico etc.

Area in Gujarat – 33,000 hectares. Growing districts are Valsad, followed by Junagadh, Surat, Bhavnagar, Kheda, Amreli, Bharuch, Sabar kantha and Khtch.

Uses and Composition:

Unripe fruits are used for Culinary purpose, pickles, powder, chutney, Sarbat.

Where as ripe fruits are used for Squash, nector, jam, toffee, juice, slicess and for canning of pulp and slices.

Composition	Unripe green mango	Ripe mango
Moisture (%)	90	73-86.7

Carbohydrate (%)	8.8	11.6-24.3
Protein (%)	0.7	0.5-1.0
Vit A (µg/100 g ß-carotene)	1.50	6375-20750
Vit B1 (mg/100g)	-	40
Riboflavin (mg/100g)	30	6.8-38.8
Ascorbic Acid (mg/100g)	3	0.46
Total Sugar	-	8.7-17.93

Origin and distribution:

The genus *Mangifera*, which belong to the family Anacardiaceae, originated in South East Asia at an early date. It was virtually unknown to any botanist. The name *Mangifera* was given for the first time by Bontius in 1658 when he referred to this plant as arbor *Mangifera* (the tree producing mango). Later it was mentioned in the literature as *Mangifera indica, Mangifera domestica or Mangifera sylvatica*. It is cultivated in almost all Indian states.

Mangifera indica Tropics of old world
Mangifera khasiana Assam
Mangifera sylvatica. India, Burma, Indochina

Soil :- Soils from alluvial to laterite type are best. 2.0 to 2.5 m. deep. Well drained and well fertile having good water holding capacity soils are best. Black cotton soil as well as saline and alkaline soils are not good. pH between 5.5 to 7.5 is desirable.

Climate :- Mango is tropical crop, but can grow up to an altitude of about 1400 meters. Does well within temperature range from 24-27 ^{0}C., during fruit development and maturity period, It tolerate up to 48 ^{0}C.

Higher temperature during fruit development hastens the maturity and improves fruit Size and quality. High humidity as well as rainfall during flowering is not suitable, as it increases pest, and diseases problems. Bright sunny days and low humidity during flowering are ideal. The two important considerations in mango cultivation are frost free and dry climate at flowering, and sufficient heat during ripening (maturity) periods.

Cultivars (Varieties) :-

The popular commercial cultivars of different regions in India are:

Northern region	Dashehari, Langra, Chausa and Bombay green.
Eastern Region	Himsagar, Langra, Fazli, Lakhshman Bhog, Krishna Bhog and Gulabkhas
Western region	Alphanso, Rajapuri, Kesar, Jamadar, Sardar, Dadamio, Karanjio,Totapuri, Neelum, Dashehari and Amrutang
Southern region	Bangalora, Neelum, Swarnarekha, Pairi, Baganpalli, Mulgoa and Alphanso

Hybrids:

Centre	Hybrids	Parents	Characteristics
IARI New Delhi	Amrapali	Dashehari x Neelum	Drawf, regular bearer, medium size fruits, high ß-carotene content
	Mallika	Neelum x Dashehari	Semi vigouous, regular bearer, fruits large, high b- carotene content, better quality content.
IIHR Bangalore	Arka Aruna	Beganpalli x Alphonso	Dwarf, precocious medium and regular bearer, fruits large, fibreless, good flavour,

			free from spongy tissue.
	Arka Anmol	Alphonso x Janardhan	Semi-vigourous, regular bearer, fruit medium, free from spongy tissue.
	Arka Neelkiran	Alphonso x Neelum	Semivigourous, late, fruits medium
	Arka Puneet	Alphonso x Baganpalli	Semivigourous, heavy and regular bearer
RFRS, Paria, Gujarat	Neeleshan	Neelum x Baneshan	Dwarf, regular good bearer fruits medium to large
	Neeleshwari	Neelum x Dashehari	Dwarf, regular bearer
	Neelphanso	Neelum x Alphonso	Dwarf, fruits medium
	Sonpari	Alphonso x Baneshan	Vigorous, high yielding and regular bearing, fruit weight 360-550g, free from spongy tissue
Maharashtra	Ratna	Neelum x Alphonso	Moderately, vigourous tree
	Sindhu	Ratna x Alphonso	High yielding, regular bearer, deep orange colour, good qulity and free from spongy tissue.
CISH, Lucknow	Ambika	Amrapalli x Janardan Pasand	Regular bearer, wide climatic adaptability, mature late in season
-	Rosica	-	Mutant variety
-	Xavier	-	Highest TSS 24.8 ^{o}Brix

Other Varieties:-

Olour, Bappakai, Goa, Chadrakiren, Bellari, Salem are poly embryonic types, which all mostly confined to west coast of Southern states.

Dashehari:

This is most popular cultivar of northern India because of its attractive appearance, excellent taste and pleasing flavour. It is a mid - season cultivar, maturing, towards the end of June. The fruits are medium in size (4 to 8 kg), elliptical- oblong in shape and have an attractive greenish yellow colour. It is a good cropper, though bienneal in bearing.

Langra:

It is also a mid season cultivar. The fruits are large in size (3 to 4 per kg) oblong oval in shape and have line green colour.

Alphonso:

Biennial in bearing. It is very specific in its requirement and does best only on the west coastal of Maharashtra (Ratnagiri), although it is grown to some extent in south too. The fruits are very attractive, large sized (3 to 4 per kg) and oval in shape (with a

prominent ventral shoulder). The fruits have an attractive pinkish blush, with an excellent sugar / acid blend. The flavour is captivating. Besides it is also favoured fruit of the processing industry because it retains its characteristics flavour even during processing. It is a medium bearer.

Pairi:

This is excellent cultivar of western and southern India. The fruits are very attractive, with crimson tinted shoulders on a yellowish green background. The fruits are medium in size; ovate in shape. It is biennial in habit.

Kesar:

The fruits are medium to large sized (3 to 4 per Kg), oblong in shape with an attractive light apricot-yellow colour. The taste is very good and sugar/ acid blend is excellent. It is a moderate cropper but biennial in bearing. It is famous cultivars of Gujarat.

Jamadar:

This is another good cultivars of Gujarat. This fruits are medium sized (5 to 6 per kg), ovate-oblique in shape with apricot yellow colour. It is a medium cropper but biennial in bearing.

Neelum:

The fruits are medium in size (4 to 6 kg) and the shape is ovate- oblique. It reaches the northern market in late season i.e. end of may to the beginning of sep. keeping quality is good.

Beganpali:

Also known as *Baneshan* in the South and *Safeda* in the North. The fruits are large sized fruits and colour is very attractive golden yellow with a very smooth skin. Bearing is moderate and fairly regular.

Propagation :

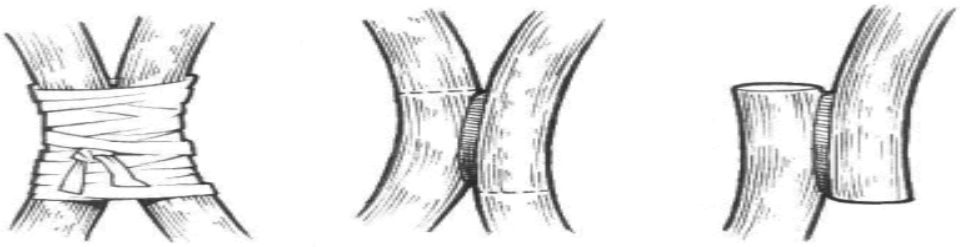
I. Seed

II. Vegetative proparation:

1. Inarching 2.Veneer grafting and side grafting
3. Cleft grating 4.Epicotyl / stone grafting
5. Softwood grafting**:** 6.Cutting
7. Budding 8. Layering- Air, 9.Tissue culture

Inarching :

For the actual inarching operation, the stock is brought close to the scion. A thin slice of bark about 6-8 cm long about 8 mm in thickness at a height of about 20 cm above ground level is removed with a sharp knife from the stock. A similar cut is made in scion. Thus the cambium layer of both stock and scion are exposed. These cuts area brought together and tied firmly with the help of polythene strip.



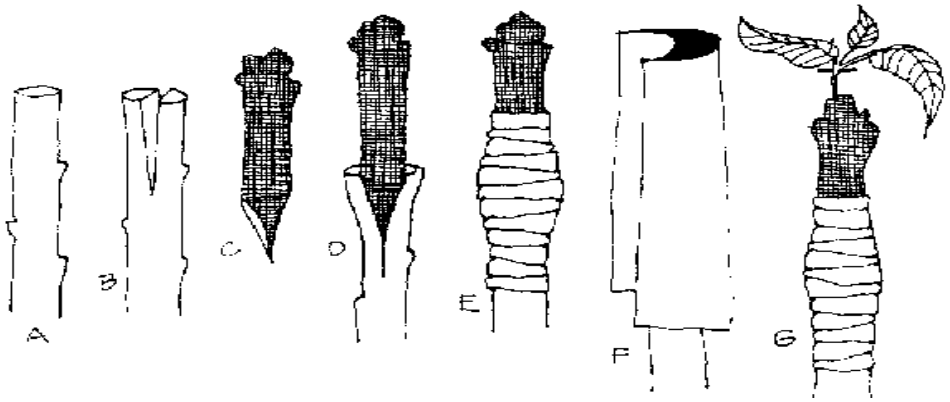
The stems are bound tightly together with string, tape or raffia.

After graft union heals, the stock plant is cut above the union and the scion is cut below the union

Softwood grafting:

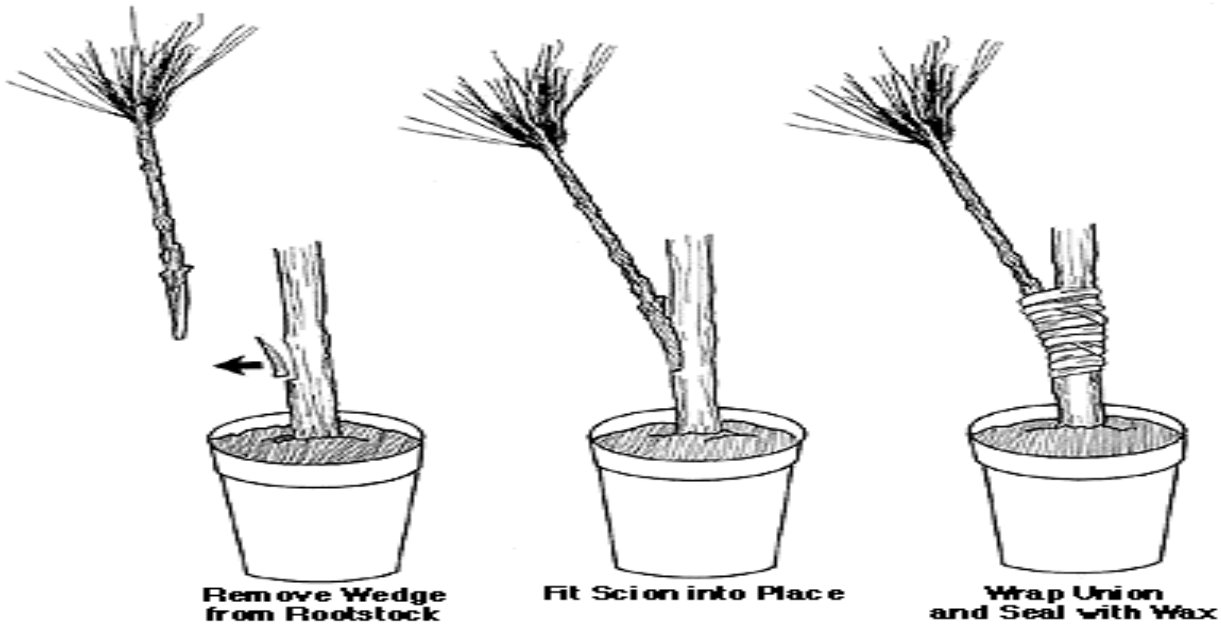
In this technique, grafting is done with mature, procured scion on the emerging soft coppery red shoot of rootstock. The leaves on the stock must be retained while grafting to high success. The technique is effective on dry, hot weather or in area of low rainfall.

Arid and semi arid regions inarching grafting are not well established due to disturbing of tap root system so that *in situ* softwood grafting is recommended. Dr. R. S. Amin, Retd. Professor GAU, Anand has developed this method in 1971.



Veeneer grafting/ Side grafting

This method is used for propagating mango. In this method, a terminal shoot of 10-15 cm length having pencil thickness is used as a scion. The swollen shoot is used as scion. About 10 days before grafting the scion-shoot is defoliated to facilitate swelling of bud. Shallow, downward and inward cut ensuring V-shape incision in lower portion of rootstock is prepared. Similar matching cut in slanting manner is prepared on lower portion of scion. Both rootstock and scion are fastened together using 300 gauge polythene tape of 1 cm width. During May and September this system is quite successful and good result is obtained. In about 3-4 weeks union is completed. When scion sprouts completely, the upper portion of rootstock above graft union is removed in 2-3 installments



Planting:–

Systems of planting:

◙ The systems in vogue are the 1. Square 2. Rectangular 3. Quincunx 4. Hexagonal and 5. Contour. Of these, square system is the most popular in mango the planting distance will vary with the vigour of the cultivar and the location ranging between 10-12 m.

◙ **High Density Planting:-** Amrapali could be planted at a spacing of 2.5 m x 2.5 m with a density of 1600 plants per ha; Dashehari at 3.0 x 2.5 m gave 24.3 to 94.3 q yield/ ha during 15-18 years compared to 1.9-3.2 q/ ha under normal density (12 x 12 m)

Preparation of land :-

Usual ploughing, harrowing and leveling as well as preparation of irrigation channels. Square system of planting is most popular for mango cultivation.

Preparation of pits and planting :-

Planting distance will vary according to vigor of variety and type of soil. Generally it ranges from 10 to 12 meters.

Pits of 1×1×1 meters are dug during summer (two months before monsoon). Kept Open under the sun. Pits filled with mixture of 50 kg. FYM and soil. Mix 100 g. termite killing dust.

Planting is done during the rainy season when the soil in the pits has already settled while planting one should be careful that earth ball does not break and graft union remains well above the ground level. The planting should preferably be done during cloudy weather and in the evening. The plants should be irrigated immediately after planting.

Protection of the plants:

In the initial 2-3 years, it is advisable to protect plants against low temperature injury by covering plants with some sort of cover, leaving the eastern side open for entrance of light. Building up slow fire, which emit smoke and restoring to flood irrigation may also be essential to ward off the ill effects of frost.

Irrigation:

Young trees should be irrigated frequently during lean period for quick growth. However, the amount and timing vary with climatic conditions and physical properties of soil.

Non bearing trees :- 7-8 days interval during winter and 4-8 days interval during summer. There should not be stagnation of water in the pit or basin.

Bearing trees :- 10-15 days interval during fruit development period. This will be helpful in improving size of fruit and in reducing fruit drop.

For good flowering, irrigation must be stopped for 2-3 months before flowering. Drip irrigation method is the best method for this crop

Manuring:

Manure's and fertilizers :- (per tree per year).

Sr.	Year	FYM (kg.)	Chemical fertilizer (Kg).					
			A.S.(kg)	N2.(g).	S.S.P.(kg)	P_2O_5. (g).	M.P.(Kg)	K_2O. (g)
1.	First year	10	0.375	75	0.100	16	0.125	75
2.	Two to nine	(increase same doze in each Year)						
3.	Tenth year and above	100	3.750	750	1.000	160	1.250	750
	Adult tree	**100**	3.750	**750**	1.000	**160**	1.250	**750**

Time of application :-

Apply full quantity of FYM, phosphorus and potash, and half quantity of nitrogen during June. Remaining half doze of nitrogen during February**.** If no facility of irrigation then, full doze of nitrogen is applied in June.

Mode of application :- Apply 15 cm. deep at-the periphery of tree in the basin.

Full-grown mango root is located between 1.2-2.4 m from trunk, for better utilization by the plant fertilizer application for such bearing trees should be made only within the area.

Micronutrients:

3000 ppm B produced desirable effects in respects of vegetative and reproductive growth.

Zn (0.4%) + Urea (1%) produced the highest fruit number and yield B (0.4%) + Urea (1%) fruit quality improved.

Inter-Cropping :- Grow some intercrops in the orchard during initial years (non bearing period) to get extra income. Uncultivated land will lead to weeds. Onion, tomato, radish, carrot, cabbage *etc*. and fruit crops like papaya, phalsa, banana *etc*. can be grown as intercrop.

Cover-Cropping :- grow sunhamp, dhaincha *etc*. to protect orchard soil from erosion and also to enrich the soil.

Pruning and training:

The mango, being an evergreen plant, hardly needs any pruning. The only pruning that it required is periodic removal of the dead and diseases branches, as and when one notices them. Training however is an essential practice in initial 2-3 years. This is done with a view to providing good framework for the future so that the branches are spaced properly and these do not break with the crop loads of the bearing stage. These branches are not encouraged too low on the trunk or too high from the ground level.

Interculturing :- Maintain good sanitary condition. Plough at least three times i.e. before monsoon (June), after monsoon (October) and during December.

Flowering :-

Nov-Dec. in A. P. and states of S. India.
Feb-March in Northern India.
Jane.- Feb. in Eastern parts of India.

Dec. -Jan. in Gujarat

Generally period of flowering is of two weeks. Low temp. extend it, and higher temp. shorten it.

Two types of flowers in each panicle, (Male and Perfect). Number of flowers/panicle-1000-6000. Only 0.001% fruits reaches to maturity. Highly cross pollinated crop. Pollination through insects & wind.

Biennial bearing or Alternate Bearing :-

It is most burning problem in mango crop. Yield is in alternate years i.e. heavy or optimum fruiting in 1st year called ON year followed by little or no fruiting in next year called OFF year.

Factors responsible or causes : (1) Climate (2) Age & size of shoot : most varieties do not differentiate until shoots are of certain age & girth. (3) C:N ratio. High C:N ratio favors bud formation. (4) Hormonal imbalance : High level of auxins and low levels of inhibitors as well low level of GA_3 favors flowering.

1. Climatological factors

Rain, high humidity and low temperature sometimes convert an on year into off year directly or by promoting the incidence of diseases like powdery mildew and anthracnose frost causes dropping of fruit. However they do not form basic factor.

2. Age and Size of shoot:

Certain and cultivars could not differentiate flower buds unless the shoots are of certain length and girth and with a number of leaves of particular size. But in biennial bearer it is throught that it lacks some vital substance or substances necessary for flower bud formation.

3. Carbon / Nitrogen ratio:

The available evidence suggests that in fruit plants, nitrogen and carbohydrate reserves play important roles in flower bud initiation even if these do not forms the primary cause of the phenomenon of biennial bearing.

4. Hormonal balance:

Inverse relations between the levels of endogenous inhibitor content promoted flowering in mango.

Control of biennial bearing problem:

Control :- (1) Proper maintenance of orchard. (2) Deblossoming in 'On year'. (3) Smudging & chemical regulation. Smudging (smoke) is age old practice in Philippines. In India not followed. Spraying of 200 ppm Etheral during 'off year' induce flowering. Auxins, KNO_3 also beneficial. (4) Pruning (5) Planting of regular varieties like Bengalora, Totapuri, Neelum, Romania, Red small, Rumani, Mallika, Amrapalli

Pests :-

(1) Mango Hopper :- Nymph & adult suck sap from tender fruit, Panicle *etc*. seen throughout year. But damage during flowering & in rest period hibernate under the dried bark of stem. They secrete honey-dew on which sooty mold develops. Dusting 0.15 % carbaryl. or 0.05 % phosphomidion or 0.15 % melathion or 0.04 % endrin or nuvacron, once at panicle stage & next at fruit-set stage.

(2) Mealy Bug : Nymph emerge from soil in Dec-Jan. & climb. Suck juice from tender shoot, panicle etc. Affected part dry. Controlled by (1) Mixing 10 % BHC in soil around trunk. (2) Stick 30 cm wide Greece band at 30 cm above on the trunk in Dec-Jan. (3) Spray monochrotophas 0.04 % or melathion 0.08 %.

(3) Mango Stem Borer :- It tunnels trunk & branches. Controlled by (1) Any wound on branch/trunk should not be kept open. (2) Clean the tunnel with hard wire & pour petrol

or kerosene or endosulfan & seal the hole with mud.
(4) Fruit fly : Fly lays eggs under the rind of fruit, before fruit matures. The affected fruit begins to rot & drop down. Controlled by (1) Keep the orchard clean. (2) Collect & destroy damaged fruits. (3) Spray Fenthion 10 ml in 10 lit of water. (4) Use Methyl euginol trap.
(5) Termites : Destroy galleries of termites from trunk. Mix 10 % BHC at planting in soil mixture.

Diseases :-
(1) Powdery mildew : Fungal disease. Favoured by high humidity, cloudy weather and low night temp. during panicle development & fruit-setting period Greyish white powdery bloom on flower buds & fruits. Which results failure of crop. Controlled by (1) Spray wettable sulphar 0.2 %, Bavistin 0.1 %, Benlate 0.1%. First spray at pre-bloom stage & two sprays at full bloom & fruit set stages.
(2) Anthracnose : Fungal disease More in humid & high rainfall regions. Panicles, leaves, tender shoots etc. are affected with black necrotic areas & die back. Controlled by pruning affected dead twigs. Spray B. M. (3:3:50), Bavistin 0.1 %, Benlate 0.1 % in Feb, April & September.
(3) Bacterial canker or bacterial spot : Affected fruit crack & gum oose out. Spray BM (3:3:50) or streptocycline.

Physiological Disorders :
(1) Black Tip : More in Punjab, UP, Bihar & W.Bengal. The distle end of fruit becomes black & hard. Premature ripening of fruit which is not marketable. It is due to fumes of brick klines near 630 m. perifery of orchard. CO_2, SO_2 & acetylene are constituents of this fume. Spray Borax 0.6 & Caustic soda 0.8 %.
(2)Leaf scorch: Due to excess chloride in the soil, which makes potash unavailable. It is common in saline soils or where Murate of potash is used. It can be controlled by use of potassium sulphate in place of Murate of potash.
(3)Spongy tissue: Ripe fruit look normal, but on cutting, spongy development found in flesh, which is bed in odor, ceramic white in color & unpalatable. It is due to accumulation of radiant heat in fruit tissues during April-May. Commonly found in Alphanso (30 %) and Zamadar. Controlled by (1) Mulching dry leaves, straw etc. under the tree. (2) Avoid harvesting during hot period of day. (3) Harvest fruit at ¾th maturity
(4) Mango malformation : Widely found in Punjab, Delhi, U.P. & some extent in Gujarat & M.S. Southern region of country are free.
(1) ***Vegetative Malformation:*** Common in young nursery plant. Leaves become rosette in shape.
(2) ***Floral Malformation:*** Panicles show suppression of apical dominance. Hang on the tree throughout the year. They suck nutrients and live at the cost of other panicles. It is due to (1) Lack of cultural practices (2) Nutritional imbalance (3) Attract of mites (4) Attack of virus and fungus (5) Low temperature. Controlled by (1) Single spray of 200 ppm NAA in 1st week of Oct. (2) Deblossoming at bud burst stage (3) Cutting and removing of affected panicles .Variety 'Bhadauran' if free but fruits inferior.
(5) Fruit Drop: Natural fruit drop is 99 %. Highest drop during initial 4 weeks. Different fruit drop stages are (1) Pin drop: It is at fruit set stage (2) Pea stage: It is after fruit set (3) Premature drop: It is before harvest (April-May)
Causes: [A] Internal factors (1) Lake of pollination (2) Low stigmatic receptivity
(3) Defective perfect flowers (4) Self-incompatibility (5) Drought or lack of irrigation.

[B] (1) External factors: (1) Unfovourable soil & climatic conditions (2) High incidence of diseases like powdery mildew, anthracnose, (3) High incidence of insects like mango hopper, mealy bugs etc.
Control : (1) Regular irrigation during fruit development. (2) Timely & effective control of insect pest & diseases. (3) Spray 20 ppm NAA + 2% urea at pea stage or 20 ppm 2,4-D.

Harvesting

Maturity indices

Various criteria recommended for judging maturity are

1. Slight color changes on fruit from dark green to light green.
2. Development and exposure of shoulders.
3. Development of white bloom (powder) on the skin of fruit.
4. Development of white dot (glands) on the fruit.
5. When one or two ripe fruits fall from the plant naturally.
6. When the specific gravity of fruits attains the ranges from 1.01-1.02. The last method is dependable.
7. Fruits generally mature between 90-120 days from fruit set stage.

Time of harvesting

Normally the fruits should be harvested during morning hours and in evening after 5.00 pm. The temperature is lower at this time which reduces the respiration rate of the fruit. If harvesting is operated during hot period (30-35^{o} C or more), the shelf life is reduced.

Method of harvesting: Most satisfactory method available at the moment is the one which makes use of a bamboo hand tool, called mango picker Locally known as VEDO. Consists of long bamboo pole fitted with a cutting shear at the distal end, and under which a fruit collecting net is tried.

Yield :- Seedling tree after 8-10 yrs. Grafted tree after 4-5 yrs. Av. yield = **80-100 kg.**

Marketing :- Freshly harvested matured fruits are packed in 10 kg volume card-board box. & send for market. Mango is climacteric fruit, so stored properly for ripening. Mature fruits ripen after 5-6 days. Ethylene (3000 ppm) can accelerate ripening.

Storage: The mango is a climacteric fruit and unless the fruits are stored properly, one cannot be sure of the conditions in which the fruits will reach the desired market.

In general, green but mature fruits store better than these harvested ripe from the trees. Fruits harvested with stalks were less susceptible to storage decay then fruits harvested without stalk. Low temperature may cause chilling injury.

2.BANANA

B.N. : (1) ***Musa paradisiaca*** L.
(2) ***Musa cavedishii*** Lambert.
(3) ***Musa sapientum*** L.

Family : Musaceae **Origin:** South-East Asia (Assam, Burma etc.)

One of the oldest fruits in India. It is second in importance next to Mango in India. Rich source of energy. All parts of plant are useful.Unripe fruits are used for powder and ripe fruits are used for jam, fruit salad, religious purpose. It is cultivated in various states in India South India- (Kerala, TN, Karnataka), Western India- (Gujarat, Maharastra), Eastern India- (Assam, Bihar).

Total area under banana in India is 2.40 lakh ha, (i.e. 20% of total fruits.) with 34.46 lakh tone's production. Gujarat-28530 ha. with 11.41 lakh tone's production. Surat, Valsad, Bharuch, Vadodara, Kheda, Junagadh, Bhavnagar are growing regions.

Origin and distribution

The edible banana is believed to have originated in the hot tropical regions of South-East Asia, Plants of the Musaceae family as a whole are strictly old world plants and predominantly Asian. India has the second largest diversity of indigenous bananas in the world more than 600 types of *Musa* germplasms comprising wild forms and cultivated species arc reported the world over. India has more than 300 types of germplasms although there are numerous synonyms of each cultivar.

Soil : Banana can be grown in almost all types of soil provided adequate soil moisture is available. Deep, well drained, fertile, loamy soil with adequate organic matter is ideal for its cultivation. Shallow rooted crop, so depth & drainage are essential. Can grow in slight alkaline but not in saline soils.

Climate :- Banana is well adapted to tropical climate in the warm and humid parts in Asia. Among the climatic variables, temperature, frost occurrence, light/solar radiation and rainfall distribution, relative humidity and wind velocity largely influence the growth morpho¬logy and productivity of banana. It Can grow in temp. range 10-40 ^{0}C. frost sensitive. Wind breaks necessary.

Varieties :- Basrai, Harichhal, Gross Michel- (best all over world.), Grand naine, Poovan, Nendran, Lal kela, Safed Velchi etc. wild species found in Assam & Arunachal, whose pseudostem is used for paper & rope making.

They are (1) ***Musa sanjunia***, (2) ***Musa mani*** (3) ***Musa velity.***

Propagation :- vegetatively propagated. (1) ***Suckers :***

Sword suckers	**Water suckers**
Leaves are pointed, narrow & upright Leaves are Broader, spreading. with roundish tip.	Leaves are Broader, spreading with roundish tip.
Rhizome is conical with sound heart	Rhizome flat with

	non-sound heart.
Growth is vigorous & fast	Growth slow.
Bearing is early (11 months.)	Bearing late (15 months.)
Sword suckers are best.	

(2) ***Rhizome :*** Except coastal region of Saurashtra, usually rhizome planting is followed.
(3) Tissue cultural plants

Planting of suckers : Sword suckers of 3-4 months old separated from mother rhizome & planted.

Planting of rhizome :- Pseudostem of sucker is completely removed from rhizome. Such rhizomes are stored under shade in cool & dry place for 2 months. The conical rhizomes with sound heart & few side buds are used for Planting.

Distance of Planting: Tall varieties – 2.5 x 2.5 m; Dwarf varieties – 1.8x1.8 or 1.2 x 1.2 m. 31.6 tones of rhizomes i.e. 3000 numbers required per ha.

Planting Season: - 15 June to 15 July. If early planting, bunch will emerge during severe winter, which reduce the yield. High temp. of Sept-Oct. and severe cold of winter reduce the growth of bunch. Pits of 30 x 30 x 30 are dug during summer. Filled with FYM (10-15 kg) + soil. Before planting, planting material is treated with Aureofungin 6g in 135 lit. water for 1.1/2 hour or with $KMnO_4$ 100g + 100 lit.water.

Irrigation :- Water requirement of banana varies according to topography, soil, climate, cultivar and type of culture. If there is no rain, the plants should be irrigated immediately after planting. The soil in banana plantation should not be allowed to dry completely. Banana requires high amount of water ranging from 1800-2500 mm annually. The requirement is met either through well distributed rainfall or through irrigation. Therefore, rainfall is an important aspect to be considered before growing bananas. Banana needs plenty of water throughout the life. Summer- 7-8, winter 10-12 days interval. It needs totally 40-50 irrigations.

Drip irrigation schedule: For example for 1.5 m x 1.5 m spacing the drip system should be operated on alternate day for a period of 1.5 to 2.25 hrs during winter and 2.5 to 2.75 hrs during summer at a pressure of 1.2 kg/cm^2.

Manures&fertilizers: Nutritional requirement is very high.

Time of Apply **FYM** 10-15kg /plant at the time of filling the pits

	A.S.(N) (g)	**SSP(P_2O_5)(g)**	**MP(K_2O) (g)**
3rd month	300 (60)	190 (30)	125 (60)
4th month	300 (60)	190 (30)	125 (60)
5th month	300 (60)	190 (30)	125 (60)
Total	**900 (180)**	**570 (90)**	**375 (180)**

For more improvement 2 % urea can be sprayed. It is recommended to apply above RDF to vaieties other than Grand Naine. For Grand Naine, RDF is 300:90:200g NPK/plant along with 10-15 kg/plant FYM.

Intercropping :- Intercrops can be easily raised in banana plantation at the early stages of growth. It is a subsistence farming or cash economy in banana culture. Radish, cauliflower, cabbage, spinach, chilli, brinjal, colocasia, yam, dioscorea, lady's finger, basella, cucurbitaceous vegetables, marigold, tuberose are grown as intercrops), Mixed cropping with arecanut and coconut is a common practice in South India

Essential operations :

(1) ***Weeding :*** weed free condition is necessary to control pest & diseases.

(2) ***Desuckering :-*** Suckers are produced from the rhizome of banana. The number of suckers produced per clump varies depending on cultivar, soil fertility, environment *etc*. Removal of unwanted suckers is one of the most critical operations in banana cultivation and is known as desuckering. It is done either by cutting off the sucker, or the heart may be destroyed without detaching the sucker from the parent plant. Removal of unwanted suckers. Only 2 are kept.

(4) ***Earthing up :*** During rainy season to give the support, to provide drainage & to avoid water-logging.

(5) ***Propping :-*** The lodging of banana plants particularly at mature stages results in heavy loss. The falling of the pseudostem may occur due to strong winds, rhizome rot, burrowing nematode or tall cultivar. There is no doubt that strong wind is one of the important limiting factors in banana production. Supporting with bamboo at bunch emergence period.

(6) ***Sleeving or Wrapping :-*** Covering of bunches with gunny cloth or dry leaves to protect from sunburn, hot wind, dust *etc* which improves colour of fruit.

(7) ***Threshing: -*** Pruning of surplus leaves is a common operation in banana production. Leaf removal helps to reduce the disease spreading through old and senescent leaves. The micro climate is changed by leaf pruning, especially light and temperature.

(8) ***Nipping off*** of male flower head.

Economic life of plant is 2-3 years.

(9) ***Mattocking***: It is the process of cutting the pseudostem after harvesting of bunches. After harvesting the pseudostem should be cut leaving a stump of about 0.6m hight, the left over stump with its stored food material continues to nourish the daughter sucker (follower) till it withers and dries up.

Flowering & Fruit Development : Flowering starts after 6-8 months of planting. Inflorescence has hermaphrodite flowers. Edible banana are parthenocarpic, where as wild are having seeds. Banana plant is monocarpic (having only one flower bud). Therefore, plant produce only one bunch in it's life.

Harvesting & Yield and Post harvest technology: The fruit is harvested when maturity sign was observed.

Signs of maturity of fruit :-(1) Drying of leaves. (2) Change of colour of fruit skin from deep green to light green. (3) Ridges of the fruit turn round from angular.

The dwarf varieties of bananas are ready for harvest within 11 to 14 months after planting. Tall varieties ready to harvest after 14-16 months. Main harvesting season is Sept. to april Bunch yield 25-30 t/ha. but if good management 40-60 t/ha. tall-15-20 t/ha. (5-10% loss during transport.)

Storage :- Banana can be stored at a temperature slightly above 55°F (13°C) and with a relative humidity of 85 to 95 per cent for about three weeks, and is ripened in a week or two at 62 -70°F (16.5°-21°C). Banana fruit becomes blackened at lower temperatures and should not be placed in a refrigerator.

Ripening :- Climacteric fruit. Must be ripened in store room. Smoke treatment : (2) Chemical treatment- 3000 ppm Ethrel.

Pests :

(1) ***Banana stem borer:*** Larva feeds on corm. Leaves turn yellow, weather & plant dies. Controlled by clean cultivation.

(1) ***Banana Aphids :*** They are the vectors of virus of 'bunchy top' disease. Can be

controlled by spraying Dimethoate or Melathion, (10 ml in 10 lit water).

(2) ***Nematodes :*** Affected plants do not respond to fertilizers, irrigation, cultural practices *etc*. Root become reddish & rot. It can be controlled by (1) Treating plant material with Furadon granular insecticide. (2) Use nematicide.

Diseases :-

(1) Panama disease OR Banana wilt :- Soil borne fungal disease. Gets entry through roots. Serious in poorly drained soils.Yellow leaves hang on the stem. Not serious in Gujarat. Can be controlled by (1) Planting of resistant varieties like Basrai or poovan. (2) Uproot the affected plant & burn.

(2) Bunch Top : It is a viral disease transmitted through vector Aphid. Plant remain stunted & produce poor bunch. Can be controlled by. (1) Destroying affected plants with rhizome. (2) Spray insecticide to control aphids.

(3) Leaf spot OR Sigatoka disease :- It is a fungal disease. Light yellow spots which become dark brown on the leaf. Killing of large part of leaf. Gross Michael & Cavendish are highly succeptible. Can be controlled by. (1) Improving drainage & reducing humidity in plantation. (2)Remove affected leaves (3) Spray Dithane M-45.

(4) Kokkan disease (Banana bract mosaic virus)

Kokkan disease was first reported from **Thrissur** district in the variety **Nendran**. Later on, the disease was found to affect other varieties like Palayankodan, Kodappanillakunnan, Monthan, Kanchikela, Poovan (Rasthali), Karpooravally and Chenkadali. Nendran is the highly susceptible variety.

During the young stage of Nendran banana plant (two months old), pinkish streaks can be seen on the pseudostem. All the kokkan affected plants need not show this symptom, but once this symptom is expressed there is no doubt that the particular plant is affected with kokkan disease. Necrotic streaks are another important symptom of the disease. The necrotic streaks are initially brown, which later turn black. It occurs on all aerial parts of the affected plant except on lamina, the length being a few mm to 10 cm. All the kokkan-affected plants will exhibit the necrotic streaks from third month onwards at one stage or other. Some of the affected plants retain the necrotic streaks throughout the growth period. In certain cases it disappears with the senescence of the affected portion.

The affected plant produces only a small bunch. The fingers are small, curved and widely divergent with pale green to ashy green colour as compared to the healthy ones. The abnormal colour and reduction in the size of the bunch depend upon the severity of the disease.

Control

- Suckers should not be taken from affected plants, which show necrotic streaks or abnormal colour of the pseudostem.
- When the young plants show the symptom of pinkish streaks, they should be uprooted and destroyed.

(5) Infectious chlorosis (Cucumber mosaic virus disease): The disease is noticed in varieties such as Nendran, Palayankodan, Karpooravally, Kosthabontha, Peykunnan, Bhimkhel, Mottapoovan, Dakshinsagar, Madhuraga, Rasthali and *Musa ornata*.

The most characteristic symptoms are the loss of leaf colour in patches; appearance of parallel chlorotic streaks on the younger leaves, giving a striped appearance on the leaves. As the disease progresses, leaves emerge distorted, margins become irregularly wavy, often with blotches of necrotic tissues and the leaf lamina is reduced in width. In severe cases, rotted areas are found throughout the leaf sheath and pseudostem. The affected plants produce only small bunches. This is a virus disease transmitted by aphids.

- Use disease free suckers for planting.
- Eradicate disease affected plants.
- Use insecticides recommended for insect vector control.
- Avoid growing leguminous and cucurbitaceous vegetables as intercrop in banana in disease prone areas.

Premature ripening of fruits:-

Observed in Kheda, Bharuch & Surat regions. Leaves become yellowish, red spots on leaves. Fruit ripen earlier. It can be controlled by (1) Dusting 300 mesh sulphur (16 kg/ha.) (2) Spray 0.025 % Carbendazim at one months interval.

Physiological disorders:

Choke throat

It is due to low temperature affecting active growth of the plant. Leaves become yellow and in severe cases, the tissue gets killed. In case of normally flowering plants, the stalk carrying bunches elongates freely so that the entire inflorescence comes out of the pseudostem and hangs down. Bunch development is normal, but when the time of flowering synchronizes with low temperature, the bunch is unable to emerge from the pseudostem properly. The distal part of the inflorescence comes out and the basal part gets stuck up at the throat. Hence, it is called **Choke throat.** Maturity of the bunch is delayed by taking 5-6 months instead of 3.5-4 months for harvest. Provision of shelter belts using Casuarina or Eucalyptus to prevent the effect of cold wind blowing into the orchard and planting low temperature tolerant varieties like Kullan check the disorder.

Chilling injury

Chilling occurs when pre-harvest or post-harvest temperatures fall below 14°C for various time periods. The peel of banana become dark and the fruit exhibit uneven ripening. Ripening fingers show dull yellow to smoky yellow colour and watery dark patches are observed on the skin. Brittleness of the fruit and fungal invasion is also observed. The vascular bundles of the sub epidermal layer show brown streaks. The discoloration is ascribed to the enzymatic oxidation of dihyroxy phenylalanine.

Kottai vazhai

It is a serious malady in Poovan variety of banana, reducing the production by 10-25%. The symptoms are distinctly conical and illfilled fruits with a prominent central core having many underdeveloped seedy structures making the fruit inedible. The pseudostem exhibits streaks, striations and blotches on the surface. Bunches are held at an angle above the horizontal position. Pollen grains are infertile, shriveled, shrunken and broken while the pericarp is smaller and the locular cavity is bigger than normal. The absence or the occurrence of auxin, gibberellin and cell dividing factors at sub epidermal levels affect the development of parthenocarpic fruits. Application of 2,4- D 25ppm and GA 100ppm after the opening of last hand favours development of parthenocarpic fruit.

Formation of splitted fingures : Symptoms are appears longitudinal cracks in fruits this disorder prominent in rainy month occurred immediately after the dry spell. due to the severe water stress,tissue of the fruit get damaged with the absorbtion of water. This damaged tissue tend to expand from cracks.

Potassium deficiency Chlorosis:

The most characteristic of the K deficiency symptoms is the yellowing of older leaf tips followed by inward leaf curling and death.

Stunted growth : Usually, a K deficient banana plant will grow slowly and have a sturdy appearance due to the shortening of internodes.

Bunch deformation : The banana bunches in K deficient plants are short, slim and deformed as a consequence of poor fruit filling caused by reduced photosynthesis and sugar transportation.

3. Citrus

Botanical Name : *Citrus spp*
Family : Rutaceae
Introduction

- ✓ It is world's leading tree fruit crops
- ✓ Domestic consumption is the principle market
- ✓ The major citrus providing countries viz., Spain, USA, Israel, Morocco, S. A. and sizeable export to EC, Russia, Cannada, S. Arabia, Kuwait & Hong kong.
- ✓ The USA is the largest producers of citrus, covering about 30-40% of world's total production.
- ✓ Citrus plantation in Israel is occupies more than 40,000 hect and 80% of Israel Agril. Exports goes to citrus.
- ✓ In Japan, Citrus occupy the first place among all fruit crops.
- ✓ In India, it is with 3rd position and occupies about 9% of total fruit crops. The most important of citrus in India is mandarin followed by the sweet orange and acid lime.

Consumption

- The principal constituents of edible portions are sugars (glucose & sucrose) and acid (Citric acid & malic acid).
- The rind of fruit contains pectin and certain essential oils as well as certain glycosides
- It also contain considerable amount of ascorbic acid (25-85 mg), TSS (8-12%), acidity (0.5-1.5%).

Uses

1. Used as a fresh fruits (orange) and orange marmalade
2. Grape fruit and other types are also used in the this way
3. Citrus fruit juice are bottled and canned in large scale
4. Lemon-barley water is prepared from lemon
5. Citrus acid, pectin etc. are produced

Origin & distribution

- Most of the *spp* under genus citrus are native to tropical and sub tropical region of south east asia particularly India, China & region between two countries.
- The north eastern region of India is considered as a one of the natural home of citrus
- Many *spp* are believed to be developed from intercrosses between India & China

Species and Varieties

Citrus fruits are members of the "Rutaceae" family which contain more than a thousand species mostly found in tropical region of Africa, South-East Asia and Australia. Out of them only 16 *spp* are with horticultural important.

Large number of inter generic were developed like

1. Citranges (Trifoliate orange x S' orange)
2. Citrumelos (Trifoliate orange x Grape fruit)
3. Citradias (Trifoliate orange x Sour orange)
4. Citrumuats (Trifoliate orange x Kumquat)
5. Limquats (Kumquat x West Indian lime)

Some inter specific hybrids were also developed

1. Lemonimes (Lemon x Lime)
2. Tangors (Mandarin x S'orange)
3. Tangelos (Mandarin x Grapefruit)

The following are varieties of citrus extensively cultivated in India.

1. Acid group :

Lime group

a. Acid lime : *Citrus aurantifolia*
b. Tahiti or Persean lime : *Citrus latifolia*
c. Rangpur lime : *C. limonia*
d. Sweet lime : *Citrus limettoides*

Acid lime

✓ Highly polyembryonic
✓ Fruit round to oval, greenish yellow, thin skinned, juicy, high acidic
✓ Kagzi Lime, Vikram, Pramilini, PKM-1, Seedless, Tahiti *etc*.

Sweet lime

✓ Indian origin, fruit is larger than acid lime, fruit is smooth, greenish yellow with thin skin, flesh pale yellow to straw color, flavour inspide and juice sweet with little bitter
✓ Cultivars- Mitha nimbu, Sharabati

Karna khatta : *C. Karna*

✓ Widely used as a root stock in North India, Cultivar – Soh sarkar

Lemon group

a. Lemon : *Citrus limon*
b. Rough lemon : *C. jambhiri*
c. Citron : *C. medica* (Kidarankai in Tamil, used for pickling)

Lemon

✓ Weekly polyembryonic with medium sized spreading tree
✓ Fruits oval to elliptic with pointed nipple
✓ Fruit surface smooth, light yellow & core solid, juice abundant & acidic.
✓ The cultivars are Eureka & Lisbon (USA), Femin-ello and Monachello (Italy), Kaghazi kalan, Italian round, Asam lemon, galgal, pant lemon, Barmasi etc.
✓ Lemon oil is one of the most important citrus oil used for flavouring purposes in soft drink, baked foods, confectionery etc.

Rough lemon

✓ Fruit skin rough & brown in color
✓ One of the most important rootstock of citrus (tristeza virus)

Citron

✓ Fruit semi smooth to rough surfaced, rind thick to very thick, pulp is acidic but juice is scanty.

2. Orange group :

a. Sweet orange : *Citrus sinensis*
b. Sour orange :*Citrus aurantium* (Narthankaai in Tamil, for pickling)
c. Multiple leaf orange : *C. multifolia*
d. Japanese summer grape fruit : *C. natsudaidai*

✓ Highly polyembryonic of Chinese origin
✓ Fruit sub globose to oval, orange color, tight skinned with solid central core, pulp juicy and sour sweet e.g. Mosambi, Sathgudi, Valencia Late, Jaffa, Pineaaple

4. Mandarin group : (loose jacket)

a. Coorg mandarin, Nagpur Santra and Kodai orange : *C. reticulata*
b. Japanese Satsuma mandarin : *C. unshiu*
c. Willow leaf mandarin : *C. deliciosa*
d. King mandarin : *C. nobilis*
e. Kinnow mandarin : King x willow leaf
f. Tangerine orange var Dancy (trifoliate x mandarins) : *Citrus tangerine*

Mandarin is highly polyembryonic in nature, fruit is medium sized, globose, sweet, segment easily separable, loose skinned, orange in color, rind thin & easy separable, usually 10-14 segments, seeds pointed. The important cultivars Coorg mandarin, Nagpur Santra and Kodai orange, Khasi etc.

5. Pummelo and grape fruit group:

a. Pummelo : *C. grandis*
b. Grape fruit : *C. paradisi*
c. Kumquat : *Fortunella sp.*

Pummelo

- Large sized, indegenous to Malaysia, thornless
- Fruit sub globose, pyriform with thick and spongy rind, test is sweet and juicy, rind thick, smooth with large oil glands. Cultivars, white & pink flashed

Grape fruit

- ✓ Originated in china
- ✓ Fruit is large, rind surface 7 flash is yellow, highly juicy, sweet with bitter after taste
- ✓ Cv. Foster, Ruby, Marsh, Duncan & Thomson etc.

6. The fifth group consists of mainly hybrids of different citrus fruits with trifoliate orange (*Poncirus trifoliata*) and mainly used as rootstock. *e.g.* Citrange (*Poncirus trifoliata* x *C. sinensis*) var. Troyer, var. Carrizo

a. Citrangor (Citrange x *C. sinensis*)
b. Tangelo (Tangerine x grape fruit)
c. Citrangequat (Citrange x kumquat)

Varieties

Acid Lime

Acid lime fruits

- This variety is often referred to as Kagzi lime in some parts of India and is grown extensively all over the state.
- The fruit is round to oblong in shape, the rind thin, smooth and yellow; the apex round and slightly nippled; the pulp is light greenish-yellow, juice and very acidic.

Sweet orange

- Three varieties of sweet orange viz., Sathgudi (or Cheeni) Mosambi, and Batavian are popular in the state.

Mosambi

Mosambi fruits

- As the name suggests, the fruit originates from Mozambique. It has prominent streaks on the rind and a circular grove at the styler end.
- The fruit is subglobose in shape; juice is not plentiful and though sweet, sometimes it can be almost insipid due to an unbalanced sugar-acid ratio.
- This variety contains more seeds than the satgudi

orange.

Sathgudi fruits

- The name Sathgudi owes its origin to a place "Sathgur" in Tamil Nadu.
- This variety is popular among cultivators in Andhra Pradesh because of higher yield potential, wider adaptability and better consumer acceptance.
- The fruit is spherical in shape with a smooth surface, the rind is thin, semi-glossy, finely pitted and orange coloured when fully ripe.
- It has 10 to 12 segments, abundant juice (45%), T.S.S. (Total Soluble Solids) 6.4%, acidity 0.69% and an ascorbic acid content of 44 mg/100g.

Batavian

- Popular in the North coastal districts of the state, this is similar to sathgudi. It develops yellow patches on the green rind of the fruit when it is basketed to protect itself from the sucking moth.

Sour orange

- Grown in the coastal districts, the Vadlapudi orange, also known as the Guntur Orange, is very popular and a much favoured sour orange. It is highly susceptible to root rot and collar rot disease.
- Over the last five decades, efforts have been made at the Fruit Research Station, Anantharajupet (Kodur) to introduce and evaluate different varieties of citrus species. Among the many sweet orange varieties tested.
- Sathagudi and Valencia Late were found to have the best potential.
- As Valendia Late matures late in the season, it commands a good price in the market.
- Also, the performance of Washington Navel, Buckey Navel and Blood Red cualtivars is good, indicating their desirability for commercial cultivation.

The following high-yielding varieties in each kind of citrus fruit were selected and recommended

Citrus Fruit	Variety
Sweet Orange	Mosambi, Sathgudi, Valencia Late, Jaffa, Pineaaple
Mandarin	Nagpur, Coorge, Kinnow and Dency Tangerine
Lemon	Malta, Nepali Oblong, Lemon Long
Acid Lime	Kagzi Lime, Vikram, Pramilini,
Pummelo	Red Sweet

ACID LIME

Botanical name : *Citrus aurantifolia* Swingle
Family : Rutaceae
Origin place : Probably a native of India and South Eastern China

Acid lime *(Kagzi* lime, Acid lime, Mexican lime) in Hindi is known as *'Neebu'.* It is a profusely branched thorny shrub or small tree. The leaves are small with narrowly winged petioles. The flowers are small, pure white and are borne in clusters. The fruits are more or less round or oval, smooth having thin rind (papery) attached lightly. The

immature fruits are dark green in colour which changes to light yellow when ripe. The colour of the pulp is light greenish-yellow; taste is acid, aromatic; cells fine and shiny. The number of segments is 9-11. The number of seeds per fruit is 9-10.)

Sour lime is found in most parts of the tropics. In India, it is cultivated in Tamil Nadu, Maharashtra, West Bengal, Punjab, Madhya Pradesh, Andhra Pradesh, Delhi, Uttar Pradesh, Kamataka, Gujarat. It is cultivated in the plains and up to 1200 m elevation . The small fruited lime is the variety grown all over India. A large number of types differing in size, shape and colour of the fruited are cultivated. Some thorn less types are known but they are not grown commercially. 'Bearss' or 'Sersian' is very important type in Florida: produces fruits larger than the conventional lime, totally seedless, smaller and less thorny tree, easier to harvest

Uses

1. Lime is a good source of Vitamin-C and is extensively used for culinary purposes.
2. It is used for flavouring jams, jellies, marmalades and alcoholic drinks.
3. It is used as a garnish for fish and meat.
4. It is also used for preparing beverages such as limeade and lime rickey.
5. Important products made from lime are: lime juice, lime cordial, lime oil and calcium citrate, dried or dehydrated lime peel, lime powder and pickle.
6. Dried lime feed powder and lime sediment obtained when lime juice is clarified, are utilized for cleaning metal ware.
7. Lime peel is also used as cattle feed.

Climate

Sour lime requires tropical climate. It is tender to frost. Strong winds are harmful. Hot wind & excessive heat during flowering and fruit set are highly deterimental for good bearing and causes fruit drop and sun burn of fruit.

Low humidity for better fruit color, while more, for more juicy with thin rind. In the more humid areas of Assam and West Bengal where the rainfall is above 125 cm, the lime becomes highly susceptive to citrus canker, which makes the trees unproductive and short lived.

It is light loving plant and it is sensitive to shading. High light for foliage color, while, under shade, deep foliage color and poor yielder.

It may not be cultivated in the area where the temperatures occasionally fall below the freezing point. Usually low temperature -6.6 to -4.4 is injurious. Sour lime is successfully cultivated in west and south India where winters are free from frost and the annual rainfall does not exceed an average of 75cm. Sour lime can successfully be grown from sea level to 1000 m or so elevation.

Best fruits are produce in semi arid & sub tropic region.

Soil

For the plantation of sour lime, soil should be at least 1.5 m deep. It should be well drained. Heavy soils should be avoided for planting. A high water table of a permanent or fluctuating nature is unsuited and low-lying localities which are subjected to water stagnation should always be avoided. Ideal pH 5.5 to 7.5, however, tree is not possible to salt injury and can't thrive well in saline alkaline soil.

Area and Production

	Area	Production	Productivity
World	-	84.7 million ton	-
India	3.89 L. ha	44.3 Lakh ton	14.8 kg/ha
Guaj `	8000 hac	1.28 Lakh ton	16.00 kg.ha

- USA is the world's largest producer of citrus

- In India, Mandarin is larger followed by S'orange & acid lime
- AP, MH, KT & Punjab are the leading states

Types/Varieties of lime

Varieties :- Kagzi lime, Vikram (Ms), Pramalini (Ms)

Though lime has been in cultivation for several centuries, there are not improved varieties. Commonly grown lime is the acidlime called kagzi lime. There is not much variation among lime trees. Though they all have been multiplied sexually, because of the well-known phenomenon of polyembryony, there is a great variation in Maharashtra, Andhra Pradesh and Tamil Nadu. The improved varieties are:

Kagzi lime

It is the best variety grown all over the country. It has two types of fruit, round and oval.

Pramalini:

It bears fruits in clusters of 3–7 and yields 30% more than the normal kagzi lime. The fruits have 57% juice, which is higher than Vikram (53%) and normal lime (52%). In Maharashtra, Pramalini and Vikram are 2 varieties identified by clonal selection. These have been released for commercial cultivation as they are canker-free and prolific-bearer.

Vikram:

This also bears fruits in clusters of 5–10 and some off-season fruits during September, May and June. It gives 30–32% more yield over the normal lime.

Chakradhar:

This variety of lime was derived from cv. 'Kagzi'. It has round fruit with thin papery rind, and a 60-66 per cent juice content. It is a thornless and seedless selection. It has a greater yield and vitamin-C (ascorbic acid) 118.2-140.8mg/100g and acid content (8.3-9. I%) than 'Kagzi'. Trees of 'Chakradhar' begin bearing in their 4th year and are compact and semi-spreading.

The plants are erect, compact and dense in habit. It bears fruits during January–February, June–July and September–October.

PKM 1:

Its fruits are round, medium to large-sized, with an attractive yellow skin, and 52.31% juice. It is high-yielder than the local strains.

Selection 49:

It is a prolific-bearer, producing better-sized quality fruits. It has a tendency for bearing summer crop and shows tolerance to canker, tristeza and leaf-miner.

Seedless lime:

It is a new selection of lime. Fruits are oblong, skin thin, primrose coloured, prolific-bearer, yields double that of normal lime but late.

Propagation.

CITRUS

1. Seed due to polyembryonic charactristics

Sour lime is mainly propagated by seed. Propagation by seeds is followed due to polyembryonic nature of it. In sour lime about 78 per cent seeds possess polyembryos. Each polyembryonic seed produces three to four seedlings. Among them, one is sexual origin and remaining are nucellar. Nucellar or apogamic seedlings breed true to type.

Raising of seedlings

Freshly extracted seeds are sown on well prepared nursery bed at the distance of

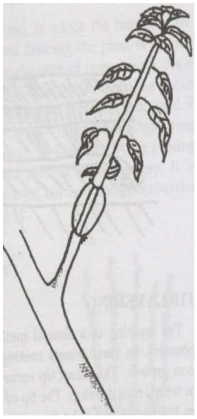
20 x l0 cm and 1.5 to 2 cm deep. Germination completes within 3 weeks. The sexual seedlings, which are usually stunted and poor in growth compared to apogamic or nucellar seedlings, are uprooted carefully. Removal of sexual seedlings is essential because they do not breed true to type. The apogamic seedlings are identical to the parent in growth and production. Seedlings are ready for transplanting 6 to 9 months after sowing. However, usually one year old seedlings are preferred for transplanting.

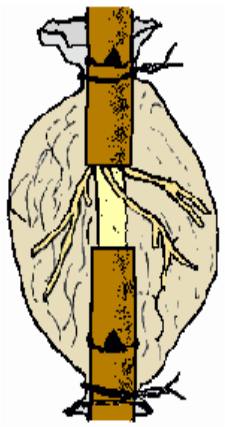
Besides, vegetative methods like air layering is commercially adopted

1. **Air layering**

It is also known as pot layering, Marcottage or Gootee. For the purpose of air layering one year old or previous season shoot of pencil thickness is selected. About 5 to 7 cm away from the base of selected shoot, a girdle of 2.5 to 3.0 cm size, by removing the bark, is prepared. The girdled portion of the shoot is scrapped using gunny bag or rear side of the blade. This process helps in removal of phloem and ultimately prevents the formation of bark at the girdled portion. The girdled portion is then covered using moist sphagnum moss grass. Covering with moss grass retains better moisture at the point of air layering. The girdled portion is now wrapped using transparent polythene tape and both the ends of tape are tied air-tightly.

Depending upon of success rooting appears in about 2-3 months. When root emergence is there and it becomes visible from the transparent wrapped tape the layered shoot is separated from mother plant giving 2-3 cuts in installments. The layered plants are planted in nursery under partial shade where frequent watering is provided and high humidity is maintained. Usually air-layering is practiced in the month of July-August. Air-layering is practiced in litchi, lime, jackfruit, cashewnut, guava, Black jamun, Pomegranate *etc*. In case of hard-to-root type plant application of IBA at 3000-5000 strength is practicable.





Budding also done in citrus for budding following root stocks are used

Some of the commonly used rootstocks are sour orange, rough lemon, trifoliate orange, citranges, Rangpur lime, mandarins, etc., brief characteristics of which arc as below.

1 Sour orange *(C. aurantium)*

Sour orange had been extensively used in the past as rootstock of sweet orange, grape fruit, mandarin orange and lemon (Batchclor and Rounds, 1948). Trees on sour orange rendered good yield (Wutscher, 1978) with better fruit quality (Blondel, 1977). However, it is susceptible to tristeza virus, citrus nematode and burrowing nematode (Baines *el a/.*. 1960). Trees on sour orange were usually smaller than those on rough lemon and were moderately cold hardy (Gardner and Horanic, 1958).

2 Rough lemon (C. ***jambhiri)***

Rough lemon is probably of hybrid origin (Chapot, 1975) and is highly polyembryonic. This is the best known of all rootstocks in South Africa (Broembsen, 1984) and largely used in different countries of the world. Trees on rough lemon stocks turned out high yield with good fruit size but fruits were of poor quality - rough, thick and poorly-coloured skin (Ziegler and Wolfe, 1961). It is tolerant to tristeza and relatively tolerant to saline and calcareous soils but susceptible to foot rot (Grimm and Hutchison, 1973) and blight (Smith, 1975).

3 Trifoliate orange *(Poncirus trifoliata)*

A deciduous relative of *Citrus.* The trifoliate orange is an excellent rootstock for Satsuma in Japan but is susceptible to exocortis disease and blight (Reitz, 1984) but tolerant to most other major virus diseases, *Phytophthora* foot rot and citrus nematode (Zeigler and Wolfe, 1961). Trees on trifoliate gave high yield with excellent fruit quality (Vuillaume *etal.,* 1981) which were also resistant to frost (Korsantiya *et al.,* 1985).

4 Mandarin (C. ***reticulata)***

The most common mandarin rootstock is Cleopatra. It is the most salt tolerant of the common citrus rootstock cultivars with the ability to exclude sodium and chloride taken up by the foot system (Broembsen, 1984) but to accumulate boron (Cooper, 1961). Cleopatra is tolerant to tristeza, exocortis and xyloporosis and fairly tolerant to *Phytophthora* foot rot. However, the yield is comparatively low on this rootstock. Casamayor *et al.* (1982) obtained cumulative production of 60.2 tonnes per hectare in the first five crops of Orlando tangelo on sour orange compared with 58.5 tonnes per hectare on Cleopatra mandarin.

Sunki mandarin is used as a rootstock for orange in Brazil (Sobrinho *et al.*, 1978). It is susceptible to foot rot (Bitters, 1974), sensitive to exocortis (Olson *et al.*, 1962) but tolerant to tristeza (Salibe, 1947b).

5 Sweet orange *(C. sinensis)*

A moderately cold hardy rootstock having wide range of soil adaptation. Trees on sweet orange are little affected by blight (Lawrence and Bridges, 1973) and is resistant to tristeza, exocortis, xyloporosis, sour orange scab and mal secco (Klotz, 1973). Trees on sweet orange rootstock had higher N, P and Cu content in leaf (Wutschcr. 1974) and the quality of fruit was also good on sweet orange rootstock (Bitters, 1974).

6 Rangpur lime (C. *limonia)*

A vigorous hardy rootstock with good adaptability to wide range of soil, particularly for heavy soil. It is tolerant to tristeza and also to salt (Cooper, 1961). However, trees on Rangpur lime are susceptible to foot rot (Carpenter and Furr, 1962), exocortis and xyloporosis. Rangpur lime rootstock is used for orange, grapefruit and tangelo scions. The quality of fruit on Rangpur rootstock is fairly good (Salibe, 1947a).

7 Troyer and Carizzo citrange

Citranges (sweet orange **x** trifoliate orange hybrid) are now used widely as rootstock to replace sour orange. Trees on citrange are salt sensitive (Cooper, 1961). Of the citranges, Troyer is mostly used in California which is tolerant to tristeza and inter¬mediate resistant to foot rot (Klotz *et al.,* 1972). Orange and grapefruit trees on Troyer are very productive and fruit quality is good (Hutchison, 1978). The name Carizzo was given in 1938 to a citrange tree produced from seedlings of the original hybrids raised near a town called Carrizo Springs in Texas (Savage and Gardner, 1965). In Florida, Carrizo is a popular rootstock and is considered as burrowing nematode resis¬tant (O'Bannon and Hutchison, 1974).

Planting.

The pits are dig during summer with a dimension of 60-75 cm^3. They are filled with

a mixture of top soils and well decomposed compost or farmyard manure at the ratio of 50: 50. The filled pits are left till first shower of monsoon. Planting is done in the centre of the pit with a single healthy seedling or graft. The root zone of transplant is set properly and pressed around it. Planting is followed by irrigation in the absence of rains.

Sour lime is planted at a distance of 5 x 5 or 6 x 6 m. Distance can further be reduced to 6 x 5, 6 x 4m if soil is poor. The lime tree declines after certain period of cropping, but it is early, if they are planted closer. But decline can be prevented by removing alternate row of plants or alternate plant from the row, that will provide sufficient growing spaced and will avoid competition for essential requirement like solar radiation, water and nutrients. Closer plantation has also been reported to have more incidence of pests and diseases which may lead to decline and reduced production.

The best time of sour lime planting is the onset of monsoon. The survival and establishment of lime plants remain very high during monsoon season. However, planting can also be done during September-October or February-March, when assured irrigation facilities are available.

Manures and fertilizers

Generally, about 50 kg of FYM, 900 g N, 750 g P_2O_5 and 500 g K_2O, (in two spilt first in oct and second in March-April) 100 g $FeSo_4$ & 50 g $ZnSo_4$ per plant from fifth year and onwards, every year it is applied first in October-November before spring flowering, and the second application is done in March-Aril. These timings of application can be adjusted according to climatic conditions of the region in which it is grown. However, the following doses of fertilizers (g/tree) and FYM (kg/tree) are applied in different states.

States	Age (year)	N	P_2O_5%	K_2O	FYM
Andhra Pradesh	4tli & above	1500	600	800	-
Bihar	10th & above	150	250	325	50
Gujarat	**Bearing**	**900**	**750**	**500**	**50**
Haryana	“	500	320	105	100
Himachal Pradesh	„	800	500	600	20
Karnataka	„	242	145	242	25-30
Maharashtra	„	800	100	200	100
Mizoram	„	900	720	600	10-15
Orissa	2nd year	90	230	90	15
Tamil Nadu	6lh & above	600	200	500	30
Uttar Pradesh	10th & above	750	400	750	-

Irrigation

As stated earlier, the very first irrigation is done just after planting. Subsequent irrigations are needed during rainy season if rains are regular. During winter, lime plants are irrigated 15-20 days intervals whereas during summers at 8-10 days intervals. Sufficient soil moisture is maintained during fruit setting and fruit development. Sufficient moisture during fruit setting and fruit development.

Fertigation : Recommendation of drip irrigation with 4 dripper, 4 lit/hrs capacity 3 hrs during winter and 5 hrs during summer.

Interculturing and intercropping

During rainy season, weeds become a problem, hoeing once or twice will keep down all the weeds. Proper cleaning is done during post monsoon season during (September-October). Only shallow cultivation should be done. Much of clean cultivation practices will not be beneficial.

Sour lime is a evergreen in nature, after harvesting it should be given some rest during the month of October to November, in the South and Western India, and in the month of December and January in the North India, developmental stages which results in high percentage of fruit retention *(i.e.* low percentage of fruit drop and ultimately high fruit yields).

Sour lime tree develop full canopy in 4 to 6 year. Intercrops can easily be taken during early stages of crop growth depending upon population density. Usually vegetable crop, particularly legume vegetables are grown with advantages.

Training and pruning.

The young plants may be provided with support with bamboo split slicks if needed. Later when new sprouts form near to ground level are removed as and when they are seen. Bearing trees may be pruned for unwanted branches like criss-cross branches, diseased and dead and branches which are profusely growing on the ground, and the water sprouts. Pruning operation provides good framework to the tree which should be attended to yearly.

Skirting : Reduce the fruit contact with soil

Flowering and fruiting

Sour lime starts bearing flowers and fruits from the fourth year onwards after planting. Under natural conditions, the trees flower all the year round each flush bringing forth new blossom. The fruits mature in six months after flowering. In Gujarat, about 60 per cent of the total crop is harvested during July to September, 30 percent from October to January and 10 per cent from February to May. In north India, the main harvesting season is in the months of August-September.

Higher fruit setting, minimum fruit drop and higher fruit yield of sour lime are obtained with the spraying of $ZnSo_4$ at 0.6 per cent + 2,4-D at 20 ppm in early January for the spring flush and in early May for the summer flush followed by GA_3 at 50 ppm + $ZnSO_4$ at 0.6 per cent.

Pollination

- Self pollination, however, cross pollination is not uncommon, if mixed planting
- Receptivity of stigma is 6-8 days, honey bee is pollinator
- Cross pollination reported to increase seedlessness

Crop regulation

- ✓ Regulation by withholding the soil moisture
- ✓ Fruit thinning
- ✓ Adjustment of fruit harvesting
- ✓ Use Hasta bahar

Harvesting

Sour lime fruits are ready for picking when the rind colour changes from green to yellow. The fruits are conveniently harvested by means of a pole-harvester fitted with an iron hook at the end. The fruits fallen on the ground are collected. However, fruits of outer periphery of the tree can easily be plucked by hands.

The yield varies from 80-150 quintals per hectare.

Post harvest handling and storage.

After harvesting, unwanted fruits (severely cankered, bruished, injured, cracked, deformed fruits *etc*.) are sorted out. The healthy fruits are quite hardy and can withstand rough handling and transport. The fruits are filled in gunny bags for shifting from one place to another. Under ordinary room temperatures, the fruits can be stored in fresh condition for about 3 to 4 weeks, However, under cold storage fruits can be stored for about two months or so.

Ripening retardants may help delay in ripening and increasing shelf-life of lime fruits. Lime fruits cv 'West Indian' when they were treated with GA_3 at 100 or 200 ppm and stored in sealed polythene bags at ambient temperature extended their storage period up to 65 days.GA_3 at 1000 ppm retards the yellow colour development of lime fruit stored at 50°F temperature. Whereas, Cycocel at 4000 ppm hastens yellowing of Egyptian lime fruits. CCC at 1000 ppm increases the TSS content of Kagzi lime fruits. Treatment of lime fruits by dipping in Waxol (6%) can prolong shelf-life for considerable period under room temperature.Calcium nitrate at 1 per cent is very effective in minimizing the loss in weight, reduces the rate of respiration, rot percentage and maintains the edible quality an marketable ability of lime fruits for more than 6 days by delaying the onset of senescence during storage under ambient temperature.

Pests :-

1. Citrus leaf miner : Serious pest in all species. Larvae mine the leaves resulting curling. Spray Monocrotophos (0.03%) weekly during flush or Imidachlopride
2. Lemon Butterfly : Larvae feed on leaves. Fruit drops. Dusting of BHC (5 %) or spraying carbaryl (0.1%).
3. Fruit sucking moth – Suck juice from fruit, fruit drops. unmarketable. Spray monocrotophos (0.03%).
4. Citrus psylla : Vector of PLO or greening virus
5. Aphid – Brown & black aphid : Vector of tristeza virus
6. Scale : Sap sucking insect

Diseases :-

1. **Citrus canker (Bacterial):**

Wide spread in India. Serious in Acid lime. Leaves, twigs, fruit & thorns affected. Fruits of poor quality. Controlled by pruning & burning, diseased parts. Spray Bordeaux Mixture (10:5:100) to new flushes. Spray 500 ppm streptomycin sulphate.

2. Greening :

Caused by mycoplasma. Chlorosis of leaves resembling Zn deficiency, thickening of leaf, shortening of internodes and twigs, off season blooming, fruit small in size, lopsided, remain green for longer period, contain curved collumelas aborted seed and fall pre maturily & die back. Spread by vector *Citrus psylla*. Controlled by removing infected trees. Control *Citrus psylla* by pesticide.

3. Phytophthora Rot (Root rot, collar rot, crown rot, gummosis, *etc*.) fungal.

Most serious, soil inhabitant. Controlled by raising nursery in disease free condition, avoid water logging, paste bordeaux paste 60 cm on the trunk. Use tolerant root stocks like Sour Orange, Trifoliate Orange, *etc*. Apply Quadris funngice (1 g in 10 lit water)

4. Tristeza

Virus by citrus aphid, leaves with varying deficiencies symptoms, leaf falling, root decay, twigs die back and ultimately death of tree.

Control: Use of root stock- rough lemon, rangpur lime & trifoliate orange, Control Aphid and use Cross Protection techniques of milder strain of tristeza virus

5. Xylopososis

Peg like over growth & gum on bark

6. Exocortis & Porosis

Physiological disorder

Granulation

- Juice become hard, grayish color, enlarged with increased pectin, lignin & other polysaccharides resulting in decrease juice, TSS & acid

Causes

High RH, Temp., time of picking & tree vigour, nutrients

Control

- Lime spray
- Less and frequent irrigation management
- Spray of 2,4-D

Citrus decline:-

Symptoms

Death of twig & small branches, yellowing of leaves, reduction in leaf size and poor yield

Causes

- It is complex phenomenon
- Improper soil, irrigation & fertilizer management
- Graft incompability
- Excessive intercropping
- Micro nutrients
- Pests and diseases
- Viruses like tristeza, xyloporosis, greening & porosis, nematodes

Controls

- Control of soil salinity and soil management
- Control dis-pests, correct deficiencies of nutrients
- Control tristeza and other by vectors
- Disease free planting materials
- Use resi. Rootstocks
- Cross Protection Techniques

Research Achievement

1. Introduction of varieties like Jaffa, Valencia and P'apple in S'orang
2. Use of Kinnow mandarin for North India
3. Use of different root stocks like Rangpur lime, Rough lemon, Jatti khatti etc.
4. Std. of tree injection of tetracycline as an antibiotic against greening virus
5. Use CPT for immunization of nursery plants of acid lime with the milder strain of tristeza
6. Use of trifoliate orange for the breeding of rootstock for res. To phytophthora
7. Acid lime Hyb. -2, NS-52
8. PHT
    - De greening of Nagpur mandarin by 48 hrs at 26-28 C and 90-95% RH using 5 ppm ethylene
    - Pre harvest spary of GA at 10-15 ppm at marketable stage to delay ripening

- Nagpur mandarin stored at 6-7 C + 90-95 RH
- Packing –wrapping in cryovac film & poly. – 3 week.

TABLE : Difference between lime and lemon

Lime	Lemon
1. Botanically, it is *Citrus aurantifolia* Swingle.	1. Bolanically, it is *Citrus limon* Burm
2. Leaves and flowers are small.	2. Leaves and flowers are medium size.
3. Marked petiole wings.	3. Petiole wings very narrow or absent.
4. Stamens are around 25.	4. Stamens are around 30.
5. Peel is very thin.	5. Peel is medium thick.
6. Pulp vesicles are small and thin.	6. Pulp vesicles are comparatively big and thick
7. Pulp is greenish in appearance.	7. Pulp is pale yellow in appearance

4.Grapes

B.N. : ***Vitis vinifera*** L. **Family.:** ***Vitaceae***

Origin.: Asia (Iran, Afganistan & Asia minor)

Grape (Vitis vinifera) is a deciduous crop. Its natural habitat is temperate climate. It was introduced into north India from Iran and Afghanistan in 1300 AD by the Muslim invaders; and into south India in 1832 by the Christian missionaries from France. However, grape was known in ancient India though it was not commercially cultivated until the 14th century. Wild grapes grown in Himachal Pradesh were used to prepare local wine. Presently grape cultivation is concentrated in the peninsular India, accounting for 90% of the total area. Major grape-growing states are Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, and the north-western region covering Punjab, Haryana, Delhi, western Uttar Pradesh, Rajasthan and Madhya Pradesh

Climate:- Temperature, humidity and light are important for grapes. Hot and dry climate is ideal. Areas with high humidity and high rainfall are not suitable. Mild temperature, not exceeding 35°C in summers, impairs the fruiting of vinifera grapes, particularly, in Thompson Seedless. Higher night temperatures (above 25°C) during ripening hamper the colour development in coloured grapes. Cool nights and hot days even though congenial for coloured grapes, pink pigmentation develops in green grapes if the diurnal differences are more than 20°C during ripening. The total amount of rainfall is not the criterion, but the timing, frequency and duration of rainfall are important considerations for grape cultivation. Rainfall during flowering, and berry ripening cause enormous damage to grapes. If rains coincide with flowering, the panicles are destroyed by downy mildew. Rains during ripening cause berry cracking and rotting.

Soil:- Grapes are grown on a variety of soils in India, alluvial in north, heavy black clay in Maharashtra and north Karnataka, red loam in southern Karnataka and Tamil Nadu and very light sandy soils in Andhra Pradesh. Soil with good drainage and water-holding capacity in a pH range of 6.5—7.5 is ideally-suited for grapes.

Varieties:- More than 20 varieties are under cultivation. However, some varieties are commercially grown. i.e. Thompson Seedless, Beauty seedless, Bangalore Blue, Anab-E-Shahi. Some hybrids are Arka Kanchan,Arka Shyam,Arka Hans.
Currently, Thompson Seedless is the ruling grape, occupying 55% of the area with its clones. Bangalore Blue occupies approximately 15% of the total area while Anab-e-Shahi and Dilkhush (15%), Sharad Seedless (5%), Perlette (5%) and Gulabi and Bhokri together (5%).

Propagation:- Grape is mostly propagated by hardwood stem cuttings. Four-noded cuttings from well mature canes on proven vines are made. The diameter of cuttings should be 8—10 mm. Cuttings are mostly obtained from October pruning in the peninsula. Rooting of cuttings is not a problem. To increase the rooting of stem cuttings, they should either be soaked or dipped to cover the basal buds in IBA solution. For overnight soaking, 500ppm IBA solution is used, while 2000ppm solution is used for quick dipping for 10 sec. before planting the cuttings. Quick dip method is preferred. Cuttings after treating with IBA should be planted in the nursery or directly in the field.
Spacing :-Depends on training system. Bower, Telephone, Kniffen & Head. 4.5 x 3 or 3 x 3 or 3 x1.5 m.
Planting :- January to March in North .Monsoon in South.
Training and pruning

Different systems of training—head, kniffin, telephone, V, expanded Y and gable—are in vogue in India. Productive potential of vines is better exploited on bower than on any other system of training. But this system is expensive, encourages diseases, and is not suitable for mechanization of cultural operations. On head, kniffin and telephone systems of training not only the yields are low but the fruits are exposed to sun resulting in sun-burn of berries. The V and Y systems are slightly better than these systems in respect of sun-burn, but the yield is the same. The expanded Y with long arms and gable system connecting the side arms of adjacent rows are best-suited for training seedless grapes, since these systems possess the advantages of bower and at the same time do not have disadvantages associated with it.

In north India, vines are pruned in winter (December–January). Half of the canes are pruned to renew spurs and the rest for fruiting canes. One or two buds from the cordon (arm) are retained in renewed at spurs and 12 buds are retained on fruiting canes. The number of buds left on fruiting canes depend on variety and thickness of cane. Thick canes are pruned longer and the thin shorter. The fruited canes are pruned to renewal spurs and the canes developed from renewal spurs are pruned to fruiting canes in the next winter.

In Maharashtra, Andhra Pradesh and north Karnataka, vines are pruned twice (April and October). The April pruning is generally termed as back pruning or foundation pruning. While October pruning is called fruit pruning or forward pruning. All the canes are pruned to spurs at back pruning, irrespective of the variety or cane thickness. The number of buds retained on a cane at forward pruning depends on variety and cane thickness.

Manures:- FYM 25 t/ha and
T.seedless = 300 kg N+500kg P+1000 kg K/ha (IIHR)
Anab-E-Shahi= 500 kg N+500kg P+1000 kg K/ha (IIHR)

Table 1. Manurial schedule for grape

Variety	Doses of Nutrients (Kg/ha)						
Anab-e-Shahi and other seeded grapes	**April**	**May**	**June**	**October**	**November**	**December**	**January**
N	150	50	-	100	100	100	
P_2O_5	200	100	-	200	-	-	-
K_2O	-	-	300	100	200	200	200
Thompson Seedless and other seedless grapes	**April**	**May**	**June**	**October**	**November**	**December**	**January**
N	100	-	-	100	50	50	-
P_2O_5	200	100	-	200	¬	-	-
K_2O	-	-	300	100	200	200	200

Irrigation

Grape is a shallow feeder. Light and frequent watering is better for grapes. Water requirements of grape are very high during berry growth. This period coinciding with hot and dry weather, more water is required at this stage. Least water is required during fruit-bud formation. This period if coincides with cloudy weather and rains, watering are totally to be stopped. Reduced irrigation during ripening, i.e. (one month prior to harvesting) improves the quality of grapes and hastens the ripening.

The quantity of water to let through drip irrigation daily depends not only on the stage of growth of the vine but also the evapotranspiration in a vineyard. Putting these two factors together the water requirement of grapes through drips is given in **Table**

Table 3. Water requirement of grape through drip irrigation

Stage of growth		Water required/ha (litres/day)
1-40	days after summer pruning	48,000-60,000
41-100	days after summer pruning	24,000-32,000
101	days after summer pruning to winter pruning	15,000-20,000
1-45	days after winter pruning	20,000-24000
46-75	days after winter pruning	16,000-20,000
76¬100	days after winter pruning	48,000-60,000
111	days after winter pruning untill harvesting	36,000-48,000
	After harvesting untill summer pruning	20,000¬24,000

Use of growth regulators

Growth regulators-CCC, GA and hydrogen cyanamideare being used commercially in grapes. The CCC is used to suppress the vigour of vines and increase the fruitfulness of buds. It is sprayed at 500 ppm concentration at 5-leaf stage after back pruning. If weather is cloudy, cool and rainy, it is sprayed on the foliage once again at 10-leaf stage. Gibberallic acid (GA) is used invariably in all seedless varieties. It is

sprayed at 10 ppm to elongate the clusters, 22–25 days after forward pruning (4–5leaf stage). It is also sprayed on clusters @ 40ppm at 50% bloom stage for thinning the berries. For increasing the berry size, the clusters are dipped in 60ppm GA alone or in a mixture of GA (30ppm) with 10 ppm BA at pearlmillet or *bajra* grain-sized berries and again at redgram sized berries. Care must be taken not to treat the clusters with GA before *bajra* grain-sized berries. Otherwise, berries of uneven size form a cluster. For increasing berry size, vines are girdled. Girdling is a process of removing 2–3mm wide strip of bark around the stem without injuring the wood. This is also to be done at the *bajra* grain-sized berries.

Hydrogen cyanamide is used to hasten and increase the bud-break at winter pruning. Buds are swabbed with cotton soaked in 1.5% solution of hydrogen cyanamide 48 hr after pruning. Hastening the bud-break with hydrogen cyamide also hastens the ripening of grapes in the north. Thiourea (4.0%) mixed with 1% Bordeaux mixture is also used to increase bud-break in south.

Harvesting and Postharvest management

Grapes are harvested when fully ripe, since they do not ripen after harvesting. In seeded grapes, the seeds become dark brown when they are fully ripe, while in seedless varieties, their characteristic berry colour develops fully.

The yield potential of grape in India is highest in the world. Grape variety Anab-e-Shahi has recorded yield as high as 92 tonnes/ha, whereas Thompson Seedless has 48 tonnes/ha. The average yield of Anab-e-Shahi and Bangalore Blue is 40–50 tonnes/ha, while that of seedless varieties is 15-20 tonnes/ha.

Grapes should be harvested during cool time of the day. Harvested grapes are trimmed, graded and packed. For local markets, grapes are packed in bamboo strip baskets using newspaper and grape leaves as cushioning material. One basket contains 6 kg of grapes. For distant markets (within the country), wood or corrugated cardboard boxes are used for packing. Old newspapers, hay and paper shreds are used as cushioning material. The size of packing is 6 or 8 kg in wood boxes, and 2 or 4 kg in cardboard boxes. Transport of grapes is mainly by trucks. Grapes are exported to middle-east, Europe and South Asian countries. Grapes are packed in ventilated cardboard boxes using dual release sulphur dioxide releasing pads (grape guard) as an in packing material to check the postharvest diseases during transit and storage. Strict cold chain is maintained right from harvesting by precooling and cold storage. Boxes are stored at 0°–1°C temperature and 90–95% relative humidity in cold storage. They are transported by sea in refrigerated containers.

Most of the grapes produced in India, irrespective of variety, are consumed fresh. Negligible quantities of Bangalore Blue are crushed to make juice and wine for household consumption. Wine is also produced in India with French collaboration by some private industries growing certain French varieties.

Raisins are the only processed products in India. Approximately 30% of seedless grapes are dried to produce 15,000 tonnes of raisins. Golden bleached raisins are produced by shade drying the clusters after dipping in either boiling solution of sodium hydroxide (0.2–0.3%) and exposing to sulphur fumes. Dipping in soda oil (dipping oil) containing ethyl oleate and potassium carbonate and shade drying is the most common method of preparing raisins in India.

Seeded grapes of Anab-e-Shahi are also dried in very small quantities to make raisins.

Production:- 15-20 t/ha (Highest of world)

Diseases:- Powdery Mildew, Downy Mildew, Anthracnose.

Physiological disorders

Uneven ripening, post-harvest berry drop, flower-bud and flower drop and pink berry formation are major ones.

Uneven ripening

Presence of green berries in a ripe bunch of coloured grapes is called uneven ripening. It is a varietal character and a problem in Bangalore Blue, Bangalore Purple, Beauty Seedless and Gulabi grapes. Within a variety this problem varies from bunch-to-bunch. Generally inadequate leaf area, and non-availability of reserves to a developing bunch is the reason. Cultural practices like cluster thinning, girdling and use of growth regulators can reduce uneven ripening. Application of Ethephon (250 ppm) at colour break stage is recommended to reduce the problem.

Postharvest berry drop

This is due to weak pedicel attachment to the berries. This is common in Anab-e-Shahi, Cheema Sahebi and Beauty Seedless. Spraying of NAA (50 ppm), a week prior to harvesting can minimize the post-harvest berry drop.

Flower-bud and flower drop

When panicles are fully expanded, the flower-buds drop before the fruit set. This is common in north India but not in the south. The reasons for this disorder are not known. Stem girdling about 10 days prior to full bloom can reduce the problem.

Pink berry formation

It is a common disorder in Thompson Seedless and its clone Tas-A-Ganesh in Maharashtra. Pink blush develops on a few ripe berries close to harvesting. The pink colour turns to dull red colour and the berries become soft and watery. They do not stand for long after harvesting.

Although the definite cause of the disorder is not known, it is recommended to spray a mixture of 0.2% ascorbic acid and 0.25% sodium diethyl dithiocarbamate at fortnightly intervals commencing berry softening.

5.PAPAYA

B. N. : ***Carica papaya*** **Fruit : Berry**
Family : Caricaceae **Edible parts : Meso carp**
Origin : Tropical America **X : 9, 2n – 18,36**

Introduction

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

Papaya *(Carica papaya)* also called papaw or pawpaw, is a quick growing, typically single-stemmed, short-lived, large perennial herb. Branching may occur with age or if the apical growing point is damaged and can bear fruits for more than 20. Though not economical from commercial point of view. It is now distributed throughout tropical and subtropical regions of the world. It is a highly problematic, complicated and interesting fruit crop from botanical genetical, cytogenetical and horticultural points of view.

Composition and uses

Composition

Papaya is a very wholesome fruit. It ranks second only to mango as a source of the precursor of vitamin A. While this vitamin is generally associated with carotene, the yellow pigment in the papaya is not carotene but caricaxanthin. Cultivar differences and geographic effects on the carotenoid composition and vitamin A value of papaya have also been reported, ß-cryptoxanthin (8.1 ug/g) is the major pigment representing 62% of the total carotenoid content in the yellow/orange fleshed common cultivars. In red fleshed cultivars, lycopene is the major pigment accounting for 61% of the total in Solo. Fruits of cv. Formosa from Bahia, (warmer climate) contained higher amount of ß-carotene, ß-cryptoxanthin and lycopene than fruits from Sau Paulo, Brazil.

Current status

1. Papaya is thermo sensitive crop. So frost is the limiting factor for papaya cultivation
2. Area of papaya is 60,921 ha & production is 13.29 lakh tonnes.
3. It is limited to as an intercrop
4. It is cultivated for fresh fruit and papain production
5. Leaf curl and mosaic are serious viral disease whereas root rot and crown rot are important fungal disease.
6. PRSV devastating disease of papaya in N. western & N. eastern part, but is not notice to tropical value

Uses

1. Papaya has higher nutritional values and is the second rich in Vit. A after mango
2. The ripe fresh fruits of papaya are eaten throughout the tropics and subtropics.
3. They are used in preparation of jam, soft drinks, ice-cream flavouring, crystallized fruits and in syrup. Unripe fruits are commonly used as vegetable for cooking.

4. The seeds are also used for their medicinal value.
5. The young leaves are eaten in Java as vegetables.
6. Papain. prepared from the dried latex of immature fruits is a proteolytic enzyme similar in action to pepsin and is used as meat-tenderising preparation; in manufacture of chewing gum and cosmetics as drugs for digestive ailments; in the tanning industry for bating hides; for degumming natural silk and to give shrink resistance to wool. The dried and powdered latex had a protcolytic activity slightly higher than that of the fresh latex.

Origin and distribution

The papaya is an important fruit of tropical and subtropical regions of the world. It is a native of tropical America and was introduced in India in the 16th century. The papaya cultivation is confined to 32°N and S latitudes of die equator on the globe. It is now grown in all the tropical and subtropical countries like Australia, Hawaii, Taiwan, Puerto Rico, Peru and Florida, Texas, California in the USA, Gold Coast, various parts of Central and South Africa, Pakistan, Bangladesh and India.

According to Ram (1996), the cultivated papaya might have originated as a cross between two species of the genus *Carica* native to Mexico. It is closely related to *Carica peltata* which occurs in this area, and may have arisen by hybridization, It was taken by the Spanish to Manila in the mid-16th century and reached Malacca shortly afterwards. From there it was brought to India. The exact date of introduction of papaya to the Hawaiian islands is still obscure. It might have been introduced in between 1800 and 1823 by Don Moris, the Spanish horticulturist who settled in Hawaii or it came to the islands via Asia and the South Sea islands before the Europeans appeared there (Ram, 1996). *C. pubescens* (mountain papaya) probably originated from the South American Andean highlands. It is mainly cultivated in Chile, and to a lesser extent in Colombia, Ecuador. Peru, Venezuela, Hawaii. New Zealand and India (Scheer and Ludders, 1997). The area and production of papaya in different states of India are presented in Table

Area and production of papaya in different states of India

State	Area (000 ha)	Production (000 tonnes)
Assam	7.27	109.6
Bihar	3.76	45.12
Gujarat	3.21	127.51
Karnalaka	5.47	476.07
Kerala	12.79	55.31
Maharashlra	1.67	15.09
Orissa	13.98	181.20
West Bengal	5,50	166.50

Indian Horticulture Database, National Horticulture Board 2010, Govt of India

Climate and Soil

Papaya is a tropical fruit. However, it also grows well in the mild subtropical regions of the country up to 1,000m above mean sea-level. Temperature is one of the most important climatic factors which determine the success of papaya culti¬vation. Night temperature below 12°-14°C for several hours during winter season affects its growth and production severely. High temperature also adversely affects yield during anthesis and dry spell during 2nd flush of papaya. Optimum temperature is 21-33 °C, high temperature induce maleness. Night temperature below 12-14 °C in winter affects the growth & yield. It is very much sensitive to frost, strong winds and water stagnation.

Best fruit quality in low humidity i.e. 60% is optimum, water stress causes chlorosis of older leaves followed by shedding of leaves which reduce future water loss from young leaves.

It can grow in a wide variety of soils, provided these are well-drained and aerated. A rich, well-drained sandy loam soil is ideal for its cultivation. It grows well in deep, rich, alluvial soils on banks and deltas of big rivers of India. Papaya can also be grown in calcareous and stony soils provided with heavy dose of organic manures. Soils with high pH (8.0) and low pH (5.0) should be avoided.

Species and Varieties

- It contains four genera and 31 species
- Edible fruits are found only in carica fruits of *C. papaya*
- Other spp. are known as mountain papaya, grown to height of 10 m. Produced multisided fruits through out the year which are rich in juice and Vit. C & A.
- *C. rathrocarpa* is similar to *C. papaya*, but fruit has red flush, while *C. quuercifolia* produce fruit in cluster of small fruit and *C. gracilis* ornamental spp.
- *C. monoica* is monocious plant susceptible to virus, grown in Amazon basin.

Varieties

A large number of varieties are cultivated. As a matter of fact many of these are not real varieties since these cannot be relied upon to reproduce the parental char¬acters in all their progenies. However, well-known varieties with certain specific plant and fruit characters are described below.

Pusa Delicious

It is a gynodioecious variety with 100% productive plants with good fruit yield and quality having excellent taste and good flavor.

Pusa Majesty

This is also gynodioecious variety with high productivity and better keeping quality of fruits. This is also one of the highest papain yielder.

Pusa Giant

This is a vigorous variety and is dioecious in nature. The plants are sturdy and tolerant to strong winds. The fruits are suitable for tooty-fruity and candies like *petha.*

Pusa Dwarf

It is a dwarf-statured dioecious variety with good yield. Fruits are medium-sized with oval shape and are preferred by consumers.

Pusa Nanha

An extremely dwarf variety, it is suitable for kitchen gardens, pot and roof-top cultivation. This is ideal for high-density orcharding.

CO 1

A dwarf and dioecious variety. Fruits are medium-sized with spherical shape.

CO 2

It is medium-tall, dioecious variety, having good fruit quality with high papain content. It is predominantly cultivated for papain production.

CO 3

It is a gynodioecious variety with tall, vigorous trees. The fruits are medium-sized, with high sugar content and red coloured flesh. This is preferred for dessert.

CO 4

It is a dioecious variety with medium-tall, vigorous trees. There are purple tinges on the stem, petiole and leaf. It is suitable for home-gardening.

CO 5

It is a selection from Washington variety, cultivated mainly for papain pro¬duction. It yields l,500-l,600kg/ha of dried papain.

CO 6

A selection from Pusa Majesty, it is dioecious having dwarf stature. It produces large-sized fruits. It is recommended both for papain and dessert purposes.

Coorg Honey Dew

A selection from Honey Dew, it is a gynodioecious variety having excellent fruit quality under south Indian conditions.

Pink Flesh Sweet

It is a selection with excellent-quality fruits. Fruits are medium sized with pink flesh, The TSS is 12-14° Brix. It is a good dessert variety.

Pant 1

Its plants are dioeciously providing medium-sized fruits. It is recommended for *tarai* area in Uttar Pradesh.

Sunrise Solo :

This is a gynodioecious variety having pink flesh and good taste.

Taiwan :

This is also gynodioecious variety with blood-red coloured flesh and good taste.

Flowering and sex expression

- Polygamous in nature which contains three sex, male, female & hermaphrodite (Staminate, pistilate & hermo.)
- Pistilate flower is stable which is not reversal even in environment condition.
- Male flowers are devoid of functional pistil
- Maleness in papaya is controlled by satellite chromosome
- Ten stamens, arranged in two groups of five each are attached to the corolla tube of male flower
- Hermaphrodite in three groups, Inter media, Elongata, Pentandrin
- The elongate is normal bisexual

Types of flowers

1. Gynodiocious : Pistillate and hermo. on different plants
2. Gynomonocious : Pistillate and hermo. on same plants
3. Androdioeciou : Staminate and hermo. on different plants
4. Andromonocious : Staminate and hermo. on same plants

Propagation

Papaya is commercially propagated by seed. Gynodioecious varieties breed true-to-type and are preferred by commercial growers. Tissue culture or micro propagation are recent techniques for propagating papaya. These, however, need to be standardized. Since papaya is commercially grown by seed, production of quality seed is most important for successful production and establishing papaya-based industries in the country.

Cultivation

Sowing

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

The seeds should be sown 1cm deep in rows 10cm apart and covered with fine compost or leaf-mould.

Light watering should be done with water can in the morning. The nursery-

beds may be covered with polythene sheet or dry paddy straw to protect seedlings. Tender seedlings should also be protected from heavy rainfall. Dusting of insecticides to protect the seedlings against insect pests is also advised. Damping off is most serious disease. Treating seeds with 0.1% Monosan (phenyle mercury acetate), Ceresan, Agrosan or Thiram dust before sowing is the best preventive measure to check it. The nursery-beds should also be treated with 5% formaldehyde solution before sowing. If disease appears in the nursery, Bor¬deaux mixture (1%) or copper oxychloride (0.2%) should be sprayed.

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

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

Field preparation

Since papaya does not withstand water logging, a well-drained upland should be selected for its cultivation. Its plants are also sensitive to strong winds. In open and high-lying areas, where plants are exposed to strong winds or storm, suitable windbreaks are essential to protect them. Such windbreaks also save the trees to a great extent from damage caused by cold winds or frost.

The seedlings are planted in pits of 60cm x 60cm x 60cm size. The pits are dug about 15 days before in summer and filled with top soil along with 20kg farmyard manure, 1kg neem or karanj cake and 1kg bone-meal or fish-meal. Tall and vigorous varieties are planted at greater spacing, while medium and dwarf ones at closer spacing.

Planting

Time

Papaya is planted during spring (February-March), monsoon (June-July) and autumn (October-November). Spring planting is done in areas where the climatic condition is mild throughout the year. Monsoon planting is preferred in the frost-prone areas, and autumn planting generally done in the regions where the rainfall is high and virus problem is acute in rainy season. Plants are protected against frost damage by covering them with a polythene-sheet.

Planting distance

It is determined by the integration of light interception, cultivar and economic consideration. A spacing of 1.8m x 1.8m is normally followed for most of the cultivars. A closer spacing of 1.33m x 1.33m (5,609 plants/ha) is optimum for variety Coorg Honey Dew. The spacing of 1.4m x 1.4m or 1.4m x l.6m is best-suited for papaya Pusa Delicious under subtropical condition of Bihar. Spacing of 1.6m x 1.6m gives highest yield of fruits as well as papain in Tamil Nadu. A closer spacing of 1.2m x l.2m for Pusa Nanha is adopted for high-density orcharding, accommodating 6,400 plants/ha.

Planting method

Planting of papaya seedlings should be preferred in the evening. The seedlings from nursery-beds are lifted with a ball of earth and planted in the field. Plants raised in polythene bags are planted after removal of polythene. Three seedlings should be planted in each pit followed by light irrigation. Only one seedling may be planted with

pure gynodioecious varieties. It is also important to keep some extra plants reserved in the nursery or in polythene bags for gap filling in the field.

After care

Proper care should be taken to save the seedlings in the field especially against insect pests and heavy rainfall in early stage. In frost-prone areas, they should be protected with small thatches or polythene structure. Some extra seedlings reserved in the nursery may be utilized for gap filling.

Since sufficient space is available between rows, papaya-based cropping sys¬tems (sequential and intercropping) are most remunerative. Papaya + tobacco intercropping in north Bihar is ideal. It is advised not to grow crops like chilli, tomato, brinjal and lady's finger to avoid viruses as they act like hosts. No intercrop should be taken when flowering and fruiting start. A suitable crop rotation must be followed to maintain soil fertility and to avoid replant problem.

Intercropping

- Intercropping leguminous crops after non-leguminous ones, shallow-rooted crops after deep rooted ones are beneficial.
- Papaya based system, Papaya + Tobacco in Bihar
- Not to grow chilli, tomato, brinjal & Okra to avoid viruses as they acts like hosts.
- No intercrop at flowering & fruiting start.

Weed control

Weeds grow luxuriantly in papaya fields and exhaust most of the applied nutrients. In the beginning, they also compete for light, air and water, resulting in poor fruiting. Deep hoeing is recommended during first year to check weed growth. Hoeing should not be done in rainy season or after fruiting since its plants are shallow-rooted. Overgrowth of weeds also causes water logging condition and makes the plants vulnerable to root-rot and foot-rot in rainy season. Therefore weeding should be regularly done, especially around the plants. Application of Fluchloralin or Alachlorin or Butachlorine (2.0g/ha) as pre-emergence 2 months after trans¬planting can control all weeds for 4 months.

Removing unwanted male plants

It is necessary to keep 10% male plants in papaya orchards for good pollination, where dioecious varieties are cultivated. As soon as the plants flower, extra male plants should be uprooted. The hermaphrodite plants produce good-quality fruits and should not be confused with male plants while removing them from the orchard. Weaker and diseased plants should be uprooted, after ensuring 1 plant/pit. Ear thing-up should be done 30cm in radius around the plants on or before the onset of monsoon to avoid water logging. It also helps plants to stand erect.

Manuring and fertilization

Papaya is a heavy feeder and needs heavy doses of manures and fertilizers. Apart from the basal dose of manures applied in the pits, **FYM 30 kg, 200g each of N and 200 g P_2O_5 and 125g K_2O (N four split P two split FYM and K basal)** are recommended for getting high yield. Application of 250g N is optimum for fruit yield but papain yield increases with increase in N up to 300g. A dose of 250g N, 250g P and 500g K/plant is recommended for papaya Coorg Honey Dew under Bangalore conditions, while 200g each of N, P and K in split doses in the first, third, fifth and seventh month is recommended for papaya CO 1 under Coimbatore conditions.

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

Irrigation

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

Generally basin system of irrigation is used but care is taken to avoid water stagnation around the plant. In low rainfall area, where the water is scarce, sprin¬kler or drip system can be adopted.

Papaya plants are very susceptible to water logging. Even 24 hrs stagnation with water may kill the well-established plants. Therefore it is most important to select upland for papaya plantation. It may further be shaped sloppy in heavy rainfall areas to make a few furrows or trenches for quick and complete drainage of water during rainy season.

Pot cultivation

Papaya can also be grown in big pots. Half cut iron drums and wooden crates can also be used for this purpose. The size of pot should not be less than 75cm x 40cm. Papaya seedlings can be raised in August-September. The polythene bags used for raising seedling should be filled with one-third part each of sand, compost and soil. The seeds should be sown 1cm deep with 5-6 seeds in each bag. It should be watered regularly with watering can. When seedlings are 10-15cm high they should be planted in pots already prepared during October-November. At least 4 plants in each pot should be planted. These are thinned down to one after removing male and other diseased or weaker plants.

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

Harvesting and post harvest management

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

The post-harvest losses in papaya has been estimated to be between 5 and 25% in Costa Rica and up to 75% in Hawaii. These losses are often blamed on mechanical damage, chilling injury and degree of ripeness. The occurrence of sunken, green patches of skin on fully ripe fruits appeared to be induced by mechanical injury. It has been suggested that the use of liners in the field bins may reduce skin injury caused by

abrasion and puncture.

Packaging and transport

Commercial trade of papaya between Hawaii and the mainland of the USA is signifi¬cant. The fruits from Africa are transported to Europe by air and sea. Fruits are packed in bamboo baskets for local market. For long distance transport they are packed stem end down in single-layer in wooden crates or fibreboard containers padded with cushion materials (paper or wood wool) at the bottom, sides and between fruits. For local consumption the fruits after harvest, are stored in a single layer of straw for better colour development. For sea shipment, papayas are held at 8°C and storage for up to four weeks is possible at this temperature for fruit of minimum maturity at harvest (Marriott and Proctor, 1982). Almost 56.5% of the growers in Costa Rica employed bulk transport, usually consisting of 3 or 4 layers of fruit in the truck The most common fungal disease caused by *Cottetotrichum gloeosporioides* was found to spoil the fruits during storage and it could be controlled by immersion in hot water (50°C) for 20 minutes.

Ripening and storage Ripening

The papaya fruit was classified as climacteric. Ethylene peaks were recorded when fruits were still green (before colour-break), whereas respiratory peaks were associated with colour-break. Ripening was characterized by an increase in the activities of enzymes.

Storage

Room temperature (28°-32°C) was found to be practically unsuitable for storage of fruits. A temperature between 13 and 16^0C has been reported to be adequate for storing papaya. Low temperature (7°C and below) caused chilling injury to fruits. Temperature above 20°C made the fruit susceptible to fungal attack, while at lower temperature the onset of the climacteric respiration was delayed and chilling injury was manifested. Fruits stored continuously at 17°C, showed delayed ripening over fruits held at 20°C and exhibited reduced development of yellow skin colour.

Physiological Disorders

Skin freckles

The cause and factors that influence this disorder are unknown. Freckle-like blemishes occurred on ripe papaya fruits (cv. Sunset). Young fruits (less than 40 days old) were free from freckle. The freckle diameter increased during the last phase of fruit growth as the fruits approached maturity.

More freckles were seen on the exposed side of the fruit away from the stem. Faruit freckle index and freckle diameter were lowest during the late summer-autumn part of the year. Wrapping young fruits in white paper bags significantly reduced freckle incidence.

Dieback

It is a severe problem for the Queensland industry, although the cause of this disorder is still unknown. The plants displayed a brown discoloration of the vascular tissue, developed external symptoms that initiated in the stem zone which supported leaves that developed acropetally into the stem apex and basipetally into the trunk and in part of the root system. The discoloration was auto fluorescent under blue or ultraviolet light and was associated with laticifers in xylem and phloem tissue and in ray paren¬chyma. It is suggested that low calcium content represents a secondary symptom of the disorder.

Papain

The immature papaya fruit contains a milky latex. The dried latex called “papain” is in great demand in the international markets,particularly in the UK and USA. Papain has several uses in the industry as an essential ingredient in pharmaceutical, textile and tanning industries. Papain is used in tenderising meat; for clearing beer; in the manufacture of cosmetics like snow and face creams and also dental paste; in degumming silk and rayon; in the pre-shrinking of wool. It has also several uses in the medical field in the treatment of necrotic tissues, dyspepsia and other digestive ailments, ring worm and round worm infections, skin lesions and ulcers, eczema and other skin diseases and in kidney disorder. Papain is used in detecting stomach and intestinal cancers and also in correcting diphtheria.

Papain production is influenced by several factors :

1 Fruit size
2 Fruit maturity
3 Season
4 Cultivars
5 Growth regulators

Papain extraction

Papaya fruits, which are about 90-100 days old (fully mature but not ripe) are selected for tapping. In the morning hours before 10.00 a.m., four longitudinal incisions are given on the four sides of the selected fruit from the stalk end to the tip. The depth of the incision should be about 0.3 cm. On incising, the latex starts flowing and this is collected in suitable containers (arecanut spathes. aluminium trays or glass vessels).

Care should be taken not to use any other container for papain collection, since it will react with papain rendering it unfit for any use. The latex that solidifies in the cuts should also be scrapped carefully and added to the liquid latex. This process of making four incisions in the untapped fruit surface at 3 to 4 day intervals is repeated thrice or four times over a period of 12 to 16 days. The latex thus collected every time should be dried in the sun or in driers at temperatures ranging between 40 and 60°C. The time taken for the fresh latex to dry (solar drying) varied from about 1.5 to 36 hours. Potassium metabisulphite (0.05%) is added to the liquid latex in small quantities before it is dried, since this helps to extend the storage life of papain. The drying of papain is continued until it comes off in flakes having a porous structure. The dried papain is powdered, sieved in a 10-mesh sieve and stored in polythene bags or in any other suitable container. The latex, whether dripped or congealed, dried as pale yellow flakes which could easily be powdered and had a proteolytic activity slightly higher than that of the fresh latex. The biochemical analysis of fruits revealed that latex extraction has no effect on the quality of fruits.

Papain yield

Saniival (1931) reported that a papaya tree would give 8 oz (227 g) of papain and Sankaram (1942) stated a yield of 1/3 lb (151.3 g) of crude papain from a plant or 175 lb (79.45 kg) per acre. Sanders and Robertson (1944) estimated 60 to 100 lb (27.24-45.4 kg) per year as the acre yield of papain. Virendrakumar (1952) reported that the yield of papain was about 100 lb (45.4 kg) per acre while Singh and Tripathi (1957b) estimated 60 to 75 lb (27.34-34.0 kg) per acre. Muthuswamy *et al.* (1962) found the papain yield to range from 1.23 to 7.45 g per fruit in 9 cultivars, the cv. Washington recording the highest mean yield of 7.45 g per fruit.

Pest and Diseases :

DISEASES	MANAGEMENT

Powdery mildew	Wettable Sulpher 1g/liter
Damping Off	Captan 2g/kg
Anthracnose	Carbandazin 1g/liter
Stem rot or foot rot	Carbandazin 1g/liter
PEST	**MANANGEMENT**
Fruit fly	Dimethoate 0.045%
Aphid	Dimethoate 0.3%
Stem borer	Do
Red spider mite	Do

6. SAPOTA

B.N.:- ***Manilkara achras*** **(Mill.) Fosberg** **Origin :- Tropical America**
FAMILY :- SAPOTACEAE

SAPOTA or Sapodilla *(Manilkara achras),* popularly known as *chiku,* is an impor¬tant fruit. Native to tropical America especially from south Mexico or central America, this species is mainly grown for its chickle, "the gutta parcha" extracted from its latex from stems. It is used as a base material in chewing gum and the some other industrial uses. However, in India it is cultivated for its delicious sweet fruits. The fruit is fleshy berry, variable in shape, size and weight (75-150g). The skin is thin, rusty brown somewhat scurfy looking like Irish potato, and the pulp soft, melting, crumbling with a sandy or granular texture with 1-5 hard, black seeds. The fruit is a good source of digestible sugar (12-18%) and an appreciable source of protein, fat, fiber and minerals, Ca, P and Fe. It has become most popular fruit crop in Gujarat, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and Kerala,

CLIMATE AND SOIL

Sapota, a crop of tropical region, needs warm (10°-38°C) and humid (70% relative humidity) climate where it flowers and fruits throughout the year. However, it taken to sub tropics or higher elevation like in Punjab and Haryana, it gives only one crop from summer flowering in April and May. Under moisture-stress also, it produces one crop only.

VARIETIES

There are about 41 varieties spread all over the country. However, commercially sapota industry is based on a few varieties and in some areas it is only monoculture like Kalipatti in Gujarat and Maharashtra. Distribution of cultivars according to region is given in Table.

Table : Distribution of sapota cultivars in India

State	Cultivars
Andhra Pradesh	Pala, Kirtibarthi, Cricket Ball, Dwarapudi and Guthi Jonavalasa
Gujarat	Kalipatti, Bhuripatti, Pilipatti, Dhola Diwani, Jhumakhia and Cricket Ball
Maharashtra	Kalipatti, Cricket Ball and Murraba
Karnataka	Kalipatti, Cricket Ball, Kirtibarthi, DBS 1 and DHS 2
Tamil Nadu	Guthi, Kirtibarthi, Pala, Co 1, Co 2 and PKM 1
Others	Cricket Bal], Calcutta Special, Round, Oval and Baramasi

PROPAGATION AND ROOTSTOCK

Sapota is propagated through seed, which has been the basis of its variability in India. But inarching using *rayan* as rootstock, air-layering and softwood cuttings, using IBA (2,000 ppm) treatment are successful methods of propagation. However, plants raised through air-layering or cuttings establish poorly and are vulnerable to wind damage. However in west-coast, air-layering is common and such plants perform better in shallow soils. For air-layering, 1-2 years old 45-60cm long juvenile matures shoots of pencil thickness with plenty of healthy dark green leaves are selected. On the base of such shoots a ring of bark (2.5-3 cm wide) is removed on which IBA + NAA (10,000 ppm) each in lanolin paste is applied, covered with rooting media like sphagnum moss,

vermiculite or garden soil and wrapped with plastic. In 3 months, roots emerge, then layers are slowly separated and establish in nursery. They are planted in the next season.

Sapota on *rayan* is the best in respect of plant vigour, productivity and longevity. Propagation of sapota by inarching using *rayan* as rootstock is the most accepted method of its commercial cultivation. Two years old potted *rayan* plants with pencil thickness are utilized and grafting is done in December-January. The plants are ready for separation in June-July of following year. This method is tedious, cum¬bersome and time-consuming. Softwood grating using *rayan* as rootstock gives 93% success *in-situ.* It is an economically viable, faster, efficient and best technique. July-August is ideal time for it. Since detached scion is used in this method, it is possible to store scion sticks in banana sheath to help exchange of plant material.

CULTIVATION

Planting

Since sapota is a crop of warm and humid tropics, it can be planted in any season provided irrigation facilities are available. But it is beneficial to plant the grafts in beginning of the rainy season. In areas having heavy rainfall, it can be planted in September. In light soils, pits of 60cm x 60cm x 60cm size, whereas in heavy and gravely soils pits of 100cm x 100cm x 100cm size are made in April-May and exposed to sun for 15 days. Top 30cm soil is mixed with equal quantity of well-rotten compost or farmyard manure, 3kg superphosphate and 1.5kg muriate of potash are used for pit filling. To begin with all sides and bottom of the pit are dusted with 5% BHC dust and pits mixture is added to fill the pit and remaining vacant space is filled with remaining soil to a height of 15cm above soil surface. Such pit are left to monsoon rains for settling and then planting is done at appro¬priate time. At the time of planting, a small hole sufficient to accommodate the ball of soil and roots of grafts is made in the centre of the pit and planted with scion in the direction of heavy wind to avoid damage to joint.

After planting, soil around the plant is gently and firmly pressed and stakes are provided to avoid wind damage. Planting should preferably be done in the evening to avoid sun heat. The plants are then lightly watered. Young plants should also be protected against sun scold by providing dry grass thatch on top and three sides excepting the south-east for sunlight. Such well-cared plants establish fast.

Since sapota tree makes uniform all-round growth, square system of planting is recommended. However, in land with 5-15% slope, contour planting is recom¬mended. Depending on growth habit, sapota orchards are planted at 10m x 10m but being slower in growth, it takes longer period to occupy allotted space. There¬fore, high-density plantations having 5m x 5m spacing up to the age of 13 years are very remunerative. Thereafter yields begin to decline.

Training and pruning

A seedling tree grows excellently giving a shape of an umbrella. However, plants raised through inarching require training for appropriate shape and frame¬work development. No definite system of training has been developed for sapota. Most trees are trained in central leader system.

Sapota being an evergreen tree requires no regular pruning but regulation of vegetative growth to improve productivity and quality of fruits is necessary. At times thinning of branches is affected in old plantation. Pruning in sapota is con¬fined to open the tree to light, and removal of dead and diseased branches.

Manuring and Fertilization

Owing to evergreen nature of the plant, any inadequacy in its nutrition leads to sub-optimal yield. Deficiency of N leads to yellowing of leaves from margin to mid-rib. The P-deficient plants have purplish flecks on lamina with rusty pigmen¬tation all over and inadequacy of K is marked by development of chlorotic symptoms along leaf margins which become dark grey in advanced stage. Zinc deficiency is marked by small and erect leaves, short internodes and defoliation of terminals, whereas in calcareous soils Fe deficiency causes general yellowing of leaves with premature shedding.

A dose of 50kg farmyard manure, l000g N, 500g P_20_g and 500g K_2O/tree/year is optimum. This quantity can be regulated on the basis of age of tree and status of nutrients in soil especially of P and K. Under rainfed conditions, dose of N should be raised to 1.5kg/tree. Castor cake is beneficial for high-quality fruits, The nutrient doses prevalent in the country are given in Table.

Under rainfed condition, fertilizers should be applied before the onset of monsoon. However, under irrigated conditions it should be applied in 2 splits. Total quantity of organic manure and half of chemical fertilizers should be applied at the beginning of monsoon and remaining half in the post-monsoon period (September-October).

Since 90% of active roots are distributed within drip up to a depth of 30cm, nutrients should be applied under tree canopy and mixed thoroughly in soil up to a depth of 15cm, In Zn and Fe deficiency, the requirement should be met through application of organic manures and spraying of $ZnS0_4$ and $FeSO_4$, (0.5%).

Table : Fertilizer doses for sapota (per tree)

State	Farmyard manure	N (g)	P_2O_5 (g)	K_2O (g)
Andhra Pradesh	50.00	400	160	450
Assam	1.25kg bone-meal+ 8kg castor cake			
Gujarat	**50.00 caster cake**	**900**	**450**	**450**
Karnataka	50.00	400	160	450
Kerala	55.00	500	360	750
Madhya Pradesh	50.00	500	250	125
Maharashtra	30.00	500	-	-
Orissa	15.00+200g stera meal	45	150	-
Tamil Nadu	50.00	750	640	1,200

Aftercare

Depending on growth habit of sapota tree a planting distance of 10 m x 10 m is ideal. Being a slow-grower, it takes longer to occupy allotted space. Therefore, intercropping is imperative. Intercropping banana, papaya, pineapple and cocoa; French bean, tomato, brinjal, cabbage, cauliflower and cucurbits is recommended depending on climate and water resources. In established orchards, pre-monsoon and post-monsoon intercultivation is recommended for better aeration and effective weed control. In young orchards, weed hazard is common. Use of 2kg Bromacil * 2kg

Diuron/ha as pre-emergence spray is effective for a period of 10-12 months. Mixed plantation with mango and guava should be avoided to reduce the problem of fruit fly.

Irrigation

Habit of tree and its vegetative growth demand continuous supply of water. But sapota is grown both under irrigated and non-irrigated conditions. Sapota requires irrigation at 30 days interval in winter and 15 days in summer. Adoption of drip irrigation system is also beneficial, saving 40% water with 70-75% higher net income.

This system should be laid out with 2 drippers spaced 50cm from tree during initial 2 years and 4 drippers at 1m from tree until 5 years of age. With dripper discharge rate of 4 litres/hr, the system should be operated for 4 hr during winter and 7 hr during summer on alternate days. Under short supply of water, timing could be 3hr and 30 minutes in winter and 5hr and 40minutes in summer.

HARVESTING AND POSTHARVEST MANAGEMENT

Maturity Indices

1. Sapota takes about 7-10 1/2 months from anthesis to maturity of fruits depending on variety and climate. Fruits follow double sigmoid pattern.of growth.
2. Properly developed fruits have high TSS and sugar, and reduced acidity, astringency, latex and vitamin C.
3. Maturity is decided on the basis of ease with which brown scruff gets off the fruit surface and development of yellowish tinge intermixed with corky-brown colour on the surface of the fruit.
4. At this stage, practically no green tissue and milky latex are seen on fruits when scratched with nails.

Harvesting methods

The fruits are hand picked or harvested with special harvester which has a round ring with a net bag fixed onto a long bamboo. Depending on management level, 15-20 tonnes fruits are harvested from a hectare.

After harvest

Since sapota is a climacteric fruit, it has to be ripen artificially. Fruits are highly perishable and they undergo rapid ripening changes within 5-7 days during which the fruits become soft, sweet and develop excellent aroma with decline in tannins, latex sapotin, aldehydes and acidity. These changes are associated with increase in production of ethylene, rate of respiration, catalase, peroxidase and PME activities. These changes can be regulated through chemicals, temperature and storage gas composition.

Harvested fruits should be cleaned of latex and scurf by washing in clean water to make them look attractive. Such fruits should be graded into big, medium and small sizes. Fruits should be tightly packed in cardboard boxes of 10kg capacity with rice straw as padding material and with ethylene absorbents and transported quickly to wholesale markets. For extending shelf-life and to avoid storage rots, fruits can be dipped in GA 300ppm + Bavistin l,000 ppm solution at prepacking stage.

For uniform and rapid ripening Ethephon (l000ppm) can be utilized at 20-25°C. Modified storage with 5-10% (c/c) CO_3 can be employed for long storage (21-25 days). Refrigerated vans (12-13°C) should be utilized for long distance and export markets.

PHYSIOLOGICAL DISORDERS

Wilt or die-back is common where sapota cultivation is being extended to

tradi¬tionally rice-growing regions. Due to anaerobic conditions in monsoon and post-monsoon season in such areas wilt is of common appearance aggravated by *Fusarium* spp. This can be controlled by effective drainage facility before planting.

The shape of fruit is related with number of seeds in it which depend on con¬ditions for pollination at anthesis. High temperature and rainfall during flowering cause oblongation of fruits. Therefore, cultivation of sapota in areas with extreme summer temperature should be avoided.

Sometimes fruits do not develop into their normal shape but develop a de¬pression or furrow towards the calyx-end. This symptom usually appears immedi¬ately after heavy rainfall and is aggravated by high intensity of irrigation. Therefore over-irrigation should be avoided.

The fruits exposed to intense sunlight do not ripen uniformly, developing corkiness during winter. This is probably due to killing of hydrolysing enzymes by alternating moisture accumulation and heating of fruit surface in winter. Thus its trees need to grow vigorously.

Pests:

(1.)***Flower bud eating caterpillar:*** 1-2 sprays of Monochrotophos. (10ml + 10 lit. water.)

(2)***Bark eating caterpillar:*** (*Inderbella*) : Bore under the bark. Pour petrol or kerosene into the hole & plug.

(3) ***Fruit Borer :*** Spray Dimethoate (30 ml + 181 lit. water)

Disease :

1. ***Leaf spot :*** Fungal disease. Kalipatti & CO-2 are tolerant. Cricket Ball susceptible. Monthly spray of 0.2% Dithane M-45.

2. ***Wilt of Sapota :*** Tree dry from bottom. Roots damaged. Drench 1% Bavistin 5-6 buckets/tree.

7. GUAVA

B. N. : *Psidium guajava* **Type of fruit : Berry**
Family : Myrtaceae **Edible : Thalamus and pericarp**
Origin : Tropical America (Maxico to Peru) **X = 11 , 2n = 22,23**

Guava *(Psidium guajava)* is a very popular fruit. It is available throughout the year except during the summer season. Being very hardy, it gives an assured crop even with very little care. Its cost of production is also low because its requirements for fertilizer, irrigation and plant protection are not much. Further its nutritive value is very high. Therefore it is an ideal fruit for the nutritional security. Guava is also grown as a backyard fruit to a great extent. Best quality guavas are produced in Uttar Pradesh, particularly in Allahabad region.

Table : Composition of guava fruits*

Constituents	Content (%)	Constituents	Content (%)
Moisture	77.9-86.9 %	Acidity	0.22-0.39
Dry matter	12.3-26.3	Ascorbic acid	75.2-234.3
Ash	0.51-1.02	Thiamine	0.03-0.07
Crude fat	0.10-0.70	Riboflavin	0.02-0.04
Crude protein	0.82-1.45	Niacin	0.20-2.32 mg/100g
Crude fibre	2.0-7.2 g/100pulp	Calcium	10.0-30.0
Reducing	2.4-5.2	Phosphorus	22.5-40.0
Non-reducing	2.5-3.8	Iron	0.60-1.39
Total sugar	4.9-10.1	-	-

Uses

Guava fruit is relished when mature or ripe and freshly plucked from the tree. Excellent salad and pudding are prepared from the shell of the ripe fruit. It can be preserved by canning as halves or quarters, with or without seed core (shells). The cv. Allahabad seedless white guavas have been reported to be more suitable for canning as halves. The guava jelly is well-known to all with an attractive purplish-red colour, pleasant taste and aroma. The common sour wild guava makes the best jelly. High quality nectar can be prepared from guava and nectar prepared from the hybrids was rated better than that of the commercial cultivars

Origin and distribution

The common guava originated, along with a number of other fruits, in tropical America and seems to have been growing from Mexico to Peru. The trees were domesticated more than 2,000 years ago. Spread rapidly throughout the world's tropics by the Spanish and Portuguese soon after the discovery of the New World, It is now cultivated in most tropical and subtropical regions of the world. It is grown in Ceylon from sea level to an elevation of 5000 feet (1515 m) and throughout Burma. At present the major guava producing countries are Southern Asian countries, the Hawaiian Islands, Cuba and India. It is believed to be introduced in India at a very early date, as it is mentioned by Burton who was in India early in the 17th century.

Guava occupied 131625 ha in India. Though it is successfully grown all over the country, the most important guava-growing states are Uttar Pradesh (18800 hec¬tares), Bihar (27296 hectares), Madhya Pradesh (6969 hectares) and Maharashtra (7676 hectares). Uttar Pradesh is by far the most important guava-producing state of India, and Allahabad

has the reputation of growing the best guava in the country as well as in the world.

Species and cultivars Species

The genus *Psidium* belongs to family Myrtaceae and contains about 150 species. The Brazilian or Guinea guava *P. guajava* var. *aromaticum* yields small size fruit while the fruits of *P. pomiferum* is round and that of *P. pyriferum* is pear-shaped in nature. The mountain guava, *P. montanum* is a shrub, about 1.5 m high, with flat round branchlets. Fruits of Chinese guava, *P. friedrichsthalianum* are small and globose in shape with high acid content}

Climate and soil

Owing to its hardy nature, guava is grown successfully in tropical and subtropical regions up to 1,500m above mean sea-level. Best quality guavas are obtained where low night temperatures (10°C) prevail during winter season. It tolerates high tem¬peratures and drought conditions in north India in summers but it is susceptible to severe frost as it can kill the young plants. An annual rainfall of about 100cm is sufficient during the rainy season (July-September). The rains during harvesting, however, deteriorate the quality.

It cultivated on varied types of soils-heavy clay to very light sandy soils. Nevertheless, very good quality guavas are produced in river-basins. It tol¬erates a soil pH of 4.5-8.2. Maximum concentration of its feeding roots is available up to 25cm soil depth. Thus the top soil should be quite rich to provide enough nutrients for accelerating new growth which bears fruits.

Varieties

The varietals characteristics in guava are not as distinct as found in majority of other fruits. Its propagation through seeds reduces the distinctive characteristics of a variety in commercial cultivation. Important guava varieties are:

Lucknow 49

Also known as Sardar, its fruits are large, roundish-ovate in shape, skin prim¬rose-yellow and pulp white, very sweet and tasty. The TSS and vitamin C contents are high. The plants are vigorous.

Allahabad Safeda

The most famous variety of Allahabad, it has acquired large variations due to seed propagation. The fruits are large in size, round in shape, skin smooth and yellowish-white. The flesh is white, firm, soft having pleasant flavour, high TSS and vitamin C content. The seeds are numerous, bold and hard. The trees are tall with profuse branching and broad crown. It can withstand drought conditions.

Chittidar

This variety is very popular in western Uttar Pradesh. The fruits are charac¬terized by numerous red dots on the skin, high sweetness, and small and soft seeds. It is otherwise similar to Allahabad Safeda fruits in size, shape and pulp. It has higher TSS content than Allahabad Safeda and Lucknow 49 but lower vitamin C content. The tree characters resemble to those of Allahabad Safeda.

Harijha

Harijha is more popular in Bihar because of profuse bearing. The trees are of medium vigour due to sparse branching. The fruit is round in shape, medium large in size and greenish-yellow in colour. Flavour is sweet with good keeping quality,

Hafshi

It is a red-fleshed guava having good taste. It is mainly grown in Bihar. Fruit is of

moderately big-size, spherical in shape with thin skin. Trees are of medium vigour but productive.

Apple Colour

Its fruits are medium-sized and pink-coloured. They are sweet in taste with good keeping quality. They require temperature for the development of good pink colour.

The trees are of medium vigour but their leaves are greener than others. However, it is a moderate-yielder.

Seedless

All the seedless varieties-Saharanpur Seedless, Nagpur Seedless and oth¬ers are the same. Two types of fruits, completely seedless and partialy seeded, are borne on a plant of seedless variety. The completely seedless fruits develop on the shoots rising from the stem and these are bigger in size and irregular in shape. The partialy seeded fruits are born on normal shoots at the periphery and are small in size and round in shape. Seedless variety is unfit for commercial cultivation because it gives very low yield. The plants are very vigorous.

Arka Mridula

This is a seedling selection of variety Allahabad Safeda. Its medium-sized fruits are of excellent quality with high TSS. The white pulp has only few soft seeds. The plants are of medium vigour but high-yielding.

Allahabad Surkha

Allahabad Surkha is an outstanding variety of large, uniform pink fruits with deep pink flesh. The plants produce up to 120kg fruits in its sixth year of fruiting. The fruit is sweet, strongly flavoured with few seeds and is slightly depressed at both ends. The plants are vigorous, dome-shaped and compact.

Propagation

Guava is propagated both by seeds and vegetative. But vegetative propagation is commercially followed.

Seed propagation

The propagation of guava through seeds should not be encouraged because the seedlings have long juvenile phase, give lower yields and bear poor quality fruits. But the seedlings serve as rootstock material for grafting or budding. The seeds should be sown as soon as possible after extraction from the ripe fruits. Soaking of seeds in water for 12hr or in hydrochloric acid for 3 min. gives about 90% germination. About 1-year-old seedlings become ready for grafting or budding. For planting seedling, seeds should be collected from the plants producing high-quality fruits and high yield.

Vegetative propagation

In northern India, guava is propagated by inarching, giving a very high per¬centage of success during rainy season. But inarching is cumbersome and gives limited number of plants from the mother plant.

Budding has been adopted only on a limited scale in some parts of the country where the atmospheric humidity is high. The main problem encountered in this method is disbudding of rootstock making it labour-intensive. Among the various methods of budding-shield, forkert, patch and chip—the patch budding is ideal giving highest percentage of success. However, the best time of budding differs from locality-to-locality.

Layering is being commercially followed in the southern and western India with very good results. After bending the plant, its branches are covered with soil leaving the terminal portion open. In a few months the rooting of branches takes place which are

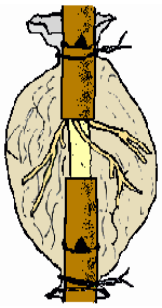
then separated from the mother plants and planted in the nursery for further sale. Layering is a labour-intensive method. A limited number of plants can only 'be multiplied from a mother plant.

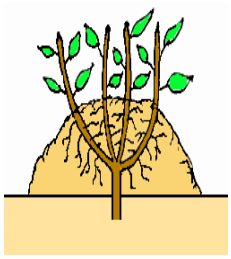
When mother plants are very tall, air-layering of shoots is done during the rainy season using polythene and moist sphagnum moss. Use of root-promoting plant growth regulator, IBA (3,000ppm), promotes the rooting of air-layers up to 100%. The main limitation of air-layering is the poor establishment of air layers in the nursery after detachment from the mother plant. Further, the method is very cumbersome and labour-intensive.

Air layering

It is also known as pot layering, Marcottage or Gootee. For the purpose of air layering one year old or previous season shoot of pencil thickness is selected. About 5 to 7 cm away from the base of selected shoot, a girdle of 2.5 to 3.0 cm size, by removing the bark, is prepared. The girdled portion of the shoot is scrapped using gunny bag or rear side of the blade. This process helps in removal of phloem and ultimately prevents the formation of bark at the girdled portion. The girdled portion is then covered using moist sphagnum moss grass. Covering with moss grass retains better moisture at the point of air layering. The girdled portion is now wrapped using transparent polythene tape and both the ends of tape are tied air-tightly.

Depending upon of success rooting appears in about 2-3 months. When root emergence is there and it becomes visible from the transparent wrapped tape the layered shoot is separated from mother plant giving 2-3 cuts in installments. The layered plants are planted in nursery under partial shade where frequent watering is provided and high humidity is maintained. Usually air-layering is practiced in the month of July-August. Air-layering is practiced in litchi, lime, jackfruit, cashewnut, guava, Black jamun, Pomegranate etc. In case of hard-to-root type plant application of IBA at 3000-5000 strength is practicable.





Mound Layering

1. **Mound Layering:-**

Stooling is the easiest and cheapest method of guava propagation. The self-rooted plants (cuttings or layers) are planted 0.5m apart in the stooling bed. These are allowed to grow for about 3 years. Then these are cut down at the ground level in March. New shoots emerge on the beheaded stumps. A 30cm wide ring of bark is removed from the base of each shoot rubbing the cambium of the exposed portion in May. All the shoots are mounded with the soil to a height of 30cm. The soil is covered with mulch to conserve the moisture. After a period of 2 months of the onset of monsoon, the shoots are detached from the mother plant at ringed portion and planted in the nursery. The shoots are headed back to maintain the root and shoot balance before planting in the nursery.

By following the technique of ringing and mounding of the shoots, second time

stooling is done on the same mother stools in first week of September.

The rooted stool layers are detached in first week of November. Thus stooling is done twice on the same mother stools in a year. The stooling of a mother stool can be done for many years. With the advancement in its age, the number of stool layers also increases every year. The growth and development of stool layers are better than seedlings. The application of rooting hormone is not required. A semi-dwarfing rootstock for guava Aneuploid 82 has been developed.

CULTIVATION

Planting

The field for planting is prepared during summer season by ploughing, levelling and removing weeds. The pits of 1m x 1m x 1m size are dug and filled with a mixture of farmyard manure and soil. If soil is good and irrigation facilities are available, the preparation of land and digging of pits are not required. The planting is done during the rainy season by adopting square planting system.

Guava is commercially planted at a distance of 5-8m. The exact planting distance is, however, decided according to variety, soil fertility and availability of irrigation facilities. Guava Lucknow 49 needs more spacing than Apple Colour and Allahabad Safeda. Under irrigation and high soil fertility, the plants become very vigorous requiring more spacing. In normal conditions, a planting distance of 7m is optimum. High-density planting reduces total soluble solids, sugars and ascorbic acid but increases titratable acidity.

The lower plant population results in the spread of crown, while higher planting density causes erect growth of branches making the plant tall and compact. High-density planting gives higher yield/unit area in early years of fruiting.

Training/pruning

Traditionally, no pruning is done in guava because the plant bears heavily even without it. But no pruning results in the formation of narrow crotches, limb breakage due to heavy fruit load and overcrowding. Therefore, training of plants in young stage to build strong framework and to avoid weak crotches is necessary, whereas fruiting trees should be pruned to check overcrowding in the orchard, The plants should be trained as low headed trees to facilitate multiple hand pick¬ings. The open centre or delayed open centre system may be adopted. The scaffold branches in young plants are to be tipped back to encourage secondary branching.

The root suckers, water sprouts and criss-cross branches are to be removed alto¬gether. In Maharashtra, bending of horizontal branches is practised to some extent by tying the branches of 2 adjoining plants to increase fruiting in young plants but it is labour-intensive and creates hindrances in cultural operations.

In every growing season, a large number of new shoots emerge in guava a majority of which are lateral and a few are terminal. These shoots produce fruits. After 1 year most of the lateral shoots dry out, while terminal shoots put forth the extension growth. Hence, to check the overcrowding and to control the plant height, the terminal shoots on the periphery may be headed back at about 40cm level in alternate years.

Pruning also takes place during harvesting as the fruit is plucked along with the shoot on which it is borne. Pruning is usually recommended after harvesting or in spring. Summer pruning may damage the plant by sun burning.

Irrigation

Guava is mostly grown under rainfed condition and irrigation is rarely prac¬tised wherever this facility is available. However, irrigation enhances the yield of guava by

making the plant more vigorous and increasing the fruit set. Irrigation is especially desirable after planting for survival of the plants and thereafter for 2-3 years to obtain early good growth. Irrigation of fruiting plants depends upon the adoption of a particular cropping pattern. For the whole year, cropping pattern which is commercially adopted all over the country except the northern region, irrigation is given during summer and autumn season and for the rainy season crop, the irrigation is essential during summer season. Normally, winter season cropping pattern is adopted in north India which requires fortnightly irrigation during October—November. Irrigation is given to make the soil of root zone moist; thus heavy irrigation is unnecessary. The fruit quality of guava is adversely affected by high soil moisture content during harvesting.

Manuring and Fertilization

Although guava is grown without the application of any manure and fertilizer, it responds very well to their application by giving higher yield and better quality fruits. For guava-growing regions of the country, different fertilizer schedules-600g N, 400g K in northern region; 260g N, 320g P and 260g K in eastern region; 900g N, 600g P and 600g K in southern region **and 500g N, 250g P and 250g K/plant/year in western region**—have been recommended. The fertilizer application should be based on leaf nutrient status of an orchard, wherever feasible.

Time of fertilizer application depends on the crop taken and the region. In north India, fertilizer is given in the first week of May for rainy season crop and in first week of July for winter season crop. In West Bengal, fertilizers are applied in 2 equal split doses, one in January and the other in August. At Bangalore, full K and 70% N are applied in June and full P and 30% N in September. Since 48% of feeder roots of guava are found in the surface soil up to 25cm depth, the fertilizer should be placed in 25cm trenches 1m away from the trunk for better uptake.

Sometimes guava suffers a deficiency which is characterized by reduction in leaf size, inter veinal chlorosis, suppression of growth and dieback of leaders. It can be corrected by spraying of $ZnSO_4$ (0.45kg) and hydrated lime (0.32kg) in water (33 litres). Bronzing is another common problem in guava. It is caused by the deficiency of B, Zn, N, P and K due to low soil pH. The soluble P level of leaves is a better index for bronzing. Guava Lucknow 49 is more susceptible than Allahabad Safeda. It can be reduced by improving the soil pH and treating the soil with N, P, K and Zn at 200, 80, 150 and 80g/year respectively, or fortnightly foliar spraying of these nutrients each at 2% for 4 months.

Micronutrients

Guava sometimes suffers from deficiency of zinc. The usual symptoms of zinc deficiency are interveinal chlorosis, sparsity of foliage, reduced leaf size and less fruit production. Spraying the trees with 1 lb (0.45 kg) zinc sulphate and 0.7 lb (0.34 kg) slaked lime dissolved in 16 gallons (72.736 litres) corrects the deficiency and improves growth and yield. Spraying of zinc oxide at 200 g per 100 litres of water in the spring to control Zn deficiency. The number of sprays to be done is dependent on the severity and extent of the deficiency. Pre-flowering spray with 0.4 per cent boric acid and 0.3 per cent zinc sulphate increased the yield and fruit size. Copper deficient plants exhibited chlorosis and marginal necrosis of young leaves, brown pigmentation at both sides of the midrib and dieback of the main and axillary shoots. Spra¬ying of copper sulphate at 0.2 to 0.4 per cent also proved effective in increasing the growth and yield of guava.

Crop rgulation

Mrig bahar

Guava is the year round crop. However, mrig bahar is suggested in guava. During

ambe bahar, the fruits are developed and ripened during kharif season. The fruit quality is inferior and more dangerous of fruit fly and other disease-pests. For mrig bahar, the fruits are developed and ripened during winter season which is better in quality due to low biotic pressure. So mrig bahar is recommended in guava. The mrig bahar is practiced as follows

1. Withdrawal of irrigation water from February-March up to May and apply rest to the trees
2. The resting should be after harvest of previous crops.
3. Interculturing in orchard and exposing of basin.
4. Light pruning, terminal shoots at periphery may be headed back up to 40 cm
5. Prune the shoot up to 3/4th length during May
6. Remove diseased and dried branches
7. Apply irrigation and recommended fertilizers
8. The rainy season crop can be removed by spraying of urea (10%) on Allahabad Safeda and 20% on Lucknow-49 at the time of peak flowering in summer season.
9. The methods of removing rainy season crop are hand removal of flowers and fruits, spraying of bioregulators, root exposure, withholding irrigation and pruning of ¾ th of flower-bearing shoots are either costlier or impractical or ineffective.

Aftercare

- ✓ Guava plants do not require much care after planting due to its hardy nature.
- ✓ The weeds are removed by shallow cultivation.
- ✓ Green manuring should be done during rainy season and clean cultivation during rest of the year. Leguminous crops can be grown as intercrops during first 3 years of planting to obtain more income and to increase the N content of the soil.
- ✓ Both rainy and winter season crops are very heavy compared with spring crop. Fruit quality of the winter crop is best. Therefore, winter crop is preferred over the rainy season crop.
- ✓ In northern India, normally hot and dry summers along with low soil moisture do not allow summer flowers to set the fruits. But in mild summer and normal soil moisture, the summer flowers set fruits for rainy season crop which is known for its poor quality fruits and severe incidence of fruit fly and fruit-borer.
- ✓ The practice of taking winter crop instead of rainy season crop is known as crop regulation.

Harvesting and yield

Guava are harvested throughout the year (except during May and June) in one or the other region of the country. However, peak harvesting periods in north India are August for rainy season crop, November-December for winter season crop and March-April for spring season crop. In the mild climatic conditions of the other parts of the country, the peak harvesting periods are not so distinct.

Guava fruits develop best flavour and aroma only when they ripen on tree. In most of the commercial varieties, the stage of fruit ripeness is indicated by the colour development which is usually yellow. For local market, fully yellow but firm fruits are harvested, whereas half yellow fruits should be picked for distant markets. The fruits are harvested selectively by hand along with the stalk and leaves.

The plants begin bearing at an early age of 2-3 years but they attain full bearing capacity at the age of 8-10 years. The yield of a plant depends on its age, cropping pattern and the cultural practices. A **10-year-old plant yields about 100 kg of fruits every year**. If both rainy and winter season crops are taken, more yield may be obtained in the

rainy season.

Ripening of guava starts on the tree and continues even after harvest. It is accelerated in rainy season due to high temperature and slows down in winter season due to low temperature. The fruits are packed in baskets made from locally available plant material. For distant markets, wooden or corrugated fiber board boxes are used along with good cushioning materials-paddy straw, dry grass, guava leaves or rough paper. Good ventilation is necessary to check build up of heat. Guava is a delicate fruit requiring careful handling during harvesting and transporting. The fruits should reach the consumer in a firm condition.

Yield

The yield varies in different cultivars and with the care and management of orchard. age of the plant and season of cropping. The average yield per tree estimated to be 90 kg from the seedling tree and 350 kg from the grafted plants. Yield records at Allahabad showed 55-60 kg from a 3-year-old grafted L-49 guava. In trials with 3-year-old grafted plants of different cultivars and the cultivars produced greater yield in the rainy season compared with that obtained in winter (Table). The cultivars L-49, Allahabad Safeda and Chittidar were superior in yield compared with other cultivars studied.

Table: Fruit yield of different guava cultivars (3-year-old grafted plants)

Varieties	Yield	Plant (kg)	Yield/plant	Yield/ha (q)
	Rainy	Winter		
Allahabad	16.0	12.0	28.0	77.84
Apple Colour	15.2	10.2	25.4	70.6 1
Banarasi	14.8	10.6	25.4	70.61
Barupur	16.8	8.7	25.5	70.89
Behat Coconut	13.2	9.3	22.5	62.55
Chittidar	16.2	14.2	30.4	86.51
Harijha	12.8	10.1	22.9	56.63
Luckncnv-49	21.1	18.1	39.2	108.98
Pear Shaped	11.3	7.8	19.1	53.09
Red Fleshed	15.0	10.8	25.8	71.72
Seedless	3.2	2.2	5.4	15.01

*** Mitra *et al.* (1981)**

Packaging and transport

After harvesting the fruits are packed in wooden boxes or bamboo baskets and transported to the market or processing units. Fruits should never be packed in hessian bags as it may cause considerable damage to the fruits even in short-distance trans¬port. For long-duration transport, a layer of cushion material (dry grass, paddy straw. paper-wool *etc*.) should be used at the bottom of the container. Refrigerated transport can reduce the spoilage of fruits. Siddiqui *el al.* (1991) stated that fruits positioned in the natural posture with the pedicel end vertically upward during transport showed better keeping quality than fruits kept in the reverse or horizontal position. Individual wrapped fruits showed less water loss and decay than fruits packed without wrapping.

Ripening and storage

Ripening

Guava is a nonclimacteric fruit, showing a typical increase in respiration and

ethylene production during ripening (Brown and Wills. 1983). The colour of the skin changes from green to yellow or red during ripening while the colour of the flesh may change from white to creamy white, yellowish pink, deep pink or salmon red (Wilson, 1980). The flesh colour at ripening may be influenced by the presence, of carotenoids, lycopene and beta-carotene (Wilberg and Rodriguez-Amaya. 1995). The loss of tissue firmness during ripening is accompanied by a decrease in the level of total pectin (Lazan and Ali. 1989).

Storage

The shelf-life of guava fruit at ambient condition is relatively short due to rapid development of fungal rots. However, the fruits may be stored for a few days to adjust the market demand. Because of their perishable nature, guavas are disposed off immediately after harvesting in the local market and a very small quantity is sent to distant markets. Since fruits are sold at a cheaper price and are available for a very long period of the year, they are not kept in cold storage. However, shelf-life of guava can be extended up to 20 days by keeping them at low temperature of 5°C and 75-85% relative humidity. It can also be stored for about 10 days at room temperature (18-23°C) in poly bags providing a ventilation of 0.25%.

Chundawat *el al* (1976) reported that all the cultivars except Allahabad Safeda could be stored for 2 days at room temperature. Fruits can be stored for 2 to 4 weeks at relatively low temperature coupled with high humid conditions However, chilling injury may occur at 0°C (Wills *et al,* 1983). Singh *et al.* (1976) stored guava successfully up to 6 days in perforated polythene bags and wooden boxes without rotting and much weight loss. Das and Acharya (1969) observed that fruits with 2 or 3 dips in 6 per cent wax or one dip in 9 per cent wax stored well for one month. Mature green fruits were treated with different concentrations of 2.4-D, 2,4,5-T or GA_3 at 100 and 200 ppm or MH at 500 and 1000 ppm.

DISEASE	**MANAGEMENT(control measure)**
Wilt	Carbandazim 1g/liter
Fruit rot	Do
Anthracnose	Do
Leaf spot	Do
PEST	**MANAGEMENT(control measure)**
Fruit fly	Methyl eugenol trep +Mono + ddvp
Green shield scale	Phenthoate 0.05%
Bark eating catter piller	Carbaryl 0.1%

Guava wilt

Guava plants are attacked by wilt, which alone causes heavy losses. It is very difficult to find out an orchard of guava more than 30 years in age because most of its plants die at about 20 years of age due to wilt. Varius fungi causing wilt are *Fusarium roseum oxyaporum, f. psidii, F. solani, Macrophomina phaseolina* and *Gliocladium roseum.* Resistant rootstock is the only solution. The planting material should not be obtained from a wilt-infected region or nursery.

8.PINEAPPLE

B.N. ***Ananas comosus.*** Mirr. **Family**:-**Bromeliaceae** **Origin:-Brazil.**

Pineapple *(Ananas comosus)* is an important fruit crop in India. Originated in Brazil, it has spread to other tropical parts of the world. A good source of vitamins A and B, pineapple is fairly rich in vitamins C, calcium, magnesium, potassium and iron. It is also a source of bromelin, a digestive enzyme.

The cultivation of pineapple is confined to high rainfall and humid coastal regions in the peninsular India and hilly areas of north-eastern region of the coun¬try. It can also be grown commercially in the interior plains with medium rainfall and supplementary protective irrigations. At present pineapple is grown commer¬cially in Assam, Meghalaya, Tripura, Mizoram, West Bengal, Kerala, Karnataka and Goa, and on a small scale in Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh, Orissa, Bihar and Uttar Pradesh.

Origin and distribution

Experimental evidences indicate two main regions in which *Ananas* and *Pseuda-nanas* species grow spontaneously after critical analysis reported that one region covers the south-east extremity of Brazil Paraguay and northern Argentina.

In India, the area under pineapple is about 72.000 ha. It is grown mostly in West Bengal, Karnataka. Kerala, Manipur, Meghalaya, Assam and Tamil Nadu.

Climate and Soil

The pineapple is a crop of humid tropics. The fruit grows well near the sea coast as well as in the interior, so long as the temperatures are not extreme. The optimum temperature for successful cultivation is 22°-32^{0}C. Leaves and roots grow best at 32°C and 29°C respectively. Their growth ceases below 20°C and above 36°C. A high temperature at night is deleterious and a difference of at least 4°C between day and night temperature is desirable. It can be grown up to 1,100m above mean sea-level, if the area is frost-free. Although optimum annual rainfall for its com¬mercial cultivation is 100-150cm, it grows remarkably well under a wide range of rainfall. In areas where the rainfall is less, supplementary protective irrigations are necessary during dry season.

The plants come up well in any type of soil except on very heavy clay soil. Sandy loam soils are ideal. The soil should be 45-60cm in depth without hard pan or stones. Low-lying areas with high water table should be avoided. The plants prefer a soil pH of 5.0-6.0.

VARIETIES

Kew

It is a leading commercial variety valued particularly for canning. Its fruits are big-sized (1.5-2.5kg), oblong and tapering slightly towards the crown. The fruit with broad and shallow eyes becomes yellow when fully ripe. The flesh is light yellow, almost fibreless and very juicy. The leaves often have a short sector of small margin of spines just behind the tip, and irregularly on the base near its attachment to the stem.

Giant Kew

Cultivated in certain regions of West Bengal, it is synonymous to Kew except the size of plant and fruit which are larger than Kew as the name signifies.

Charlotte Rothchild

It is partially cultivated in Kerala and Goa. The fruit is similar in taste and other characters to that of Kew.

Queen

Widely grown in Tripura, and partly in Assam and Meghalaya, its fruits are rich yellow in colour, weighing 0.9-1.3kg each. The flesh is deep golden-yellow, less juicy than Kew, crisp textured with a pleasant aroma and flavour. Eyes are small and deep, requiring a thicker cut when removing the skin. The leaves are brownish-red, shorter and very spiny.

Mauritious

A mid-season variety of the Queen group, it is grown in some parts of Kerala. Medium in size, its fruits are deep yellow and red. Yellow fruits are oblong, fibrous and medium sweet compared with red ones. This is ideal for table purposes.

Jaldhup and Lakhat

These are 2 indigenous types grown in Assam, both being named after the place of their production. Both are under Queen group with fruits smaller than Queen. Lakhat is markedly sour in taste, whereas Jaldhup has its sweetness well-blended with acidity. The fruits of Jaldhup again have a characteristic alcoholic flavour of their own and can be easily distinguished from other fruits of the Queen group on the basis of this character alone.

Propagation

Pineapple is easily propagated by vegetative methods. It can be propagated by shoot suckers, ground suckers, slips, crowns, stem-bits and from splitted crowns. Slips were found to be the best planting materials followed by side suckers and crowns. Suckers from main stem bear little earlier than slips, but slips produce larger and uniform fruits. Flowering is delayed by about 70 days in plants from crown and about 350 days from stem-bits compared with that from slips

Flowering

Pineapple plant generally flowers after attainment of certain vegetative growth and ripeness-to-flower stage is attained 11-12 months after planting and formation of at least 40 leaves. A pineapple plant produces only one fruit during its life time and it is often observed that even after 15 to 18 months of growth under optimal nutritional and environmental conditions only 50 to 60 per cent plants come to flowering. Therefore, for induction of flowering, besides optimal nitrogen and potash nutrition, use of growth regulators is considered necessary.

Planting

Time of planting is dictated by the season in which the first plant crop is required. Planting time is very important for natural flowering period, which differs from region-to-region. By the time of natural flowering, if the plant does not attain the optimum physiological maturity, either it escapes flowering the next season or if flowering induced in the season the plant bear a very small fruits hence the ideal time of planting 12 to 15 month before the peak flowering season under natural condition is varies from December to march in different regions time of planting also varies from place to place depending on time of the monsoon and the intensity of its precipitation in Gujarat May-June, Assam planting should be done during August-October while in kerala and Karnataka the best time of planting is April to June delaying in planting as late as September delays crop at least 7 to 9 months the peak flowering under this condition comes during January to March. The ideal time of planting in north west Bengal is

October to November and June to July for other part

System of planting varies according to land and rainfall. There are 4 planting systems-flat-bed, furrow, contour and trench. Plant density of pineapple depends on growth of the plant and system of plant¬ing. Adoption of low-planting densities has been the major constraint in India, contributing to high cost of production. The plant density of 63,400 plants/ha (22.5cm x 60cm x 75cm) is ideal for subtropical and mild humid conditions, whereas for hot and humid conditions a plant density of 53,300 plants/ha spaced at 25cm from plant-to-plant within a row, 60cm from row-to-row and 90cm from trench-to-trench (**25cm x 60cm x 90cm)** provides high yield. In rainfed, high fertile and hilly areas in north-eastern states, a plant density of 43,500 plants/ha spaced at **30cm x 60cm x 90cm** is recommended. The yield of 70-105 tonnes/ha may be obtained under high-density planting, the increase in yield/unit area being 45-85 tonnes/ ha. Adoption of high-density planting does not have much adverse effect on fruit size, quality and canning recovery. Less weed infestation, protection of fruits from sun-burn, increased production of propagules (suckers and slips)/unit area and non-lodging of plants are added advantages of high-density planting.

Manuring and fertilization

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

Application of 12g N/plant for Kew pineapple is ideal to obtain high yield at Bangalore, Chethalli (Karnataka) and Thrissur (Kerala). A dose of N, P_20_5 and K_2O at 12, 4 and 12 g/plant/year respectively is optimum under Jorhat conditions. No response to P application has been observed. However, in the ratoon crop 4g P_20_5/plant increases fruit weight and yield. Plants receiving 12 g K_2O/plant/crop give higher yield without any adverse effect on fruit quality both under irrigated and rainfed conditions. For medium-fertile soils in West Bengal, N (12-16g), P_20_5, (2-4g) and K_2O (10-12g)/plant are optimum.

It is thus advisable to apply N and K_20 each ® 12g/plant. There is no need for P application. However, if the soils are poor in P, 4g P_2O_5/plant can be applied. The N should be applied in 6 split doses. The first dose of N can be given 2 months after planting and the last one 12 months after planting. The K should be given in 2 split doses. Entire P and half of K can be given at the time of planting and the remaining K 6 months after planting. Application of fertilizer under rainfed con¬ditions should be done when moisture is available.

Interculture

Earthing up*:*

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

Weed control

Weeds could be effectively and economically controlled by appli¬cation of Diuron (3 kg/ha) or a combination of Bromacil + Diuron@ 2 kg/ha each as pre-emergent spray and

repeated with half of the dose, 5 months after first appli¬cation. The quantity of each herbicide should be mixed in 1,000 litres of water for a hectare of crop.

Mulching

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

Removal of suckers, slips and crowns

Suckers start growing with the emer¬gence of inflorescence, whereas slips grow with the developing fruits. The fruit weight increases with increasing number of suckers/plant, while the increased number of slips delay fruit maturity. Crown size has no bearing on the fruit weight or quality. Hence desuckering can be delayed as much as possible, while the slips are recommended to be removed as soon as they attain the size required for plant¬ing. Removal of crown is not required as it mars the appeal of the fruit and also makes handling difficult. Partial pinching of crown consisting of the removal of the innermost whorl of leaflets along with growing tips 45 days after fruit set is ideal to get fruits of better size and shape.

Irrigation

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

HARVESTING

Pineapple plants flower 10-12 months after planting and fruits become ready 15-18 months after planting. Irregular flowering results in the harvesting spread over a long period. Under natural conditions, pineapple comes to harvest during May-August. Fruits which mature in winter are acidic. There is a scope of altering fruit size and maturation with the use of chemicals or plant growth regulators.

With a slight colour change at the base of developing fruits, it could be har¬vested for canning purpose. But for table purpose, the fruits could be retained till they develop golden yellow colour. The fruits with the crown, can be kept without damage for 10-15 days after harvesting.

Ratooning in high-density planting reveals that the average fruit weight in the first and second ratoon is 88% and 79% respectively of the plant crop. The plant stand is also reduced resulting in the reduction of fruit yield by 49.3 and 46.2% in first and second ratoon crops respectively. Prolonged ratooning results in the reduction of flowering plants, consumer appeal of the fruit, fruit size and number of fruits suitable for canning, but in the increase of fasciated fruits. It is also not possible to prevent the reduction of fruit yield in ratoon crop by increasing the irrigation or by higher doses of nitrogenous fertilizers.

Yield :- 40-50 tonnes / ha.

Ripening and Storage

Pineapple has been reported to be a non-climacteric fruit. Ripe¬ning of pineapple could be considered as the terminal period of maturation during which the fruit attains the most desirable quality; one aspect of this concerns fruit shell colour which generally develops with an unmasking of the carotcnoid pigments through a decline in chlorophyll content

Storage

In tropical climate pineapple could be stored for more than 10 days when refrige¬rated and at 10-13°C fruits could be stored well for 20 days

Pests : Mealy bug, Fruit eating beetle,Termites

9.Jackfruit

B. N. : ***Artocarpus heterophyllus Lam.*** **Family : Moraceae Origin :** India

Jackfruit is popularly known as the poor man's food in the eastern and southern parts of India. A rich source of vitamin A, C, and minerals, it also supplies carbohydrates. Tender jackfruits are popularly used as vegetable. The skin of the fruit and its leaves are excellent cattle feed. Very popular in U.P., Assam, Bihar, & Southern India. Fruit is largest in size & weight among edible fruits. (upto 40 kg/fruit). It is a monoecious tree. Female flowers born on main stem & branches.

Climate :- Tropical to subtropical. It grows well in a warm, humid climate up to an elevation of l,500m. In south India, it performs satisfactorily in arid and warmer plains. However, it cannot tolerate cold and frost.

Soil :- Deep, fertile, well drained. Can not tolerate moisture stress & high water table.

Varieties :- Kathal, Kathali, Barmasi. 'Gulabi' (rose-scented), 'Champa' (flavour like that of champak) and 'Hazar' (bearing a large number of fruits).

Propagation & Planting :-. It is commonly propagated through seed.. Seeds should be sown immediatly after extraction since they lose their viability during storage. Soaking seed. in 25 ppm NAA for 24hr improve, their germination and seedling growth.

Air-layering, grafting (inarching and epicotyl) and budding (forket, chip and patch) are means of its vegetative propagation.

Planting:- 10x10m in monsoon.

Manures :- 75g N+60g P+50g K/tree/yr till 8th year
and then 9th year onward 600g N+480g P+400g K/tree/yr.

Irrigation :- Hardly irrigated, but sensitive to draught during summer.

Yield :- 10-12 tonnes/ha. (March-June.)

10.Litchi

B.N. *:- Litchi chinensis* **Family :- Sapindaceae** **Origin :- South China**

Introduction

Litchi is most important subtropical, evergreen fruit trees native of South China, it reached India by the end of 17th century. India second in the world next to China in litchi production. Most area falls in Bihar comprising Muzaffarpur, Vaishali, Samastipur, Begusarai, Champaran and Bhagalpur districts. Litchi is famous for its excellent quality pleasant flavour, juicy pulp (aril) with attractive red colour. Although litchi is liked very much as a table fruit, dried and canned litchies are also popular. highly flavoured squash is also prepared from its fruits. The fruit consists of juice, 8% rag, 19% seed and 13% skin varying upon variety and climate, Litchi also an excellent source of vitamin C (40.0—90mg/l00g) but it contains insignificant amount of protein (0.8—0.9%), fat (0.3%), pectin (0.43%) and minerals especially calcium, phosphorus and iron (0.7%).

Climate

Generally it flourishes best in a moist atmosphere, having abundant rainfall free from frost. Its plants grow luxuriantly at 30°C. The maximum temperature during flowering and fruit development varies from 21°C in February to 38^0C June in Bihar. Humidity is another important factor for litchi. The dry hot winds in cause fruit cracking and subsequently damage the pulp (aril).

Soil:-

Litchi grows in a variety of soil types. However fairly deep, well-drained soil rich in organic matter is best suited for its cultivation. Light sandy loam is ideal. High lime content in soil is also beneficial to its trees.

Varieties

A large number of varieties are grown in different parts of India. Of these, Early Seedless (Early Bedana), Rose Scented, Dehradun, Gulabi, Calcuttia, Purbi, Kate Shahi, Bombai, Late Seedless (Late Bedana), China and Deshi are important. Shahi, Rose Scented and China are commercial varieties of Muzaffarpur. Kasba and Purbi are choicest litchies of the eastern parts in Bihar.

Propagation

Litchi is raised both through seed and vegetative means.

Seed propagation

Propagation by seed is not common because the plants raised from seed take 7-12 years to come into bearing. These plants normally do not produce true-to- type fruits and often produce fruits of inferior quality.

Vegetative propagation

Litchi can be propagated successfully by cuttings and grafting (splice and inarching). Budding is not commonly practised. The most common and easiest method adopted all over the world is air-layering.

Planting

Pits of 1m x 1m x 1m size should be dug at the desired places a few weeks before the actual planting. These are kept open for 15 - 20 days and then refilled with a mixture if well-rotted farmyard manure, leaf-mould and canal silt. A mixture of farmyard manure (20 - 25kg), bone-meal (2kg) and sulphate of potash (400g) is also recommended to be mixed with a basket full soil in a pit from a litchi orchard, containing mycorrhizal fungi. It is helpful in establishment and quick growth of newly-planted plants. The pits are watered to set this mixture with the earth. Planting is done after a week. Water is applied immediately after planting.

Litchi trees are usually planted in a square system, **10 X 10 m apart**. The new plantation is recommended during early monsoon season. Planting can also be done in the spring, if irrigation facilities are available. Planting is not advisable when the weather is either too dry or too wet.

Training and pruning

Training young litchi plants for making a good framework is necessary. the desired shape and a strong framework is achieved, pruning is not required, except removing dead or diseased branches and damaged shoots.

Manuring and fertilization

In India, litchi is grown mostly in natural fertile soil. A little or no manure is given. The fertilizers dose for adult tree :-FYM 60 kg/tree + Calcium ammonium nitrate 3.5kg + Superphosphate 2.25 kg + Muriate potash 0.60 kg/tree. Fertilizer should be applied just after harvesting during the rainy season.

Intercrop

Since litchi is a slow-growing tree taking at least 6 years to come to flower and fruiting, intercropping vegetables, pulses and berseem is advised. Some growing fruit plants like phalsa and papaya can also be grown in early years

Irrigation

The fully grown trees are irrigated by flooding or by furrow irrigation, depending on the availability and source of water as per their requirement, The frequency of irrigation ordinarily depends on soil type. Generally weekly irrigation should be given in summer. No irrigation is required during winter in fruiting trees before fruit set.

Harvesting

Generally litchi fruits, mature 50 - 60 days after fruit set. The development of colour on fruits is a dependable criterion of maturity but it differs from variety-to-variety. Generally fruits turn deep red when fully ripe. Fruits harvested at this stage possess excellent fruit quality. They are harvested in bunches along with a portion of the branch and a few leaves. It prolongs the storage life of fruits. Harvesting of litchi is usually done in May and June. In Bihar, it is done in early- May, whereas in Uttar Pradesh and Punjab it starts during late-May to early- June. In India, yield varies from **80-150 kg fruits/tree** depending upon variety and tree vigour.

Physiological disorder

Sun-burning and skin-cracking:-

Sun-burning and skin-cracking in developing fruits is a serious problem in litchi. High temperatures, low humidity and soil moisture conditions during fruit development promote this disorder. Inadequate moisture during early period of fruit growth results in the skin becoming hard and sun-burnt. It may crack when it is subjected to increase internal pressure as a result of rapid aril growth following irrigation or rain. Fruit cracking in litchi is also favoured if temperature goes above 38°C and relative humidity less than 60%.

Control measures:- Although effective control measures have not been recommended, frequent and adequate irrigation to bearing trees during fruit growth and development period is most useful.

Growth regulators NAA (20mg/litre of water), GA (40mg/litre of water) 2,(10mg/litre of water), 2, 4, 5.T (10mg/litre of water) and Ethephon (10mg/litred water) reduce the incidence of fruit cracking. Spraying with $ZnSO_4$ (1.5%) week or $CaNO_3$ (1.5%) fortnightly from pea - size to harvesting of fruit is an effective method to reduce cracking incidence

11.Carambola or starfruit

B.N. ; *Averrhoa carambola Family ; Oxalidaceae origin: Indo Malaya*

Carambola or starfruit (***Averrhoa carambola***) is native to Indonesia. The acidic nature of the pulp is due to its oxalic acid content. Although carambola is not an economically significant crop in India, one can come across this fruit-cum-ornamental tree in several gardens. It is a small tree with drooping branches and bears attractive, golden-yellow, 3–5 ribbed, oval-elliptic fruits measuring 12–15 cm in length. A fruit crop akin to carambola, bilimbi (*A. bilimbi*) produces gherkin-like fruits which are used for making pickles and curries due to the presence of high amount of acid (6 %) in the pulp.

Fruits of carambola contain a juicy pulp which may be acidic or sweet depending on type. The fruit is a good source of vitamin A, B and C together with valuable minerals and iron but not calcium. Various plant parts of this fruit are credited with medicinal properties, e.g. root extract is used as an antidote for poisoning, and the crushed leaves for curing chicken pox, ring worm and scabies. The pulp of immature fruits is used for cleaning brassware.

Climate and soils

Carambola prefers warm moist climate and can be grown on the hills up to 1,200 m. A well-distributed rainfall encourages normal growth and cropping. It can grow on any type of soil with good drainage, but deep rich soil supports better plant growth. Although it grows both in acid and alkaline soils, it prefers acid soil. Trees growing on calcareous soils sometimes require zinc sprays.

Varieties

Specific varieties are not known in carambola, but 2 main types are distinguished, viz. sour and sweet. The sour types contain as much as 1% acid and the sweet types have low acid (0.4%) with 5% sugars. Some Chinese types like Fuang Tung are very sweet and Brazilian ones are rich in vitamin C. Some superior types of carambola are available at Columbia (Icambola), Taiwan (Tean Ma, Min Tao) and Hawaii (Golden Star).

Propagation

Carambola is often propagated through seeds, but budding, grafting and layering are recommended to produce true-to-type plants. The seeds have low viability and hence should be sown fresh. After cleaning and drying the seeds, they should be sown in pots and regularly watered. The seedlings are transplanted to individual pots or plastic bags and allowed to harden. They are then transplanted to the field. When seedlings are to serve as rootstock, they should be at least one year old, on which budding (shield) or grafting (veneer or approach) can be taken up.

Cultivation

Planting

The planting of carambola trees on orchard scale is seldom done. Planting can be taken up by providing 8m × 8m spacing when one plans to raise a regular orchard.

Pruning

Practically no specific training or pruning operation is advocated for carambola trees.

Manuring

There are no recommended nutrient dosages. However, it is a good practice to manure the trees once in a year (40–50 kg of farmyard manure/tree) and also apply some nitrogenous and phosphatic fertilizers, the doses depending upon the age and size of the tree and the fertility of the soil.

Aftercare

For better orchard establishment, operations like watering of the young plants as and when required, staking, basin cleaning and protection from cold are important.

Irrigation

Irrigation is provided when there is a long dry spell. This helps to secure a good crop.

Harvesting and Postharvest management

Seedlings take about 4 years to come to bearing but grafts produce crop in 1–2 years. Carambola produces flowers and fruits even on the trunk. The fruits are borne year round, but peak yields are obtained during January–February and September–October. Yield varies according to the age, variety and plant health. About 80 kg fruits can be harvested from a grown-up tree.

Fruits of sweet type are eaten fresh and the sour ones can be used for making refreshing drinks, pickling or as a substitute for tamarind. Good quality squash, jelly, preserves and candy can also be prepared from fruits. With proper packing, fruits of carambola ship well, but the fruits are mostly supplied to near markets.

12. Durian

B.N. : ***Durio zibethinus*** **Family: Bombacaceae origin :- Borneo**,

Durian (*Durio zibethinus*) native to Borneo, an island in the Malaysian region, produces fruits with a unique appearance, taste, flavour and aroma. This fruit tree grows tall and straight to a height of 30m in the forests, however grafted orchard trees seldom grow over 12m. The durian fruits are ovoid to ellipsoid, large, weighing up to 5kg with thorny surface like jack and normally olive- green in colour. People have strong like or dislike for this fruit. Many like it, because of its sweet, delicious and filling taste, while others dislike it for its highly objectionable odour. The penetrating odour is comparable to that of rotten onion and is unacceptable to many.

However, once the odour barrier is overcome by a strong determination, the experience of eating a good durian is never forgotten. The durian is grown intensively and commercially for its fruit only in Indonesia, Malaysia and Thailand. In India, there are no large orchards or commercial plantings of durian, but for some trees in and around Nilgiris (Tamil Nadu) and West coast.

The 5-loculed fruit has 2–3 seeds in each locule, surrounded by light colour, mealy, sweet aril, and the edible pulp. The seed is readily separable from the pulp, and are edible when fried, roasted or boiled. The pulp is rich in sugars (12%), protein (2.8%) and carbohydrates (34%) in addition to Fe, B, vitamins especially the uncommon but valuable vitamin E. When durian fruit is consumed, it gives a feeling of internal warmth, followed by a glowing sensation, and this has led to a strong belief that the fruit has aphrodisiacal qualities. The fruits are highly prized both as fresh fruit and in processed form. Durian also has some pharmacological properties, e.g. decoction of roots is used to treat fever and that of leaves and roots is used to check inflammation, infections and to treat jaundice.

Climate and soil

Durian thrives in humid, equatorial climate with short or no dry season. An annual rainfall of 200cm is a minimum requirement, but heavy rains prior to flower initiation affect normal flowering, and the production decreases. If minimum temperature falls below 8°C, the tree suffers from cold injury. Trees of durian grow on different types of soils with 5–6.5 pH, provided they are moist, well-aerated and rich in organic matter. Deep silt or loams with good drainage and high level of fertility are ideal for its cultivation. However, the trees are susceptible to strong winds, which cause breakage of limbs or even trunk.

Varieties

There are more than 27 species of *Durio*, the genus to which durian belongs. Apart from *D. zibethinus*, at least 6 of them have some edible value: *D. testudinarum, D. graveolens, D. grandiflorus, D. dulcis, D. oxleyanus* and *D. kutejensis*. Of these, *D. testudinarum* is almost as important as *D. zibethinus*. Each of these species has many variants for fruit size, fruit colour and leaf area.

As many as 300 strains/varieties of durian are reported, but only a few of these are propagated by commercial nurseries in countries where these are popularly grown. There are distinct variations in flavour, aroma and other fruit characteristics among the cultivars, which are readily distinguishable even on cursory examination. Those with better market demand have less of the objectionable flavour and small seeds. Chanee, Kanyao, Frog, Bojol, Ketan, Gombat, Mong Thong, Golden Pillow, Kob Champa, Lalong,

Otong and Hepe are prominent cultivars. Planting of more than one variety/clone should be done in an orchard to facilitate cross-pollination and better fruit set.

Propagation

Usually the growers propagate durian by seeds and its off-springs vary from generation-to-generation due to genetic heterozygosity. However, the recommendation would be to go for vegetative propagation of proven elite trees.

Although no standard rootstocks are known, better results are obtained if rootstock of the same species is employed. The seeds of durian are variable in size and are notoriously short lived, the viability is affected by exposure of seeds to sunlight or high temperature for long period of time. Seeds do not store well even at low temperature. Large, healthy, fresh seeds are sown in well-drained soil, preferably in polybags or earthen pots. Seeds germinate in 3–4 days and subsequent growth of the seedlings is fairly rapid, producing a good-sized seedling suitable for grafting in about 2 months. The modified Forkert method (modification of patch-budding), inarching and approach grafting are common methods of propagation. However, air-layering and propagation by cuttings are impractical.

Cultivation

Planting

Planting can be taken up at **10–12m** spacing on the square system. Other principles of planting are same as in avocado.

Pruning

Durian is neither pruned in nursery nor after planting in the field. It usually takes a pyramidal shape by itself. However, after harvesting, the tree can be cleared off dried and old twigs.

Aftercare

Since durian is a native of rain-forest, its young plants are prone to desiccation needing regular watering till they establish. Other aftercare practices as explained for avocado cultivation may be followed.

Irrigation

Good soil moisture is essential for satisfactory growth and production. Irrigation is necessary if there is a long dry spell. A good mulch helps conserve moisture, reducing the need for irrigation.

Manuring

Exact information on the fertilizer requirement of durian is not available. Tentatively, the recommendations made for avocado may be followed, as durian is similar to avocado in respect of plant growth, and bearing habit.

Harvesting and Postharvest Management

Grafted durian trees are precocious and produce crop in 4–5 years, while seedlings require as long as 10 years. The fruiting is clearly seasonal, available 2 times in a year. Immature fruits are picked only for use as ‘vegetables’. Fruits take about three-and-a-half months to reach maturity. When mature, the fruits drop but it should be harvested since the fallen fruits do not keep long. Harvesting is done manually or with the help of bamboo poles when the fruits are smooth, flat with far-

apart spines. The yield varies with the age, variety, and agroclimate of the region. However, 100–120 fruits/tree are considered as good.

The rich aroma of durian develops as fruits ripen and reach their peak in 3–4 days after harvesting and becomes soft. The ripe fruits deteriorate rapidly and cannot be transported over long distances. The arils of ripe fruit, is eaten fresh, which normally forms 33% of the total fruit weight. The arils can also be processed into durian cake (lempok) and durian jelly (tempoyak). The jelly is prepared from over-ripe fruits and is sour. Dehydrated durian powder prepared either by spray or drum drying could be used as a flavouring ingredient for beverages, pastry, ice-cream etc. Ripe fruits can last for 4 days under refrigeration, while the mature ones can be stored up to 14 days at 10°–15°C or may be frozen for 2–3 months. The arils can be kept for about 3 months at –24°C.

13. Passion fruit

B.N. :- *Passiflora edulis* family : -Passifloraceae Origin :- Brazil

Passion fruit, (*Passiflora edulis*) is native of Brazil. In India, it grows wild in the Nilgiris, Wynad, Kodaikanal, Shevroys, Coorg and Malabar. Recently, its cultivation has been extended to some areas in Himachal Pradesh, Nagaland and Mizoram. The juice of passion fruit with an excellent flavour, is quite delicious, nutritious and liked for its blending quality. It is extensively used in confectionery, and preparation of cakes, pies and ice-cream. A rich source of vitamin A, it also contains fair amount of sodium, magnesium, sulphur and chlorides.

It is a perennial climber, cultivated in the tropics. Flowers are borne singly in the axils of leaves at the terminal region of new growth. The vine, bears hen's egg-sized fruits in abundance. They are smooth, ovoid and purple-yellow on ripening. The rind afterwards shrinks and becomes wrinkled. The rind is bordered by white pith, and inside small, hard, black seeds are surrounded separately by a soft, slightly acid, fragrant and juicy orange-yellow pulp

Climate and Soil

It prefers tropical to subtropical climate and grows well up to 2,000m with a rainfall of 1,000–2,500mm annually. It can grow in light sandy loam to heavy loam soils with a pH of 6–7. Soils should be well drained.

Varieties

There are 2 recognized varieties—purple (*P.edulis* Sims) and yellow (*P. edulis* var. *flavicarpa*). Purple passion fruit is more productive. It is grown at higher elevations in south India. More prolific varieties bear larger fruits but are poor in juice content and flavour, higher in TSS, acids and carotenoid pigments. The fruits of purple variety are susceptible to collar-rot, wilt, brown leaf-spot, thrips and nematodes, while those of yellow have field tolerance. Kaveri, a hybrid of Purple × Yellow, is high-yielding, tolerant to resistant to collar-rot, wilt, brown leaf-spot and nematodes. Noel's Special, a cultivar, is tolerant to *Alternaria passiflorae*. It is precocious and can bear even at one year's age, but is self-incompatible and needs a pollinator for satisfactory fruitfulness.

Propagation

It is propagated by seeds, cuttings, and grafting on resistant rootstock. The tropical American species - *P.alata* and, *P.ambigua*, *P. cincinata*, *P.guazumaefolia*, *P.molliformis*, *P.mucronata*, *P.nigradenia*, *P.nitida*, *P.riparia*, *P.seemani*, *P.serratifolia* and *P.serrato-digitata*,—are good rootstocks. Seedlings or grafted plants are more vigorous than cuttings. Propagation by seed should be avoided as it induces variability. Cuttings 30–35cm long having 3 nodes obtained from selected mature vines are raised on suitable media. Rooting takes place after about a month. They can be transplanted to the main field after 3 months. Maintain a spacing of 3m from plant-to-plant and 2m from row-to-row. The best time for planting is during the monsoon.

Cultivation

Training and pruning

Skilful trellising is quite important in regulating yield as it has to support a considerable weight for 5 years. Weak and faulty construction of trellis may result in sagging and loss of vines. Two-arm kniffin system is ideal. The trellis should always run across the slope or in north-south direction to facilitate even exposure to the sunlight. Once the vines reach the wire, the tips are pinched to facilitate leader formation. Two leaders are directed on either side of the wire in opposite direction which in turn develop laterals. These laterals are trained downwards hanging from the wire and form

the fruiting area of the vine.

Since passion fruit vine bears fruits only on current season's growth, systematic pruning encourages new growth. Pruning should be done after harvesting the crop in April and November–December. It is done by cutting back of laterals to the nearest active bud as otherwise with increase in age of the lateral, the basal buds become dormant or sterile. Indiscriminate and drastic pruning of inactive or dormant vine may lead to a setback in growth, resulting in lower yield.

Manuring and irrigation

Application of 100g N 50g P_2O_5 and 100g K_2O/ vine annually in 2 splits for purple and 110, 60 and 100g N, P_2O_5 and K_2O/ vine/year for Kaveri is optimum. During prolonged dry spell (January–March), it should be irrigated at fortnightly intervals, otherwise the development of flowering laterals is adversely affected.

Harvesting and PostHarvest Management

The fruits are obtained from the 10th month and full bearing reaches by 16–19 months. Although its plants flower and provide fruits throughout the year, there are 2 main periods of fruiting from August to December and March to May. About 80–85 days are required from fruit set to harvest. The ripe fruits fall down from the vine. Slightly purple coloured fruits along with a small portion of the stem should be picked up. Purple variety yields 8–10kg/vine, whereas Kaveri 16–20kg/vine, the total yield being 12–20tonnes/ha annually. The fruits should be disposed off quickly to prevent loss in weight and their appearance. Storing them in polythene bags, however, reduces this problem to some extent.

A number of processed products—nectar, squash, carbonated drink and juice concentrate—could be prepared. These products are in great demand both in domestic as well as export market. There are possibilities even for fresh fruit export which remains unexploited.

14.Avocado or butter fruit

B.N. : *Persea americana* Family ; - Layraceae origin:- Mexico

Avocado or butter fruit (*Persea americana*) is a subtropical, evergreen fruit tree. Its trees can be short, spreading and fairly bushy or grow erect to a height of 20m or more. The demand for this fruit has been increasing over the past few years in many countries. It has become an important fruit in the international trade. Mexico, Brazil, USA, Israel, New Zealand, South America and South Africa are the major producers of avocado. In India, it is grown as a backyard tree and is found in small pockets on hill slopes of Tamil Nadu, Kerala, Karnataka and Maharashtra. It is consumed primarily as fresh and is neither sweet nor acidic. The edible pulp has a nutty flavour with a buttery texture. It is reputed as a nourishing food of high dietetic value. Its nutritional values are comparable to ripe olives with an average of 2.1% protein, 1.32% minerals and 24–26% fat. It is also a good source of potassium, iron and vitamin B. Since the fruit contains not more than 1% sugar, it is recommended as high energy food for diabetics. Its energy value is twice as much as banana fruit. Avocado is eaten fresh on bread or in salads with lemon juice, salt and pepper, but in India people prefer to eat it after mixing the pulp with sugar. Avocado oil is used in preparation of cosmetics.

Climate and Soil

Avocado comes up well in tropical and subtropical climate with a mild winter at an elevation of 600–1,500m and an annual rainfall of 125–180cm. However, it can be grown even in areas with low or ill-distributed rainfall, if the irrigation facility is assured. High humidity during flowering and fruit set is necessary to secure a good crop. Varieties of the Mexican race and its hybrids are well adapted to the cool climates, while the west Indian types are best adapted to the low land tropical conditions of high temperature and humidity. The Guatemalan race is intermediate. Because of the differences in adaptation, avocado offers good opportunity for selecting an appropriate variety for a given climate. Thus, it is presently grown on a commercial scale in different parts of the world having extremely different environment. The climatic extremes range from almost desert condition (Israel) to high land tropics (Mexico) to cool mist belt conditions (Queensland). However, planting of this crop in sites with violent winds should not be taken up or else windbreaks must be provided, as avocado plants have branches that break easily.

Cultivation of avocado can be taken up on loamy or sandy loamy soils of alluvial origin having 5–7 pH. This crop is sensitive to waterlogged condition, hence raising on poorly drained soils should be avoided. Shallow soils, soils with gravelly sub-soils and those poor in organic matter are also not suitable for avocado cultivation. It does not tolerate salinity, excepting varieties of west Indian race. This fruit has been grown successfully on a limited scale in India in the hill slopes of Nilgiris, coastal region of Karnataka, Kerala and Maharashtra.

Varieties

More than 400 varieties are known in avocado and they are classified into 3 distinct horticultural or ecological races: Mexican, West Indian and Guatemalan. They may be recognized as subtropical, semi-tropical and tropical. Each race is identifiable by their unique characteristics like fruit size, peel, texture and maturity date. The varieties of Mexican race are characterized by anise-scented leaves, small fruits, thin glossy skin, high oil percentage and large seeds. West Indian and Guatemalan races lack leaf scent and bear moderate to large fruits. Like Mexican race, fruits of West

Indian race mature in 6 months and contain large seed with loose cavity, while Guatemalan fruits mature in 9 months and have smaller seed and tight cavity. West Indian cultivars have generally fruits with smooth leathery skin and those of Guatemalan possess coarsely granular skin.
Some of the well-known cultivars of these 3 races are as follows:

- Mexican—Gottfried, Duke, Pernod
- West Indian—Pollock, Simmond, Black Prince, Fuchsia, Peterson, Waldin
- Guatemalan—Taylor, Linda, Queen, Benik.

Many cultivars of commercial significance are hybrids of these 3 races. They are Fuerte, Collinson, Winslowson, Fair child and Long. The most leading avocado cultivar in the world Fuerte, a Mexican × Guatemalan hybrid, bears pear-shaped fruits each weighing on an average of 400g with a smooth, thin, dull green skin and a tendency towards alternate bearing. The pulp has a buttery texture, a rich nutty flavour and contains oil up to 26%. Nabal, Hass, Lyson, Dickinson, Linda, Pollock and Waldin are some important cultivars of California and the coastal Florida. Sri Lanka grows mainly Trapp, Pollock, Dickinson, Duttan, Lyon, Mayapah and Gottfried.

In parts of south India and Maharashtra where avocado is successfully grown, 2 varieties; Purple (West Indian race) and Green (Guatemalan race) are popular. Purple variety bears pear-shaped fruits with a long neck weighing about 450g. The fruits have smooth, moderately thick, leathery skin and the pulp is firm, deep yellow, fine in texture with a rich and nutty flavour. The fruits of Green variety are oval to obovate, large (450–680g) with a rough, moderately thick, brittle skin. The flesh is soft, greenish-yellow with a mild nutty flavour. Single trees of avocado are not productive at times. For want of pollination, hence, while raising a plantation in new area, mixed planting of cultivars is desired instead of mono-clonal stands.

Propagation

Although seed propagation is sometimes practised, to ensure superior traits of the parent trees it is necessary to prefer asexual propagation which can be achieved by cuttings, layering, budding and grafting. Budding and grafting are most popular. Seeds quickly lose their viability, and hence should be sown soon after extraction from the fruit. Soaking of the seed in water for about 8hr or removing the seed coat and a thin slice at top and bottom may accelerate germination. Seeds are planted in nursery at a spacing of 30cm × 60cm and then transplanted to polybags when they have putforth 4–5 leaves. When seedlings reach 80–90cm in height, they can be transplanted to their permanent location.

Generally, vigorously growing seedlings irrespective of source are used as rootstocks. However, cultivars have also been recognized with specific objectives for using as rootstocks. For example, Duke seedlings are resistant to root rot and cold hardiness and Pollock stock can overcome salinity problem. Similarly, Green and Purple also do well as rootstocks. Green imparts more vigour to the scion than Purple. Side, veneer, cleft grafting or shield budding on 30–40 cm tall, robust, succulent seedlings is generally practised. Trees on rootstocks produced by clonal propagation usually bear fruits early and more uniform than trees grafted on seedling rootstocks.

Cultivation

Planting

Before establishing a plantation, the field should be well ploughed, harrowed and leveled, keeping in mind the possible intercropping, often with vegetables. The commonly recommended spacing is 7m × 7m, but it may vary from 6–12m on the square. The spacing is determined by the crown size of the variety and soil type. Trees

in deep soils with a high percentage of organic matter need more space, because they grow taller and larger under these conditions.

Pits of 60cm × 60cm × 60cm are dug and left open to sun for about 10 days. These are then filled with top soil mixed with approximately 30kg of well-decomposed farmyard manure or leaf mould. Add 20 g of superphosphate at the base of the pit for good root growth. Planting can be carried out anytime during the year, but when adequate irrigation facilities are lacking, monsoon is the appropriate time for planting. While planting grafts, it is important to keep the graft-joint well above the ground. Once planting is done, regular watering is essential till the plants establish.

Pruning

Like most tropical trees, avocado has a good natural shape and hence it need not be controlled by pruning. But selective and mild pruning of dead wood, basal branches touching the ground and very old devitalized branches which have seized to produce fruits may be attended to once the harvesting season is over. Severe or unnecessary pruning lowers yield by eliminating potential flowers produced on young branches at the periphery of the tree.

Manuring and fertilization

Nutrient requirements of avocado vary according to variety, spacing and soil type. Before fertilizer application, the basin should be weeded and the fertilizer broadcast but not within 30cm radius of the trunk. After applying fertilizer, irrigation is useful if soil moisture is not adequate. Though it is difficult to specify exact dose common to all soils and varieties, a recommended fertilizer dose is given in **50 kg FYM, 200g N, 45g P and 165g K**

While, P and K deficiencies are less conspicuous, N and Ca levels in leaf marketly influence yield, fruit size and postharvest quality. The Mg, B and Fe are also important. The growers are advised to get the soil tested and consult soil specialist for specific recommendations. In California, healthy leaves of avocado Fuerte, have been reported to contain 1.8% N, 0.15% P, 1.5% K, 2.2% Ca, 125 ppm Fe, 50ppm Mn, 50 ppm Zn and 45ppm B.

Aftercare

After planting, young trees must be watered and supported by stakes. To protect trees from sunburn, they should be provided with shade. Sometimes, the trunks of the young trees are whitewashed. To start with 60cm^2 basin around the plant is adequate, however, once in a while, size of the basin should be expanded with increase in the canopy size. Other aftercare operations involve regular watering during dry periods, occasional weeding, shallow digging of the basin so as not to injure the surface roots, removing of sprouts on the rootstocks (in case of grafted plants), attending to plant-protection measures and manuring.

Intercropping in young orchards can be taken up by selecting a suitable vegetable crop as it gives additional income to the growers. Moreover, an intercropping system keeps the soil cool, adds organic matter, suppresses weeds, improves soil structure and may fix nitrogen. But these crops should not be raised very close to the avocado trees lest they compete with them for nutrients.

Irrigation

Commercial avocado is successful if trees are regularly irrigated and the frequency should be adjusted depending on soil and weather conditions. The avocado trees show water stress suddenly by shedding fruits and leaves or by wilting as they have shallow root system. Loose and sandy soils require larger quantities of water than heavy soils. Generally in summer, trees should receive irrigation once in 10 days and

adequate soil moisture after fruit set is necessary to sustain fruit growth, because any setback in growth is irreversible.

Harvesting and Postharvest management

The regular harvesting commences from fourth year. Its fruits are harvested in August-September in south India. They should be plucked when they are fully mature which can be assessed by change in fruit colour, fruit size and sometimes the oil content. In Purple variety, fruits are plucked when they show a purplish blush, and in Green when they develop yellow tinge and once the glossy shine diminishes. If fruits are retained for longer periods, they drop before softening. Picking poles (with a net or cloth bag at the end) can be used for harvesting the fruits. Although a 25-year-old tree yields as high as 2,000 fruits, a yield of 400–500 fruits/tree is considered fairly good.

Well mature avocado fruits ripen in 4–5 days after harvesting, but ripening can be accelerated by ethylene (10 ppm) treatment. Ripening takes place satisfactorily at 15°–21°C and is hampered above 30°C. Mature fruits can be held for a month at 6°–9°C coupled with 80–90% humidity. An extension of shelf-life can be obtained by storing at low temperature after enclosing the fruits in polyethylene bags. The ripening time of fruits stored is generally always less than the non-stored fruits. Packing is done in a single layer in well-ventilated wooden boxes so that they arrive in markets in good condition.

15.Mangosteen

B.N.:- *Garcinia mangostana* L. Family :-Guttiferae Origin :- South East Asia

Mangosteen (*Garcinia mangostana*) is a broad-leaved, medium-size, ever-green tree. It is considered by many to be the most delicious fruit of the tropics with a universal appeal. According to some, it is 'the finest fruit of the world' or 'queen of fruits'. The exquisite flavour of the fruit is likened to that of nectar and is the only fruit in which glucose is in readily available form. Mangosteen cultivation is popular in Indonesia, Philippines, Burma, Sri Lanka and Malaysia. The fruit was introduced more than a century ago in India, but currently it is successfully grown only in selected places on slopes of Nilgiris (Tamil Nadu), Malabar and Kanyakumari (Kerala).

The mature tree reaches a height anywhere between 10 and 25m with a dense pyramidal crown and glossy bright leaves. Mangosteen fruit resembles small-sized orange with a smooth reddish purple cortex (rind) which is about 0.6 cm in thickness. Inside the fruit, 4–6 segments are found but only 1–2 of them contain seeds that have the size and shape of a shelled almond. The pearly white pulp is so soft and juicy that it almost melts in mouth with an indescribably sweet and pleasant flavour. The cortex is used in treating chronic diarrhoea, uretural irritation, gonorrhea etc. It is also used in tannary because of higher content of tannins up to 13%.

Climate and soil

Mangosteen is a fruit of humid tropics and comes well in south India up to an altitude of 400–900 m and areas receiving 180–250 cm rainfall. Generally, frost-free regions with equatorial climate that lie at the foothills are suitable for cultivation. Very high humid or arid conditions over a long spell in a year are not suitable as these lead to 'gamboge'—a disorder wherein there is excessive exudation of latex by branches and fruit pericarp.

Although mangosteen is not very specific in its soil requirement, it thrives successfully in deep, well-drained soil with high content of organic matter. The trees have been observed to grow well in contrasting soil environments, in soils that are moist naturally throughout the year (Sri Lanka) and in areas where the annual rainfall is just 15cm but trees receive irrigation once in a fortnight (Hawaii). Generally, mangosteen come up well close to water bodies when the watertable is below 2m, provided the soil is non-alkaline. It can develop normally when no shade is provided.

Varieties

Elite mangosteen varieties are unknown, though it has been cultivated for centuries. The occurrence of natural variability is also limited by the fact that 'seeds' are of asexual origin, they are formed from the nucellar tissue in the parthenocarpic fruit. However, a general grouping of cultivated mangosteen into 2 types is possible: one with large leaves and fruits of variable size and the other with small leaves and small fruits. In Philippines, a variety called Jolo produces fruits that are larger, with big seeds but more delicious pulp than the common cultivated type.

Propagation

Since its seeds are azygotic and they produce trees resembling mother, mangosteen is commonly propagated through seeds. Freshly extracted large, plumpy seeds are planted in a humus-rich medium with good drainage. The nursery bed should be deep enough for the growth of tap root. Sometimes 2–3 plants are formed from a single seed and only vigorous plants should be chosen at early stage. As seedlings

attain 2-leaf stage they should be transplanted to 30cm deep earthen pots. Additional care needs to be taken while transplanting the seedlings as they have a lengthy delicate tap root. A few lateral roots do not compensate for any injury or loss to the main root. Sowing the seeds directly into polybags/earthen pots, then transferring the saplings at appropriate time to permanent sites can circumvent the risk associated with transplantation operation. The seedlings grow slowly and even after 2 years of growth seedlings do not reach more than 15cm height. The slow and poor growth of seedlings is attributed to lack of adequate fibrous lateral roots. It can be considered as a major barrier in its cultivation.

Attempts to propagate mangosteen by vegetative means has proved unrewarding. The poor rooting when cuttings or air-layering are tried, and non-availability of suitable rootstock although several allied genera have been tested, for grafting or budding, has discouraged large-scale vegetative propagation.

Cultivation

Planting

Planting distances vary from 8 to 10m between trees, depending on soil fertility. Transplantation of mangosteen is a vital operation and plants should be taken out from the containers with utmost care, and planted carefully in the permanent site with a ball of earth. Other points as described for avocado may be considered.

Pruning

No elaborate pruning can be advocated for general adoption by the growers. However, it is a good practice to prune old, diseased, and damaged branches, and those branches that touch the soil and suckers that grow up from the base of the trunk. Severe pruning and removal of growing tips or branches should be avoided. It is better to prune when the tree does not have flowers, fruits or new flushes of leaves.

Manuring and fertilization

Mangosteen crop in the field is often not fertilized, but when in nursery, a mixture of N:P:K (20:20:20) containing trace minerals may be given to each seedling at the rate of 5ml/4 litres of water. It may be applied to soil as well as foliage once in 15 days. Because soils vary in fertility, it is difficult to specify common fertilizer dose. The general recommended dose is given in Table 1. It can be modified depending on soil type and tree growth.

Age of the tree (years)	20-20-20 NPK* mixture (kg)	FYM (kg)
1-2	0.25	20
2-4	0.50	20
4-6	1.00	40
6-8	2.00	50
8-14	4.00	60
Over 15	**7.00 (1400 N: 1400 P2O5 :1400 K2O**	**60**

*Proportion of N, P_2O_5 and K_2O expressed as percentage

(Table 1. Annual fertilizer and manurial recommendations for mangosteen plant to be applied in 2 splits)

Irrigation

Mangosteen needs regular irrigation in places where rainfall is light and good drainage where rainfall is heavy. The frequency of irrigation should be decided on the basis of weather and soil moisture. Mulching with grass or dried leaves helps the trees

as the process conserves soil moisture.

Harvesting and Postharvest Management

Well attended trees begin to fruit at 7 years of age; the average time of fruit bearing being 8–10 years. The time of flowering and fruiting are influenced by elevation and presence or absence of shade. Usually a single crop is produced annually, but 2 crops, viz. August–October and April-June, have been obtained from the trees at the Nilgiris hills. The August–October is the main crop. Fruits are picked with peduncle when slightly soft and colour change occurs from greenish-brown to dark brown or reddish-purple. As mangosteen trees grow vary tall, long bamboo poles and/or folding aluminium ladders are helpful in harvesting. Even fruits that fall from the tree when ripe may be picked at the earliest possible for immediate use. The yield from a tree ranges from 500–1,500 fruits, depending on the development of the tree.

Mangosteen fruit should be handled and packed with care especially to avoid damage from the still attached peduncle. It is recommended to treat the surface of the fruit with Bordeaux mixture to avoid rot during shipping and the shipment should ensure that the fruit arrives at the market near or at maturity. Mangosteen can be stored for 2–3 weeks at room temperature and at optimum conditions (4–6°C with 85–90% relative humidity) fruits can be kept up to 50 days without much loss in aroma and flavour. The fruits are normally consumed as fresh. A number of processed products like jelly, paste, syrup and canned fruit segments can be prepared from the fruit. However, much of the fine aroma is lost during processing.

Physiological disorders

Gamboge and fruit splitting are physiological disorders in mangosteen. Gamboge is characterised by yellow exudation of gum on the fruits and branches. Fruit splitting results in swollen arils with a mushy pulp. Gamboge is more pronounced in fruits exposed to direct sunlight, and in crop that matures in summer. Heavy and continuous rains during fruit ripening favour gamboge and fruit splitting in certain locations.

16.Pomegranate

B.N.:- ***Punica granatum.*** L. **Family. :** Punicaceae. **Origin :-** Iran

Cultivated in Spain, Egypt, Iran, Afghanistan etc. In India, maximum in Maharashtra, followed by AP, UP, TN, Karnataka and Gujarat. Gujarat occupy 850 ha. with production of 5780 t. Dholka, Bhavnagar, Mehsana etc.

Sugar –14-16 %, minerals-0.7-10 %, Acidity 0.5-3 ml/100 ml. Used as salad and beverages. Root, rind & seed has medicinal value. Dry seeds of sour varieties used as Anar dana.

Climate :- Subtropical crop. Hot and dry climate during fruit development & ripening is good. Humidity lowers the quality. In tropical & sub tropical region, it is evergreen or partially deciduous. In temperate, it is deciduous. Drought resistant.

Soil :– All type of soil. Tolerate alkalinity & salinity. Deep, loamy, well drained & fertile is best. Sensitive to moisture fluctuation.

Propagation :- 1. Seed: 2. Cutting : i.e. Hardwood cutting, IBA 3000 ppm used. 3. Air layering in monsoon.

Varieties :- Ganesh, Dholka, Bhavnagari,

Planting :- 5 x 5 or 6 x 6 m. pit size 60 x 60 x 60 cm. Planting in June-July.

Training & Pruning : Trained on single stem, but multistem is good because if one stem lost, though it survive. Fruit born terminally on short spurs of mature shoots, so limited pruning. Remove suckers.

Intercropping : Pulses and vegetables.

Irrigation : Regular during fruiting season. Irregular irrigation results fruit cracking. 7-10 days in summer and 15-20 days in winter.

Manuring :- 50 kg FYM + 500 g N + 250 g P + 500 g K. per tree per year. ½ in June and ½ in Sept.-Oct.

Fruit Cracking :- Serious physiological disorder. Young fruits crack due to boron deficiency. Larger fruits crack due to soil moisture fluctuation and day-night atmospheric moisture.

Control :- 1. Maintain soil moisture. 2. Cultivate tolerant variety-Bedana Bosec and Khog. 3. Harvest early. 4. Spray Ca(OH)2 after fruit set. & fruit initiation. 5. Spray borax.

Harvesting : Fruits ready after 5-7 months. Harvest when skin turn yellowish and give metallic sound.

Yield :- 100 fruits or 40 kg/tree. Economic life. 30 yrs.

Pests :-

1. ***Anar Caterpillar*** (fruit Borer.) : Dangerous in all over India. Female lay eggs on calyx and small fruits. Larvae bore fruit. Fruit rots by bacteria and Fungi & fall down. Extent of damage 50-90 %. Spray Metacid 1 ml/lit. Water or phosphamidon 3ml/10lit. water at fortnightly.

2.Barkeating caterpillar :- (Inderblella) Bore the bark of tree. Older tree and unmanaged trees have more attack, gives poor yield. Keep the orchard clean. Clean the bore & pour petrol or kerosene & seal with cotton wool.

Diseases :-

1. ***Fruit spot :*** By Fungus. Fruits become small. Irregular spots turn into strips and ring become brownish. Pruning dead and affected branches. Spray Dithane M-45. 500g in 200 lit. water, after fruit setting.
2. ***Fruit Rot :*** Fungal disease, during monsoon. Poor fruit setting. Immature, soft & rotted

fruit. Remove infected twigs and fruits. Spray Dithane M-45 at 15 days interval.

Bahar Treatment :- 1. Mrig Bahar- June-July. Flowering. 2. Ambe Bahar- Feb.-Mar. Flowering. 3.Hast Bahar- Sept.-Oct. Flowering. Only one bahar is taken on the basis of availability of water and market prices. Mrig Bahar is not preferred because fruit available in winter, but flower and fruit development in monsoon, so attack of insect peasts & diseases are more therefore, in Gujarat, Hast Bahar is preferred. Hast Bahar fruits available in summer and at that time no other fruits in market. Fruit develop in winter so less pest and diseases. and good quality fruits.