STUDY MATERIAL


PRINCIPLES OF HORTICULTURE
AND
PRODUCTION TECHNOLOGY OF FRUITCROPS

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Principles of Horticulture

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What is horticulture?

The term "**Horticulture**" is derived from two Latin words i.e. "**Hortus**" meaning garden or enclosure and "**Cultra**" meaning cultivation. So, horticulture literally means garden culture or culture of garden crops.

The term "**Agriculture**" refers broadly to the technology of raising plants and animals .On the other hand "**Horticulture"** which is a part of agriculture is concerned with the raising of so called garden crops.

In olden days staple (food) crops (Paddy, Maize, Wheat etc.) were grown in open fields on a large scale, while some crops of special interest like fruits, vegetables, flowers etc. were grown in the back yard of houses in an enclosure. In cases where fruits, vegetables and flowers were grown in areas other than backyards, they are protected by erecting walls, by raising live fences, non-live fences etc. i.e. they are enclosed. As such the term Horticulture in the original sense referred to the cultivation of crops with in the protected enclosure, which is often called as a garden (Crops grown in a protected enclosure). So, the culture of crops in gardens is referred as "**Horticulture**".

At present, fruits, vegetables, flowers etc. are grown not only with in the back yards, but also in large areas in open fields on a commercial scale. Traditionally garden crops include fruits, vegetables and flowers. But today's horticulture deals not only the fruits, vegetables and flowers but also other important crops like spices, condiments, plantation crops, medicinal and aromatic plants etc,. Besides cultivation of these crops, present day horticulture deals with the utilization and improvement of these crops. Hence, modern horticulture may be defined as a part of agricultural science, which deals with the production, utilization, and improvement of fruits, vegetables, flowers, ornamentals, plantation crops, medicinal and aromatic plants etc.

Divisions of horticulture:

Horticulture crops include fruits, Vegetables, flowers, plantation crops, Spices, condiments, Medicinal and Aromatic crops etc. In addition to these, Horticulture also deals with raising of trees for shade, ornamental and avenue purposes, planning and raising of ornamental gardens, parks and raising of seed and planting material. Further, horticulture also deals with the utilization of horticulture produce and improvement of horticulture crops.

Hence, based upon the crops dealt and also their purpose and utilization, the branch of horticulture is sub-divided in to the following divisions for convenience.

Pomology: It is derived from two words i.e." **Pomum**" meaning **fruit** and "**Logos**" meaning **discourse or study**. So, pomology is study or cultivation of fruit crops.

E.g. Mango, Sapota, Guava, Grape, Banana etc.

Fruit: It is a developed and matured ovary with or with out accessory parts and which is generally eaten as raw.

Olericulture: It is derived from two words ie."**Oleris**" meaning **Potherb** and "**Cultra**" meaning cultivation. So, Olericulture literally means **potherb** cultivation. In the present days it is broadly used to indicate the cultivation of vegetables.**Eg.** Brinjal, Okra, Tomato, Pumpkin etc.

Vegetable: It is any part of the herbaceous plant that is generally used after cooking as a principal part of the meal.

Floriculture: It is derived from two words i.e. "Florus" meaning flower and "Cultra" meaning cultivation. So floriculture means study of flower crops.

In this there are again two sub-divisions. (1) **Commercial Floriculture** (2) **Ornamental Floriculture**.

Commercial floriculture: Deals with the cultivation of flower crops grown on commercial scale for profit (Income). **E.g.:** Rose, Jasmine, Carnation, Aster, and Marigold etc.

Ornamental floriculture: It deals with the raising of flower crops for ornamental, pleasure and fashion purposes. **E.g.:** Dahlia, Zinnia, Cosmos, Hibiscus, Balsam, Nerium, Poinsettia, Hollyhock, Gerbera, and Gaillardia etc.

Arboriculture: This branch deals with the raising of perennial trees meant for shade, avenue or ornamental purposes. **Eg.**Polyalthia, Spathodea, Cassia, Gulmohar etc.

Plantation crops: Are those crops, which are cultivated in an extensive scale in large contiguous areas, owned and managed by an individual or a company and whose produce is utilized only after processing.**Eg.** Coffee, Tea, Rubber, Coconut, Cocoa etc.

Spices and condiments: This branch deals with the cultivation of crops whose produce is used mainly for seasoning and flavouring dishes.

Spices: Are those plants the products of which are made use of as food adjuncts to add aroma and flavour. **Eg.** Pepper, Cardamom, Clove, Cinnamon, All spice etc.

Condiments*:* Are those plants the products of which are made use of as food adjuncts to add taste only. **Eg**.Turmeric,Ginger,Red chillies,Onion,Garlic etc.

Both spices and condiments contain essential oils, which provide **aroma, flavour and taste** and they are of little nutritive value.

Medicinal and aromatic plants: It deals with the cultivation of medicinal plants, which provide drugs and aromatic crops which yields aromatic (essential) oils.

Medicinal plants- are those plants, which are rich in secondary metabolites and are potential sources of drugs. The secondary metabolites include alkaloids, glycosides, coumarins, flavonoides and steroids etc. **Eg.** Periwinkle, Opium, Menthi, Cinchona, Dioscorea Yam, Belladona, Senna, Sarpagandha, Aswagandha, Tulasi etc.

Aromatic plants- are those plants, which possesses essential oils in them. The essential oils are the odoriferous steam volatile constituents of aromatic plants. **Eg**. Lemon grass, Citronella, Palmrosa, Vetiver, Geranium, Davanam, Lavendor etc.

Fruit technology: It deals with the processing and preservation of produce of horticulture crops.

Landscape gardening: It deals with the planning and execution of ornamental gardens, parks, landscape gardens etc.

Nursery and seed production: It deals with the production of seeds and planting material of horticulture crops on commercial basis.

Plants grown for aesthetic value are also included in horticulture. Though crops like potato, cowpea and several condiments are grown as field crops they are included under horticultural crops when they are grown as vegetables in small areas.

Role of horticultural crops in human nutrition

From human nutrition point of view horticulture is most important to our daily living. Many of the horticulture crops and their products find place in our meals and diet. Human body requires vitamins, minerals, proteins, energy etc. for its health. All these are supplied by horticultural crops. Fruits and vegetables are the chief sources of vitamins, minerals, carbohydrates, fats, proteins etc.

Fruits and vegetables are recognized as **protective foods** as they are necessary for the maintenance of human health.

Vitamins: These are the important constituents of fruits and vegetables and are indispensable part of human diet. Although required in very minute quantities, they are absolutely essential for the maintenance of health. The deficiency of any vitamin from the diet for considerable period may lead to diseased state or disorder conditions. Fruits and vegetables supply several vitamins.

Vitamin-A**:** It is essential for normal growth, reproduction and maintenance of health and vigour. It affords protection against cold and influenza and prevents night

blindness. The deficiency of this vitamin results in cessation of growth in young children, night blindness, drying up of tear glands in the eyes, eruption of skin (Rashes on the skin) and
brittleness of the teeth
Sources: ***Fruits-***Mango, Papaya, Dates, Jackfruit, Walnut etc. ***Vegetables-***Greens like palak, spinach amaranthus, fenugreek, carrot, cabbage lettuce, peas, tomato etc.

Vitamin B_1 (Thiamine): Tones the nervous system and helps in proper functioning of the digestive tract. Its deficiency in human diet results in "**Ber-beri**", paralysis, loss of sensitivity of skin, enlargement of heart, loss of appetite **,**loss of weight and fall in body temperature.
Sources: ***Fruits***-Orange, pineapple, jack fruit, cashew nut, walnut, dry apricot, almond, banana etc,.***Vegetables-***Green chilli, beans, onion, sweet potato, tomato (red), leaves of colocasia .

Vitamin B_2 (Riboflavin): This vitamin is required for body growth and health of the skin.
The deficiency of this vitamin causes sore throat, anorexia cataract, and loss of appetite and body weight and also development of swollen nose.
Sources: ***Fruits***- Bael, papaya, litchi, banana, apricot, pomegranate, pear etc. ***Vegetables-*** Cabbage, cauliflower, potato, peas and beans, methi, lettuce, asparagus, green chillies, leafy vegetables etc,.

Vitamin -C (Ascorbic Acid): This vitamin promotes general health and healthy gums, prevents scurvy disease which is characterized by pain in the joints and swelling of limbs (rheumatism), bleeding of gums, tooth decay and keeps the blood vessels in good condition.
Sources: ***Fruits:*** Amla**,** guava, ber, citrus, strawberry, pineapple etc. ***Vegetables:*** Tomato, palak, menthi, cabbage, green chillies, spinach, potatoes, peas and beans and carrot etc,.

Vitamin-D: This vitamin is necessary for building up of bones, preventing rickets and diseases of teeth.
Sources: All green leafy vegetables are rich in this vitamin.

Vitamin-E: Has an important effect on the generative functions and promotes fertility.
Sources: Green lettuce and other green vegetables.

Vitamin-K: This vitamin prevents blood clotting
Sources: All green leafy vegetables are rich in this vitamin

Minerals: Human body requires minerals like P, Ca, Iron, and Iodine etc. for maintaining good health.

Calcium: It is essential for development of bones regulation of heartbeat, controlling blood clots

Sources: ***Fruits-*** Acid lime, Orange, Fig, Dried apricots, wood apple etc. **Vegetables**-Cabbage, greens, beans, carrot, onions, peas, tomatoes, agati, spinach drumstick leaves etc.

Iron: It is required for production of haemoglobin and it is constituent of red blood corpuscles. Its deficiency causes anaemia, smooth tongue, pale lips, eyes and skin and frequent exhaustion.
Sources: ***Fruits-*** Custard apple, Guava, Pineapple, Straw berry, Grape, Black currents, dried dates etc. and *vegetables* like Carrot, Drumstick leaves, beans and agati etc.

Phosphorous: It is essential for maintaining the moisture content of tissues and for development of bones.
Sources: ***Fruits-***Guava, Grape, Jackfruit, Passion fruit, Orange and ***vegetables*** like Carrot, Chilli, Drumstick leaves, Beans, cucumber and onion.

Proteins: These are bodybuilding foods. These are essential for growth of the body. The deficiency of proteins in the body causes retarded growth and increases susceptibility to diseases and causes lethargy.
Sources: ***Fruits-*** Most of the fruits are low in proteins except Guava and Banana.
Vegetables like peas and beans are rich in proteins.

Enzymes: These are required for controlling several metabolic activities in the body**.**
Sources: Papaya-Papain and Pineapple-Bromelin.

Fibre and roughages (Cellulose and pectin): Fruits and vegetables supply roughages These are required for digestion and prevention of constipation.
Sources: Fruits contain low content of fibre. Guava and anola are better sources compared to other fruits. Leafy vegetables are rich in fibre content

Energy foods: Fruits and vegetables contain Carbohydrates and fats there by supply energy to human body. Those fruits (Banana, Dates, Apple etc.) and vegetables (Potatoes, Sweet potato, Beans, Peas etc.), which contain Carbohydrates, are called as "**energy Foods.**" Nut fruits like Walnut, Cashew nut and almond etc supplies proteins besides energy.

Importance of horticulture in the national economy

1. Horticultural produces contribute to national wealth. They are the important exportable commodities in many countries. In India also through export of horticultural produces our country is earning foreign exchange.

India exporting **flowers** to America, Netherlands, Germany, Japan, UK, **Onions** to Malayasia, UAE, Singapore, Srilanka and Bangladesh. **Vegetables** to Srilanka, America, UAE, Spain, Saudi Arabia, Bangladesh, U.K., Kuawait, **Fresh grapes** to UK, Netherlands, UAE, Bangladesh, Germany, **Fresh fruits** to Bangladesh, UAE, Saudi Arabia, UK and Srilanka. **Processed vegetables** to Egypt, Srilanka, UAE, America and Turkey and **Mango pulp** to Saudi Arabia, UAE, Netherlands, Kuwait and Germany. **Pickles and Chutneys** to UK, America, UAE, Spain etc.

Export of horticulture products from India (1988-'99)

Products	Quantity (' 000 tones)	Value (Rs. In millions)
Fruits and vegetables	387.43	5,360.20
Processed fruits and vegetables	238.60	7,056.80
Fruits and vegetable seeds	6.06	663.30
Floriculture	18.72	966.00
Coconut	56.oo	3,021.00
Cashew& its products	75.02	16,099.00
Tea	205.86	21,918.40
Coffee	211.62	17,510.00
Total	1,451.29	90,315.70

Export of plantation cops and their products from India (2001-02)

Product	Quantity ('000 tonnes)	Value (Rs.In millons)
Coconut&its products	----------	140.30
Cashew &its products	99.36	17,809.90
Spices	243.20	19,405.49
Tea	190.00	16,960.00
Coffee	213.00	10,500.00
Natural rubber	13.35	---------

2. Horticulture is a mother for many axillary industries like canning industries and processing industries etc. Several agro industries, based on horticultural products are being established there by solving the unemployment problem to some extent.Eg.Rubber, Coir (Coconut) and sago (Tapioca) industries.

3. Horticultural crops provide gainful employment for small farmers and agricultural labour through out the year. One hectare of fruit production generates 860 man-days per annum as against 143 man-days for cereal crops. Some industrial attribute crops

and cultural intensive crops like grape, banana and pineapple, generate much large employment ranging from 1,000 to 2,500 man-days per hectare.

HORTICULTURAL ZONES OF INDIA AND ANDHRAPRADESH

Horticultural zones of India

India has diversified climates right from temperate to tropical climates. So, India has been divided into 3 horticultural zones. They are:

- **TROPICAL ZONE**
- **SUB-TROPICAL ZONE**
- **TEMPERATE ZONE**

TROPICAL ZONE: Entire South India below the Vindhya hills comes under this zone. This zone is again sub-divided in to 3 sub-zones. They are:

- **Central tropical zone**
- **Southern tropical zone**
- **Coastal tropical humid zone**

Central tropical zone: States of Maharastra, Orissa, Southern part of Madhya Pradesh (Chattishgarh) and Telengana area of Andhra Pradesh comes under this zone.

Fruit crops recommended: Mango, Cashew, Citrus, (Sweet Orange, Mandarin orange, and limes), Grape, Guava, Sapota, Banana, Sithapahal, Fig, Ber, Pomegranate, Jamun, and Jackfruit.

Southern tropical zone: Andhra Pradesh excluding Telengana, Tamilnadu, Kerala and Karnataka states comes under this zone.

Fruit crops recommended: Mango, Coconut, Banana, Cashew, Sapota, Pineapple, Mangosteen, Breadfruit, Jackfruit, Sitaphal, Areca nut, Rubber, Pepper, Turmeric, Clove, Nutmeg, Cocoa, Coffee, Citrus (Sweet Orange, Mandarin orange, and limes).

Coastal tropical humid zone: Areas covering all along the coast of different states of peninsular India up to about 160 km inside to the sea shore line. The climate will be always humid and warm. Temperature will not be mild in winter when compared to southern tropical zone.

Fruit crops recommended: Coconut, Banana, Cashew, Jackfruit, Mango, and Pineapple.

SUB-TROPICAL ZONE: The area above the Vindhya hills comes under this zone. Occasionally frost occurs in this zone. This zone is sub-divided into TWO sub-zones basing on the direction. They are:

North-Western Subtropical zone: States like Rajasthan, Punjab, Haryana, Gujarat, Parts of Bihar, U.P, M.P and west Bengal comes under this zone.

Fruit crops recommended: Litchi, citrus (sweet orange, mandarin oranges), dates, guava, sapota, Papaya, phalsa, fig are some typical subtropical fruits grown but other tropical fruits like Mango, jack, banana can also be grown etc.

North-eastern sub-tropical zone: Areas like parts of UP, Bihar, West Bengal, Assam, Meghalaya, Manipur, Nagaland, Mizoram, Arunachal Pradesh, and Tripura.

Fruit crops recommended: Litchi, Citrus (Sweet Orange, Mandarin oranges), Dates, Guava, Sapota, Papaya, Phalsa, Fig, Mango etc.

TEMPERATE ZONE: Areas comes in this zone are Jammu and Kashmir,Kulu,Katrain,Kangra valleys of Punjab, parts of Himachal Pradesh and kuman hills and also high altitude regions in South India-Nilagiris and Palani hills of TamilNadu.This zone frequently experiences frosts.

This zone is further sub-divided in to two sub zones based on elevation. They are:

1. Higher elevation and 2. Lower elevation

Higher elevation: Elevation ranges from 1500—2500 m MSL.

Fruit crops recommended: Apple, Pears, Walnut, Almond, Cherry and Strawberry etc.

Lower elevation: Elevation ranges from 1200—1500 m MSL.

Fruit crops recommended: Peaches, Persimmons, Japanese plum etc.

Although Peach is a temperate fruit crop, a no. of varieties like Sharbati, Honey stone, Sunred and Safeda can be successfully grown in the northern plains of subtropical zone. Similarly Rome beauty an apple variety is grown around Bangalore.

Elevation is not only the factor which decides the prospects of fruit cultivation in temperate zone. Other factors like hail storms, rainfall etc which should also be considered for selection of site for fruit cultivation in temperate zone. Eg. Simla and Solan at 2100 and 1400 m of elevation from sea level respectively. But they are not suitable for growing fruits because of hail storms. But Kulu valley and Kotagarh regions in Punjab are free from hailstorms and are suitable for growing temperate fruits.

HORTICULTURAL ZONES OF ANDHRAPRADESH

The climate of Andhra Pradesh is essentially or mainly tropical. However, two main fruit growing zones are recognized in Andhra Pradesh. Viz, **Tropical zone** and **Sub-tropical zone.**

TROPICAL ZONE: This zone is again divided in to three sub zones. They are- **1. Arid tropical, 2.Humid tropical and 3. Coastal humid tropical**

Arid tropical zone: In this zone the percentage of humidity (moisture in the air) is less. High temperature exists uniformly almost through out the year. Moderate to scanty rainfall is received from both South-West and North-East monsoons. Rainfall is ie.50-75 cm.

Areas of A.P come under this zone:

- Western parts of Adilabad, Karimnagar, and Nalgonda
- Districts of Medak, Khammam, Nizamabad, Mahaboobnagar, Kadapa, Kurnool, Ananthapur and chittoor.
- Western parts of Nellore, Prakasam, Guntur, Krishna and West Godavari.

Fruit crops recommended: Custard apple, sweet orange, guava, grape, banana and mango.

Humid tropical zone: This zone receives heavy rainfall and temperature is more or less uniform throughout the year. Humidity is also more in this zone. This zone is sub-divided into 2 sub-zones. They are: 1.**Heavy rainfall areas 2. Low rainfall areas**

Heavy rainfall areas: This zone receives 120-150 cm rainfall annually. Elevation is up to 600m.Humidity is also very high.

Areas come under this zone: Polavaram and Rampachodavaram.

Low rainfall areas: This zone receives 100-150 cm of rainfall annually. Humidity is less (Aridity).

Areas comes under this zone: Parts of Adilabad, warnagal, Kurnool and Kadapa comes under this zone.

Fruits recommended for humid tropical zone are: Banana, Sweet orange, Guava, Papaya, Ber etc.

Coastal humid tropical zone: This zone receives 75-100 cm of rainfall mostly from South-West monsoon and partly from north- east monsoon. Humidity is also high.

Areas come under this zone: Coastal areas from Nellore to Srikakulam.

Fruits recommended: Banana, Cashew, Coconut, Pineapple and Jackfruit

SUB-TROPICAL ZONE: Based on the amount of rainfall received, this zone is again subdivided in to two sub-zones. They are**: 1. Arid sub-tropical and 2. Humid sub-tropical**

Arid-sub tropical: This zone receives an annual rainfall of about 75-100 cm.Elevation is about 450 m. Cold between October and February.

Areas come under this zone: Hyderabad, Ranga Reddy, Horsely hills, Penukonda of Ananthapur district.

Fruit crops recommended: Grapes, Sweet orange, Mandarin, Lime and Phalsa.

Humid-sub tropical zone: This zone receives an annual rainfall up to 200 cm and elevation up to 620 m MSL.

Areas come under this zone: Parts of Visakapatnam and Srikakulam districts, Araku valley.

Fruit crops recommended: Peach, Japanese plum, Avocado, Litchi, Jack fruit, Bread fruit, Cocoa, Rubber, Coffee, Pepper etc.

Sl.No.	Crop	Area (in '000ha)	Production (in '000MT)	Productivity (In MT.)
1.	Apple	264	2002.00	7.58
2	Banana	843	7574	8.98
3	Citrus	647	23205	35.86
4	Grape	64	1677	26.20
5	Guava	178	1975	11.10
6	Litchi	69	418	6.10
7	Mango	2205	13792	6.25
8	Papaya	80	2686	33.60

Crop Wise area, Production and Productivity of Major fruits in India (2007-08)

9	Pine apple	80	1216	15.20
10	Pomegranate	122	858	7.0
11	Sapota	150	1238	8.25
12	Others	1071	6862	6.40
14	Total	5773	63503	11.00

Source: ICAR &Indian Horticulture Data Base2003
&Ministry Of Agriculture, Govt. of India & ICAR(11394)

Area and production of major fruit crops in A.P.
Year-2007-08

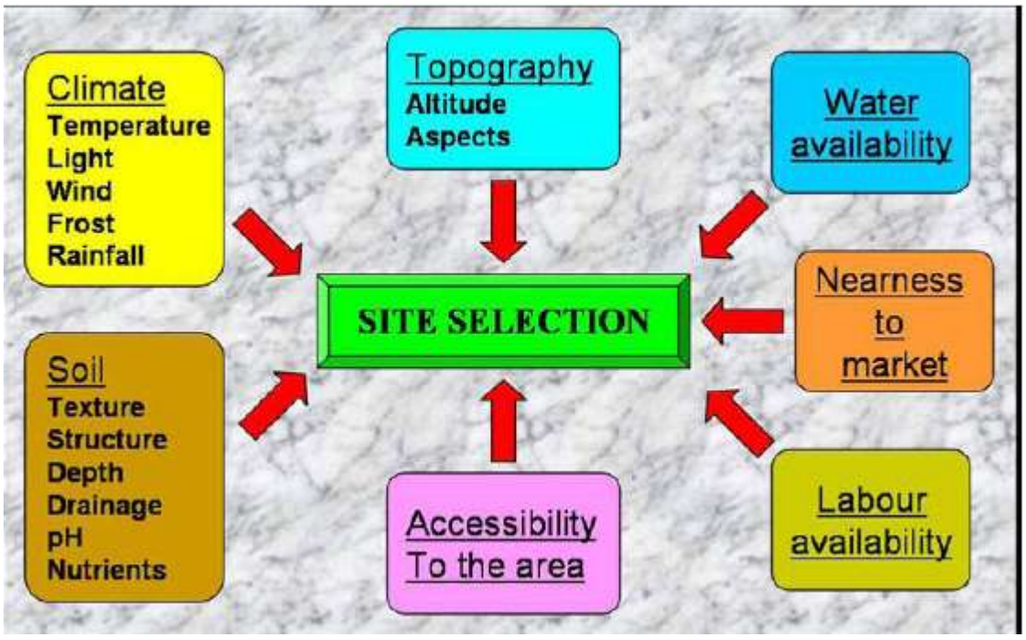
SL.No	Crop	Area (ha.)	Production (Mt. tonnes)	Productivity (Mt.Tonnes)
1.	Banana	75,177	26,31,195	35
2.	Mango	4,83,480	41,57,928	8.6
3	Guava	9,626	1,44,390	15
4	Grapes	2,764	58,044	21
5	Orange& Batavia	1,94,395	26,24,333	13.5
6	Papaya	14,945	11,95,616	
7	Sapota	18,731	1,87,310	10
8	Lemons	58,866	8,82,990	15
9	Total fresh fruits	8,89,362	1,22,14,370	13.7

Source: Dept of Horticulture-Govt. of A.P.

ESTABLISHMENT OF ORCHARD

Establishment of an orchard is a long term investment and deserves very careful planning. The selection of proper location and site, planting system and planting distance, choosing the varieties and the nursery plants have to be considered carefully to ensure maximum production.

Selection of site: The following factors are to be considered before selecting a site for an orchard.



1. Climate: The climate of the locality should be suited to the fruits, or the fruit chosen should be suited to the climate. Enquires should be made on the following points to assess how climate affects the fruits intended to be grown.

1) Experience of the fruit growers and research stations in the locality regarding the acclimatization of the fruits under consideration.
2) The seasons of heavy rainfall, hail storms and hot winds.
3) The seasons and intervals of cyclones, heat waves, gales and other catastrophic features

2. Soil: Few prospective sites should be examined for both physical and chemical properties. For this purpose profile pits of 2m depth should be dug in each representative part of the site as suggested by external appearance, Samples should be collected and analyzed for deciding the choice. Soil samples must be analyzed to know the suitability of soil for growing fruit crops. Soil analysis gives information on the type of soil, its fertility; its pH value etc. As far as possible flat land should be selected .There should be no hard pan up to a depth of 2m.

3. Irrigation facilities: Most of the horticulture crops are raised under irrigation. So the water facilities should also be taken in to consideration (quantity and quality).Water table should be below 2 m depth.

4. Nearness to the market: Saves the over head charges in transport and gives close touch with market tastes (in the case of market gardens).In most cases a large percentage of the retail price of fruits is accounted for by transport charges. The hill bananas and the apples of Kulu valley are produced cheap but they are sold at high prices on the plains owing to heavy cost of transport.

5. Transport facilities: Fruits being perishable cannot be moved for long distances with out quick and refrigerated transport. Bananas from the south are not reaching northern market in our own country owing to the absence of refrigerated transport. But under refrigerated conditions, they can be transported to longer distances. So; the orchards must be located where there is quick transport, preferably a refrigerated transport system.

6. Power (electricity) supply: It would be a great advantage if electric power lines are running in the proximity of the area as it can be tapped easily.

7. Proximity to established orchards: It is an added advantage if the site is in proximity to the already established orchards because of compactness of areas of production facilitates provision of transport and storage facilities. It also enables formation of co-operative societies and other associations which can collectively own grading and spraying machinery and other costly equipment including storage facilities. If there are compact blocks of single crop say citrus, banana, mango etc. the spread of diseases and pests are more.
In selecting a site close to other orchards, one must make sure that they are free from devastating pests and diseases like citrus scale, canker, panama disease of banana, the tristeza disease of citrus.

8. Availability of labour: Large orchards are started often in out of the way places and forest areas away from populated centres.It would therefore be necessary to ensure that adequate labour is available for orchard operatins.This point is of important in plantation crops particularly.

9. Social factors: These assume importance when large contingents of labour and managerial staff are to be employed as plantations or large orchards. They should be provided with medical and educational facilities, so that, they are content and stick on to the jobs.

10. Presence of nurseries close by: It is an advantage if the nurseries are close by to the selected site for selecting the plants for the orchard after studying the scion parents personally. It will also help to get cheap and quick transport of plants which will ensure better establishment.

11. Cost of the land: Cost of the land comes up for consideration when all the other requirements listed above have been satisfied. It should never be the prime consideration in the choice a little extra cost paid for the foregoing amenities is more than repaid in the long run.

Orchard plan

It is of great advantage to prepare a plan of the orchard in advance, be it a home or market garden or a commercial orchard. A detailed survey of the site is carried out including the levels and a good map to scale is drawn. A full knowledge of the fruits to be grown and their cultivation is also prerequisite for efficient planning.

The guiding principles in the preparation of plan are:

1) The orchard should be managed most profitably
2) It should present as attractive look as possible.

The following **general principles** may be borne in mind while drafting a plan and as many of them as possible should be fulfilled. It should be recognized that not all of them can be adopted in every case.

- If the entire area is not of the same type of soil, each fruit should be allocated to the soil type it prefers.
- The irrigation sources should be marked and channels indicated along gradients with a view to achieve most economical conduct of water.
- Irrigated fruits should be close to the source of irrigation to avoid long irrigation channels and consequent loss of water during conduct.
- Tall wind breaks should be planted especially on the sides from which high winds are expected. There should be adequate clearance between the wind breaks and the crop.
- Roads should be planned to occupy the minimum space consistent with economy of transport of orchard requisites and produce. The space between the wind break and the first row of fruit trees may often be utilized for roads and canals etc. with advantages.
- Drains should follow the gradient of the land, should be as straight as possible and concealed from the visitors, if possible.
- When varieties with pollen preferences are planted they should have the pollenizer in an adjacent block or in alternate rows so as to ensure good crop set.
- Fruits which ripen at the same time should preferably be grouped together to facilitate easy watching and harvesting.
- Assign rear areas for tall trees and the front for shorter ones will besides facilitating watching, also improves the appearance of the orchard. The orchard should in general present an aesthetic appearance so as to provide marked attraction.
- The spacing adopted should be the optimum.

The spacing allowed is usually such that the fringes of the trees will just touch one another cutting out light but should not interlock.

With in reasonable limits, closer spacing gives more yields in the earlier age. But in later life, the trees tend to grow taller than broad resulting in difficulty in pruning, spraying and harvesting. They also suffer from root competition inadequate nutrition, fewer fruits which tend to be smaller with comparatively poorer in colour development. So, adoption of closer spacing to accommodate more plants per acre proves to be a false economy in the long run. The spacing given to fruit plants depends on the following factors.

a) The habit of growth of the plant: The spacing being equal to the spread of the plants.
b) Rainfall: In the case of rain fed crops closer spacing is given in lighter rainfall areas than in heavy rainfall areas.
c) Nature of soil: Trees on stiffer soils may be given less spacing as both their top and root spread are limited in such soils.
d) The root stock: Root stock influences the spread of the trees and to that extent determines the spacing to be adopted.
e) Pruning and training
f) Irrigation system.
g) The method of layout should be fixed in advance so that the no. of plants required is worked out and arranged for.

Steps in establishment of an orchard

After the selection of the site and drafting the plan, next comes the establishment of an orchard with fruit plants. For this, the selected site should be thoroughly surveyed for studying its size, topography, flow of irrigation water, drainage and fertility gradients. The positioning of main and subsidiary roads, wells, wind breaks etc.should be planned clearly.

Steps:

1. Clearing of the land: Preparation of the soil depends largely on its condition, previous history and grower's plans. If the land has been under cultivation and has been well maintained, nothing further may be required. On the other hand if the site is a new one and was never under cultivation earlier, much has to be done well in advance for planting. If the land is a virgin land i.e. it is not under cultivation previously, the existing vegetation is to be cleared. Standing trees, shrubs, bushes etc. should be cut down and uprooted along with the stumps and removed. No vegetation should be left on the site. Otherwise, they may shade the young plants; compete for water, light and nutrients. Further, their removal at a later date is expensive and risky. All the stumps and roots may be removed. Otherwise they may harbour white ants, termite hills, diseases etc. and spread to the new plants. Along with vegetation, stones, rocks and ant hills, termite hills etc.should be removed.

2. Leveling: Leveling is important for efficient irrigation, drainage to check soil erosion and also for improving appearance. If the land is sloppy contouring (if the slope is 3 to 10%) or terracing (if the slope is >10%) is to be done. During leveling sub soil should not be exposed.

3. Fencing: Fencing is necessary to protect trees from stray cattle, human trespassing and also for attractiveness. The fence may be of stone, barbed wire or live fence. Growing of live fence is an expensive one. At the initial stage it may be cheap but afterwards the maintenance is costly. Live fence needs periodical punning or trimming to shape and also to control their growth and encouraging more branching. This is one of the costly items of the orchard cultivation.

Characteristics of a good fence plant:

- Drought resistant
- Easy to raise from seed
- Quick growing
- Should have dense foliage
- Should stand severe pruning
- Should not be hard to secature
- Should be preferably thorny

Live fences are sown at the commencement of rainy season to minimize irrigation. They are dibbled in 3 rows; 20-30 cm apart in a trench dug 60cm deep and manured soil.

Examples of **non-thorny fence plants**: Tamarind, Thevitia, Lawsonia, Casuarina, Gliricidia etc.

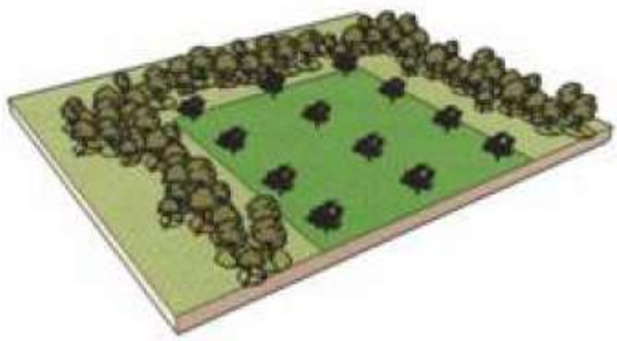
Examples of **thorny fence plants**: Agave, cactus, Prosophis, Commiphora *barli, Inga dulcis* etc.

4. Wind break plants: The wind breaks are provided to resist the velocity of wind which causes loss of bloom, wind erosion and evaporation of moisture and to keep the orchard warm by checking frost and cold waves. The beneficial effect of wind break is felt up to a distance equal to 3 times its height.

The characteristics of a tree suitable as wind break are:

- It should be fast growing
- It should be easily estabishable
- It should be able to acclimatize to the environment
- Should have dense canopy
- It should not harbour pests and diseases
- It should be frost resistant
- It should be drought resistant

- It can be propagated by various methods
- Planting material should be easily available and cheap
- It should have multipurpose uses like fuel wood, fodder etc.
- It should with stand periodical pruning.



Wind Breaks

Some plants usually employed for growing as wind break plants are: Casuarina (Most effective in open sandy soils), *Pterocarpus santalimus* (Redsanders), *Erythrina indica* (Requires pruning to make tree top bushy),Cassia's and *Polyalthia longifolia* (Slow growing) are some trees which can also be used. For mango orchards, seedling mangoes and polyembryionic mangoes may be planted as wind breaks to provide chance seedlings and root stocks.

There should a spacing of 12m between the row of wind break and the first orchard row. This space may be occupied by roads and drains. The wind break trees should be planted closer than their spread so as to form a thick screen. A spacing of 5m is maximum for most plants.

5. Roads and drains: These are laid out according to the plan prepared in advance taking the convenience and levels into consideration. Main irrigation channels also have to be plotted. Open drains should be straight, running parallel to the gradient. Silt catching devices should be employed in the drains. Covered drains should be filled with big stones at the base and smaller ones over them and the top 12 inches should be covered with the orchard soil so as not to impede ploughing and other operations.

6. Tillage: Tillage including sub soil should be done thoroughly at this stage, since it cannot be done after planting without disturbing the roots of the trees.

7. Sowing green manure crops: A green manure crop is sown thick and uniformly all over the area to be planted. Apart from the manurial value the crop reveals by its growth, infertile patches of the land, so that they can be examined and suitable steps are taken for amending them.

8. Marking plant positions: The system of layout should be decided first. Then one of the fence lines or a road should be chosen as the base line. In deciding the base line, due regard should be given to appearance of the rows from the road along which the visitor or the manager is expected to walk.

9. Digging and filling of pits: Generally the pits are dug 2 to 3 months in advance of planting i.e. March to May. Allow the pits to weather. A planting board (a plank about 1.5m long or longer with two end notches and a center notch) is applied to the marking peg by its central notch and two pegs are driven at the end notches. Then the board and the marking pegs are removed and a pit of 1-meter cube is dug. The two pegs driven at the end notches remain in position on either side of the pit. All pits are dug similarly so that plant position is not altered at planting time. While digging, the topsoil should be kept on one side and the bottom soil on another side separately as the topsoil is somewhat fertile than the bottom soil.

While filling the pits, the topsoil is mixed with farmyard manure or compost, leaf mould or green leaf and a kilogram of super phosphate. Then the pits are filled with the bottom layer of soil first and then with the topsoil mixed with the manures. The soil after filling should rise about a foot over the orchard level so as to allow for shrinkage on setting.

10. Filling of pits: Filling is done a fortnight or two after digging pits. The pits are filled with a mixture of Top soil; FYM, leaf mould and bone meal. Pits are filled a few inches above the ground level for shrinkage and settlement.

11. Selection of plants from the nursery: Generally the plants are purchased from the nursery well in advance. The grower should visit the nursery and select the plants. Plants are selected on the basis of certain characters of the plants.

Branching: The main branches on the young plants become leaders on a grown up tree. These branches arise on a plant at an angle (crotch).This crotch should neither wide nor narrow but it should be medium i.e. 40-50$^{O.}$ If the crotch is wider splitting or breaking of limbs will occur because of heavy crop load. If it is narrow (<30^{O}) forms weak frame work. So plants having medium crotches are best. The branches on the trunk should not be opposite or in a whorl but alternate with at least 15cm spacing.

Growth of the plant: The plants should be uniform in growth and is determined by uniform length of internodes. For immediate planting, plants in active growth should not be selected because they may wilt during transit and die on planting. Deciduous fruit plants should be planted when dormancy is about to terminate. They put up new growth quickly and establish early.

Age of the plants: Growers generally prefer older plants believing that these plants come to bearing early. For this there is no experimental evidence. Younger plants

make up in a few years and become equally vigorous and out grow older plants. So, no benefit of selecting older plants. Choosing young plants have many advantages like cheaper in cost, easier to transport and they withstand transplanting shock and easier to transplant.

Pests and diseases: Plants should be free from pests and diseases like scale insects, mealy bugs, aphids, nematodes etc and diseases like canker, and viral diseases.

12. Lifting and packing: Before lifting of plants from the nursery the nursery is thoroughly irrigated one day in advance for easy lifting of the plants without damage to the root system. Then the plants are lifted carefully along with a ball of earth attached to the root system. The roots are wrapped in straw or grass or covered with a gunny cloth and placed in a basket or a wooden crate for packing.
Depending on the size of the basket or crate 6-7 plants are kept for each basket.4-5 long bamboo splinter or wooden pegs are forked into the sides of the basket and tied at the top. In between the plants and at the top of the basket after filling, the plants re covered with straw so as to avoid falling during transit.

13. Season of planting: The distribution of rainfall in the tropics and subtropics and the break of spring growth in temperate zone determine the season of planting. In tropical climate, most trees are planted between July and December and few in January also. In general planting is done during the monsoon in moderate rainfall areas and at the close of the monsoon in heavy rainfall areas.
Planting should be done on cloudy days and preferably in the afternoons rather than in the morning.

14. Planting: The planting board should be used at the time of setting the plants, so that they are in a perfect line. The plants should be set in the soil to the same level as it was in the nursery. The bud / graft joint should not be covered with soil. Plants should be irrigated once copiously to get the soil particles to closely adhere to the roots and also to drive away the air around the roots completely. The plants should be staked with a straight bamboo piece or other twig. Graft bandage should be removed if not already done. Any buds on the rootstocks should be rubbed off.

15. Heeling inn: If the plants after transport are not directly planted in the field, they may be kept in shade in a slanting position along the side of a trench moistening the ball of earth .They may be left in this position till active growth commences by which time they should be planted in the field. This process is known as healing inn.

Influence of environmental factors on horticultural crop production

Temperature: It is an important determinant of plant growth. High as well as low temperatures influence the growth of plants. Broad leaved, ever green plants are very much susceptible to low temperature. Fall of temperature below $5^{O}C$ put a strain on the survival of such plants. Deciduous plants by their adoptive mechanism to shed foliage are better able to tolerate low temperature. Such plants pass their lives in dormant stage during winter. Generally, a temperature range of 20 - $30^{O}C$ is considered ideal for majority of tropical and subtropical plants. Temperate plants require chilling winter. In majority of temperate fruit plants, flowering commences

subject to fulfillment of chilling temperature ranging from 2^{O}C to 7^{O}C.High temperature above 40^{O}C causes scorching in plants. The leaves show burning symptom along tip and margin. High temperature causes bolting and seed formation in spinach and lettuce. Development of red colour in oranges is governed by low temperature. More severe winter favours discontinued synthesis of chlorophyll and unmasking of carotenoids which imparts red colour to oranges. The optimum temperature for most of the plants varies in the range of 22^{O}C to 27^{O}C. High fluctuation in day and night temperature badly influences the growth and production of plants.

Humidity: It is a crucial component of climate affecting growth and production of crop. Humidity is essential for growth of the plants and qualitative development of the fruits. The kharief plants and vegetables grow fast with abundant humidity during monsoon season. The colour, TSS (total soluble solids), sugar and acid blend is bettering in dry atmosphere having very little humidity. The oranges grown under high humidity have thin rind and more juice. Low humidity favours better colour development in oranges. High humidity favours resurgence of diseases and pets also. High humidity during March causes powdery mildew disease in mango. Fruit fly incidence is more in mango if there is high humidity in atmosphere at the time of fruit ripening. Fluctuation in atmosphere humidity is the main attribute behind cracking of fruits. Under less humid conditions the fruit skin is smooth, thin and shiny and it is important where the fruit skin is edible like Guava, ber, apple etc.

Wind: High velocity and hot winds cause heavy damage to fruit trees. They cause breakage of limbs of fruit trees. High velocity winds also cause shedding of flowers and dropping of fruits. Dry winds bring scorching and torning impact on the leaves of banana. The increasing wind velocity retards the activity of pollinators. Bee activity is maximum when wind is still, gets little reduced when wind is 2-3 km per hour, gets greatly reduced when wind velocity is 25 km per hour and their activity is altogether ceased when the wind velocity is 40 km per hour.In wind storm, spray of pesticide and other chemicals become difficult.

For successful cultivation of fruit crops, raising of dense windbreak rows around the orchard is necessary. The trees like eucalyptus. shisham, casuarina, seedling mango, and jamun may be used as wind breaks.

Rainfall: The amount and distribution of rainfall is important factors in growth and development of crop. Rain at the time of flowering washes out pollen grains and greatly reduces the fruit set. A year of normal rainfall creates conducive condition and yields better growth and harvest of plant. The fruits like guava, pomegranate, ber and sapota in which flowering synchronizes to rainy season, normal rainfall brings bumper harvest. Water is required at different stages of plant growth. Water shortage at the time of early growth, bud differentiation, blossoming, and fruit set and development results in undesirable effect. Rains before harvesting cause softening of fruits in

banana and date palm and induce infection of fruit fly in guava and peaches. It is generally observed that fruits are more juicy where they mature during rainy season due to high atmospheric humidity. Fruits that mature during rainy season contain less sugar and more acid than fruits maturing during dry season. Keeping quality of fruits and vegetables developing under high atmospheric conditions may not be good.

Hailstorms: These causes great damage to the fruit crops. Occurrence of hail at the time of flowering and fruit maturity is very disastrous because flower and fruit drop is heavy and the growers get poor returns for their produce. For successful cultivation of fruit crops, only those areas where hailstorms don't occur should be selected.

Solar radiation: It is the primary source of energy to plants. For the transformation of light energy to chemical energy leading the production of photosynthates, solar radiation is must. Orchard, located on southern side of the slope receiving better amount of radiation, bears better yield than other side. The periphery and top most portions of plants are more productive due to better and direct absorption of solar radiation. Training and pruning of plants are maneuvered in a way; so that the plant may be better able to absorb more solar radiation required for good productivity.

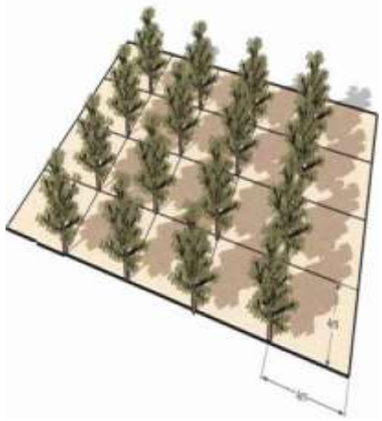
Systems of orchard plating

The arrangement of plants in the orchard is known as lay-out. The following points need to be considered before choosing a system of planting.

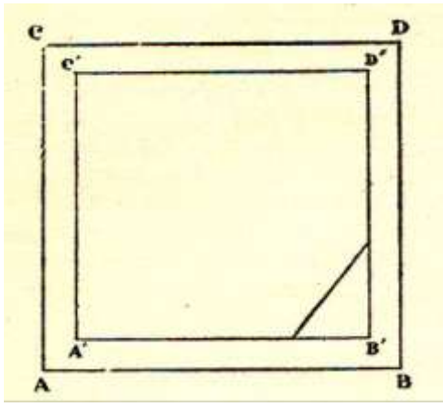
- It should accommodate maximum number of plants per unit area.
- It should allow sufficient space for the development of each tree.
- It enables equal distribution of area under each tree.
- The intercultural operations such as ploughing,spraying etcare easily carried out.
- It makes supervision more easy and effective.

Descriptions of the different systems:

(1) Square system:

	➢ In this system a tree is planted at each corner of a square what ever may the Planting distance. ➢ The distance between row to row and plant to plant is same.

Procedure for lay out:



Step no. –1: “ABCD” is the area where the trees are to be planted. The first step will be establishing a base line. Select the baseline parallel to the road or fence or the boundary of the orchard. This should be drawn at half a distance of the spacing that is to be followed. For example, if the spacing is 10m, the base line should be drawn at a distance of 5m from the periphery of the plot.

Step no.-2: Towards end of the base lines leave again a gap of half the spacing from the boundary or road or fence etc. and put the peg on one end of the base line. From this peg measure one planting distance and put the second peg on the base line. Thus, continue placing pegs at each of the planting distance till the total length of the base line is covered. The distance from the last peg to the boundary should also be at half the spacing.

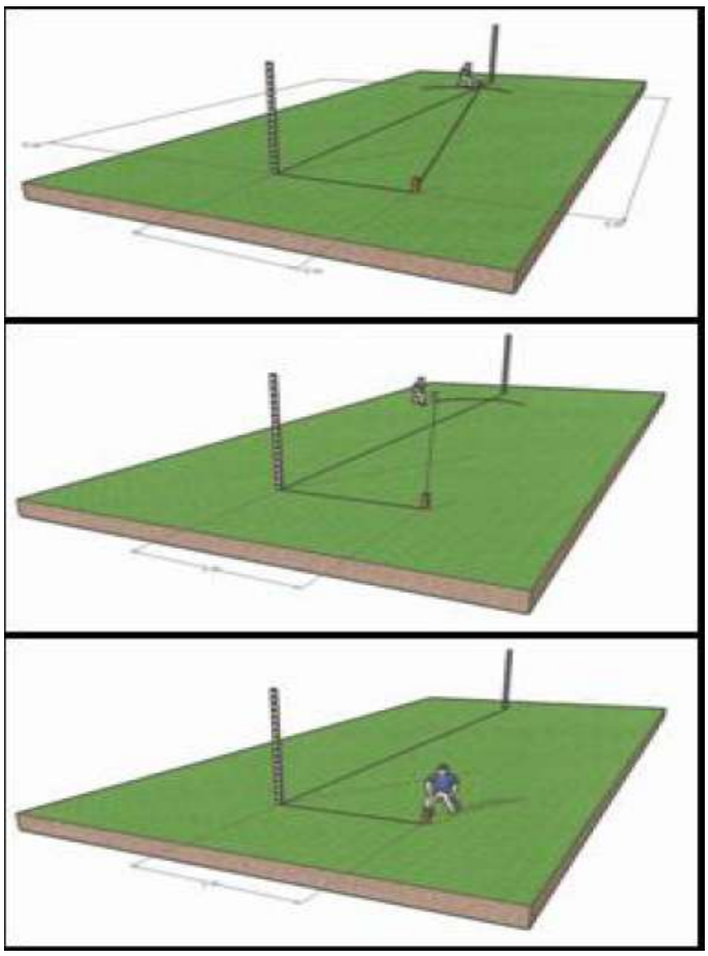
Step no.-3: From the first peg and the last peg on the base line, draw perpendicular lines. The perpendicular lines may be drawn by adopting any of the following methods.

Cross staff method: Cross staff comprises of a wooden block with two perpendicular slits made on its surface and fixed to an iron rod.

- Fix the iron rod in the position of the first peg. See thorough the slit parallel to the base line and see that it lies in line with the base line.

- Now see through the other slit perpendicular to the first one and fix a ranging rod or a bamboo stick at a convenient distance from the base line.
- Extend a straight line from the position of the first peg through the position of the bamboo stick .This gives a perpendicular line to the base line at the position of the first peg.

Pythagoras theorem method: Adopting a right angled triangle with the sides and hypotenuse in the proportions of 3:4:5, a perpendicular line can be drawn.



3, 4, 5 Method

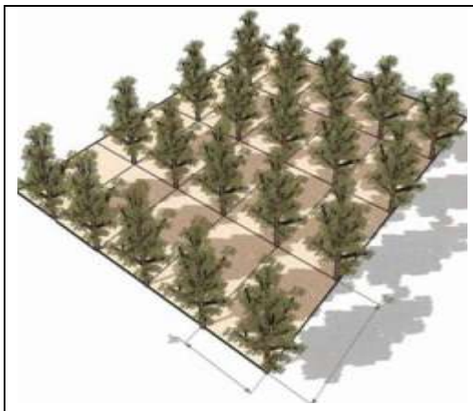
- On the base line from the first peg measure a known distance in proportion of 3 and mark the point
- From the first peg, measure a distance in the proportion of 4 and draw an arc away from the base line.
- From the point previously marked on the base line now measure a distance in the proportion of 5 and draw a second arc intercepting the first one.
- Now extend a straight line from the position of the first peg through the point of intersection of the two arcs. This gives a perpendicular line to the base line from the position of the first peg.

Merits and demerits:

1) Most commonly followed and simplest of all and easy to lay out.

2) The possibility of cultural operations in two directions is the greatest advantage of this system.
3) The major disadvantage of this system is that a lot of space in the centre of each square is wasted.

(2) Rectangular system:

	➢ Similar to square system, except that the distance between plants in the row and distance between rows is not the same but different. ➢ Row to row distance is more than that from plant to plant in the row.

Procedure for lay out:

Step no's: 1, 2 and 3 are as same as in square system.

Step no.4: Mark the planting positions on both the perpendicular lines following the spacing to be adopted between the rows.

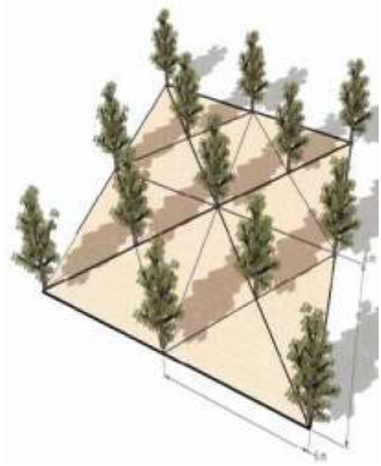
Step no.5: It is same as in square system, but following the spacing to be adjusted between the rows.

Step nos. 6, and 7 are as same as in square system.

Merits and demerits:

1. It has almost all the advantages of the square system but cultivation is some what difficult, especially when the trees have fully grown.

(3) Quincunx or filler system:

	➢ This is also known as filler or diagonal system. ➢ This is the modification of a square system of layout distinguished to make use of the empty space in the center of each square by planting another plant is called filler tree. Generally the filler tree will be precocious and shorter duration and not be of same kind as those planted on the corner of the square. Guava, phalsa. plum, papaya, peaches, kinnow are important fillers. They yield some crop before the permanent trees come into bearing. ➢ The filler tree is removed when the main fruit trees grow to full stature and start bearing.

This system is followed when the distance between permanent trees exceeds 8m or more or where permanent trees are very slow in their growth and also take longer time for coming to bearing. **Eg.** Sapota, Jackfruit**.**

Procedure for lay out:

Step no-1: Lay out the square system

Step no.-2: Draw diagonals of each square.

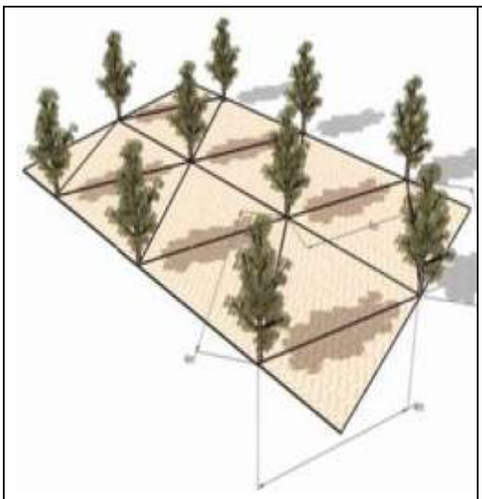
Step no.3: Mark the planting position of the filler tree by fixing a peg at the point of intersection of the two diagonals in each square.

Merits and demerits:

1. The main advantage of this system is that the plant population is about double than the square system.

2. The greatest disadvantage of this system is that, it is difficult to carry out intercultural operations on account of the filler tree.

(4) **Hexagonal system:**

	➢ This is also called as equilateral system. Some times a seventh tree is planted in the centre of the hexagon, and then it is called **septule** system. ➢ In this system the trees are planted in each corner of the equilateral triangle. ➢ This system differs from the square system in which the distance between the rows is less than the distance between the trees in a row, but the distance from tree to tree in six directions remains the same. ➢ This system is usually employed, where land is expensive and is very fertile with good availability of water.

Procedure for lay out: Steps-

- Mark the four sides as in the case of square system with the distances shown in the sketch. Locate the positions of the plants also on the first row.
- Take a rope slightly more in length than double the distance between the plants.
- Put a knot in the centre, so that the length of the rope on either side of the knot is as much as the tree to tree distance **or**
- Take an iron chain with a ring in the centre and either arm equal in length to the tree to tree distance.
- Hold the ends of the rope or chain, each at the positions of two consecutive plants on the first row, and stretch from the centre to give an equilateral triangle and there by the position of a plant on the second row is fixed.
- In this way the field can be laid out.

Merits and demerits:

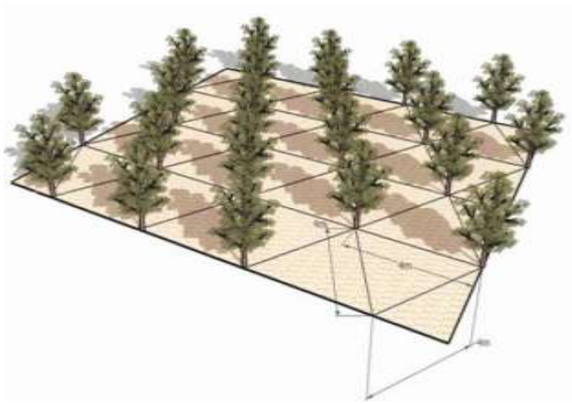
1. This system permits cultivation in three directions.

2. The plants occupy the land fully without any waste as in square system

3. This system allows 15% more plants than the square system of planting.

4. This system is not generally followed because it is difficult to adopt in practice in the field and the inter-cultivation in such gardens is difficult to carry out.

(5) Triangular system:

	➢ The trees are planted as in square system but the difference being that those in the even numbered rows are midway between those in the odd rows instead of opposite to them. ➢ Triangular system is based on the principle of isolateral triangle. The distance between any two adjacent trees in a row is equal to the perpendicular distance between any two adjacent rows. ➢ However, the vertical distance, between immediate two trees in the adjacent rows, is equal to the product of (1.118 x distance between two trees in a row).

Merits and demerits:

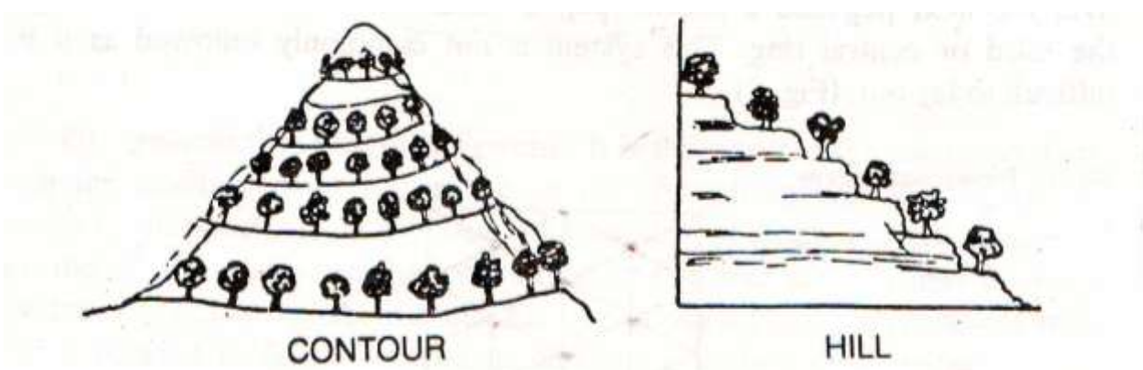
1. This system is not much of practical importance.

2. Plants are not placed at equal distance from all sides.

3. When compared to square system, each tree occupies more area and hence it accommodates few trees per hectare than the square system.

All the above systems are possible when the land is flat, plain or level, but not on uneven lands and sub-mountane areas (hilly areas).On undulating lands and hill slopes different types of planting systems are followed,Viz.,contour and terracing.

(6)Contoursystem:



It is generally followed on the hills where the plants are planted along the contour across the slope.

- It particularly suits to land with undulated topography, where there is greater danger of erosion and irrigation of the orchard is difficult.

- The main purpose of this system is to minimize land erosion and to conserve soil moisture so as to make the slope fit for growing fruits and plantation crops.
- The contour line is so designed and graded in such a way that the flow of water in the irrigation channel becomes slow and thus finds time to penetrate into the, soil without causing erosion.
- Terrace system on the other hand refers to planting in flat strip of land formed across a sloping side of a hill, lying level along the contours.
- Terraced fields rise in steps one above the other and help to bring more area into productive use and also to prevent soil erosion.
- The width of the contour terrace varies according to the nature of the slope. If the slope becomes stiff, the width of terrace is narrower and vice-versa.
- The planting distance under the contour system may not be uniform.

- When the slope is <10% contour bunding is practiced and if the slope is >10% contour terracing is practiced.
- In this system the trees are planted along the contour line at right angles.
- Cultivation and irrigation can be practiced along the tree rows only.

Merits and demerits:

1) The trees may not be set at equidistance.
   The no. of plants per unit area will generally be less than other system

Calculation of number of plants in different systems of planting

Square system of planting:

$$\frac{\text{Area of the land}}{\text{Area occupied by a single tree}}$$

Area of the land = 1 ha. (10000 sq. m^2)

Spacing between the plants and rows =10 m

Area occupied by a single tree =10 m X 10 m=100 m^2

No. of plants required per hectare= $\frac{10{,}000\ m^2}{100\ m^2}$ = 100 plants.

Rectangular system:

$$\frac{\text{Area of the land}}{\text{Area occupied by a single tree}}$$

Area of the land = 1 ha. (10000 sq. $m^{2)}$

Spacing between the plants =10 m

Spacing between the rows =12 m

Area occupied by a single tree =10 m X 12 m=120 m^2

No. of plants required per hectare= $\frac{10{,}000\ m^2}{120\ m^2}$ = 88 plants.

Quincunx system:

$$\frac{\text{Area of the land}}{\text{Area occupied by a single tree}} \times 2$$

Area occupied by a single tree

(Double the no. of plants of a square system)

Area of the land = 1 ha. (10000 sq. m^2)

Spacing between the plants and rows =10 m

Area occupied by a single tree =10 m X 10 m=100 m^2

No. of plants required per hectare= 10,000 m^2

---------- = 100 X2=200 plants.

100 m^2

As the plants are planted additionally in the centre of the square, hence first, the no. of plants are calculated for square system of planting which is:

$$\frac{\text{Area of the land}}{\text{Area occupied by a single tree}} = \frac{10000\ m^2}{10 \times 10m} = 100.$$

Additional plants = (No. of rows length wise –1) X (No. of rows width wise--1)

In 100x100 Sq metre field if planting distance 10x10 m then the number of rows length wise and width wise will be 10.

Hence, no of plants = (10-1) x (10-1) = 9x9=81.

So total no. of plants = plants planted in square system of planting + additionally planted plants in the center of the square =100+81=181.

Hexagonal system = $\frac{\text{Area of the land}}{\text{Area occupied by a single tree}}$

Method--1

In this system each tree occupies a parellogram area

Each parallelogram consists of 2 equilateral triangles.

Area of each parallelogram consists of 2 equilateral triangles.

Area of each equilateral triangle is 3/4 X a^2

Where **a** is the length of a side of a triangle ie. Spacing between the trees in a row.

So a tree occupies = **3/4** x $a^{2 x} 2$

Suppose if spacing is 10 m i.**e. a**

Area occupied by a single tree is **3/4** x $a^{2 x} 2$ =1.732 X10X10X2=86.60 m^2

Area of the land = 10000 m^2

No. of plants per hectare = 10000 m^2

$$\frac{\text{10000}}{\text{86.60 m}^2} = 115/116.$$

Method-2

Suppose plant to plant distance is 10m, then row to row distance will be calculated as under:

ABC is equilateral triangle

Hence AB=AC=BC =10m

A perpendicular line AD is drawn on BC which divides it into two halves .It means BD=DC=5m

As per Pythagoras therom

$AC^2=AD^2+DC^2$ or $AD^2=AC^2-DC^2$

$AD^2= 10^2 - 5^2 =100-25=75.$

$AD= 75 = 8.66m^2$

Area occupied by a single tree is = Plant to plant distance x row to row distance

$=10x8.66=86.66\ m^2$

No. of plants per hectare = $10000\ m^2$

$$\frac{\text{10000}}{\text{86.60 m}^2} = 115/116.$$

Method-3

Each equilateral triangle area can be worked out by S(S-a) x(S-b) x (S-c)

Where S = half of the sum of three sides length of the triangle

a,b,c –lengths of the three sides of a triangle.

Space occupied by each plant= S(S-a) x(S-b) X(S-c) x 2

Area of the land=$10000\ m^2$

No. of plants required = $\frac{\text{10000}}{\text{S (S-a) x (S-b) x (S-c) x 2}}$

High density planting / high density orcharding

Planting of fruit trees rather at a closer spacing than the recommended one using certain special techniques with the sole objective of obtaining maximum productivity per unit area without sacrificing quality is often referred as 'High density planting' or HDP. This technique was first established in apple in Europe during sixties and now majority of the apple orchards in Europe, America, Australia and New Zealand are grown under this system. In this system, four planting densities are recognized for apples viz., low HDP (< 250 trees/ha), moderate HDP (250-500 tree/ha), high HDP (500 to 1250 trees/ha) and ultra high HDP (>1250 trees/ha). Recently, super high density planting system has been also established in apple orchards with a plant population of 20,000 trees per ha. In some orchards, still closer, planting of apple

trees is followed (say 70,000 trees/ha) which is often referred as 'meadow orchards'. The exact limits of plant density to be termed as is not yet well defined. It varies with the region, species, variety, rootstock, cost of planting material, labour and likely return from the orchard and agro-techniques adopted for a particular crop.

High density planting is one of the improved production technologies to achieve the objective of enhanced productivity of Indian fruit industry. Yield and quality of the produce are two essential components of the productivity. High density planting aims to achieve the twin requisites of productivity by maintaining a balance between vegetative and reproductive load without impairing the plant health.

The underlying principle of high density planting is to make best use of vertical and horizontal space per unit time and to harness maximum possible return per unit of inputs and national resources. In India, the usefulness / vitality of this technology has been proved in an array of fruit crops eg. pineapple, banana, papaya, mango, apple and citrus.

Advantages:

1) It induces precocity/precocious bearing
2) Higher yields. The average yield in apple is about 5.0 t/ha under normal system of planting and it is about 140.0 t/ha under high density planting.
3) Higher returns per unit area
4) Early returns
5) Easy management of orchard tress
6) Reduces labour cost resulting in low cost of production
7) Enables the mechanization of fruit crop production and facilitates more efficient use of fertilizers, water, solar radiation, fungicides, herbicides and pesticides.

Dis- advantages of high density planting:

1) HDP results in over crowding, over lapping not only in the tops, but also in the root system and heavy competition for space, nutrients and water.
2) More important is build up of high humidity, lack of cross ventilation in the orchard, which is more conducive for build up of pests and diseases.
3) Reduction in yield in the long run after 10-12 years of age.
4) Production of small sized fruits and poor quality fruits.

PROPAGATION

Plant propagation refers to the multiplication of an individual plant or group of plants, which have specific value to mankind. Perpetuation of plants is called propagation. It involves multiplication of one plant into several plants –development of new individuals. New plants or new individuals are required for establishing **new plantings / new gardens/ new orchards**.

Methods of propagation: Broadly grouped in to two. (a) **Sexual** and (b) **asexual.**

Sexual (Seed) Propagation

It refers to multiplication of plants by seed. In sexual process male and female gametes are fused to produce seed. Meiosis division takes place in course of fusion and the chromosome numbers, as in parents is reduced to half, which after fertilization becomes normal. In sexual propagation during meiosis segregation, reassortment or rearrangement of characters takes place. So, the plants thus produced may or may not be similar to their parents and the propagated plants may also be different from each other**.** It is called as seed propagation, since the propagation is through seed and also sexual propagation because sexes are involved

Seed is the result of fusion of male and female gametes. Seeds are fertilized ovules, containing embryos resulting from the union of a male and a female gamete during fertilization. The embryo in the seed gives rise to a new plant on germination. Plants that are produced from seeds are called **seedlings.**

Advantages of Seed propagation:

1) Seedling trees generally live longer, bear more heavily and are hardier than vegetatively propagated trees.
2) Seedlings are comparatively cheap, and can be more easily raised than vegetatively propagated materials.
3) Plants which are difficult to propagate, e.g., papaya and phalsa by vegetative method can only be propagated by seed.
4) In breeding for evolution of new varieties, the hybrids are first raised from the seed and it is, therefore, essential to employ this method in such cases.
5) Seed propagation, some times results in the production of **Chance seedlings** with superior characteristics, which may be of great benefit to the horticulture industry.
6) Rootstocks, on which desirable scion variety is budded or grafted, are usually raised from seeds.

7) Seeds of some fruits like citrus and mango varieties are capable of giving out more than one seedling from one seed. They arise from the cells of the nucellus and are called poyembyonic.The nucellar seedlings can be utilized for raising uniform plants, if they can be carefully detected at the nursery stage.
8) Since most virus diseases are usually not transmitted through seed propagation. Hence, it is useful in producing virus free plants.
9) Seeds also offer a convenient method for storing plants for a long time. Seeds when kept properly may remain viable for very long periods.Eg. Indian lotus remains viable for over 1000 years.

Disadvantages of seed propagation:

1) Owing to genetic segregation in heterozygous plants, seedling trees are not uniform in their growth, yielding capacity and fruit quality compared with asexually propagated plants. Seedling trees are not usually true to type and show variation.
2) Seedling trees take more time to come to bearing than grafted plants .For example mango seedlings take 8 -10 years to come to bearing ,compared with 3-4 years for grafted trees.
3) Seedling trees, being very large, pose problems for efficient management of orchard trees, i.e., harvesting, pruning spraying etc. become more difficult and expensive.
4) It is not possible to derive the benefits of rootstocks, if the plant is not propagated vegetatively by means of grafting or budding.
5) Continuous seed propagation leads to inferiority in the progeny.
6) Sexually propagated plants have long juvenile (pre-bearing) period.
7) Choice or chance tress or hybrid trees can not be multiplied true to type because of segregation of characters.
8) Seeds loose viability with in a short period.Eg.Citrus, mango, jack, papaya, jamun etc.

Asexual propagation

It is called with different names -- Asexual propagation, Vegetative propagation, Clonal propagation. Asexual propagation is reproduction by means of vegetative parts of the plant such as roots, shoots, or leaves other than seed. In this propagation sexes are not involved–hence it is called **asexual propagation**. It involves the use of any part of the plant, other than seed i.e. vegetative parts –hence **vegetative propagation**.

The vegetative organs of many plants have the capacity (ability) for regeneration, to produce new individuals.

For instance: (a) stem pieces (cuttings) produce root system

(b) Root pieces (root cuttings) develop root system.

(c) Leaves generate both roots and shoots.

Vegetative parts possess somatic cells. They divide (multiply) by mitosis –does not involve reduction in chromosomal number, but involves the duplication of chromosome

structure -the same genetic constitution is seen in the resultant plants – no variation. Whatever the characters present in the parent –the same are carried in the new plants i.e. duplicated without any change –true to mother plant-variation is eliminated.

Advantages:

1) There are many horticultural plants that normally produce little or no viable seeds. Common examples of such plants are some varieties of banana, pineapple, fig, orange, grape, rose, and gardenia. The edible seedless fruits are certainly very important economic crops but, unless they can be propagated by vegetative means, perpetuation of these plants is not possible and these will be lost in no time.
2) Most of our choicest fruits such as mango, citrus, apple, peach etc. are cross-pollinated plants and naturally are highly heterozygous. Such cross pollinated plants are not true to type and loose many of their unique characteristics when raised from seeds. For example, seedling mango varieties like the langra or dasheri bear fruits quite unlike those of parent plants. The fruits vary greatly in size, shape, colour, quality, maturity period, keeping quality, chemical composition and other Characteristics. In contrast the trees raised by vegetative means (grafting) bears fruits just like those of the tree from which the scion has been collected. Hence, asexual propagation helps in maintaining the characteristics of each cultivar.
3) Propagation by vegetative means is some times easier, more rapid and economical than that by seeds. In some species the germination is very poor or slow or there may exist complex dormancy problems (Peach and Olive) or the seed may loose its viability very quickly (mango, Litchi, Citrus). Moreover, seedlings of many species grow slowly and take a long time to reach salable size (Date palm, Litchi). In all these cases, use of vegetative means is more convenient method of propagation.
4) It often happens that certain species or varieties (which are otherwise desirable) are susceptible to some insects or diseases, where as others may be largely or entirely resistant. The root system of European grapes (*Vitis vinifera*) is susceptible to insect **phylloxera**, but the American species (*Vitis americana*) is fully resistant to the attack of this insect. Thus by growing European grapes on American stock, this deadly insect can be easily eliminated. Like wise trifoliate orange when used as a root stock of sweet oranges, which is susceptible to **gummosis**, imparts resistance against this disease.
5) Budding or grafting may be used to make certain fruits adaptable in unfavorable environmental conditions. Frequently, certain root stocks are better adapted to the environment than the roots of the variety desired or other rootstocks. For instance trifoliate oranges are much better adapted to severe winter freeze than other rootstocks. Similarly rangapur lime is more salt tolerant than other citrus rootstocks.

6) Vegetatively propagated plants are usually less vigorous than seed propagated ones. Moreover, by using certain rootstocks (vigorous, semi dwarf or dwarf), the size of a tree can be controlled greatly. For instance apple on **malling IX**, pear on **quince** root stock are noticeably dwarf, and as a result many orchard operations such as pruning, spraying and harvesting can be done more easily, conveniently and cheaply
7) Vegetatively propagated plants are more precocious in bearing (flower earlier than seed propagated plants). Pre-bearing period is less. No juvenility. For example, seed propagated mango plants take at least 8-10 years to flower, where as grafts flower with in 3-4 years.
8) Another use of vegetative propagation is found in fruit plants, which are self-incompatible. Instead of planting occasional variety suitable for pollination, a single branch of the pollinizer variety may be grafted on to the main variety. A composite plant bearing fruits of different varieties can be developed by grafting the varieties upon a rootstock. Similarly, an inferior variety can be made into a choicest one by means of top working, when a desired scion is grafted to the existing stock.
9) Plants are propagated asexually to perpetuate a particular form of the plant, for example, citrus trees are normally thorny, especially in the juvenile stage, but when buds are collected from the thorn less portions of mature plants and are used for propagation, the size of the thorns is greatly reduced in the resulting budded plants. Similarly ornamental plants having a particular growth habit (upright or horizontal, drooping or weeping) or unusual form of leaves or flowers are propagated vegetatively to maintain its particular desirable form.
10) Certain injuries can be repaired by means of bridge grafting.

Dis-advantages:

1) No, new variety can be evolved by means of the vegetative method of propagation.
2) Vegetative propagation in many cases is more expensive than seed propagation.
3) Vegetatively propagated plants are comparatively short lived. Lack of tap root system in vegetatively propagated plants results in poor anchorage in the soil. Consequently, such plants are easily uprooted in storms and or other such severe conditions.
4) Vegetatively propagated plants are comparatively less hardy.
5) Transmit viral diseases from plant to plant.

Which method of propagation is the best?

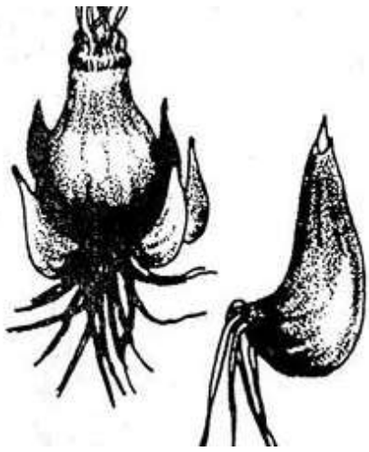
Considering the merits and demerits of both the methods, particularly in fruit crops and other perennial crops, vegetative propagation is more preferable than seed propagation because of uniformity (even in delicate characters like shape, taste, flavour etc.) and precocity.

Plant Propagation by Separation and Division

Many herbaceous species that die back at the end of the growing season have under ground food storage organs that survive the dormant winter period. These organs are also vegetative propagation structures that produce new shoots in the growing season. The variety of under ground storage organs may be grouped into two classes based on how they are propagated; plants propagated by separation and plants propagated by division.

Plants propagated by separation: Separation is a method of propagation in which underground structures of plants are divided not by cutting but by breaking along natural lines between segments. Separation is breaking away of daughter structures from the parent structure to be used to establish new plants. Two specialized underground structures-bulbs and corms-produce such materials.

Bulb



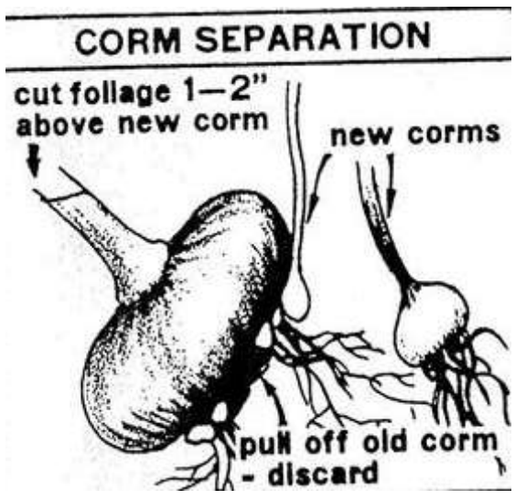
Seperation of bulblets

Bulb: A bulb is a specialized underground organ that consists predominantly of fleshy leaf scales growing on a stem tissue (basal plate).The scales wrap around a growing point or primordium to form a tight ball. Lateral bulblets, or miniature bulbs, originate in the axils of some of these scales and when developed (offsets) may be separated from the mother bulb to be planted independently as new plants.

There are two types of bulbs-***Tunicate*** and ***non-tunicate bulbs***.

Tunicate-These bulbs have outer bulb scales that are dry and membranous. This covering called tunic, provide protection from drying and mechanical injury to the bulb. The fleshy scales are in continuous, concentric layers, called lamina, so that the structure is more or less solid. E.g. Onion, daffodil, tulip etc.

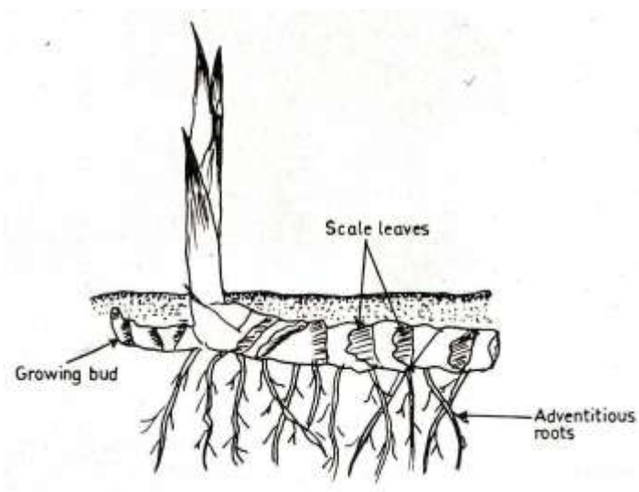
Non-tunicate (scaly) bulbs: These bulbs don't possess the enveloping dry covering. The scales are separate and attached to the basal plate. The scales are not tight but loose and can be removed individually from the bulb. In general, the non-tunicate bulbs are easily damaged and must be handled more carefully than tunicate bulbs. The daughter bulbs or bulb lets develop at the base of the of the scales of the mother bulb.Eg. Lily.

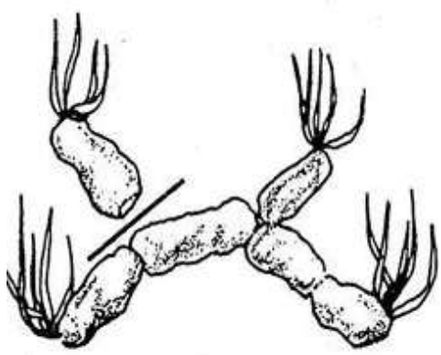


Corm

Corm: The bulb consists predominantly of modified leaves; the corm is a modified stem. Food is stored in this compact stem, which has nodes and very short internodes and is wrapped up in dry, scaly leaves. When a corm sprouts into a new shoot, the old corm becomes exhausted of its stored food and is destroyed as a new corm forms above it. Several small corms, or cormels, arise at the base of the new corm. The cormels may be separated from the mother corm at maturity (die back) and used to propagate new plants.Eg. Amorphophallus, Colocasia, Gladiolus etc.

Plant propagation by division: It is a method of propagation of plants using cut section of a particular part like rhizome, tuber and tuberous root etc.



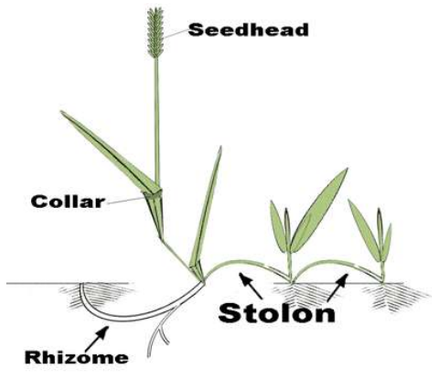


Rhizome of Canna **Rhizome division**

Rhizome: A rhizome is a specialized stem structure in which the main axis of the plant grows horizontally just below or on the surface of the ground. The stem appears segmented because it composed of nodes and internodes. The rhizome appears as a many branched clump made up of short individual sections. The rhizome tends to be oriented horizontally with roots arising from the lower side.

In propagating plants by rhizome by cutting the rhizome into different sections being sure that each section has at least one lateral bud or eye. It is essentially a stem cutting. Eg. Bamboo, Banana, Iris etc.

Stolon: It is a term used to describe various types of horizontally growing stems that produce adventious roots when come in contact with the soil. These may be prostate or sprawling stems growing above ground.



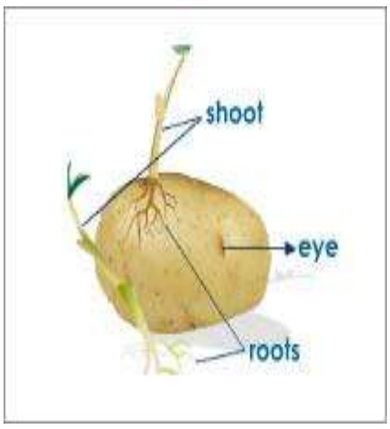
Stolon

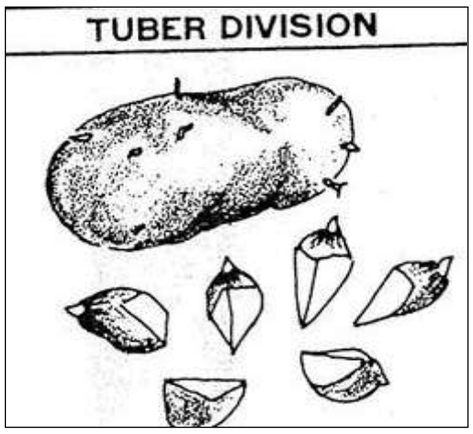
In propagating plants by stolon, the stolon can be treated as a naturally occurring rooted layer and can be cut from the parent plant and planted separately. Eg. Mint, Bermuda grass etc.

Runner of Strawberry

Runner: A runner is a specialized stem that develops from the axil of a leaf at the crown of a plant, grows horizontally along the ground and forms a new plant at one of the nodes.

In propagating plants by runners, the rooted daughter plants are dug when they have become well rooted and transplanted to the desired locations. Eg. Straw berry, oxalis, blue berry etc.

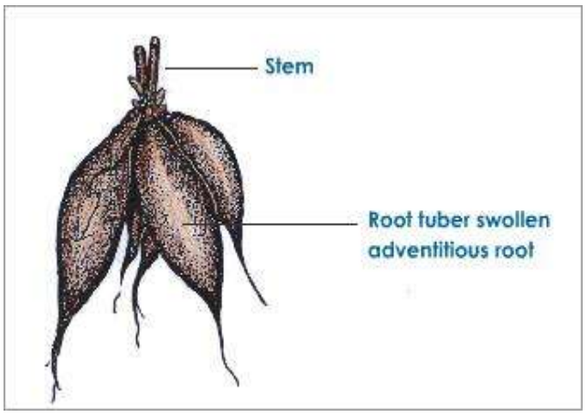


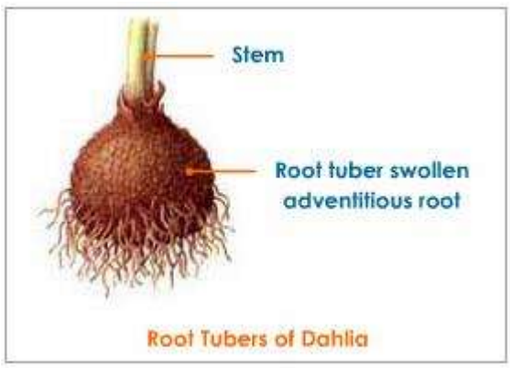


Stem tuber of Potato

Stem tuber: A tuber is specialized swollen underground stem which possesses eyes in regular order over the surface. The eyes represent the nodes of the tuber. The arrangement of the nodes is spiral, beginning with the terminal bud on the stolon to produce a new plant, the tuber is divided into sections so that each section has a good amount of stored food and a bud or eye.

Propagation by tubers can be done either by planting the tubers whole or by cutting them into section, each containing a bud or eye. Eg.Potato.

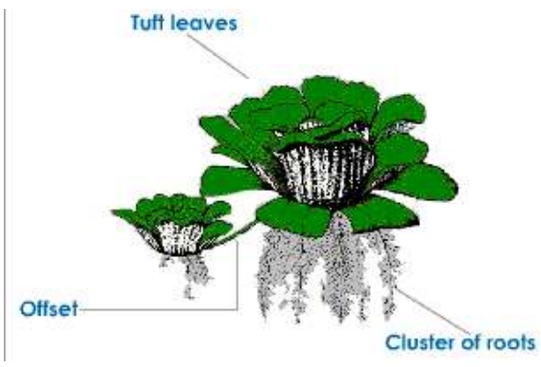




Root tuber of Sweet potato

Tuberous roots: These are thickened tuberous growth that functions as storage organs. These differ from the true stem tuber, in that they lack nodes and internodes. Buds are present only at the crown or stem end. Fibrous roots are commonly produced towards the opposite end.

Most plants with fleshy roots must be propagated by dividing the crown so that each section bears a shoot bud.Eg. Dahlia, Begonia, Sweet potato.

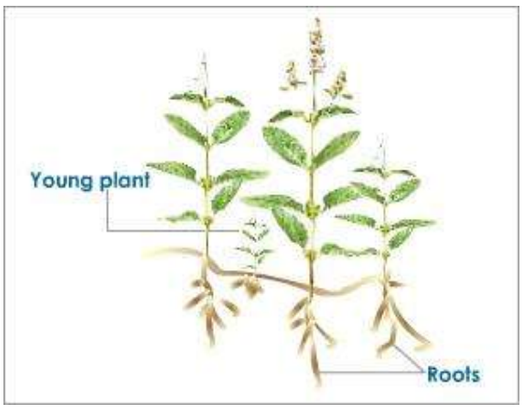


Offset of Pistia

Offset: It is a short thickened horizontal branch growing out of the crown ending at the apex with a tuft of leaves and a cluster of leaves below. These are special type of branches or lateral shoots which are produced from the base of main stem of parent plant.

The offset often breaks away from the mother plant and the daughter starts a new independent life. Eg. Pistia, Agave, Water hyacinth, Cycas, Dracaena etc.

Suckers: It is a lateral branch developing from the underground parts of the stem or roots. The suckers arise from below the surface of the soil. There are two types of suckers.



Stem sucker of Mint

a) ***Shoot suckers:*** These will arise from the base of the stem. The suckers may grow obliquely upwards and directly give raise a leaf shoot. Often it grows horizontally outwards only to certain extent but soon turn up. It strikes roots when it is still attached to the parent plant or when separated and planted.

Propagation by shoot suckers can be done by separating the suckers and planting. Eg.Chrysanthemum, Banana, Pineapple, Yucca.

b) ***Root suckers:*** The root suckers will arise from the adventitious buds on the roots.

Propagation by shoot suckers can be done by separating the suckers and planting. Eg.Guava, Millingtonia, Curry leaf,Quis quails etc.

PLANT PROPAGATION BY CUTTINGS

The process of propagation of plants by cuttings is known as cuttage. A cutting is a part of a plant that will produce roots when put in soil media and eventually produce a new plant quite true to the parent plant. A cutting may be a piece of stem, a leaf or part of a leaf, a piece of root, or root stock, or even a scale of bulb.

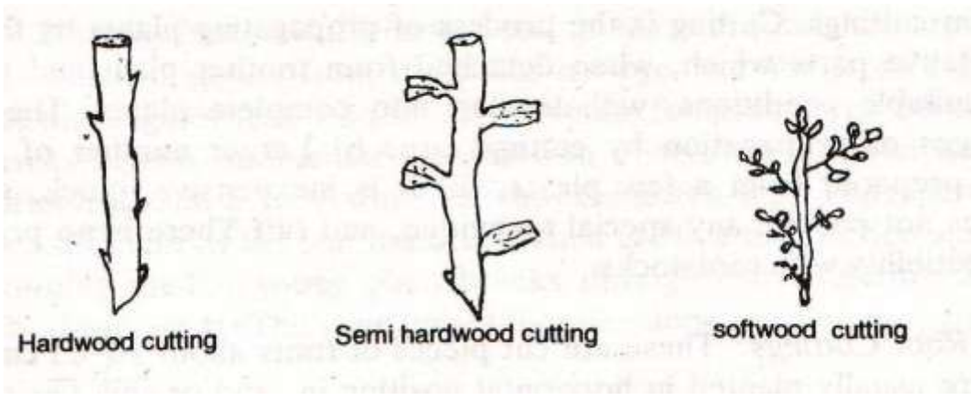
Classification of cuttings:

Cuttings are usually classified in to 3 groups according to the particular part of the plant used as cutting.

1) Stem cuttings
2) Root cuttings
3) Leaf cuttings

Stem cutting: Stem cuttings can be divided in to 4 types based on the degree of maturity and lignification of wood used in making cuttings.

- Hard wood stem cuttings
- Semi hard wood stems cuttings
- Soft wood stem cuttings
- Herbaceous stem cuttings

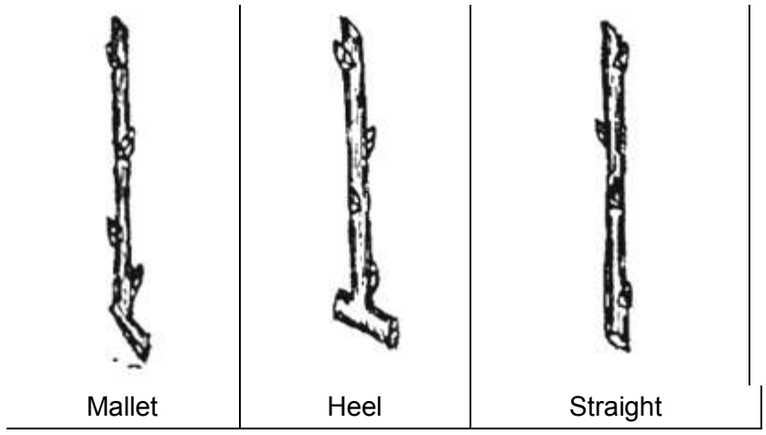


Hard wood stem cuttings: These cuttings are made from the past seasons growth or wood that has matured and lignified are known as hardwood cuttings.

Preparation and planting: Select a fully matured shoot with normal internodes from a healthy, vigorous plant growing in full sun light. Remove all the leaves with out damaging the axillary buds. Give a slant cut just below the basal node of the selected shoot. Measure the required length (about 15 to 25cm and containing 3 to 4 buds) from the base of the shoot and give a horizontal cut 1 to 2.5cm above the top node. Repeat the procedure and prepare as many cuttings as possible from the shoot. In case of difficult to root species treat the prepared cuttings with recommended growth regulators to induce rooting. Make holes in the prepared bed or pot with the help of a stick or dibbler. Insert the cuttings in the hole such that at least two nodes are inside the soil. Take care of polarity while planting cuttings. After planting press the medium firmly around the cutting and water immediately. **Eg:** Grape, Fig, Pomegranate, Bougainvillea, Acalypha,Rose etc.

Hard wood cuttings may be of three types: **Straight or simple cutting**, **heel cutting** and **mallet cutting.**

Types of Hard wood cuttings



Types of hard wood cutting

Straight or simple cutting: It consists of only the current year's wood and doesn't bear any older wood.Eg. Hibiscus, nerium.

Heel cutting: *A* small piece of older wood is retained at the base of each cutting
Eg. Rose

Mallet cutting: An entire section of the older wood is retained.Eg.Thuja.

Semi-hard wood stem cuttings: Semi hard wood cuttings are prepared from new shoots just after a flush of growth which is partially matured.

Preparation and planting: Select partially matured shoots from a healthy and vigorous growing plant and take out the terminal 7 to 15cm portion by giving a horizontal cut just below a basal node. Remove all the leaves towards the base of the shoot and retain only the terminal leaves. If the retained leaves are very large, reduce their size by cutting the top half portion. This facilitates planting the cuttings closer and also minimizes the loss of water from cutting. Plant the cuttings in the same way as hard wood cuttings are planted .Eg. Camellia,Citrus,Eranthemum,Acalypha,Geranium, Hibiscus, Jasmine, Lemon, olive etc.

Soft wood cuttings: Cuttings are prepared from the soft succulent new spring growth of species which are 4 to 6 months old.

Preparation and planting: Select the soft succulent shoots from a healthy and vigorous growing plant, growing in full sun light and take out the terminal 7 to 15cm portion by giving a horizontal cut just below a basal node. Don't remove the leaves except for the part to be buried inside the rooting media. Soft wood cuttings should be kept in green house or in moist chamber where a high humidity can be maintained which keeps the tissues in turgid condition.Plant the cuttings in the same way as hard wood cuttings are planted.Eg. Nerium, crotons, Eranthemum, Graftophyllum etc.

Herbaceous stem cuttings: This type of cuttings is taken from succulent herbaceous green house plants.

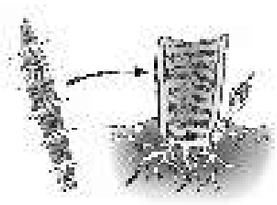
Preparation and planting: Select the succulent herbaceous shoots from a healthy and vigorous green house growing plant. Retain all the leaves. Give a basal cut below a basal node. Plant the cuttings in the same way as hard wood cuttings are planted. *Eg.* Chrysanthemum, Coleus, Carnations, Geraniums, Cactus etc.

Leaf Cuttings: Certain plants with thick and fleshy leaves have the capacity to produce plantlets on their leaves. In leaf cuttings, the leaf blade with or without petiole and axillary bud is used for starting new plants**.** Adventious roots and shoots form at the base of the leaf and form in to a new plant. However, the original leaf does not become a part of the new plant.

Frequent watering and high humidity and bottom heating are desirable for better and rapid rooting of leaf cuttings. Sand or sand and peat moss (1:1) are satisfactory rooting media for leaf cuttings.

For leaf cuttings, depending on the species the whole leaf blade, leaf blade sections or the leaf with petiole is used. So, leaf cuttings can be classified in to:

1. Leaf blade cutting
2. Leaf vein cutting / Leaf slashing
3. Leaf margin cutting
4. Leaf bud cutting



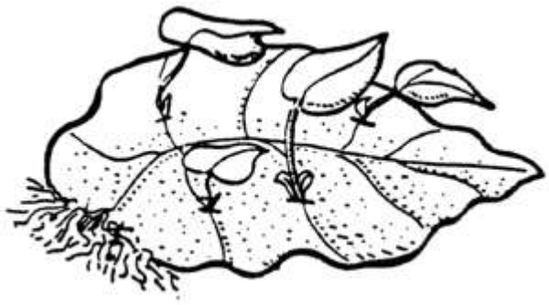
Leaf Section cutting-- Sansevieria.

Leaf blade/Leaf section cutting:

Preparation and planting: Select a healthy leaf and Give a slanting cut towards the base of the leaf. Measure a length of about 7 to 10-cm and give a horizontal cut towards the terminal end. Prepare as many cuttings as possible from the selected leaf. Insert up to ¾ of the prepared leaf cuttings in to the medium. Take care of polarity while planting the cuttings. Compress the soil around the leaf cuttings and water immediately.Eg. Sansevieria.

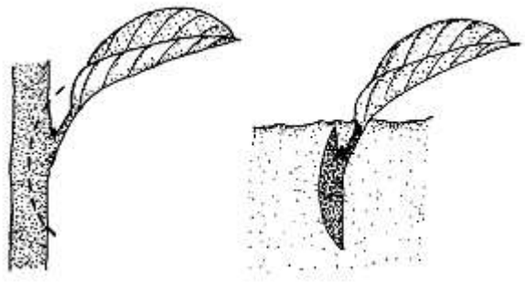
Leaf vein cutting/Leaf slashing:

Preparation and planting: Select a healthy and full mature leaf and detach it from the mother plant. Give cuts to alternate veins closer to the petiole on the lower surface of the leaf. Keep the leaf flat on the medium in such a way that the lower portion comes in contact with the medium. Pin or hold down the leaf in some manner so as to expose the upper surface and to maintain the contact between the cuts on the vein and the rooting medium. Water the cuttings carefully *Eg*. Begonia rex.



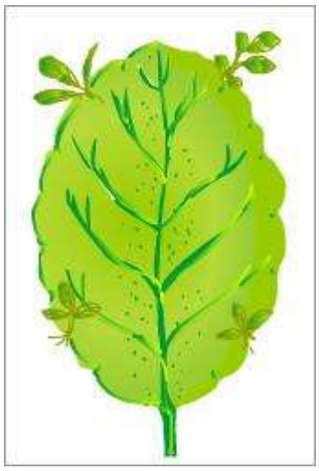
Leaf vein Cutting

Leaf bud cuttings: This cutting consists of a leaf blade, petiole and a short piece of the stem with attached axillary bud. This is practiced in species that are able to initiate roots but not shoots from the detached leaves. In such case the axillary bud at the base of the petiole provides for the essential shoot formation.



Leaf bud cutting

Preparation and planting: Select a healthy and mature shoot with well developed buds and healthy active growing leaves. Separate each leaf along with the axillary bud and a small portion of the stem. Repeat the process until possible number of leaf bud cuttings are made.Treat if necessary the cut surface of the prepared cuttings with the recommended root promoting substance to stimulate rapid root formation. Insert the prepared cutting in the rooting medium so that the bud is1.5 to 2.5 cm below the surface. Compress the medium around the cutting and water immediately. Eg. Black berry, Camellia, Lemon ,Rhododendron and raspberry etc.



Leaf Margin Cutting of Bryophyllum

Leaf margin cutting:

Preparation and planting: Select a mature and healthy leaf with the foliar embryos intact. Keep the leaf flat on the rooting medium. If the leaf is folded, just cut along the mid rib, so that the leaf can be kept flat on the medium. Keep some weight on the leaf or partially cover it with soil, so that the margin comes in contact with the medium. Water the cuttings carefully Eg. Bryophyllum.

Root cuttings: Plants which give rise root suckers freely are propagated by root cuttings.

Root cuttings

Plant propagation by Layering

Layering is the developing of roots on a stem while it is still attached to the parent plant. The rooted stem is then detached or become a new plant growing on its own roots. A layered stem is known as a layer. Layering includes several forms of ground and aerial layering. When rooting is encouraged on the aerial part of a part of a plant after wounding it is known as air layering or gooty or marcottage. When branches running parallel to ground are utilized, it is known as ground layering, The root formation during layering on a stem is stimulated by various stem treatments like ringing, notching etc, which causes an interruption in the downward translocation of carbohydrates and other growth factors from leaves and growing shoot tips.

However, the root formation in layered stems, completely depends upon continuous moisture supply, good aeration and moderate temperature around the rooting zone. Some times synthetic growth regulators like IBA, IAA etc, are also treated to layered stem to induce better rooting, as the auxins in layered stem is an important factor for rooting.

Advantages:

i. It is an easy method and does not require much care and arrangement like cutting.
ii. The mother plant supplies nutrient and other metabolites as it remains attached while rooting.
iii. By using a large branch a much larger plant can be obtained in the first instance.
iv. Some plants that cannot be satisfactorily started from cuttings can be propagated by layering.

Dis advantages:

i. It is a costlier method.
ii. It is a slow process
iii. Limited number of plants can be propagated
iv. Layered plants are generally shallow rooted
v. Interference with cultivation
vi. Require more individual attention
vii. The beneficial effect of root stock cannot be exploited.

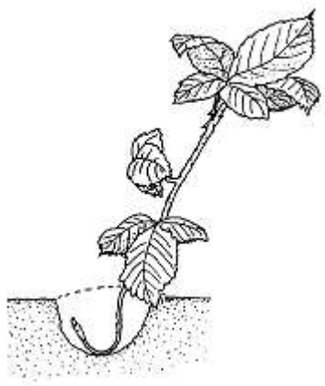
Classification of layering:

I. Ground layering

1) Tip layering
2) Simple layering
3) Trench layering
4) Mound layering or stool layering

5) Compound or serpentine layering

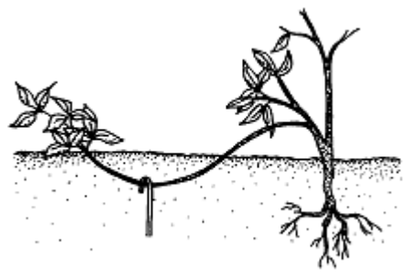
II.Air layering. (Gootee or Marcottage).



Tip layering

Tip layering: It is generally followed in plants which have trailing type of shoots. It is quite similar to simple layering.

Procedure: Dig a hole 3 to 4 inches deep. Insert the tip of a current season's shoot and cover it with soil. The tip grows downward first, then bends sharply and grows upward. Roots form at the bend. The re-curved tip becomes a new plant. Remove the tip layer and plant it in late fall or early spring. Examples of plants propagated by tip layering include purple and black raspberries, and trailing blackberries

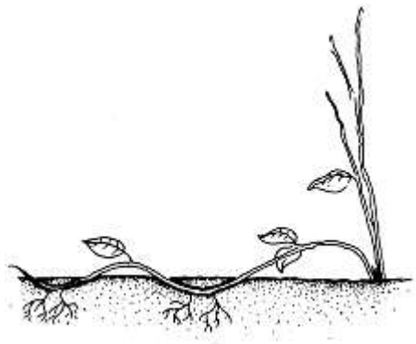


Simple layering

Simple Layering: In this method, a branch is bent to the ground and some portion of it is covered by soil leaving the terminal end of the branch exposed.Root initiation takes place at the bent and buried portion. After allowing sufficient time for root formation, the rooted stem is separated from the mother plant. Eg. Bougainvillea, Jasmine, Rangoon creeper.

Procedure: Select a healthy, flexible and sufficiently long (50 to 60cm) branch towards the base of the plant. The selected branch should be closer to the ground. At a distance of about 15 to 30cm back from the tip give a sharp, slanting inward and upward cut 1.5 to 2.5cm below a node and insert a small wood splinter. Bend the shoot gently to the ground so that the treated part can conveniently be inserted into the soil. Cover the treated region with soil. Peg down the shoot or keep a stone of brick on the covered soil to keep the layered shoot in place. Drive a vertical stake into the soil by the side of the layered branch and tie the terminal portion of the branch to keep it upright. Water the layered portion regularly so as to keep it moist all through till

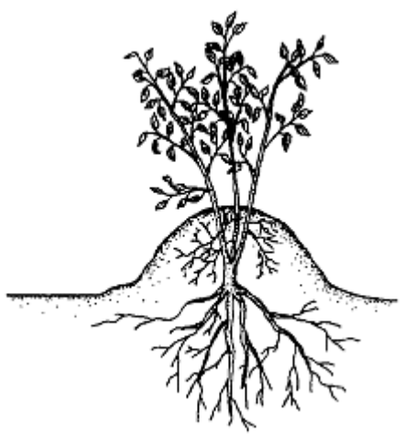
root initiation take place. After sufficient root formation separate the layer by cutting just below the rooted zone.



Compound or serpentine layering

Compound or serpentine Layering: Compound layering is essentially the same as the simple layering except that the branch is alternatively covered and exposed along its length. The branch for compound layering must be long and flexible so that it can be layered at different places along its length. **Eg.** Bougainvillea, Jasmine, Rangoon creeper.

Procedure: Select a healthy, flexible and sufficiently long (100 to 250 cm) basal branch that is close to the ground. Give a sharp slanting, inward and upward cut 1.5 to 2.5 cm below a node at 30cm interval starting from the tip leaving 3 to 3 buds in between two such cuts. Bend the shoot gently to the ground, and insert and cover the cut portions with the soil exposing the uncut portions. The remaining steps are same as in simple layering.

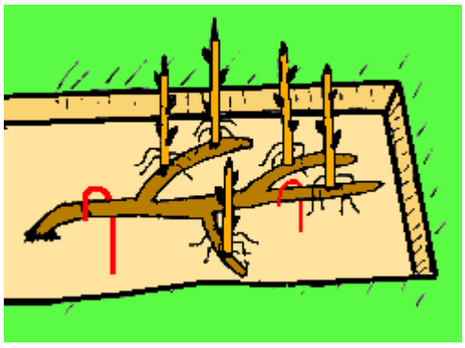


Mound or stool layering

Mound (stool) Layering: In this method, a plant is cut back to the ground level during the dormant season and soil is heaped around the base of the newly developing shoots. After slowing sufficient time for root initiation, individual rooted layers are separated from the mother plant and panted. Eg. Apple roots tocks, Guava, Litchi, Quince,

Procedure: Select the plant to be mound layered or plant a rooted layer in a trench and allow it to grow for a year. Cut back the plant to 2.5 cm from the ground level just before growth begins. Allow the new shoots to develop. When these shoots have grown 7 to 15 cm tall, girdle them at the base and treat the girdle portion with the recommended growth regulator and draw up the loose soil round each shoot to half its

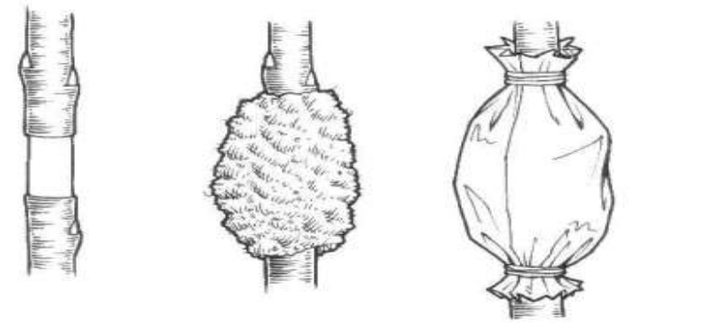
height. When these shoots have are 20 to 25 cm tall add soil again to half their height. Add soil again when the shoots grow to a height of about 35 to 45 cm. Water the heaped soil regularly and allow sufficient time for the initiation of roots. A depression can be made in the centre of the heap to hold water. After sufficient root formation, remove the heaped soil and cut the rooted shoots individually to their base. Transplant the rooted shots in pots or suitable containers.



Trench Layering

Trench Layering: Trench layering consists of growing a plant or a branch of a plant in a horizontal position in the base of a trench and filling in soil a round the new shoots as they develop, so that the shoot bases are etiolated. Roots develop from the base of these new shoots. Etiolated roots develop from the base of these new shoots. Trench layering is used primarily for woody species difficult to propagate by mound layering. Trench layering is used primarily for woody species difficult to propagate by mound layering. Eg. Apple rootstocks, Litchi, Quince.

Procedure: Dig small trenches of about 25-30cm deep and in about 1 m wide rows. Plant rooted layers or one year old nursery – budded or grafted plants in the trenches in rows at an angle of 30^{O} to 45 ^{O}and 50 to 10cm apart within the row.The rows should be1.2 to 1.5 m apart. Just before growth begins, lay the plant or a branch flat on the bottom of the trench. Plants must be kept completely flat with wooden pegs or wire fasteners**.** Cut back the shoots slightly and remove the weak branches. Add roots medium (sand or sawdust or peat moss) or their mixture at intervals to produce etiolating on 5 to 10 cm of the base of the developing shoots. Apply first 2.5 to 5cm layer before buds swell and repeat as shoots emerge and expand. At the end of the season, remove the medium and cut off the rooted shoots close to the parent plant. Transplant the rooted shoots in pots or suitable containers.



The stem is girdled to induce root formation above the cut.

The girdled stem is covered with damp moss.

Aluminium foil or plastic sheeting is wrapped around the moss and tied at both ends. This cover is removed 2-3 months after tying or when the roots can be seen.

Air Layering

II. Air Layering: In air layering roots form on an aerial shoot. The rooting medium is tied to the shoot for getting root initiation. Sphagnum moss is the best rooting medium for air layering as it holds large quantities of water till root initiation and through the root initiation and through the root development. Eg. Crotons, ficus, fig, Guava, Phalsa, Pomegranate.

Procedure: Select a healthy branch of previous season's growth. At a point 15 to 30 cm back from the tip of the shoot make a girdle just below a node by completely removing a strip of bark 2 to 3.5 cm wide all around the shot. Scrape the exposed surface lightly to remove traces a phloem or cambium to retard healing. In difficult-to-root species treat the girdled portion with the recommended growth regulator to induce better rooting. Cover the girdled portion with moist propagating medium. Sphagnum mass, saw dust, vermiculite. Tie the medium around the girdled portion using a polyethylene sheet. Tying should be perfect so that no water can enter the treated part. After observing the fully developed roots through the transparent polyethylene sheet, separate the root zone and transplant the layer appropriately.

Plant propagation by budding and grafting

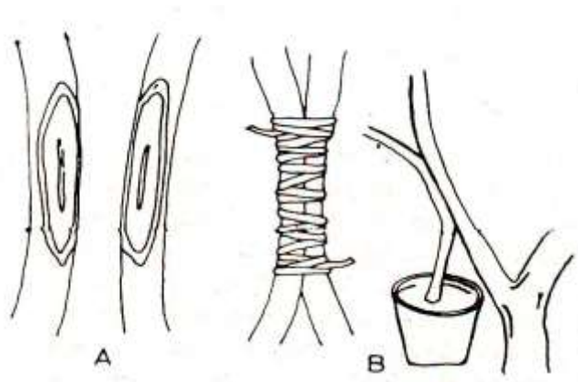
Plant propagation by grafting

Grafting is an art of joining parts of two independent plants in such a manner that they unite and grow together into single independent plant.The part of graft combination which is to become the upper portion or the shoot system or top of the new plant is termed the **scion** or **cion** and the part which is to become the lower portion or the root system is the **rootstock** or **under stock** or some time **stock**. The single plant obtained as a result of union between the stock and scion is termed as **Stion**.

Methods of grafting: Mainly in grafting there are two types. ***Attached scion methods of grafting*** *and* ***detached scion methods of grafting.***

In attached scion methods of grafting the scion is still attached to the mother plant (Scion Plant) till the graft union takes place where as in detached scion methods of grafting the scion is separated from the scion plant or mother plant just before grafting.

Under attached scion methods of grafting simple inarching or approach grafting is most important.



Simple inarching

Simple inarching / Approach grafting: The distinguishing feature of this method of grafting is that two independent plants on their own roots (self sustaining) are grafted together. This method provides a means of establishing a successful union between certain plants which are difficult to graft by any other method as the two plants will be on their own roots till the formation of successful graft. Eg.Guava, mango, Sapota.

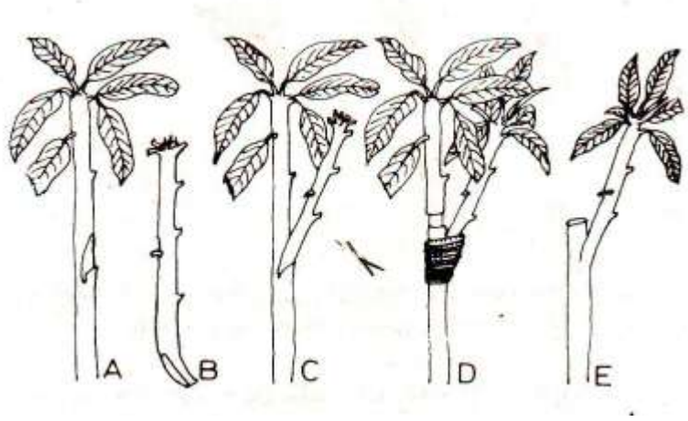
Procedure: Select a healthy shoot of having a 3.5cm girth on the selected mother plant which is to be used as a scion source. Select a root stock (raised in pot) having approximately the same size as that of the selected shoot on the mother plant. On the internodal region, where the union is to occur, a slice of bark and wood 2.5 to5 cm long is cut from both the selected stock and scion shoots. The cut should be given on the stock and scion should be of the same size. The cuts should be perfectly smooth so that a close contact of the cambial layers of stock and scion is brought about when they are pressed together.Tie the two cut surfaces together tightly with string or cloth.

Pre-curing of scion: In detached scion methods of grafting, the scion is to be procured before grafting. For precuring, a partially matured scion shoot about the thickness of a little finger is selected.The maturity is indicated by the presence of dark green leaves and grey dark colour on the shoots. The selected shoot is defoliated retaining only the petioles up to a length of about 4” from the apical bud. The defoliated shoot is left on the tree for a period of 7-10 days. During this time, the bud on the shoot begins to swell. This shoot is then called as “**Pre-cured scion**”, which is separated from the tree.

In detached scion methods of grafting there are two types-they are ***side grafting*** and ***apical grafting*** methods**.**

Among the detached scion methods of grafting the important ones are described below.

Under side grafting method Veneer grafting is important and is described below.

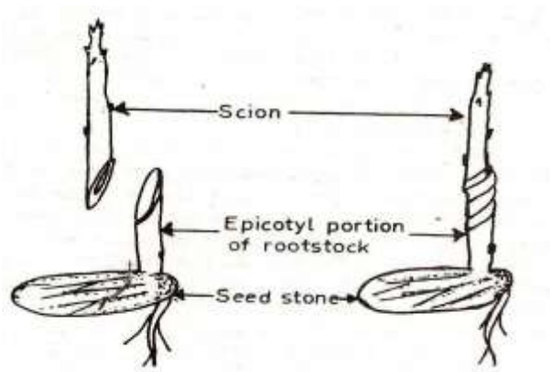


A-Prepared root stock, **B-**prepared Scion, C-Scion inserted,**D**-Girdled stock and tied graft joint,**E-**Sucessful graft,the stock being removed

Veneer grafting: This is also a kind of side grafting with slight modification .It is used widely for grafting small potted plants and *insitu* grafting .Eg. .Avocado, Mango etc.

Procedure: On the stock plant, at the desired height, in the internodal region, give a shallow inward cut running to a length of about 2.5 to 5cm. At the base of the first cut make another short and inward cut intersecting the first cut and remove a piece of wood and bark. On the scion , towards the base, give a long (2.5-5.0cm), slanting cut towards one side and another short, inward and downward cut on the opposite side. The cuts given on stock and scion should be of same dimensions, so that, the cambium layers can be matched as closely as possible. Insert the scion on to the rootstock such that a contact of cambium is established at least on one side, and tie them firmly. After the union has healed, cut back the stock above the graft union either on gradual steps or all at once.

Among apical detached scion methods of grafting the important ones are described below.



Epicotyl grafting

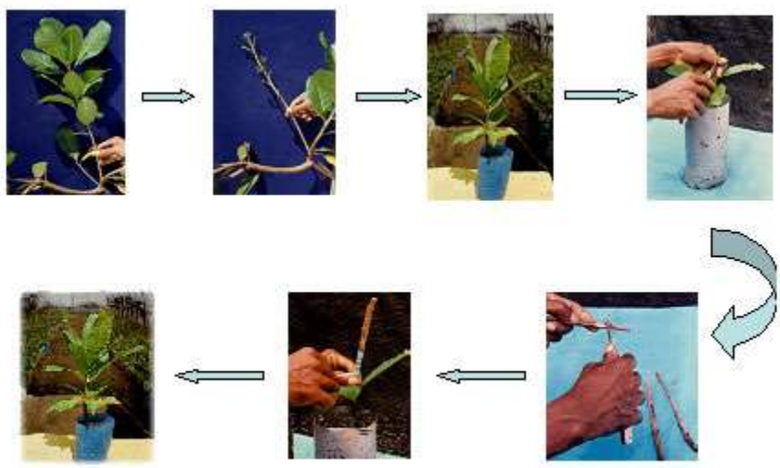
Epicotyl (Stone) Grafting: This method of grafting is done on the epicotyl region of the young seedlings; hence the name epicotyl grafting. Eg. Cashew, mango etc.

Procedure: Select very young seedling about 10 days old raised in polythene bags of size (15cmX22cm). Cut off the top portion of the chosen seedling leaving 5-6cm long shoot (epicotyl).With a sharp knife make a vertical, downward slit (2-3cm long) at the centre of the remaining portion of the epicotyl. Select a dormant 3-4 months old terminal shoot of about 5-8cm long from a proven mother plant as the scion stick. Cut the lower end of the selected scion to a wedge shape by giving slanting and inward cuts of 2-3cm on opposite sides. Insert the wedge shaped scion in the slit made on the seedling and secure firmly with polythene strips or tape. Water the graft regularly without wetting the graft region. In about three weeks the scion starts sprouting.

If the seedlings are raised in sand beds they are uprooted (with stones) 15 to 20 days after sowing (when seedlings attain10-15cm height) and grafting is done as described above. The grafted seedling is then planted in polythene bags or pots keeping the

graft union above the soil level and without damaging the stone. June to September is the best period for epicotyl grafting.

Soft wood grafting: It has been developed to graft small and young rootstocks which are grown *in situ* or in pots. Eg. Cashew, Mango.



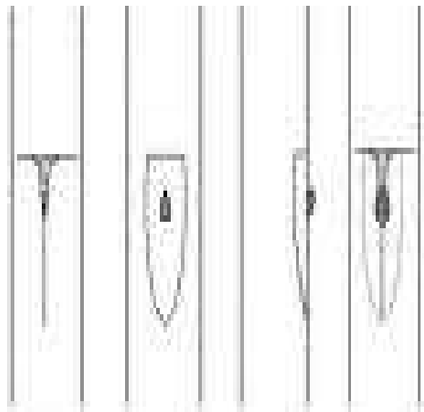
Softwood grafting

Procedure: Raise the rootstock seedlings in suitable containers or preferably in the main field itself where the grafts are desired to be grown and allow them to grow for a year or more. When the seedling attain a height of 30-45cm and the new shoot and leaves usually have bronze colour. Decapitate the top portion of the fresh growth on the stock plant with a knife, retaining bout 8 cm of the fresh stem. Make a longitudinal cut of 3 cm in the retained fresh stem. Select a scion stick of about 10cm long and about the same thickness as of the prepared stem on the stock. Cut the basal end of the scion to a wedge shape of about 3cm long by chopping the bark and a little wood on two opposite sides. Insert the prepared wedge part of the scion stick into the slit made on the stock and secure firmly with polythene strips. Water the grafted plant regularly. The scion sprouts in about three weeks.

Plant Propagation by Budding

Budding is also a method of grafting wherein only one bud with a piece of bark and with or without wood is used as the scion material. It is also called as bud grafting. The plant that grows after union of the stock and bud is known as budding.

Methods of budding:



Shield budding / T- budding

T-Budding (Shield budding): This method is known as T-budding as the cuts given on the stock are of the shape of the letter **T**, and shield budding as the bud piece like a shield. This method is widely used for propagating fruit trees and many ornamental plants. This method is generally limited to the stock that is about 0.75 to 2.50cm in diameter and actively growing so that the bark separate readily from the wood. Eg.Citrus, Rose etc.

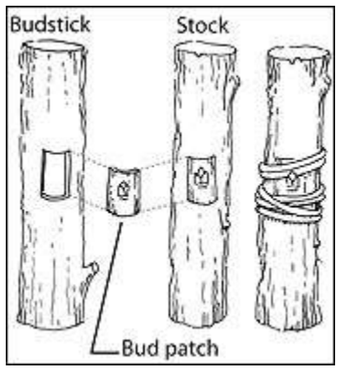
Procedure: After selecting the stock plant, select an internodal region with smooth bark preferably at a height of 15-25 cm from ground level. Give a vertical cut through the bark to a length of about 2.5-3.75cm. At the top of this vertical cut, give another horizontal cut (1cm or $1/3^{rd}$ of the circumference of the stem) in such a way that the two cuts given resemble the letter **T.** Lift the bark piece on either side of the vertical cut for the insertion of the bud. Select a required bud stick and start a slicing cut about 1.5cm below the bud and continue it upward and under the bud to about 2.5cm above the bud. Give another horizontal cut about 1cm above the bud. Remove the shield of bark containing bud. The traces of wood, if attached may be removed. Insert the bud between the flaps of bark on the stock with the help of budding knife in such a way that the horizontal cut of the shield matches the horizontal cut on the stock. Wrap the bud stick tightly with polythene strip exposing only the bud.

Successful T budding requires that the scion material have fully-formed, mature, dormant buds and that the rootstock be in a condition of active growth such that the "*bark is slipping*". This means that the vascular cambium is actively growing, and the bark can be peeled easily from the stock piece with little damage.

Inverted T- Budding: In heavy rainfall areas, water running down the stem of the stock may enter the T cut, soak under the bark and prevent healing of the bud piece. Under such conditions an inverted T ( ) budding may give better results as it is more likely to shed excess water. Inverted T budding procedure is same as that of T-budding except the horizontal cut on the stock is made at the bottom of the vertical cut rather than at the top.

Procedure: On the selected stock plant, give a horizontal cut at the bottom of the given vertical cut representing inverted **T.** Select the required bud stick. Start a slicing cut 1.5 cm above the bud and continue it downward and under the bud to about 2.5 cm below the bud. Give another horizontal cut about 1cm below the bud and remove the bud piece. Insert the bud between the flaps of bark on the stock and push upwards till the horizontal cut of the shield matches the horizontal cut on the stock. Wrap the bud piece and stock completely and tightly exposing only the bud properly.

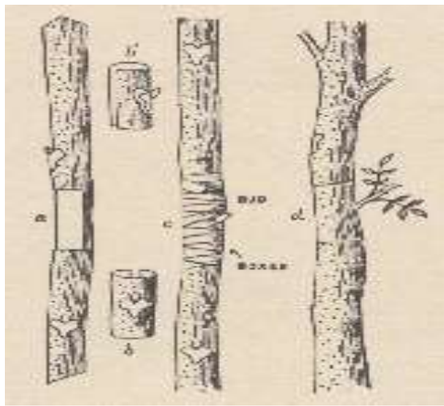
Patch Budding: In this method a regular patch of bark is completely removed from the stock plant and is replaced with a patch of bark of the same size containing a bud from the desired mother plant. For this method to be successful, the bark of the stock and bud stick should be easily slipping .The diameter of the stock and bud stick should be preferably by about the same (1.5 to 2.75cm) E.g., Ber, Citrus, Cocoa and rubber.



Patch Budding

Procedure: On the selected stock plant at the desired place (10-15cm above the ground level) give two transverse parallel cuts through the bark and about 1-1.5 cm long or 1/3rd the distance around the stock. The distance between the cuts may be 2-3 cm.Join the two transverse cuts at their ends by two vertical cuts. Remove the patch of bark and keep it in place again until the bark patch with the bud from the selected mother plant is ready. On the bud stick give two transverse cuts-one above and one below the bud-and two vertical cuts on each side of the bud. The dimensions of the transverse and vertical should correspond to those given on the stock. Remove the bark patch with bud by sliding side ways. Cuts with bud by sliding side ways. Insert the bud patch immediately on the stock in such a way that the horizontal cuts of the bark

patch and those on the stock plant match together perfectly. Wrap the inserted bud patch with polythene strip covering all the cut surfaces but exposing the bud properly.



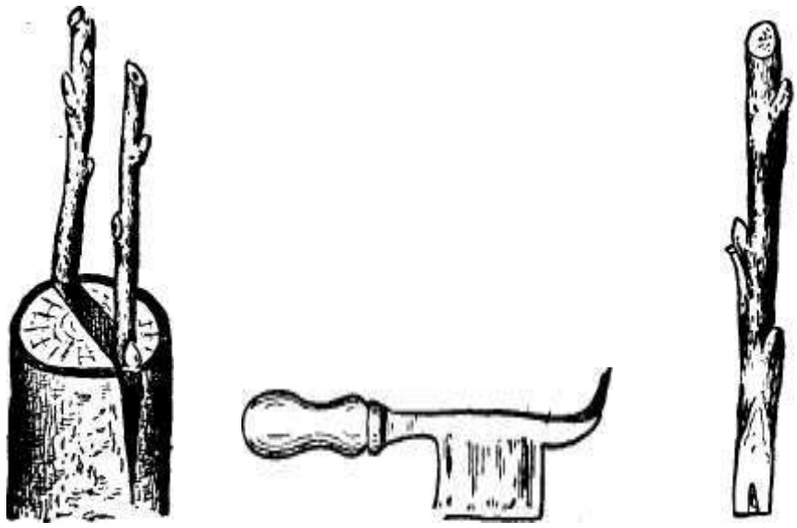
Ring budding

Ring budding: The bud is prepared by taking a ring of a bark, 3cm long with the bud in the centre. In the root stock, two transverse cut 1.5cm apart are made and these are connected with a vertical cut and a ring of bark is removed. The prepared scion bud with the ring of bark is fitted in the exposed portion of the rootstock and tied.E.g, Cinchona.

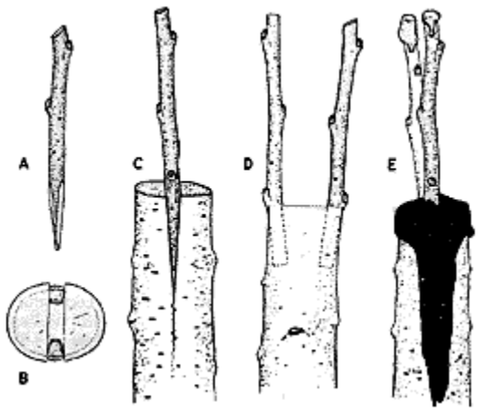
Double working: It is practiced for several purposes (1) to over come incompatibility between the stock and scion.Iincompatible stock and scion may be united by means of a piece of interstock that is compatible to both (2) to secure resistance to drought or cold by providing a disease or cold resistant trunk by means of double working.(3) To obtain resistance to pest and dwarfing effect by using a pest resistant stock and a dwarfing stock and (4) top working of grafted orchard trees is essentially a double working; here the tree trunk as an intermediate stock may exert certain influences on the new top.

The inserted intermediate stem piece is called as **sinking scion / foster mother /interstock / inter stem.**

Top working: Top-working for changing a variety is generally done on long lived species, growing in a healthy condition. Short lived species, old trees or diseased trees are not suitable for top working; in such cases new planting is considered more economical and useful than top working.



Top working by cleft grafting



Top working by cleft grafting on main branches

This practice is resorted to (1) when the existing tree is of inferior type, (2) when the tree is unproductive and (3) to provide pollenizers (4) to change the variety.

For top working different methods of grafting like cleft grafting, bark grafting, splice grafting or side grafting can be used. However, cleft is the most popular and commonly used method for top working especially when thick branches are selected .When younger and thin branches are used, whip and tongue grafting are best.

Top working of older trees is generally done over a period of two years. In the first year, half of the scaffold branches are top worked retaining the other branches as nurse branches which in turn are grafted in the second year. In the smaller and comparatively younger trees the entire tree is top worked in the first year. Here also one or more nurse branches are retained till the union is successful. Nurse branches protect the top worked scions from winter injury, sun burn and also from desiccating winds and water sprouts develop less frequently when nurse branches are retained.

Top working is most successful when relatively young trees are used. If older trees are selected for top working, it is better to select vigorous lateral branches that arise from the main limbs.

The branches to be top worked should be cut in such a way that the cut surface is smooth and is at a point of the branch where there are no knots or smaller branches. Immediately after top working the limbs should be thoroughly covered with grafting wax, sealing all the exposed cut surfaces.

CLONAL PROPAGATION

The reproduction of a group of plants from a single plant by vegetative propagation is called clonal propagation. All these plants have the same heredity / genetic constitution and are quite uniform when grown under the same conditions.

May be defined as genetically uniform material derived from a single individual parent exclusively by vegetative methods such as cuttings, divisions etc.All the plants of a clone are true to the parent in their growth and performance.

The reproduction of a group of plants from a single plant by vegetative propagation is called clonal propagation. The group of plants or horticultural variety derived from one original plant by means of vegetative propagation (e.g. rooting of cuttings, or slips, budding, grafting, bulb lets etc) have the same heredity and are quite uniform when grown under the same conditions. Also the vegetative progeny from a single seedling.

Clone of many commercial crops like potato, tea, banana, onion, turnip and many horticultural crops have been established by clonal propagation. In many plants which are heterozygous and sterile, clonal propagation is the only means of perpetuation. Clonal selection and propagation can also be used to evolve new varieties in vegetatively propagated plants.

The steps involved in the production and maintenance of a clone: There are essentially three steps in the production and maintenance of clone .(1) Selection of pedigree and pathogen free, true to type, stock plants,(2) maintenance of stocks in a

disease free condition and rouging of off types and (3) propagation and distribution of such stocks.

MICRO PROPAGATION

Micro propagation (tissue culture or invitro culture) refers to the multiplication of plants, in aseptic condition and in artificial growth medium from plant parts like meristem tip, callus, embryos anthers, axillary buds etc.

It is a method by which a true to type and disease free entire plant can be regenerated from a miniature piece of plant in aseptic condition in artificial growing medium rapidly throughout the year.

Merits of micro propagation:

a) Tissue culture helps in rapid multiplication of true to type plants throughout the year.
b) A new plant can be regenerated from a miniature plant part, whereas, in conventional methods a shoot of considerable length is required.
c) Large number of plants can be produced in culture tubes in small space with uniform growth and productivity instead of growing them in large areas in nursery.
d) Plants raised by tissue culture are free from diseases.
e) Tissue culture coupled with somatic hybridization (production of hybrid cells by fusion of two protoplasts with different genetic makeup.)helps in evolving new cultivars in a short time.
f) Micro propagation facilitates long distance transport of propagation materials and long term storage of clonal materials.
g) Tissue culture methods are particularly effective in plants that don't breed true from seeds, seeds are not viable (male sterile) or not available (banana) and in plant where propagation by conventional methods are expensive (Orchids)

Demerits of Micro propagation:

a) The cost involved in setting up and maintenance of a laboratory is very high and may not justify their use in all the horticultural plants ordinarily.
b) Tissue culture techniques require skilled manpower.
c) Slight infection may damage the entire lot of plants.
d) Some genetic modification (mutation) of the plant may develop with some varieties and culture systems, which may alter the quality of the produce.
e) The seedlings grown under artificial condition may not survive when placed under normal environmental condition.

Methods of Micro propagation: Different methods of micro-propagation are Meristem culture, Callus culture, Cell culture, Embryo culture, Protoplast culture, Shoot apex grafting, and Pollen grain culture.

Invitro: Latin for ''in glass". Reactions, responses or experiments in an artificial environment in isolation from the whole organism.

In vivo: Latin for "in living". Biological processes that occur with in the whole living organism.

APOMOXIS

The embryo is generally produced by sexual reproduction but there are certain cases in which the embryo is produced by an asexual process. This is of great value as the resulting plant can be reproduced by seed propagation in almost the same manner as it would be by any other vegetative method. The seedlings produced through apomixis are known as **apomictic seedlings**. Apomictic seedlings are identical to their mother plants and similar to the plants raised through other vegetative means, as it has the same genetic make-up as that of the mother plant. Hence, propagation by means of apomictic seedlings is equivalent to vegetative propagation.

The phenomenon in which an asexual reproductive process occurs in place of the normal sexual reproductive process of reduction division and fertilization is known as **apomixis.**

Kinds of apomixis:

Obligate apomixis: Plants that produce only apomictic embryos are known as obligate apomicts.
Facultative apomixis: Plants that produce both apomictic and sexual seedlings are called facultative apomicts**.**

Types of apomixis:

Recurrent apomixis: In this the embryo develops from the diploid egg cell (diploid parthenogenesis) or from some other diploid cells of the embryo sac, with out fertilization (diploid apogamy). As a result, the egg has the normal diploid number of chromosomes, as in the mother plant. Eg, Onion, raspberry, Apple etc.
In some plants apomixis occurs without the stimulus of pollination, in others pollination is necessary for embryo development**.**

Non-recurrent apomixis: In this type, the embryo develops directly, either from the haploid egg cell (haploid parthenogenesis) or some other haploid cells of the embryo sac (haploid apogamy). In this case haploid plants are always produced. As the plants produced by this method contain only one set of chromosomes, these are sterile and

the process is not continued for more than one generation. Non-recurrent apomixis does not commonly occur and is primarily of genetic interest. Eg. *Solanum nigrum*, *Lilium spp*.,etc.

Adventitious apomixis (Adventitious embryony or nucellar embryony): In this type of apomixis the embryo does not develop from the cells of the embryo sac, but develops from any diploid sporophytic cell, eg.,cells of the nucellus (usually), integument etc. Hence, the diploid cells of the sporophyte giverise directly to diploid new embryos. This type of apomixis is found in *citrus* , where fertilization takes place normally and a sexual plus a number of apomictic (nucellar) embryos develop. In opuntia also this type of apomixis occurs.

Vegetative apomixis (Bulbils): In this case the flowers in an inflorescence are replaced by bulbils or vegetative buds, which often sprout into new plants while they are still on the mother plant. This type of apomixis is found in some species of *Allium, agave, Diascorea*, *pao* etc**.**

Poly embryony: This is a type of apomixis.The phenomenon in which two or more embryos present with in a single seed is called polyembryony. When such seeds are sown, more than one seedling arises from the seed .Of them one is from the zygote (Sexual seedling).The others are asexual or apomictic seedlings.

The reasons for this phenomenon are many. The origin of these extra embryos or seedlings varies.

1) From nucellus-Nucellar embryony as in citrus and mango
2) From seed coats (integuments) or antipodals or synergids –rare—mango.
3) Occasionally more than one nucleus develops with in the embryo sac (in addition to the usual and regular nucleus).
4) Cleavage of the embryo during the early stages of development is common occurrence.

What ever may be the place of origin, the common thing is, these embryos arise from the maternal tissue of the plant. Eg.Citrus, Mango, Jamun, Rose, apple etc.

The poly embryonic seedlings are uniform and true to parent like other vegetatively propagated plants. They are derived by mitosis, and come from maternal tissue (not by meiosis), but they have the characteristics of sexual seedlings like juvenility, vigour, freedom from virus diseases.

Eg. Citrus, Mango, Jamun, Rose apple.

How to differentiate the poly embryonic and sexual seedlings: It is difficult to differentiate in the nursery. Generally more vigorous seedlings are considered to be polyembryonic. By rejecting about 10% of weaker and weakest seedlings, one can have fairly uniform poly embryonic seedlings.

GRAFT INCOMPATIBILITY

When most closely related plants are grafted together they unite readily and continue their growth as one plant. When entirely unrelated plants are grafted together, the usual result is the failure of the graft union.

The inability of parts (stock and scion) of the two different plants when grafted together, to produce a successful graft union and the resulting single plant to develop satisfactorily is termed as graft incompatibility. **Ex.** Apple on pear, pear on quince and apricot and almond.

Types of incompatibility:

Graft incompatibility in fruit trees has been classified in to two types.

1. Translocated incompatibility.
2. Localized incompatibility

1. Translocated incompatibility: This type involves **phloem degeneration** and this can be seen by the development of brown line or necrotic area in the bark. This is due to the movement of toxic materials through the phloem. This cannot be overcome even by inserting an intermediate stock.

2. Localized incompatibility: Incompatibility reactions are seen at the graft joint. This incompatibility can be overcome by inserting a mutually compatible interstock in

between them by avoiding direct contact between stock and scion. This may be due to **repulsive action** of stock and scion.

TRAINING AND PRUNING

Training and pruning are important operations. Both the operations form an indispensable process having direct bearing on growth and vigour of plants and yield and quality of fruits.

A properly trained and pruned plant sustain heavy crop load and produce bounteous harvest of quality**.**

Training refers to the judicious removal of plant part / parts to develop proper shape of a plant capable of bearing a heavy crop load whereas **pruning** is defined as the judicious removal of plant parts like root, leaf, flower, fruit etc.to obtain a good and qualitative yield.

Thus, it can be conceived that the **training** is related to shape and size of plants where as **pruning** is related with harvesting better yield and more so harvesting fruits of quality.

Both the operations of training and pruning work together in maintaining shape and size of tree and harvesting desirable yield.

Training is a treatment given to the young plants to get a suitable or desirable shape with strong framework. It may or may not involve pruning.

Pruning is the removal of unwanted, surplus annual growth; dead, dried and diseased wood of the plants is called Pruning.

TRAINING

Before actually discussing the subject of training, it is necessary to understand the various terms used to make the subject more intelligible.

Trunk: The main stem of the plant.

Head: The point on the trunk from which first branches arise.

Scaffold branches: The main branches arising from the head are known as scaffold branches. Trees in which scaffold branches arise with in 60-70cm height from the ground level are called **low head trees** and those in which they come out from the trunk above 120cm are called **high head trees**.

Crotch: The angle made by the scaffold limb to the trunk or the secondary branch to the scaffold limb is called **crotch**.

Leader: The main stem growing from ground level up to the tip dominating all other branches is called **leader.**

Water shoot: A vigorous growing unbranched shoot arising on any branch or leader is called **water shoot.**

Water sucker: The growth appearing on rootstock portion is called **water sucker.**

The reasons for training fruit trees, ornamental trees, shrubs etc. are:

1) There are no. of plants, which grow wild and don't bear if they are left to themselves and will not have any symmetry in their growth.
2) Most of the time, the unpruned trees put forth vegetative growth only. Hence, bearing will be delayed.
3) When plants are grown in rows at close spacing, they grow tall and occupy interspaces, making intercultural operations difficult to practice.
4) For want of sunlight, the lower branches wither and die. The shaded fruits (**apple, citrus** etc.) fail to develop colour.
5) Untrained trees will generally be less productive because of excessive vegetative growth for most of the time.
6) The framework being weak in untrained trees, it breaks easily due to strong winds as well as heavy loads of crop.

All the above problems can be overcome by training the trees. Man can train the plant to suit his desire. By training the plants, ideal conditions a can be provided for better production.

The fruit trees are trained to a particular system depending upon their habit of growth and the flowering and ornamental shrubs etc.can be trained to a particular shape like animals, birds etc.

It is necessary to pay attention to the training of a plant during the first few years when it is young. In this period, its permanent framework is built up as decided upon by the grower.

The main objectives to be kept in view in training the fruit trees are:

- To facilitate orchard cultural operations.
- To provide an attractive appearance.
- To admit more light and air to the centre of the tree and to expose maximum leaf surface to the sun
    - for increasing production
    - for complete colour development
- To protect the tree trunk from sunburn injury.
- To secure a balanced distribution of fruit bearing parts on the main limbs of the plant.

Most deciduous and evergreen woody trees are best trained to a single stem with a low head. In case of pomegranate, custard apple and fig it would be better to train two or three stem plant and remove the other stems that may grow later.

In the tropical climate, the high-headed trees are unsuitable as their exposed trunks are subject to sunscald in summer. Low headed trees are common all over the world. In such trees the heads or crown is kept so low on the trunk that there is only a distance of 60-- 90cm (2—3 ft.) between the ground and the lowest branch. Such low headed trees come in to bearing comparatively much earlier, are able to resist stormy winds more effectively and their spraying and harvesting also become easy.

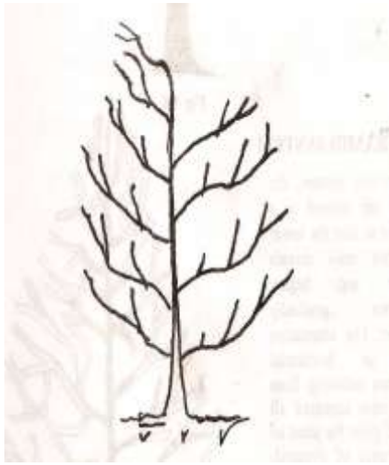
The formation of the main frame work of the tree is the most important part of the training.

1) Usually, two to four main branches are encouraged. These should be allowed to arise from different directions and also at some distance from one another, so as to form a well-balanced head.
2) The frame work is greatly strengthened, if the branches are spaced at about 15cm distance with medium crotches (40—50^0)
3) If two or more branches of equal size are allowed to arise from one place, they form a bad crotch and often split from their common joint.

The most important systems **of training** followed in most of the fruit crops are:

Central Leader system:

- In this system, a tree is trained to form a trunk, which extends from the surface of the soil to the top of the tree.
- In many kinds of trees, the central axis or the main branch naturally grows vertically upwards and smaller side branches grow from it in various directions.
- If the central leader is allowed to grow indefinitely, it will grow more rapidly and vigorously than side branches resulting in a robust close centre and tall tree. In such a tree the bearing is confined in top portion of the trees.



Central Leader System

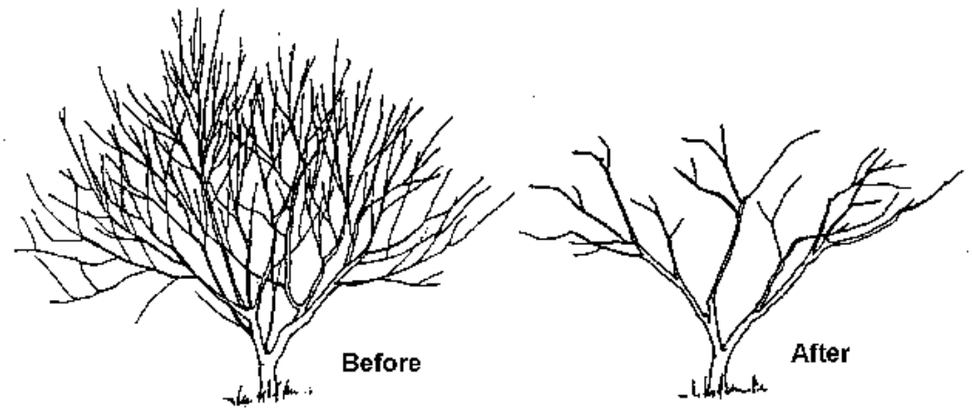
Merits and demerits:

1) The main advantage of this system is the development of strong crotches.
2) Its main disadvantage is shading of the interior of the trees.This weakens the central leader and thus shortens the life of the tree
3) Since trees are very tall, harvesting and spraying become difficult and costly.
4) The lower branches, which remain more or less shaded, become ultimately less vigorous and less fruitful**.**
5) Owing to the shading of the inferior, the bearing surface moves to the periphery (outer shoots) of the tree.Thus fruiting surface is reduced and eventually yields are reduced.
6) The very high shape of the plants makes them prone to wind damage.
7) This method of training is not suitable for high altitude and hot arid places where wind velocity is high.

This system is also called as **close centre**, since the centre of the plant is closed and also as **pyramida**l system, since the plant trained looks like a pyramid.

This system of training is practiced in case of certain **apple** varieties and **pears**.

Open Centre system:



- In this system of training, the main stem of the plant is allowed to grow only up to a certain height by **beheading** it in the young stage ie.within an year of planting and inducing all the subsequent vegetative growth by lateral branches
- This results in the **low head** in which the bulk of the crop is borne closer to the ground than in case of central leader tree.

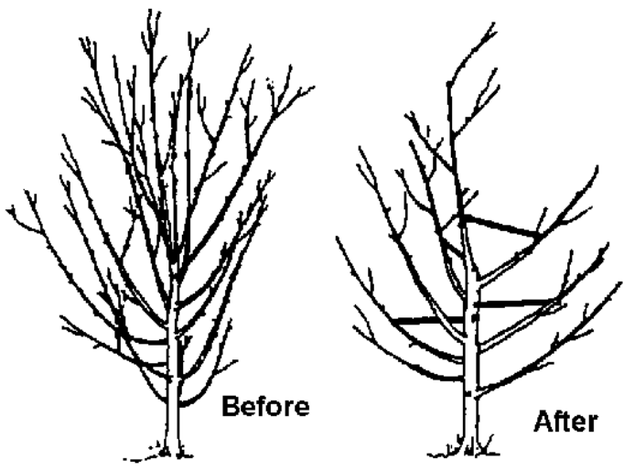
Merits and demerits:

1) It allows more light to reach all parts of the tree which is helpful (a) for better colour development of the fruit (b) fruiting area is spread all over the area of the trees.
2) Trees become low headed. So, pruning, spraying, harvesting etc., are facilitated.
3) The branches form weak and narrow crotches, which may frequently break under severe stress and strain such as bearing of heavy crop and strong winds.
4) Sun scalding of central leader is also possible.
5) The branches form very close to each other all most from the same spot.
6) In this system the plants take a ‘’**bowl or vase’’** shape, which provides a good base for setting of frost. So this system is not suitable for high altitude areas where frost observance is common.

Since the main axis is removed, it leaves the centre open and hence **open centre** and the tree looks like a **vase (bowl),** hence it is other wise called as **vase system**.

This system of training is practiced in **plums** and **peaches**.

Modified Leader system:



- This is intermediate between the above two systems and has the advantages of the both.
- This system is developed by first training the tree to the leader type allowing the leader to grow unhampered for the first four or five years.
- The main branches are allowed to arise on the main stem at reasonable intervals.
- After the required number of branches has arisen, the main stem is headed back and lateral branches are allowed to grow as in the open centre system.

Merits and demerits:

1) This results in a low-headed tree with well-spaced limbs, well distributed fruiting wood and low height to carryout orchard operations conveniently.

This system of training is practiced in fruit plants like **citrus, pear, apple** and **walnut** etc.

Which system of training is the best?

Among the above three systems of training, the modified leader system is the best and most desirable because:

- Narrow to medium crotches and there by breakages are eliminated
- The indeterminate growth of the central axis is also prevented keeping the tree height under control, so as to make orchard operations easy and cheap**.**
- No danger of sun scorching and fruit quality is good.

Principles of training:

Irrespective of the system of training practiced, the following general principles are to be observed:

1) The branches should arise on the main trunk alternatively at intervals of at least 15cm and not all at one place.
2) They should be equally distributed around the stem.
3) Up right branches should not be encouraged. Branches should have medium crotches.

PRUNING

Pruning may be defined as the removal of any excess or undesirable branches, shoots, roots, or any other parts of a plant, so as to allow the remaining parts to grow normally or according to the desire of the pruner.

Pruning is the removal of unwanted, surplus annual growth, dead, diseased, dried and broken branches of the plants

Pruning is an art of removing scientifically certain portions of a plant with a view to producing more and superior quality of fruit. Pruning of any kind according to its

severity, changes the nutritive conditions with in the tree and consequently, limits or encourages fruit bud formation.

Reasons for pruning

- There always seems to be surplus branches on a tree. But only those, which are useful to the plant in holding up the leaves to the sun to grow strong. Those which will have little chance of doing so, because of shade or other reasons become weak and eventually dry up. Evidently the plant is making a selection and eliminating the useless branches. But this process of selection and elimination is a slow one. Till they are eliminated the useless branches also draw some nutrients which is a waste for the tree ultimately. If such branches are recognized and eliminated earlier will help in conservation of food in the tree for better production.
- The second reason for pruning will be the removal of diseased twigs to check the spread of diseases
- In some fruit trees, fruits are borne on current flush (Ber, Grape etc.) which will be obtained in large number after pruning of certain no. of old branches.

Objectives of Pruning:

1) To remove the surplus branches and direct the sap flow in to the remaining branches.
2) To develop a strong frame work which can carry the load of a good crop and can with stand strong winds.
3) To train the plants to a definite shape. Ex. Fence, Hedge, Topiary etc.
4) To thin out branches so as to admit more light into the interior of the tree top so that the inner wood also becomes fruitful.
5) To limit the size of the tree top to a convenient one so as to render spraying and picking more easy and economically.
6) To regulate the spacing and distribution / direction of branches.
7) To distribute the fruiting wood in all directions and to maintain a balance between vegetative and reproductive phases.
8) To improve the growth of the spur (A short lateral branch one inch or less in length with nodes close together, so that the leaves converge to form a rosette) shoots and production of more flower buds.
9) To check the further spread of the diseases.
10) To maintain the vigour of the plant by removing the water shoots and other unwanted growth.

Responses of plants to pruning

The response of plants to pruning should be well understood for successfully achieving the object of pruning. The following are the some of the important ways in which the plants show response to pruning.

1. Activation of buds: When a branch is cut or pruned, the buds on the branch below the cut are invigorated (activated). The bud close to the cut is most vigorous and this vigour decreases in the buds as the distance increases from the cut. This is due to the elimination of the apical dominance of the terminal bud from which the auxin flows down and inhibits the growth of the lateral buds.

This response is made use of to determine the direction of the existing branches and correcting a crotch. If the crotch is a narrow (The angle between the branch and the stem on which it arises –Crotch), the branch is pruned to an outer bud, so that the bud will produce a branch towards the outer side usually at right angles to the branch or nearly so. As it grows larger, it pulls away from the stem and eventually widens the crotch. Similarly, a wide crotch can be narrowed down by pruning the branch to an inner bud.

2. Dwarfing response: The immediate effect of pruning is no doubt invigoration of new branches owing to the diversion of food, but due to removal of much foliage, there is an overall reduction in the manufacture of food resulting a shock on root growth This in turn limits the further growth of the new shoots .When the growth of the new shoot is reduced, their length is also reduced. Therefore, the net effect of pruning a tree is dwarfing, which is in proportion to the severity of pruning. Both the spread of the top as well as the spread of the root system are reduced. This also results in dwarfing of the plant.

3. Production of water shoots: Severe pruning often activates resting or adventitious buds and buds on old wood may some time be stimulated to grow. They often produce branches, which grow vertically and very vigorously with **long internodes**; **angular stems large succulent leaves** and **thorns** (as in citrus). They are called **water shoots** or **water suckers** or **bull canes**. These highly vegetative water shoots are seldom fruitful till they are several seasons old. They are wasteful and unwanted because they draw much food and grow at the expense of the fruiting wood and are better removed as soon as they appear. However, they may be profitably used in some instances to fill in the gaps occurring in trees by lopsided development or loss of branches due to other causes. Eg.Citrus,Guava,Ber,Sapota,cashew etc.

4. Delay in bearing: When pruning is severe particularly in early years of the fruit plant, bearing is delayed. Some times severe pruning may also lead to poor yields, because a major portion of the foliage and fruiting wood are lost.

Methods of pruning

1. Thinning out: When a shoot is removed entirely from the inception (from the point of origin) so that, no new shoot arises from that place, it is referred as **thinning out**. This thinning is practiced in the removal of shoots arising in unwanted places, water shoots etc.

2. Trimming: Cutting the growth of the twigs to a pre-determined level as in the case of fence, hedge and edge.

3. Heading back: When the branches grow tall and vigorously without producing flowers, these shoots are headed back. When a branch is cut almost to the base, leaving a few inches of stump, carrying few buds, it is referred as **Heading Back**. These buds left on the stump will give rise to shoots which are important to the tree either being spur bearers or bearing flower buds or filling up of gaps in the tree or forming vegetative wood from which flowers may arise in the following year. The shoot from the bud nearest to the cut takes the place of the pruned shoot.

4. Pollarding: Mere cutting back of the shoots, indiscriminately to reduce the height of the tree is **Pollarding**.

5. Pinching (tipping): Removal of the tip of the shoot to stop its indeterminate growth or to encourage the growth of the lateral buds is **pinching or tipping**. This is practiced in marigold and chillies at the time of transplanting.

6. Disbudding (nipping or rubbing): Nipping or rubbing of young buds preventing a chance of their sprouting is **disbudding**. When the buds arise in wrong places they are rubbed off. Similarly sprouts (Buds) on root stocks are disbudded.

7. De-blossoming: Removal of surplus flowers to enable the tree to produce crops regularly year after year is called **deblossoming**.This is practiced in alternate bearers like mango. apple etc.

Seasons of pruning

1. It depends on the type of wood, type of plant species and time of flower bud formation.
2. Removal of diseased, dead, and dried wood as well as water shoots can be carried out at any time of the year.
3. Pruning of healthy branches should not be done when the trees are in flowering or fruiting, since the resulting disturbance leads to loss of blossoms or fruits.
4. In deciduous trees, pruning can be done before the termination of dormancy.
5. In ever greens, pruning should be carried out before the start of active growth or after the harvest of the crops.

6. Summer pruning of deciduous trees and also the pruning of evergreens in the active growing season delays the formation of flower buds by prolonging vegetative growth.

Pruning and Manuring

The sudden invigoration of a number of buds due to pruning makes a demand on the food resource of the tree, because the new shoots are not yet ready to manufacture their own food. The reserve food in the plant often may not be sufficient to meet this demand of new growth. Further, pruning means loss of much foliage and wood. So, to compensate the loss incurred due to pruning and to meet the demand of new shoots the pruned trees should be manured

heavily, otherwise the new shoots ultimately wither and dry. This is particularly important when old (Senile) or neglected trees are pruned for rejuvenation.

Care of pruned wounds

Pruning leaves wounds and cut ends which should be protected to avoid the access of disease pathogens and insect pests through these wounds and cut ends .So, immediately after pruning, these cut ends and wounds should be protected by applying disinfectants like Bordeaux paste or blitox paste.

Unfruitfulness in fruit trees – Causes and remedies

1. Environmental causes:

1) Some varieties of a fruit crop don't flower in a locality owing to undetermined environmental factors eg. several north Indian varieties of mango have not flowered in south India. This can be remedied by top working with south Indian varieties.

2) Unfavourable temperature may cause failure of any flowering as in the case of apples in conoor due to lack of sufficient winter chilling. It has been remedied to certain extent by oil emulsion sprays and DNOC (Di-nitro-ortho cresol).

3) In tropics, plants flowering in summer may experience retarded pollen germination due to high temperatures and low humidity. The provision of wind breaks, close planting and cover cropping help in improving the situation.

4) Reduced illumination due to close planting ,over crowding of branches or shade will often reduced flowering Thinning out some trees to increase spacing, pruning trees to reduce over crowding and removal of shade can meet the situation.

5) When long day plants of northern latitudes don't flower owing to the absence of the critical length of day, they can be made to flower by providing artificial light. On an orchard scale such treatments are not practicable.

6) Late rains may prolong the vegetative growth and delay or reduce flowering in mango. It can be remedied by drying out the soil by deep ploughing and probably by artificial inhibition of growth by growth regulators.

7) Heavy rains may restrict pollinator activity, wash away pollen and prevent pollen germination. Choice of varieties which don't flower at such periods of the year is the

best way out. In crops like grapes, the pruning time may be altered to avoid the onset of flowering during the period of the rainy season crop may altogether be avoided by hard pruning.

2. Nutritional Causes:

1) Heavy nitrogenous manuring at the time of flower bud initiation often reduces flowering by promoting vegetative differentiation. The practice should be given up. Root pruning and restricted irrigation may be helpful in reducing vegetative vigour and inducing formation of male flowers.

2) Over bearing in the previous season exhausts the tree and reduces subsequent flowering as in mango and most biennial bearing trees. A complete manure mixture applied at the growth flush following the harvest will be helpful (June manuring in mango).

3) Lack of nutrition as in weak shoots causes fall of flowers before and after fruit set. A spray of urea after fruit set will help the development of fruits.

4) Lack of sufficient reserves of carbohydrates in shoots may cause sparse flowering and poor set (shoot bunches of grapes).Ringing and girdling may help. But it should not be continued as a regular orchard practice.

5) Adverse growth features like water suckers will result in a drain on the tree and reduce flowering not only on themselves but also on other branches of the tree. Such shoots arise when big branches are pruned. Then it is necessary to cut big limbs, they should always be set to a strong lateral but not stimulate a dormant bud. Late irrigation following a long drought may cause the production of water shoots

.The first irrigation after a drought should always be sparing later ones being more liberal .When water suckers are formed due what ever reason, they should be promptly removed.

6) Deficiencies of elements are sure cause of reduced flowering as well as set. A composite mineral spray at flush time will usually be very helpful. If deficiency is due to alkalinity of the soil, suitable reclamation measures should be adopted.

7) Heavy manuring and severe pruning during the pre-bearing period will prolong it. Pruning should be done while branches are young, preferably by rubbing of axillary buds themselves by frequent observation of the plants.

Seedlings and some species of plants have a long prebearing period during which no undue anxiety should be felt for hastening flowering.

Old trees suffer from inadequate nutrition especially when they are neglected. The short extension of shoots, small leaves showing various deficiencies, scanty leaves and die back of shoots indicate approaching death. Such trees may be given one chance to bear by (1) manuring them heavily with a complete mixture of nutrients (2) pruning hard up to 3-4 year old wood and (3) spraying a composite mineral mixture on young flush. Irrigate frequently and protect them from pests and diseases. This may rejuvenate the tree for a few years.

3. Inherent Causes:

1) Low proportion of female or perfect flowers as in some varieties of mango (Jehangir, Allampur baneshan etc.) often is the cause for a poor crop. There appears to be no remedy for this defect.

2) Structural features like heterostyly and habits like dicho-gamy some times restrict the availability of pollen and pollination. The presence of sufficient population of the tress and pollinators ordinarily ensures good pollination and set.

3) Inadequate quantities of pollen appear to reduce fruit set in some varieties of strawberry and some varieties of grape. Use of suitable growth regulators to get fruit setting will circumvent the difficulty.

4) Many varieties of Japanese plums and apples are self sterile. Many other fruits also partially self sterile .So planting varieties which make them fertile with their pollen will solve the problem.

5) When intersterility is the cause for low fruit set compatible pollenizers have to be provided. Mixed pollen sprays and use of synthetic growth regulators may also be helpful.

6) Triploidy and distant cross are often reasons for low fruit set. Chemical aids can get over the problem.

7) Defects of ovule development, embryo abortion etc.are observed in dropped flowers. These largely seem to be varietal characteristics and cannot largely be altered.

4. Bio-logical causes:

1) Absence of pollinating agents can be a reason for low fruit set in several fruits. Rearing bee colonies in orchards, besides being a subsidiary source of income greatly helps fruit set.

2) When specific insects' symbiotic adaptations (like the blastophaga for fig) concerned with the pollination, they must be reared (by growing Capri fig trees in this case). A wooden needle seems to perform the duties of the blastophaga quite as efficiently in promoting set of fig fruit.

3) Pests like the mango hopper which directly attacks the flowers obviously reduce the fruit set. Others which feed on leaves reduce the photosynthetic surface impair production of carbohydrates and thus reduce flowering. Several fungal diseases do the same thing; Suitable remedial measures should be taken to protect the tress.

5. Cultural causes:

1) The commonest cause of poor flowering in house gardens is excessive irrigation which restricts aeration of roots and causes sickly symptoms. Increase of intervals of irrigation and provision of drainage are the remedies.

2) Weeds and intercrops may compete with the main crop for nutrition and water in low rainfall areas .Removal of weeds and adequate manuring to meet the demands of both the fruit crop as well as the intercrops are helpful. Intercrops which clash with the irrigational and manurial requirements of fruit crops both in respect of quality and time of application should be avoided.

3) Ploughing or deep cultivation at flowering time will result in drop of flowers and should be avoided.

4) Severe pruning of large limbs which encourages production of water shoots should be avoided. If it is absolutely essential, the branches may be cut to a strong lateral. Wrong pruning techniques may also cause reduction of flowering. The following

points should be borne in mind (1) the pruning should be with regard to bearing habit of the fruit tree, (2) the pruning should be up to some fruitful buds (in grapes).Harder or light pruning will reduce fruiting, (3) a balance of vegetative and fruiting wood should be maintained in plants bearing on past seasons wood, (4) pruning should not be delayed till the new growth is resumed.

In practice good drainage, timely irrigation, manuring and culture and selection of suitable varieties will ensure good set of crops.

USE OF PLANT GROWTH REGULATORS IN FRUIT PRODUCTION

Growth mainly refers to the quantitative increase in plant body such as increase in length of the stem and root, the no. of leaves, the fresh weight and dry weight etc. On the other hand, germination of seed, formation of flowers, fruits and seeds, emergence of lateral buds, falling of leaves and fruits are qualitative changes, referred to as development.

Growth and development of the plant body are controlled by two sets of internal factors, namely, nutritional and hormonal. Nutritional factors supply the plant necessary mineral ions and organic substances such as proteins, carbohydrates and others. These constitute the raw materials required for growth. However, utilization of these substances for proper development of the plant is controlled by certain chemical messengers, called plant growth substances or plant growth regulators, which in minute amounts increase or decrease or modifies the physiological processes in plants.

The term plant growth regulators' is relatively new in use. In earlier literature these were mentioned as Hormones. "Hormone is a Greek word derived from "**hormao**" which means to stimulate. Now the term phytohormone is used in place of plant hormone.

Plant growth regulators or plant regulators are the organic compounds other than nutrients which modify or regulate physiological processes in an appreciable measure in the plants when used in small concentrations. They are readily absorbed and these chemicals move rapidly through the tissues when applied to different parts of the plant.

Plant hormones or phytohormones are also regulators but produced by the plants in low concentrations and these hormones move from the sit of production to the site of action. Therefore, the difference between the plant regulator and plant hormone is in that the former one is synthetic and the latter one is natural from the plant source.

The various types of growth regulating substances are:

- Auxins
- Gibberellins
- Cytokinins
- Ethylene
- Abscisic acid

Auxins, Gibberellins and cytokinins are **Growth promoters** and Ethylene and Abscisic acid are **growth inhibitors**. **Growth Retardants:** These are chemicals which have common physiological effect of reducing stem growth by inhibiting cell division.

Growth regulating substances have many practical applications in horticulture and some of the most important uses are:

1, Propagation of plants: The most common use of plant regulators in horticulture is to induce rooting in stem cuttings and in air and soil layers.

Rooting of cuttings: Certain kind of plants may not successfully root under normal condition and with the aid of plant regulators; they can be easily made to induce rooting. The most commonly employed growth regulators for rooting are auxins like IBA, IAA, IPA and NAA. Among these chemicals IBA is most ideally used since, it is the most effective one.

Concentrations ranging from100-500ppm are used for long dip method of treatment of cuttings for 12-24 hours and high concentrations of 10,000 to 20,000 for quick dip method for a few seconds. The concentrations differ according to the type of cutting i.e.

herbaceous, Semi-hard wood and hard wood cuttings. Applications in the form of dust as talcum preparation or in the form of a paste in lanolin are also used.

Layering: Another usage of plant regulators in plant propagation is in aiding rooting of air layering. Layering is the practice of inducing rooting on shoots/stems while it is still attached to the parent plant. This is practiced in fruit trees like guava, pomegranate etc. The main principle of layering is that a part of the aerial portion of the intact plant is girdled. This results in severing of phloem. Consequently, hormones and food substances coming from the leaves accumulate above the girdled portion. When the ring of bark is removed from the stem, the growth regulators like IBA or IAA in power or in Lanolin paste is applied at the distal end of the bark-removed portion to promote root formation

Grafting and Budding: Grafting of plants is a widely used horticultural practice of multiplying the desired genotypes in mango, citrus and others. For this, a portion of the plant is inserted in to another plant of the same species or some times compatible plants of different species or genera. There are mainly two types of grafting: bud grafting and scion grafting. Whatever may be the method employed, the principle remains the same. When the cambium of a stock plant comes into physical contact with the cambium of a scion both from new xylem and phloem simultaneously together. Consequently, these become united and grow as one plant. Since, auxins have the property of promoting cell division of cambium these are often employed. Before grafting, either stock or scion or both are dipped in auxin solution. This promotes an early union and consequently, a better success of grafted plants.

Control of flowering: The plant growth regulators are used for the regulation of flowering in certain crops. In pineapple flowering is irregular and harvesting becomes a problem and hence to regulate flower production, plant regulators are used. The treatment generally consists of pouring a required quantity of (50ml), the solution containing 0.25 to 0.5 mg of the chemical of NAA in the central core of plants. In recent studies, Cycocel and Alar at 5000ppm and Ethrel at 100-200ppm have been shown to induce flowering in mango during an off year. In *Jasminum grandiflorum,* the flowering period is extended by the application of Cycocel at 500ppm.

Flowering can also be induced in certain vegetables such as radish, beet root and carrot with the application of GA.

Fruit set: Various growth regulators like IAA, IBA, IPA, NAA, 2, 4-D, 2, 4, 5-T and GA have been found to improve fruit set in many crops. Among these chemicals 2, 4-D and NAA (Planofix) have been found in general to be most effective in increasing the fruit set. The optimum concentrations for this purpose are 10-20 ppm of auxins and 10-100ppm of GA in different crops. Spraying the flower cluster thoroughly 4-6 days after full bloom with 100 ppm GA increased the fruit set in grape. It has been found that in chillies spraying of Planofix @ 1ml in 4.5 litres of water at 60^{th} and 90^{th} day after planting is beneficial for good fruit setting.

Fruit drop: Losses resulting from pre-harvest drop of fruits have long been a serious problem. When the growth regulators have been put in to use in apples and pears, pre-harvest fruit drop can be checked by the application of 2,4-D and 2,4,5-T effectively. Pre harvest fruit drop in citrus is controlled with 2,4-D at a concentration of 20ppm2,4-D, 10-15ppm of NAA and 2,4,5-T at 15 to 30ppm at pea stage and marble stage and 2,4D at 20ppm and 2,4,5-T at 10-15ppm in mandarins. At 10ppm and NAA at 20ppm have effectively prevented fruit drop in mango. Application of planofix containing NAA at" pea seed "and" marble" size of the fruits completely controlled early fruit drop in Guava.

Parthenocarpy: Partenocarpic fruit set could be induced in a no. of vegetables like cucurbits, bhendi, brinjal, chillies and tomato and fruits like guava, straw berry, citrus, watermelon etc.IAA,IBA,NAA,NOA,NAD,2,4-D,IPA and GA are effective in different plants. Application of GA at 100 ppm induced complete seedlessness in grape varieties Viz., Anab-e-shahi,Pachadraksha etc.The problem of development of seeds in Poovan variety of Banana in Trichy area of Tamilnadu is controlled by application of 2,4-D at 25ppm in the bunches when the last hand is opened.

Fruit ripening: The plant growth regulators can be employed to hasten or delay fruit ripening. Plant growth regulators like 2, 4, 5-T at concentrations of 25 to 100ppm has been found to hasten the ripening in some varieties of plums and peaches. In banana ethrel treatment at 2500ppm induces ripening in 24 hours.

Application of 2, 4-D at 16ppm delays ripening in Washington navel oranges. In Calymirna fig maturity and ripening of the fruit is greatly hastened by spraying 2, 4, 5-T, while in apples in addition to this B-Nine also hastens ripening by about 1-4 weeks. Ethephon has been shown to hasten ripening in grapes.

In tomatoes all fruits on a plant won't mature and ripen at a time .This is a serious disadvantage for mechanical harvesting .Ethephon applied 1-2 weeks before harvest promotes degreening and ripening of tomatoes. Application of smoke is commercially employed to hasten and ripen bananas, the active ingredient responsible being ethylene. Ethyphon is also employed for degreeing and colour development of harvested fruits.

Fruit size and quality: Increase in berry size in Anab-e-shahi,Kismis and Bhokri varieties was reported when GA was applied at 40ppm at bud and flower stages. Higher concentrations resulted in the increase in the length of berries.

Sex expression: Plant regulators can be employed to modify the sex expression in crops. In cucurbitaceous vegetables the production of male flowers will be always more in number than the female flowers and this sex ratio can be narrowed down by the application of ethrel at 100 to 250ppm, if sprayed four times at weekly intervals commencing from 10 to 15 days after sowing. This growth regulator not only increases

the number of female flowers to male flowers, but also produces female flowers at earlier nodes. Application of GA, the sex ratio is shifted towards maleness in several cucurbits.

Certain plant regulators are employed to induce male sterility in crop plants, so that such male sterile plants can be used as a female plant in the hybridization work. This process dispenses the expensive work. Complete male sterility in bhendi can be obtained by spraying with 0.4% of MH. A single spray one week before floral bud initiation offers male sterility for 10 days and a subsequent spray at floral initiation extends the effect to 22 days.

Preparation of growth regulators

Solution form: To prepare an alcoholic solution of any plant growth regulator, dissolve 1 gm. of growth regulator in 50 ml of ethyle alcohol or methyl alcohol or methylated spirit and then dilute this with an equal volume of water to make 100ml of solution containing 10,000 ppm of growth regulator.
This acts as stock solution for further dilutions with distilled or de-ionized water. Stored in well-stoppered bottles in a refregirator, the solutions retain their activity indefinitely.

Dust form: To prepare a dust containing 10,000ppm of growth regulator dissolve 1 gm of the regulator in 40 ml of methylated spirit of 95% alcohol and stir this into 100g of pharmaceutical talc to form a smooth paste. This should be done in a dark room away from strong light. Stir the paste while it is drying until it becomes a fine dry powder. This prepared dust remains active for six months or more if stored in a closed opaque container in a refregirator. From this stock, before using, dilute the growth regulator by mixing the stock with talc powder.

Lanolin pastes: These are particularly convenient for use in air layering but now regarded as an obsolete treatment for cuttings and are made by stirring the growth regulators into the molten lanolin and then allowing it to cool. To make a paste containing 5,00ppm of growth regulator melt 200gm of lanolin and thoroughly stir into this molten lanolin 1gm of required growth regulator. This prepared paste will keep indefinitely if stored in a well stoppered opaque glass vessel in a refrigerator.

PRODUCTION TECHNOLOGY OF FRUIT CROPS

MANGO

Scientific name: *Mangifera indica* L **Family:** Anacardiaceae.

Origin: Indo Burma region

Mango is the most important among the tropical fruits of India and it is very popular and considered to be the choicest of all fruits grown in India. It is known as the, **"king of fruits",** owing to delicious quality of fruit, richness in vitamins and minerals and liking to Indian palate. It is also one of the best fruits of the world. Mango occupies the pride place in India as apple in temperate and grapes in sub-tropical regions of the world. Mango thus deserves to be "**the national fruit of India**". It is also one of the most ancient fruits of the country being cultivated for the past 4000-6000 years. It is a sacred tree for Hindus (because of its blossoms used in the worship of gods and its leaves made in to festoons for hanging over doorways on so many occasions).

No other country can surpass India in the number of varieties and richness of their flavour. Ripe mango is exceedingly refreshing to eat and is an excellent source of Vitamin-A and C. The immature and green fruit is used in various ways in curries,

pickles and chutneys. Ripe mango slices and pulp can be preserved and canned for use when the fresh fruit is out of season.

Mango was found throughout South- East Asia and the Malayan - archipelago in early days. The Portuguese, who opened the sea routes, were responsible for the world wide distribution of mango from indo-Burma and indo-china regions.

Out of 63 mango-producing countries all over the world, India grows it to the maximum, contributing about 11 million tonnes, roughly 58% of the world production of 19 million tonnes. In India it is cultivated in an area of 12.3 lakh hectares occupying 22% of the total area under fruits in India and with a production of about 11 million tonnes constituting about 23% of total production of fruits.

The area in AP is about 2.8 lakh hectares with a production of about 31 lakh tones and productivity of 12 tonnes per ha.

The important mango growing districts in AP are Krishna, W.Godavari, Vishakapatnam, E.Godavari, Vigayanagaram, Srikakulam, Chittoor, Kadapa and Khammam districts. In AP maximum area is in East Godavari followed by Khammam and chittoor districts.

Mango varieties: There are nearly 1000 mango varieties in India. Of these, however only about 20 varieties are grown on a commercial scale. The commercial varieties of mango in India are specific to different regions of the country.

The important commercial varieties of mangoes

Andhra Pradesh	Banganapalli, Suvarnarekha, Neelum and Totapuri
Bihar	Bombay Green, Chausa, Dashehari, Fazli, Gulabkhas, Kishen Bhog, Himsagar, Zardalu and Langra
Gujarat	Kesar, Alphonso, Rajapuri, Jamadar, Totapuri, Neelum, Dashehari and Langra
Haryana	Chausa, Dashehari, Langra and Fazli
Himachal Pradesh	Chausa, Dashehari and Langra
Karnataka	Alphonso, Totapuri, Banganapalli, Pairi, Neelum and Mulgoa
Madhya Pradesh	Alphonso, Bombay Green, Dashehari, Fazli, Langra and Neelum
Maharashtra	Alphonso, Kesar and Pairi

Punjab	Chausa, Dashehari and Malda
Rajasthan	Bombay Green, Chausa, Dashehari and Langra
Tamil Nadu	Alphonso, Totapuri, Banganapalli and Neelum
Uttar Pradesh	Bombay Green, Chausa, Dashehari and Langra
West Bengal	Fazli, Gulabkhas, Himsagar, Kishenbhog, Langra and Bombay Green

Varieties grown and recommended for different tracts of Andhra Pradesh:

Coastal districts: Suvarnarekha, Baneshan, Juicy varieties and Rajpuri.

Rayalaseema area: Neelum, Bangalora, Baneshan, Rumani, Cherukurasam, and Panchadarakalasa.

Telangana Region: Alphonso, Pairi (Peter), Mahamooda, Dashehari, safeda and Goa bunder.

The important mango varieties grown on a commercial scale in AP are- Neelum Baneshan, Bangalora, Rumani, Khader, Mulgoa, Panchadarakalasa, china suvarnarekha, cherukurasam, Janardhanpasand.

Hybrid varieties: Attempets are being made to obtain varieties with maximum desirable characters. For this purpose some hybrids were developed in different research stations, Salient characteristics of the important mango hybrids are-

Mango Hybrids and their characters

Hybrid	Parents	Distinguishing characters
Fruit Research Satation,Anantharajupet-Kadapa District		
Neeleshan	Neelum X Baneshan**.**	Late maturing and Good quality.
Neelgoa	**Neelum X Yerra Mulgoa**	Regular bearing,high yielding' good keeping quality and late maturing
Swarna Jahangir	Chinna suvarnarekha X Jahangir.	Medium yielder, fruits are attractive in colour,good transporting quality and late maturing
AU Rumani:	Mulgoa X Rumani.	Heavy and regular bearer with good keeping quality & late season
KMH-1(Kodur mango hybrid -1)	Cheruku rasam X Khader	Semi-dwarf type having regular bearing habit& good keeping quality
Fruit Research Satation,Sangareddy,Medak District		
Manjeera	Rumani X Neelum	Precocious, regular bearer& heavy yielder
Indian Institute of Horticultural Research, Bangalore		
Arka Aruna	Banganapalli X Alphonso	Dwarf, regular, prolific & medium bearer. Free from fibre and spongy tissue.
Arka Puneet	Alphonso X Banganapalli	Regular and prolific bearer. Free from spongy tissue with good Keeping quality.Suitable for table &processing.
Arka Anmol	Alphonso X Janardhanpasand	Regular & prolific bearer. Fibreless , free from spongy tissue &keeping quality
Arka Neelkiran	Alphonso X Neelum	Ideal for high density planting. Regular bearer with very good Keeping and late season.
Indian Agricultural Research Institute, New Delhi		
Amrapali	Dashehari X Nellum	Regular& late bearing. Very dwarf suitable for high density planting
Mallika	Neelum X Dashehari	Regular bearer, midseason variety &resistant to fruit drop.

Regional Fruit Research Station, Vengurla		
Ratna (Neelphonso)	Neelum X Alphonso	Semi-dwarf, regular in bearing, good keeping quality. Fruits are free from spongy tissue.
Sindhu	Back cross progeny of Ratna (RatnaX Alphonso)	Stone is extremely thin(seedless mango), regular in bearing, free from spongy tissue & fibreless
Agricultural Research Institute, Sabour, UP.		
Prabhasankar	Bombay X kalaepad	Semi dwarf, regular in bearer, fruit is of good keeping quality. Strong tendency to bear fruits in adverse weather conditions.
Mahamudbahar	Bombay X kalaepad	Tree is semi dwarf and regular in bearing.
Jawahar	Gulabkhas x Mahamooda Bahar	Semi dwarf, highly regular in bearing &precocious
Horticultural college and Research Institute, Periyakulam.		
PKM-1	Chinna suvarnarekha X Neelum	Bears fruits in clusters. Regular bearer, suitable for long distance transport
PKM-2	Neelum X Alphonso	Bears fruits in clusters. Regular bearer with good quality& keeping quality

Depending on utility:

Table varieties: Baneshan, Neelum, Bangalora, Rumani,Alphonso,Mahamooda and Goa bunder.

Juicy varieties: Chinna rasam, Pedda rasam, Cheruku rasam, Kothapalli kobbari, Panchadara kalasa. Panakalu, Phirangi laddu.

Table and juicy varieties: Chinna suvarnarekha , Peter.

Off-season Varieties: Neelum, Bangalora, Baramasi, Rumani,Royal special.

Pickle varieties: Achar pasand, Tellagulabi of Nuzivid, Alipasand, Guddemar (Hamlet)

Varieties for preservation: Baneshan and Bangalora.

Mango varieties can be divided into different groups-

Depending on time of availability:

Early Varieties: Olour, Rajpuri, Ronnet Alphonso,Suvarnarekha, Panakalu.

Mid-season varieties: Baneshan, Panchadarakalasa, Mallika, Chinna rasam, Kothapalli kobbari, Peddarasam etc.

Late varieties: Mulgoa, Jalalsaheb, Amrapali, Janardhanpasand ,Neelum and Bangalora etc.

Off-Season Varieties: Rumani, Neelum, Baramasi, Sadabahar, Bangalora, Royal special. etc.

Poly embryonic varieties: When seed of polyembryonic mango variety is sown several seedlings will arise. Only one of those is sexual and the others are nucellar seedlings, which develops from the cells of nucellus. The nucellar seedlings behave exactly like the female parent and are comparable to vegetatively propagated plants.

The polyembryonic varieties of India are unfortunately poor in quality. Their only use is as rootstock for other superior varieties. The uniformity of such rootstocks would help in standardizing the performance of scion trees and eliminate the variability inherent in monoembryonic rootstocks of unknown origin.

Polyembryonic varieties impart great vigour to the scion and influence the yield also. The yield of Baneshan and Neelum was found to be better on pahutan and Goa than on any other polyembryonic stocks in A.p.

Polyembryonic varieties of India: Bappakai, Chandrakaran, Bellary, Goa, Kurukkan, Nileswar dwarf. Olour, Pahutan, Salem, Mazagoaon, Mylepalium and vellaikolumban. —These are common in west coast i.e., Malabar region in west coast.

Polyembryonic varieties introduced from other countries in to India:Apricot, Simmonds, Higgins, Pico, Sabre, Saigon, Strawberry, Cambodiana, Turpentine and Carabao.

Climate: Although, it is a tropical fruit, the mango equally grows well under semi-tropical conditions. Mango can grow from sea level to an altitude of about 1500 meters provided; there is no high humidity, rain or frost during the flowering period. However it cannot be grown on a commercial scale in areas above 600 m. It thrives equally well from kanyakumari in south India to sub-mountainous region in N.India.

Temperature, rainfall and wind velocity are the main climatic factors, which influence its growth and fruiting. It cannot stand severe frost, especially when the tree is young. Mango requires a frost-free dry period at the time of flowering and sufficient heat during the ripening of the fruit. It can grow in temperature range of $0^{O}C$ to $45^{O}C$ but the minimum for growth lies above $10^{O}C$, the optimum near $25^{O}C$ and the maximum at $42^{O}C$. The prevailing temperature also effects the sex expression. The percentage of perfect flowers in some of the south Indian varieties has been observed to be much less under N.Indian conditions. This has been attributed to low, minimum and maximum temperatures obtained during the period of panicle development as compared to those of south India.

Most of the mango varieties thrive in places with good rainfall (75-375 cm per annum) and dry summer. The distribution of rainfall is more important than its amount. However, rain during flowering is detrimental to the crop as it interferes with pollination but also encourages greater incidence of pests and diseases. Dry period before blossoming is conducive to profuse flowering. Strong winds and cyclones during fruiting season can play havoc and blow away the crop completely.

The time of flowering is effected by the climate. In N.India flowering occurs late in February while in S.India flowering occurs early October to December. Hence the crop is ready by March-April in A.P, Tamil Nadu and Maharastra, June-July in eastern UP; July-August in western UP and Rajastan.

Kanyakumari, receiving rainfall all through the year; resulting in multiple and short periods of water showers and having virtually the same temperature through out the year, mango fruits are obtained practically all-round the year.

Soils: Mango can be grown on a wide variety of soils, ranging from alluvial to lateritic, provided it is deep (2.0-2.5m) and well drained. Suitable pH for mango is 5.5-7.0 .A soil with good drainage ,permeability, a fair water holding capacity and ground water at a depth 0f 3-4m are features of an ideal soil fro mango. Very poor, shallow, alkaline, rocky and calcareous soil should be avoided.

Propagation: Mango is a highly heterozygous and cross pollinated crop. There are two types i.e. Monoembryonic and Polyembryonic. Polyembryonic varieties can be propagated through seed because they produce true to type seedlings where as the monoembryonic varieties need to be propagated vegetatively.

Inarching or approach grafting is the principal method of propagation followed by veneer grafting. Cuttings do not root successfully in open. There is limited success under constant growth regulators. Air layering with use of growth regulators is also reported to be of some success but did not reach commercial exploitation. Shieldand patch methods of budding are practiced in Far East countries. It is not in vogue in our country. The method most commonly used in this country is therefore, inarching because of its high percentage of success.

Inarching has some drawbacks:

- The rootstocks have to taken to the scion tree for grafting.
- Scaffolding has to be built to hold the rootstock pots at scion level.
- The rootstock plants have to be watered individually while they are perched at various levels and at odd places hidden in the scion tree and all these increases the cost of production of grafts making it very cumbersome.

Several devices have been suggested to get over these difficulties:

- Grafting in rainy season, so that, the rains wet the stocks.
- Avoiding the pot of the rootstock by substituting it with grass wrapping.
- Use of grafting pot stands
- Reducing pre grafting and post grafting irrigation costs on the, by keeping the pots in a trench and letting in water to irrigate them.
- Training the scion trees to low heights.
- Wrapping roots in moss or soil and covering with polythene sheet so that no watering will be needed till union takes place

Amongst the grafting methods, the detached scion method is gaining popularity (**veneer grafting**).This has the striking advantage in using the scion sticks for propagation and the twigs from the variety to be propagated can be cut from the mother plant and taken to the rootstock seedling growing in a nursery. The scion stick, which is procured, must be 3-4 months old. It is found that scions ranging from 2.5 to 10 cm in length are suitable for the purpose. But the growth of the scion is always more when bigger scion pieces are used. If necessary the scion sticks can be stored for 6 days during April to June by wrapping them in moist paper and enclosing in an alkaline bag without any deterioration in the percentage of success. This is a less expensive and easy method of propagation to inarching.

Rootstocks: A full knowledge about the effect of using of the species of *Mangifera* and other genera of the family as rootstocks is not available. Other species of Mangifera like *M.foetida* and *M.odorata* have been found to show promise as rootstock. **Kalaypad** variety is said to be dwarfing stock and a wild mango variety **Pulima** (Ceylon) is considered as prolific rootstock. Polyembryonic seedlings which are uniform amongst themselves are recommended as rootstocks as they reduce variability due to the rootstock. Among them Pahutan and Olour are particularly good. Clonal rootstocks have-not been on trail but the rooting of mango cuttings and layers with hormones and its effects offer a great scope in selection of rootstocks for mango.

Kurukkan	**:**	Salt resistant and Polyembryonic**.**
Olour	**:**	Vigorous rootstock
Rumani,Kalepad&Vellaikolamban	**:**	Dwarfing.
Moovandan and Nekkare	**:**	Salt tolerant.
Pulima	**:**	Prolific rootstock

Planting: Planting is generally done with a ball of earth during rainy season in moderately rainy places and on the cessation of rains in the heavy rainfall areas. There is a popular preference for aged plants to young plants, but practically there is no difference in fruiting. The young plants are easy to transport and to establish. Planting is done in previously dug, exposed and filled pits of 3'X3'X3' size. Some times wood is also burnt in the pits. Application of nitrogen to young plants hastens growth and before filling the pits 50 kg. of well-decomposed FYM, 2 kilograms of super phosphate are added. If white ant problem is there 100 to 150 grams of polydol power should be added per pit. Cow dung if applied produces too much heat and attracts white ants and hence should not be applied where white ants are a serious problem. Manure is applied 2 months before planting or 6 months after planting. Planting is done on a cool day and preferably in the evenings and watered immediately and staked. While planting grafts, the graft joint or the union should be 20 cm above the soil surface to prevent entry of disease carrying organisms in to the graft joint.

Spacing: Old orchards are planted too densely and the trees grow tall and upright. Cultivation is difficult. Diseases and pests are common in closely planted orchards. So, yields will be low. Spacing depends on the spread of varieties. Spreading varieties like Peter requires more spacing when compared to varieties like Najukpasand. Normally spacing adopted for grafts is 10 X 10 M and for seedlings and in very fertile soils it is 12 X 12M. Generally square system of planting is followed.

The spacing adopted under high density planting is 5X3 / 5X2.5 / 4x4 / 3x2.5 2.5x2.5m. In high density planting for Manjeera and Mahamooda the spacing adopted is 4.5 X 4.5 M and for Amrapali it is 2.5 x 2.5 M.

Inter crops and Interculture: Vegetables like bhendi, cowpea, potato ,cucurbits and leguminous crops like groundnut and bean, dwarf banana and cover crops like sesbania and *Crotalaria juncea* can be raised and buried in the soil for green manuring.

Often young plants produce flowers. These are pinched of during first 3-4 years. Otherwise the vigour of the plant is lost. Removal of weeds is required at least twice a year. Mango requires no pruning except removal of dead, diseased and dried parts and branches arising within 3 feet above the ground level. This will help in easy cultivation.

Irrigation: The irrigation requirements of young and non-bearing trees are different from those of bearing trees. During young and non-bearing period speedy growth of the trees and expeditious development of their leaf canopy are the chief objectives to be achieved. This would require more frequent irrigations through ought the year than for the bearing trees. The newly planted young plants up to their first 4-6 months

should secure irrigations twice in a week in hot weather. For the first 4-5 years, the irrigations must be frequent and regular though of light intensity because the root spread in the initial years are not very extensive. During rainy season, the interval may be adjusted keeping in view the intensity and distribution of rainfall.

In bearing trees 2-3 months preceding flowering season, ie.during October-December profuse irrigation is not advisable to induce flowering and to arrest vegetative growth. Irrigation may be beneficial from February to June. This stop the fruit drop and helps in development of fruit size. When the trees are in full bearing stage, generally 2-3 irrigations are given between fruit set and fruit development. It is better to avoid irrigations before harvesting for better quality of the fruit.

Basin system of irrigation is generally followed to economize water. The basins may be connected in series or to a channel dug in-between rows.

Manuring: Mango orchards are not generally manured. But if manured, the yield will be more. The chief requirements during pre-bearing age are rapid growth and the development of strong framework. Good cropping, regular bearing and high fruit quality are the prime objectives of bearing trees.

For non-bearing trees liberal doses of Nitrogen, phosphorous and reasonable amounts of potassium are to be applied. During non-bearing stage nitrogen is particularly needed in heavy quantities to support healthy and fast growth.

It would be advantageous to apply substantial portion of nitrogen in the form of organic matter, so that the texture of the soil, its moisture holding capacity and ultimately the development of roots there in may be improved.

Phosphorous is needed for the development of roots, respiration and translocation of carbohydrates. Application of potassium will help in development of fruit, increases fruit quality and control of fruit drop.

During bearing age the manurial programme aims to secure sufficient vegetative growth early in the season for the next year's growth and to ensure regular bearing with superior quality. This can be achieved by heavy dose of nitrogen a little earlier than flowering in the on year to initiate vegetative growth and suppression of bud differentiation. So, that cropping in the 'on' year is reduced and the production of vegetative shoots is promoted. Mango manuring is therefore, quite complicated problem and grower has to keep in view all factors involved to get good results.

Manurial schedule:

Age of the plant	FYM (Kg)	Nitrogen (grams/plant)	Phosphorous (grams/plant)	Potash (grams/plant)
1-3 years	5-20	50-100	40-80	100-200
4-6 years	25-50	100-200	80-100	200-400
7-9 years	60-90	200-250	120-160	400-600
10 years and above	100	250	160	600

The manures and fertilizers are applied in a shallow ring dug around the base of the tree in young orchards. In old bearing orchards, they are broadcasted under the canopy of the plant leaving 30-60 cm from the trunk and thoroughly mixed into the soil. In grown up orchards there is a prevalence of different timings of fertilizers application in various regions of the country depending upon the intensity and period of rainfall, fruiting period, periods of vegetative flushes, irrigation facilities etc.,. In A.P. the manures and fertilizers are applied in two split doses. First dose is given during June-July, consisting of complete Nitrogen with half potash at the onset of monsoon. The second dose is applied during September-October with FYM, super phosphate and remaining half of potash.

Foliar application: Promotes growth, improves fruit set, yield and quality. Foliar spray is given immediately after the harvest of the crop—urea @ 1-2% and another after flowering and at marble stage to improve fruit set and to reduce fruit drop.

Training: The training of mango plants in the initial stages is very essential to give them proper shape.Specially, when the graft has branched too low, the process of training becomes very important. At least 75cm of the main stem should be kept free from branching and the first leader of main branch should be allowed after that. The main branches should be spaced in such a way that they grow in different directions and are at least 20-25cm apart. Otherwise there is every chance of breakage due to smaller crotch angles and heavy top.

Pruning: Proper pruning of mango trees after the harvest gives the best results in terms of disease and pest management, diversion of food materials to the productive shoots, increased photosynthetic activity and increased carbohydrate and starch content, early production of new flush that bear the crop in the next season. Pruning also helps in increased cytokinin, Ascorbic acid and auxin content, which is beneficial for flowering. Abscissic acid level will also increase which inhibits the vegetative growth and promote flowering. Thus pruning helps in obtaining regular fruiting and production of quality fruits.

After giving a rest period of 15-20 days after harvesting, pruning has to be taken up. The details of pruning are:

- Remove all the old inflorescences that flowered during the previous season. This encourages the production of new vegetative flushes early in the season, which can mature in winter and flower in the succeeding season.
- Remove all the lower branches, which are expected to touch the ground due to weight of fruits in the ensuing season. This facilitates easy operation under the tree.
- Prune all the diseased, dead and broken branches and twigs.

- Remove all the unfruitful branches and shoots that are lying inside the canopy to facilitate free circulation of air and to allow sunlight. These branches and twigs if not removed will harbour the pests like fruit borers, webbers, leaf miners and diseases like anthracnose, bacterial spots, powdery mildew, black band, pestalotia and red rust.
- Incase of aged trees the top has to be opened by pruning the central stem at the top. A small branch on eastern and western side may be pruned to allow sun light into tree canopy and for proper ventilation.
- Spray the trees after pruning thoroughly with 1% Bordeaux mixture or with 0.3% copper oxychloride as a prophylactic spray to control several diseases.
- Paste all the cut ends with 10% Bordeaux paste or with Copper oxy chloride paste. Collect the pruned parts and destroy by burning.

Problems in mango cultivation:

Alternate (Biennial) and Irregular bearing in Mango: It is a burning problem in mango industry since; it renders cultivation of mango less remunerative to the growers. When the mango tree bears heavy crop, the bearing season is called '**on'** year. When it bears a poor or lean or no crop, the season is called '**off'** year. In both the years the mango grower is at a loss. In the '**on'** year there is abundant fruiting and the market is flooded with fruits and the prices fall down. In the off year, there is scarcity of fruits for supply to market, prices are highly remunerative but the grower has a very little or no fruits to supply to the market. Most of the promising varieties like dashehari, Langda, Mulgoa,Kesar etc. are prone to this malady.

In some instances, however, failure to crop in one year is not followed by normal crop. Instead, two or more bad years succeeds before a good cropping year occurs again. Thus, the rhythm of bearing is not strictly alternate but irregular and erratic.

The non-bearing intervals seem to be longer in neglected orchards and old ones, while in good orchard it tends to appear a biennial bearing or alternate bearing.

Causes:

1. The habit of bearing heavy and poor or no crop in alternate years is believed to be an inherent character because some varieties, viz., Fazil, Neelum, and Bangalora are regular bearers.

   The maturity and age of trees and seasonal vegetative growth influence and control flowering in mango. In western India, vegetative flushes occur in February – March, March-April or beginning of monsoon and October-November. In Bihar, new leafy growth occurs in early spring, April-May and July-August. In U.P., vegetative growth occurs in two flushes in March-April and July-August. In South India, vegetative growth takes place in February-June and October-November. In Punjab, new flushes appear in April-may and August.

In mango a definite relation ship appears to exist between growth of vegetative flushes and fruit bud formation. An early production of shoots during the first flush (February-April), and an early cessation of the growth in the season seem to be conducive to regular bearing in mango. But in several old and neglected orchards the tree bearing heavily in a year put forth little or no vegetative growth during flowering to fruit maturity, and as such no fruiting wood is available for the following year, which consequently, turns out to be an off year for cropping.

Generally 8-10 month old mature shoots produced in spring and early summer that cease to grow at least 4 months prior to blossoming season will initiate flowering. Thus the spring and summer shoots get sufficient time to grow rest and mature for producing flowers but later formed shoots fail to achieve this physiological maturity. However, in regular bearing varieties,eg.,Rumani,even in December emerged shoots are capable of producing flowers to the extent of 83% only and 15% of these flowered in next year. This indicates that a vast majority of vegetative non-flowering shoots produced, though correct in stage of maturity, were lacking in vital substance necessary to induce flower buds. Thus this hypothesis doesn't hold good for biennial bearing.

2. It is also contended that irregular bearing in mango was caused by nutritional deficiency especially Nitrogen. A proportionate increase in nitrogen leads to vegetative growth, whereas its proportionate decrease induces flowering. Higher starch reserves, total carbohydrates and C: N ratio favour flower bud formation but not in Baramasi and regular bearing varieties. Studies on nitrogen content in stems and leaves of different cultivars indicated possibility of high no. of trees to flower, but no correlation between flower bud initiation and total nitrogen could be derived. Thus C: N ratio reserve, though playing an important role in flowering, is not the primary cause of biennial bearing.

3. Higher level of auxin like substances and an inhibitor (similar to ABA) and lower levels of gibberellins (GA_3) like substances are vital for floriferous shoot in mango.

4. The varieties that produce mostly terminal inflorescence and only few axillary types of flower clusters are more markedly biennial bearers; while those varieties which produce a greater percentage of axillary inflorescence are moderately regular bearing. Unfortunately, most of our good dessert varieties are biennial bearers.

5. Adverse climatic factors such as cloudy weather, rains, high humidity, convert an 'on' year in to an 'off' year by promoting incidence mango hoppers and diseases like powdery mildew and anthracnose etc., especially during flowering, preventing pollination and damaging the floral parts. Frost and low temperatures during flowering adversely affect fruit set there by turning an 'on' year in to 'off' year. However, these don't form basic causes of biennial bearing.

In view of the above various possible factors associated with this problem can be grouped as—internal factors and external factors.

Internal factors: Physiological, genetical, nutritional, sex ratio and hormonal imbalance.

External factors: Rain, wind, low temperatures, cloudy weather, light, pests and diseases.

Suggested measures to overcome alternate bearing:

- Planting of varieties which are regular bearers Eg., Totapuri, Rumani, Banglora, Neelum, Mallika, Amrapali and Ratna.
- Plough and harrow the orchard twice in a year, in the beginning of the monsoon after harvest and in October.
- Apply the fertilizers as per recommended schedule.
- After the harvest of the crop, dead and diseased branches and the Loranthus parasite should be cut off and removed.
- **Deblossoming:** Half the no. of flower clusters are removed from the tree in the on year as soon as they emerge. The food reserves of these deblossomed shoots would be utilized by the tree in producing vegetative growths in the spring and summer and mature to produce.
- **Ringing:** A ring of bark of about 1.25cm wide is removed from branches of about 15 cm thicknesses. Ringing causes concentration of large amount of carbohydrates in the branch above the ring and it would put forth blossoms instead of vegetative growth. Ringing has to be done in month of August. This is not advisable as it devitalizes the tree and should not be followed as a regular practice.
- Over vigorous trees may be subjected to induce rest by withholding irrigation with good exposure to sunlight. Application of common salt @ 2.5 kg. Per tree in September checks vegetative growth causing accumulation of carbohydrates for induction of flowering. This is practiced in over-vigorous trees and not on weak trees.
- **Pruning:** Proper pruning of mango trees after the harvest gives the best results in terms of disease and pest management, diversion of food materials to the productive shoots, increased photosynthetic activity and increased carbohydrate and starch content, early production of new flush that bear the crop in the next season. Pruning also helps in increased cytokinin content, Ascorbic acid and auxin, which was beneficial for flowering. Abscissic acid level will also increase which inhibits the vegetative growth and promoted flowering. Thus pruning helps in obtaining regular fruiting and production of quality fruits.
- Smudging during October-December is reported to be useful in forcing Mango to flower with limited practical utility.
- **Hybridization:** By crossing good quality variety with regular bearing varieties may be helpful in inducing regular bearing tendency in to the hybrid. Eg. Mallika and Neeleshan.

- Providing orchards with wind breaks, regular ploughing, and liberal manuring at appropriate intervals and adequate irrigation and other cultural practices are also recommended for regular bearing.
- Spraying **Ethrel** during October at 200 ppm at 20 days interval till flowering appears.
- Spraying 1% urea immediately after harvest of fruits in rain fed orchards and prophylactic sprays against mango hopper during September- October, also helps in regularity in bearing.
- Application of growth retardants like Placlobutrazol (Cultar) especially in areas like Konkan where the climate is hot and humid which results in continuous vegetative growth, inhibits the growth promoting gibberellins with in the tree with the result that vegetative growth gets restricted and trees put forth regular flowering.

Mango malformation: It is a complex and serious malady in North India and not so common in South India. Some varieties like Chausa, Bombay green and Fajri jafrani are more susceptible than others in N.India.

This malady has been distinguished into two groups i.e., **vegetative malformation** and **Floral malformation.**

Vegetative malformation is more pronounced in young plants. Affected mango seedlings or young plants develop excessive vegetative branches which have limited growth, swollen and with very short internodes and develop abnormally compact rosette like shoots presenting a bunchy top appearance.

Floral malformation: The affected inflorescence becomes clustered and round. Most of the flowers lack essential organs and don't set fruit and its inflorescence continuously hang on the tree for months, being more green and sturdy.

Causes: Various causes like nutritional disorders, physiological, viral, fungal and acarological are reported**.**

The available literature doesn't appear to support the above causes except the fungal; the only positive evidence for the cause of this is fungal origin. I.e., ***Fusarium moniliforis***.

Control measures:

a. Destruct the infected small plant or plant parts
b. Spraying a fungicide like Captan @ 3grams or Bavistin @ 1gram / litre of water
c. Remove the affected parts by pruning 30cms below and paste with Bordeaux paste.
d. Early deblossoming combined with NAA 20ppm spray during October also reduces this considerably.
e. Bhardhan variety of U.P. is resistant and free from this infestation.

Spongy tissue: A non-edible patch of flesh develops in the mesocarp of the fruit and becomes spongy, sour and yellowish is termed as **spongy tissue.** This can be detected only after cutting the ripe fruit. It is a physiological disorder in which the fruit pulp remains unripe because of unhydrolised starch due to inactivation of ripening enzyme because of high temperature, convective heat, and post harvest exposure to sunlight are the causes.

Alphonso variety is very susceptible to this spongy tissue.

Remedial measures:

- **Sod culture** and **mulching** are useful in reducing spongy tissue.
- Growing mango hybrids **Ratna** and **Arka Puneet,** which are free from this problem.
- Harvesting fruits when they are **three fourths matured** rather than fully matured ones also reduces this malady.

Fruit Drop: Fruit drop is serious problem in mango and cause great loss to the growers. A tree producing several thousand panicles yields only a few hundred fruits. Most of the flowers falling down after full bloom or at later stage of development. Only 0.1 to 0.25% perfect flowers or even less develop in to mature fruit. Fruits drop at all stages of maturity. Maximum fruit drop takes place in last week of April or first week of May depends upon favourable condition. The fruit drop can be divided in to three distinct phases eg., pin head drop, post setting drop and May drop.

The flower drop as well as the fruit drop is primarily due to the formation of an abscission layer at the point of attachment of the fruit with the twig. Several factors have been considered responsible for the formation of abscission layer. The causes can be divided in to two;

External causes:

- Unfavourable climatic conditions.
- High incidence of serious diseases like **powery mildew** and **anthracnose** and pests like **hoppers** and **mealy bugs**.

Internal causes:

- Poor soil
- Lack of pollination
- Low stigmatic receptivity
- Defective perfect flowers
- Poor pollen transference
- Occurrence and extent of self incompatibility.
- Abortion of embryo
- Degeneration of ovules.
- Competition between developing fruit lets.
- Drought / lack of irrigation.

Measures to prevent fruit drop:

- Spraying of 2, 4-D @ 10 ppm or NAA @ 50 ppm at pea stage and at marble stage helps in preventing fruit drop.
- Providing pollenisers for self incompatible types.
- Maintaining sufficient soil moisture also prevents fruit drop and helps in increasing the size of the fruit.
- Provision of wind beaks all around the orchards, which prevents drop due to high velocity winds at the time of fruit development.

Cropping: Grafted mango usually starts bearing from the 4^{th} to 6^{th} year after planting. The precocious varieties like dasehari start bearing even from the third or fourth year onwards. A grafted mango tree usually continue to bear till up to 50 years, but its most prolific years of bearing are generally from the 10 to 14 years. Seedling trees usually take about 8 years to come to bearing but their productive life is much longer**.**

Harvesting indices: It requires considerable experience to judge the stage of maturity at which the fruits are to be picked. If the fruits are harvested at an immature stage, they develop white patches and the normal TSS / Acid ratio is also not obtained. On the other hand, if the fruits are harvested when over mature or fully ripe, more microbial and physiological spoilage occurs due to increased susceptibility of fruits, thus reduces the shelf life of fruits. The correct stage of harvesting of fruits can be judged in several ways.

- Attainment of full size of a variety is indicated by stoppage of increase in size and flesh becomes soft.
- Appearance of bloom (Whitish waxy layer), characteristic colour or spots on the skin and development of typical flavour of a variety are also important indications of maturity.
- When a few ripe fruits have fallen on their own accord from the tree, the rest of the fruits are considered sufficiently mature.
- The sap which exudes at the stem end on picking a mature fruit is thick and dries quickly.
- If the fruit sinks in water, if it is dropped in to water indicates its maturity.
- Specific gravity, TSS and pressure tests are also employed for testing the maturity of fruits. Generally a specific gravity of 1.01 and 1.02. TSS of 12 to 15 % and a pressure of 1.75 -2.0 kg. Per sq. cm will give a fair index of maturity.
- In some varieties, oil glands on skin of the fruit become distinctly clear.
- Measurement of the percentage of the starch in the flesh is found to be a comparatively accurate method for judging the maturity of the fruit.
- For judging the maturity, the physical development of the fruit such as rounding of ventral edge, development of beak, outgrowing of shoulders, filling up of

hollow at the stem end, broadening of apical end should also be considered for judging the maturity of the fruit.

For judging the maturity of the fruits one should not rely only on one criterion but should consider as many criteria as possible.

Harvesting of fruits: The fruit injured or even slightly bruised during the picking operation losses its keeping quality and becomes unfit for dispatch to distant markets. The usual practice of harvesting the fruits is knocking down the fruits or shaking the trees violently to get the fruit down need to be discouraged. If the fruit is hanging high, it should be picked up with the help of a step ladder. In no case, the picker should climb up the tree as this practice is harmful both for the tree and the picker. The fruits should always be harvested and the harvested fruits are placed in canvass bags or padded baskets and carried to the packing house. A small fruit stalk should be kept with the fruit at the time of harvesting helps in keeping the fruits in better condition in transportation and storage.

Yield: The yield of mango depends on no. of factors like age of the plant, soil fertility, climatic conditions, variety, type of plant material like graft or seedling, management of the orchard etc.

A mango tree having an age of **5** years bears about 200 fruits and **10-20** years bears a crop of **500-1000** fruits during an "**on**" year. During **20-40** years its yield may range between 1000-3000 fruits.

BANANA

Botanical name: *Musa spp.* **Family:** Musaceae

Origin: Tropical regions of South East Asia (Assam, Burma, Indo-China region).

Banana is one of the oldest fruits known to mankind. Its antiquity can be traced back to Garden of paradise where eve was said to have used its leaves to cover her modesty. It may be one of the reasons why banana is called '**Apple of Paradise'** and botanically named *Musa paradisiaca*. Banana plants refer to Biblical legend as "**Tree of wisdom**" for good and evil in the Garden of Eden. The word *Muza* was derived from the Arabic term Muza, which probably came from the Sanskrit, word *Moka* and got its place in Koran as the "**Tree of paradise**",similar to that of "**tree of wisdom**" in Bible.

Importance: Every part of the plant has a ready use.

- The ripe fruits are delicious and are used for table purpose.
- The fruits of some cultivars are used as breakfast food after steaming.
- The end of the inflorescence, technically known as pendant is cooked as a vegetable.
- Many products are made from banana such as banana chips, fig, soft drink, flour and jam.
- Banana flour is prepared from unripe fruits and banana powder from ripe fruits.
- Starch is manufactured from pseudo stem.
- The pseudo stems of banana of all types have been used for manufacturing paperboards.
- In South India, the leaf of Banana is used as a plate for serving meals.
- The sheaths and leaves are used for making crude ropes.
- The banana species *Musa textiles* is well known for their strong fibre.

Nutritional Value:

a) Banana is a good source of vitamin A and a fair source of VitaminCand B_2
b) Banana fruits are rich source of minerals like magnesium, sodium, potassium and phosphorous and fair source of calcium and iron.

Banana is the second largest produced fruit after mango in India accounting for 21.87 per cent of the total fruit production from 10.49 per cent of the area.

Varieties: In banana there are three types. They are table varieties, culinary types and hill bananas. There are several varieties in banana but the commercially important varies are-

Table varieties -Poovan, dwarf Cavendish, Robusta, Grand nine, Rasthali,Grosmichel, Virupakshi, Nendran,Monthan.

Culinary varieties: Monthan. There are also other varieties like Yenugu bontha and boodidha bontha belonging to this group.
Hill Bananas: Virupakhi (Syn: Sirumalai, and Mala Vazhai.)

Climate: The banana is strictly a tropical crop**.** It grows luxuriantly in the warm, humid and rainy climate of tropical regions of the equator. It grows well in regions with a temperature range of 10-40^{O}C and an average of 23^{O}C. In cooler climate the duration is extended, sucker production is affected and bunches are small. Low temperature i.e. less than 10^{O}C is unsuitable since, they lead to a condition called **choke** or **impeded inflorescence** and bunch development. Banana grows well under high rainfall areas .On an average 100 mm rainfall per month appears to be satisfactory for growth of banana. Hot winds blowing in high speed during the summer months shred and desiccate the leaves. Stagnation of water is injurious and may cause diseases like panama wilt. Banana comes up well up to an altitude of 1500m above sea level in the tropics. The hill bananas in Tamilnadu are raised between elevations of 500-1500m mostly under rain fed conditions. Absence of strong winds and cyclones are important.

Soils: Banana is voracious feeder and requires a well-drained soil with plentiful organic matter. Even though banana requires heavy irrigation, it cannot with stand water stagnation. Therefore, the soil should be well drained and deep (At least 1m depth).It grows successfully in loamy soils, well drained clay soils of delta areas, irrigated medium soils. The production in lighter soils is good. Saline soils with salinity percentage exceeding 0.05 are unsuitable. Banana can grow well even under slightly alkaline soils. Such soils are found preferable for avoiding the wilt disease, which is known to be severe in acid soils.

Propagation: Banana is propagated vegetaively through suckers and rhizomes.
Suckers: There are two types of suckers. 1) Water sucker 2) Sword sucker.
Water sucker: Have broad leaves and broad pseudostem and they don't produce a healthy banana clump and hence not suitable for planting.
Sword sucker: It has a strong large base, gradually tapering to a slender point with one or two narrow sword like leaves at the tip. The sword sucker is most vigorous, grows fast and comes in to bearing early. Hence, sword suckers are preferred for planting.
Rhizomes: After harvest, a number of its suckers are encouraged to grow up to 1-2 feet. They are then dug out and their pseudostems are completely cut above the solid rhizome and roots removed. The rhizomes weighing about 450-900 grams are stored for two months in a dry place under shade. During storing the bottom remains cut off leaving the heart bud prominent at the top of the rhizome. The conical rhizomes, which

have a sound heart, will be selected for planting. Some times the rhizomes are cut in bits of 1 kilogram and are used for planting**.**

Selection of sucker: Select only 3-4 months old suckers from healthy vigorously growing and good yielding plants. The sword suckers should have 4-5" diameter at the base and 2-3 kg weight.

Preparation of the sucker: The selected suckers should be separated from its mother plant along with a portion of a rhizome. Later, the stem of the suckers should be beheaded at 20-30 cm height in a slanting manner. This helps in producing new leaves quickly. The slanting cut also prevents the stagnation of water in the sucker. The old roots should be removed and then dipped in 0.1% cereson @ 1 g.per litre of water for 5 minutes before planting.

Land preparation: The land should be deeply ploughed, harrowed and leveled and pits of 45cmx45cmx45cm should be dug at the required spacing. The pits should be exposed for weathering for about a week to control the presence of any grubs, ants, weevils etc. The soil from the pits should be mixed with the following thoroughly.

- 5-10 kg of FYM
- 0.5 kg of castor or neem cake
- 2 kg of wood ash or 50 grams of muriate of potash
- 200 grams of super phosphate.

The pits are then filled with the above-manured soil thoroughly. While filling the pits with the manured soil apply to the pit 50 grams of lindane dust to control weevil which affects the rhizome or sucker in the soil. The sword suckers are later planted straight in the pit along with a portion of rhizome at a depth of 10-15cm.

Planting: The period of planting should be such that the active growth phase of the plant may continue un-hampered during the flower bud initiation stage or stage at which embryonic bunch is formed inside the pseudostem. This generally occurs between 4 and 5 months after planting. This stage determines the no. of hands / fingers in future bunch after planting. At this stage there should be any extreme cold or hot weather or lack of soil moisture or lack of nutrients in the soil. June-July (On set of monsoon) is the planting season.

In general the beginning of monsoon i.e. June is the best time for planting banana in most parts, as the rapid growth during first 4 months of monsoon is particularly helpful. In the heavy rainfall tracts like Malabar planting is done after the cessation of monsoon from September to October. This also makes the plants quite small during the expected periods of high winds, storms and cyclones etc.

Spacing: The spacing varies greatly according to the variety and climate.

Variety	Spacing (Meters)	No. Of plants/ha.
Poovan,Monthan,Rasthali & Nendran	2.1X2.1	2150
Dwarf Cavendish	1.8X 1.8	3000
Robusta	1.8X 1.8	3000
Nendran	2.0X 2.0	2500
	2.4X 3.0	1350
Hill bananas	4.8X 3.0	670
	4.8X 4.8	420

Cultural operations in Banana:

Desuckering: During the growth of the mother plant, the suckers arise from its rhizomes from time to time. If all these suckers are allowed to grow, the mother plant looses its vigour and normal development resulting in lower bunch weight and total yield. Therefore the suckers should not be allowed to grow near the parent plant till the mother plant commences flowering**.** At flowering (six months after planting), a vigorous growing sword sucker should be allowed to grow and one more sucker is encouraged to shoot out from the soil when the parent plant matures its fruits. Thus the parent plant has completed its life, it has only two suckers. When the mother plant is harvested and removed, the first sucker which is 6 months old takes the lead and becomes the mother plant in the next generation and thus the successive generations of suckers arising one after the other at 6 months interval perpetuate.

Removal of all suckers up to flowering of mother plant and maintaining only one follower afterwards is the best desuckering practice. However under high density planting it is better to leave the follower after harvesting 75-80% of the plant crop so that uniform cultural practices can be followed. It has been observed that sucker removal had no effect on yield in the first harvest, but yield in the second harvest was highest in plants left with one sucker followed by plants left with 2 or 3 suckers and was lowest in plants without removal of suckers.

Desuckering or pruning is the removal of unwanted suckers. It is done by either cutting off the sucker or the heart may be destroyed with out detaching the sucker from the parent plant. Some times kerosene is poured into the cavity left after digging the sucker. In South India, crow bar with a chisel like end is used for damaging the sucker.

Trashing: It is the removal of undesirable material from the banana field like dried, diseased and decayed leaves, pseudo stem after harvest, male bud, last end of inflorescence and withered floral parts.

Mattocking: After harvest of the bunch, the plant stem should be cut in stages at least after 30-45 days to facilitate mobilization of the nutrients from the mother to the

developing ratoon plant. The pseudo stem should be cut leaving a stump of about 0.6m height.

Wrapping of bunches: It is covering of bunches with polythene or gunny cloth that protects the fruits from intense heat, hot wind etc. and improves the colour of the fruits.

Tipping: It is the removal of heart or male bud**.** The large heart shaped flower bud, contains infertile male flowers in reddish scale leaves. This heart flower bud persists even after the fertile flowers have developed and formed in to a bunch. It should be cut soon after the bunch is formed, other wise it is likely to use up some of the food, which would otherwise go to the development of fruits. It is a practice recommended for improving the appearance of the bunch as well as to ward off 'fingertip' disease.

Removal of floral remnants: The removal of dried and persistent floral remnants present at the apex of the fruit or finger helps in preventing the spread of fungal diseases. These floral remnants provide shelter to some of the fungal spores.

Propping: It is a method by which support is given to banana bearing plants with the help of bamboo, casuarinas or eucalyptus poles, protecting them from bending or falling down due to heavy bunch load and from heavy damage by wind. It is very essential for tall varieties.

Earthing up: It should be done during the rainy season to provide drainage and to avoid water logging at the base. It is to be done once in 2 or 3 months to prevent soil erosion from the basins and to avoid direct contact of water with pseudo stem. Due to earthing up there are fair chances of formation of good root system. It is better that whole rows of banana are strongly ridged up about 10" high.

Weeding: In the first four months after planting, it is necessary to remove weeds. The stirring of the soil by the spade after every 6 or 7 irrigations is necessary to maintain its tilth and absorptive power.

Weeds can also be checked by the use of herbicides. Diuron @ 4 kg per hectare and simazine @ 6kgper hectare control grasses and broad leaved weeds when applied after planting and repeated 30 days after planting. Glyphosate @ 1 kg a.i. per hectare at the time of planting followed by 0.5 kg a.i.per hectare at 30 and 60 days after planting of suckers is recommended.

Banana is sensitive to 2, 4-D and hence the phenoxy compounds are not used.

Nutrient sprays: Spraying of a mixture containing 2% urea and potassium Di-hydrogen phosphate immediately after the emergence of inflorescence stalk helps in increasing the size of the bunch and fruit content.

Cropping: Banana fruits develop parthenocarpically**.** Banana comes to flowering in about 9 months after planting. The dwarf bananas are ready for harvest with in 11-14 months after planting, while tall cultivars take about 14-16 months to harvest. The fruits become ready in 3-4 months after flowering. Dwarf Cavendish variety takes about 11 months, Robusta 12 months and poovan about 13 months from planting to

harvesting. Banana is categorized as climacteric fruit. Fruits don't ripe early and uniformly on the plant.

The maturity standards of banana fruit, although vary with the variety and the purpose of marketing, can be judged by physical characters as well as by chemical analysis. The physical characters like colour, shape, size and the ratio between consumable to non-consumable portions are taken in to consideration.

The total period required from planting to first harvesting is also taken into consideration for harvesting of the bunch. In India the main banana season is from September to April.

The indications of maturity for harvesting are:

- The fruits are harvested when top leaves start drying.
- Change in colour of the fruit from deep green to light green.
- Tendency of floral ends of the fruits to shed with slightest touch of the hand.
- Fruits should be plump and their angles should have rounded off i.e.; after the attainment of ¾ th full stage before the bunch is harvested.

For export purpose, three fourths of the full maturity stage (recognized by the sharp angularities of the fingers) is considered to harvest. At this stage, the dwarf Cavendish shows a pulp-skin ratio of 35:1 or 40:1.

The entire bunch is harvested with one-foot long stalk. After 15 minutes of harvest, when the latex flow ceases, the bunch should be packed properly and should not be allowed to come in contact with soil.

Yield: Yield of banana varies with variety, agro climatic situation and management practices adopted for production. Under Indian condition, varying yield between 15-40 tonnes per hectare has been reported.

Tall cultivars usually yield 15-20 tonnes /ha. Dwarf varieties are 30-40 tonnes per hectare.

CITRUS

Botanical Name: Citrus sps. Family: Rutaceae

Origin: Tropical and Subtropical regions of south East Asia.

Citrus fruits are a group of fruits comprising of mandarins, sweet oranges, grape fruit, limes and lemons etc., Citrus fruits have a prominent place among popular, extensively grown tropical and subtropical fruits. In India citrus is considered to be the third most important fruit crop.

Citrus fruits possess juice sacks. Unlike other fruits they lack firm pulp.Mostly citrus fruits are consumed as fresh fruits particularly sweet oranges,mandarinsand grape fruit. Citrus fruits are not only delicious and refreshing but also they provide vitamins, minerals and many other substances. Citrus fruits contain considerable amounts of Vitamin C. Fruits are also good source of Vitamin and P.The mild bitterness in juice is due to the presence of glucoside called Naringin which is said to have a medicinal value. The rind of the citrus fruits is rich in pectin and essential oils.

Important citrus species: There are several citrus fruits in the world. Some are ancient ones and some are recent ones. Citrus species readily crosses with each other .so new types are coming up from time to time.

There are 16 species in the genus Citrus as per Swingle (1943) and 144 species as per Tanaka (1950).Hence classification of the kinds and varieties are complicated. An abundance of locally used names and changing botanical nomenclature also hinders distinct classification.

Important Citrus Species:

1.	Sweet orange	*Citrus sinensis*
2.	Mandarin Orange	*Citrus reticulata*
3	Acid lime	*Citrus aurantifolia*
4.	Lemon	*Citrus limon*
5	Grape fruit	*Citrus paradisi*
6	Pummelo	*Citrus grandis*
7.	Citron	*Citrus medica*
8.	Sweet lime	*Citrus limettoides*
9	Gaganimma	*Citrus pennivesiculata*
10	Vadlapudi Orange	*Citrus madaraspatana*
11.	Sour Orange	*Citrus aurantium*
12	Rough lemon	*Citrus jamberi*
13	Rangapur Lime	*Citrus limonia*

Important citrus cultivars grown in India:

(1)Sweet Orange: More than half a dozen varieties are cultivated. Among them the important ones are-Sathgudi, Mosambi and Batavian.

The other varieties of Sweet Orange are-Malta, Malta Blood Red, Jaffa, Hamlin, Washington Navel Orange and Pineapple.

(2)Mandarin Oranges: The important commercially grown varieties are- Nagapur Mandarin, Coorg Mandarin, Khasi Orange, Kinnow Mandarin
Kinnow Mandarin is a hybrid between King Mandarin (*C.nobilis*) and willow leaf Mandarin (*C.deliciosa*).
The other varieties are- Ponkan, Satsuma Mandarin, Dancy Tangarin, Darjeeling or Sikkim Orange and Cleopatra Mandarin.

(3)Limes and Lemons: These are acid fruits. Generally employed for preparing drinks.
Limes-These include Acid lime, Key lime, Mexican Lime, Tahiti lime, Sweet lime, Coorg lime and Rangapur lime and sour lime. Among them the mostly cultivated one is acid lime. The important varieties of acid lime are -Vikram, Pramalini, Chakradhar, Balaji etc.
Lemons: Often confused with limes. These are grown in small scale in pockets. In this there are two types. They are seeded and seedless.
Seed Varieties-Lisbon, Villa Franca, Eureka, Nepali Round, Nepali Oblong and Rajhamundry.
Seedless Varieties- Malta, Lucknow and Italian.

Climate: The sub-tropical climate is the best suited for citrus growth and development. Temperature below - 4^0C is harmful for the young plants. Soil temperature around 25^0C seems to be optimum for root growth. Dry and arid conditions coupled with well defined summer having low rainfall (ranging from 75cm to 250 cm) are most favourable for the growth of the crop. High humidity favours spread of many diseases. Frost is highly injurious. Hot wind during summer results in desiccation and drop of flowers and young fruits. Darjeeling Mandarin (Khasi Orange type) grows in altitude upto 2000m as it is adapted to a cooler climate

Soil: Citrus can grow well in wide range of soils. Soil properties like soil reaction, soil fertility, drainage, free lime and salt concentrations, etc. are some important factors that determine the success of citrus plantation. Citrus fruits flourish well on light soils with a good drainage. Deep soils with pH range of 5.5 to 7.5 are considered good. However, they can grow in pH range of 4 to 9. Presence of calcium carbonate concentration within feeding zone may adversely affect the growth. Light loam on heavier but well drained sub-soils appears to be ideal for citrus.

Propagation: Seeds exhibit 45-90% polyembryony.The seedlings are comparatively more free from decline and other virus diseases which are not transmitted through seed. Yet the yields are not good compared to budded plants on account of the

beneficial responses of the root stock viz.,earliness,high yield and adaptability to the environment and soil, good quality, resistance to diseases and pests.

Vegetative propagation methods like budding are practiced. Shield budding or T-budding is practiced all over the world. The varieties to be propagated should be well known for their good performance and free from diseases. The root stock should be compatible with the scions and well adapted to the soils of the regions where tress are intended to be grown.

Rootstocks: The stock and scion must be compatible and should be capable of producing long lived, productive trees. The influence of the most important and widely used root stocks and their characteristics should be known to the grower for choosing the right kind of stock for the locality.

The most commonly used stocks for sweet orange as well as mandarins in India are Jamberi (Rough Lemon) and Karna Khatta.

The following rootstocks have been tried to study their influence.

1. Jamberi: With more number of seeds, high percentage of germination and polyembryony is a vigorous stock for Sathgudi. The tree top is oval. Fruits are large, rind is rough and thick and juice is insipid. Morality is very high due to quick decline or other diseases out of use.

2. Gajanimma: It has all the good nursery characters of Jamberi and has a prolific but is susceptible to gummosis and collar rot resulting in high mortality and hence disordered.

3. Trifoliate Orange: It is the hardiest root stock and does well in forestry areas. Resistant to many virus diseases. The plant gets dwarfed on this root stock and is frost resistant.

4. Karnakhatta: It is found to be most common and satisfactory rootstock for grape fruit, for heavy and wet soil to Punjab and U.P.

5. Sathgudi seedling: Suitable for moderately heavy soils. It gives smooth joint. The trees are long lived being tolerant to decline. Yields are moderate. Fruits are of fine quality and good keeping quality.

6. Rangpur lime: It is used as stock for Mosambi in Bombay region. It is a vigorous grower, resistant to many of the virus diseases chiefly Tristeza virus. It gives high yields with fruits of much better quality and hence recommended as stock for sweet orange.

7.Acid lime: Slow growth. Thorns make it difficult to bud. Resistant to high water table conditions.

8. Kichili: Drought resistant. Slow growth and gives a globular tree.

9. Pummelo: It has given a dwarf tree.

10. Wood apple: Dwarfs Sathgudi very much. Reduces prebearing period, longevity and yield but increases the sweetness of fruit.

11. Sweet Lime: It is a satisfactory stock for Nagpur Santhra with better quality and tighter skin.

Raising of root stock seedlings: - Seeds freshly extracted from mature fruits picked from healthy, vigorous and good yielding trees are sown on raised beds during July-Aug. The slimy substance on the seeds is removed by mixing by them with wood ash and drying them under shade. The seeds take 20-30 days to germinate and in another month, a pair of leaves emerge. After 3 or 4 months 60cm in height. The seedlings are transplanted late the nursery beds under shade and spaced 20cm apart and the seedlings will be ready in a year.

Selecting bud wood: Buds should be collected from a tree or trees of the desired variety. Bud sticks are commonly selected from the next to last growth flush (the wood behind the current flush) and from the current growth flush after it has matured and hardened. Older growth flushes can be used if the bark still is green.

Round twigs about the size of a pencil are preferred. The buds located in the axils of the leaves (where the leaf is attached to the wood) should be well developed, but still dormant.

After the bud wood is cut from the tree, the undesirable wood and/or growth flush should be removed and the remaining bud wood should be trimmed to lengths of 20-25 cm (8-10 inches). The leaves should be cut off leaving a stub of the petiole 3-4mm (1/8 inch) long to protect the buds.

Trimmed bud sticks should be labeled and used immediately or placed in plastic bags in a cool place. Include a moist paper towel to maintain turgidity and freshness. The label should include the variety, date of collection and source. Bud sticks are usually tied in bundles for ease of handling.

Budding: The seedlings are ready for budding in about a year and budding along with a chip of wood gives good results. In mandarin the removal of wood seems to decrease the percentage of success. Generally done winter in July or in September in South India and October and December in North India. T-Budding or Shield budding is easy to perform. The root stock is generally budded at a height of about 9”.

Sweet Orange: It is propagated by Shield or T- budding. The root stocks mainly used are Jamberi and Rangapur lime. In Andhra Pradesh mainly Rangapur lime is used as a rootstock.

Acid Lime: It is commonly propagated by seed all over the country because the seeds exhibit a high percentage of polyembryony. The nucellar seedlings are identical with the parent in growth and production. These seedlings are hardy compared to the budded plants. The seedlings take a little longer time than budded plants to start bearing but soon over take them in yield. If budded, gajanimma is a prolific stock but there is scope for the spread and transmission of diseases and the budlings are short-lived.

Lemons, Grape Fruit and Pummelo: Italian lemon which is seedless, it is propagated by budding on Jambheri in the Deccan region. For lemons the root stocks found suitable in Punjab and U.P are Rough lemon and kharna Katta.Pummelo is comparatively monoembryonic and hence budded plants of pummelo are usually raised on the root stocks of Jatti Katt, iJamberi etc.Similar is the case of Grapefruit.Pummelo as a root stock is found compatible with grape fruit.

Mandarins: Mandarins are largely propagated by seed all over the country except Nagapur Santhra which is the only budded variety grown on a commercial scale around Nagapur (Vidharba) in Maharastra producing the finest mandarins of the world.

Planting:

Preparation of the filed: The land is ploughed until a fine tilth is obtained. If it is a virgin land all the existing vegetation should be removed along with the roots. The land is leveled and pits are marked as per the system of planting to be adopted.

Lay out: The square system of layout is commonly followed for planting the citrus crop. In order to facilitate orchard management practices economically and efficiently. Citrus trees should be planted in straight rows.

Digging of Pits: Pits of ½m x ½ m x ½ m size may be dug at required distances 3-4 weeks prior to planting. But where the soils are shallow or under laid with hard pan, pits of 1mx1mx1m may be dug to facilitate better root penetration. Before planting the pits are filled with 25kg of FYM, 1kg of bone meal, 3kg of wood ash and 50g of aldrin dust powder for control of termites

Planting Season: Planting is done from July to December. In low or scarce rainfall regions, planting should be done at the beginning of the monsoon season (June/July) so that the humid weather helps the young plants to get established fast. In areas of high rainfall, (1000 mm and above) planting should be done at the end of the south-west monsoon season (October-December.)

Spacing: Spacing adopted for different citrus species are--

Sweet Orange	6-8 m
Mandarin Orange	6-8 m
Acid lime	5-6 m
Lemon	6-8 m
Pummelo	6-8 m
Grape Fruit	6-8 m

Irrigation: Sweet orange trees are much more specific in their water requirement than any other fruit crops. Higher requirement of water is needed to produce satisfactory crop. Most of the santra plantations in India are rain fed conditions. Irrigation requirement of santra trees in the plains is similar to that of sweet orange,

Irrigation should be given when the top of the soil goes dry of once in 7-15 depending on the soil and weather. Irrigation water should not directly touch the tree trunk as it spreads diseases like gummosis and the soil should not be allowed to to get excessively dry as it results in leaf fall.

Irrigation should be given immediately after manuring.Water is very essential during blossoming and fruiting periods. Any shortage of water during maturity periods causes shrinking of the fruit and drying up of the pulp. As the trees advances in age the basins should be extended up to the drip of the tree.

Manures and fertilizers: In Andhra Pradesh, citrus growers apply large quantities of farmyard manure and organic cakes (Castor, Neem, Pongamia etc) to improve soil structure and to create favourable conditions for healthy growth. Further, to meet the high demands for nutrients and to maintain plant productivity, organic manures are supplemented with chemical fertilizers. The fertilizer schedule recommended for Andhra Pradesh is

Age of Plant	**Sathgudi**			**Acid Lime**		
	N	**P_20_5 gms**	**K_20**	**N**	**P_20_5 gms**	**K_20**
1 Year	300	70	80	375	150	200
2 Year	600	140	160	750	300	400
3 Year	900	210	240	1125	450	600
4^{th} Year	1200	280	320	1500	600	800
5^{th} Year & above	1500	350	400	1500	600	800

Fertilizers should be applied in a circular band at a radial distance of 120 cm from the trunk of the plant is the most beneficial. Deep placement of fertilizers should be avoided. In fact, the maximum root activity in sweet orange plantation was found within a depth of 25 cm while in acid lime they are more surface oriented, 80-95%

being located in the top 10 cm. As such, fertilizers are worked in shallow into the surface soil.

A composit nutrient spray prepared and sprayed twice or thrice at 20-25 Days intervel commencing from the appearance of new flush will correct deficiencies and increases the yield and quality of fruits. It is prepared as follows.

Zinc Sulphate	500 g
Copper Sulphate	280 g
Magnesium Sulphate	200 g
Ferrous Sulphate	200 g
Borax	100 g
Manganese Sulphate(Amorphouse)	200 g
Lime	900 g
Urea	1000 g
Water	100 lit.

Training and pruning: In order to allow the growth of a strong trunk, all shoots in the first 40-50 cm from ground level developed in the early stage should be removed. The centre of the plant should remain open. Branches should be well distributed to all sides. Cross twigs and water suckers are to be removed early. The bearing trees require little or no pruning. All diseased, injured and drooping branches and dead wood are to be removed periodically for initiating citrus greening.

Interculture: Before manuring, the basins are dug and the weeds are removed. The tree basins should be kept free of weeds. Superficial cultivation of citrus orchards is practiced to keep them free of weeds. Deep cultivation should be avoided.
Root stock sprouts water suckers and dead wood have to be periodically removed and cut ends are pasted with Bordeaux paste. Occasionally the water suckers are to be observed and they should be removed,.

Intercrops: Leguminous crops like soybean, gram, groundnut, cow peas, french bean, peas etc., may be grown in citrus orchards. Intercropping is advisable during the initial three-four years after planting.

Bahar Treatment: If left to nature the trees may bloom and fruit irregularly through-out the year. In order to overcome this problem and to force a full crop in any of the three seasons, as required by the grower and the traders, Bahar treatment is practiced in citrus orchards. In Andhra Pradesh, the citrus trees generally bloom three times a year, i.e., in January-February (Ambe bahar or Angam), June (Mrig bahar or Edagam) and October (Hastha bahar or Gairangam). Trees are treated for Ambe bahar (January-February), in November or December. In this method, from November onwards the amount of water is gradually reduced in successive irrigations and completely stopped in December. About the middle of December, the land is ploughed. When the trees start showing wilting symptoms (3-4 weeks), the soil around

the tree to a distance of 120 cm is dug a depth of 10 cm and the recommended manure is added to the soil and the trees are irrigated. The first irrigation that follows is sparing while the subsequent ones are more plentiful. Flowers appear about a month after the first irrigation. In Maharashatra, the roots are also exposed for about 10 days as part of the bahar treatment. This method is occasionally practiced in a few places in Andhra Pradesh Consequently; plants give new vegetative growth, profuse flowering and fruiting. . However, this treatment is considered to be harmful in the long run and not encouraged as a routine practice.

Cropping: Budded sweet orange trees give a commercial crop in about 5 years. Mandarins may take one or two years more. Seedling trees take about 8 years to come to bearing. The life of budded tree is about 35 years and of seedling about 60 years.

The fruit ripens in about 9 months after flowering. The harvesting season varies in different parts of the country. Sweet orange have three seasons of flowering and fruiting. The seasons of harvest in Rayalaseema are:

Angam season from September to February which yields about 80% of total annual yield. **Gairangam** starts from July to September.**Edagaru** season starts from March to May.Cro is very negligible during this season.

Bastavian oranges yield during August -September. In North India these fruits ripen from November-February.

The mandarins have three seasons similar to sweet orange in the agency tract. The main harvesting season santras in coorg is from December to April and off season crops are available from July to September.

Fruit Drop: Fruit drop in citrus occurs more or less in three distinct stages viz., post setting drop, pea size drop and pre-harvest drop. Among which the last one is most important and causes huge loss to the farmers. Based on the causal factors, the fruit drop can be classified broadly as i) Physiological drop ii) Entomological drop and iii) Pathological drop.

i) Physiological drop-Although the initial fruit drop period in citrus is primarily from physiological reasons, the term is strongly associated to October fruit drop and describes the abscission of fruitlets as they approach 0.5-2.0 cm in diameter. This is mainly due to competition among fruits for carbohydrates, water, hormone and other metabolites. The problem is highly aggravated by water stress and humidity.

ii) Entomological fruit drop--Citrus bud mite and orange bug are some important pests which causes heavy drop of flowers and fruits in oranges. Besides fruit fly (*Daucus dorsalis*) and fruit sucking moth (*Otheris fullonica*) are mainly causing fruit

drop in the later crucial stage of fruit ripening. Pre-harvest fruit drop is mainly caused by fruit fly infestation. Its activity is first noticed during last week of October which continues till the final harvest.

iii) Pathological fruit drop--Fruit drop also occurs due to pathogenic fungi viz. Botryodiplodia theobromae, Colletotrichum gleosporoides and Alternaria citri (stem end rot) which mainly occurs predominantly on the mature fruits near ripening. High inoculum of these fungi in the orchards builds up due to dead twigs on the bearing trees. Water spot also causes fruit drop in which the rind absorbs large amounts of water in localized areas during period of prolonged rains or dampness.

Control of fruit drop—

- Maintain balance nutrients in the plants to develop sufficient foliage to support the developing fruits.
- Prune the plants after harvesting to minimize pest and disease incidence.
- Proper drainage should be made to avoid water stagnation.
- Irrigation should be applied at critical stages viz., flowering, fruit set and fruit development.
- Dropped fruits should not be left in the filed as they acts as carrier for the diseases
- Spray GA3 10 ppm + urea 1% at the time of flowering
- Spray 2, 4-D 15 ppm + Benomyl / carbendazim 1000 ppm + urea 1% one month after fruit set when the fruit size reaches pea size (8-10 mm).
- Spray GA3 10 ppm + potassium nitrate 1% two month after fruit set (18-20 mm fruit size).
- Spray ZnSo4 (0.4%) + MgSo4 (0.2%) + CuSo4 (0.3%) at fortnight interval will decrease the fruit drop and increase the fruit yield.

Harvesting: Generally, citrus trees start bearing fruits 3 - 5 years from planting (although economic yields start from the fifth year and the trees may take 8 to 10 years to achieve full productivity) and can be harvested 5 - 6 months from flowering depending on the variety and the environment.

Maturity Indices:

Unlike some other fruits, citrus fruits do not ripen further once they have been removed from the tree, so it is important that they are picked at the right stage of maturity. Maturity is measured depending on different characteristics such as color, juice content, level of soluble solid (sugar) and solids to acid ratio. Normally, citrus fruits are harvested by hand. Fruit is best harvested after 8:00 in the morning, when dew has dried up, since otherwise, if the fruit was still wet, it would become dark and get spoiled. In addition, as citrus fruits are cold-sensitive (the plant dies at 3-5º C

below 0ºC), growers must have special care to protect the trees against cold. Lemons and limes are the citrus fruits the most sensitive to cold weather.

The general way to pick the fruit is by pulling it from the stem, using gloves in order to avoid damaging the fruit. Once harvested, the fruit has to be graded, sorted, washed and waxed, before being packed for delivery to the fresh market.

Yield:

Sweet Orange	600-800 fruits/tree with a maximum of 1200
Mandarins	1000-1500 fruits/tree with a maximum of 5000
Acid Lime	3000-6000 fruits/tree
Melons	600-800 fruits/tree
Pummelo	100 fruits
Grape fruit	500 fruits

GRAPE

Botanical Name: *Vitis vinifera* **Family:** Vitaceae

Origin: Armenia near Caspian Sea

The grape is one of the most delicious, refreshing and nourishing fruits. Grapes owing to their taste, nutrient content, composition and low calorific value are refreshing fruits. It is probably and obviously the largest produced fruit of the world. It is considered to be the fruit of the temperate region but it has been successfully acclimatized to several sub-tropical countries.

In India, all most all our produce is consumed as table fruit, while in European countries 99% of their produce is used for preparation of wines. Grapes are also used for preparation of other products like raisins, fresh juice and Jams etc. The grape fruits are rich in sugar and particularly in hexose and are easily digestible. It is fairly a good source of minerals like Calcium, Phosphorous and Iron and vitamins B_1 and B_2.The juice is mild laxative and acts as a stimulant to kidneys.

In Andhra Pradesh it is grown in the districts of Mahbubnagar, Rangareddy, Medak, Anathapur, Chittoor and Kurnool districts in an area of 1676ha with a production of 33,520 tonnes.

Climate: Grape is a semi arid subtropical crop. It requires warm and dry summer and cool winter. Humid weather is not congenial for sweetness of the fruit, causes cracking of fruits and encourages fungal diseases. Parts of India having more than 100cm of rainfall are not suitable. A rain free period of 90 days from the time of pruning is most desirable. Frost does great damage if it occurs during its growing period. It thrives well in regions with a temperature range of $4.5^{O}C$ and $45^{O}C$.

Soils: Light soils are ideal but they can grow on any well drained soil which is the most important requisite for grape vine. Water table should be deeper than 2 meters. Soils at least 1meter depth with no hard pan up to 2 meters is suitable whether they are rich or poor. Compared to other horticultural crops grape vines are relatively tolerant to salinity and alkalinity but excessive lime is harmful.

Varieties: The commercial varieties of grapes grown in India belong to *vitis vinifera* (European grapes), which is indigenous to Mediterranean region. American grapes belong to *vitis labrusca* and *vitis rotundifolia*, where the skin separates easily from pulp when ripe.

The important commercially grown varieties are- Bangalore blue, Gulabi, Anab-e-Shahi, Dilkush, Patcha Draksha, Puas seedless, Thompson seedless, Beautty seedless and Perlette

Hybrids: Number of hybrids were developed by IIHR, Bangalore .The important hybrids, their parentage and their important characters are given below.

Grape hybrids and their specific characters

Hybrid	Parents	Distinguishing characters
Arkavati	Black champaXThompson Seedless	Good for raisin making
Arka Kanchan	Anab-E-ShahiXQueen of Vineyard	Late maturing and good quality
Arka Hans	Bangalore BlueXAnab-e-Shahi	Suitable for white wines, berries with poor attachment
Arka Shyam	Bangalore BlueXBlackChampa	Good for juice and wine making, suitable for double cropping in S.India
Arka Neelmani	Black champaXThompson Seedless	Table as well as red wine making
Arka Shweta	Anab-e-ShahiXThompson Seedless	Seedless and suitable for table purpose
Arka majestic	Anab-e-ShahiXBlack Champa	Table purpose
Arka Chitra	Angoor KalanX Anab-e-Shahi	Table purpose
Arka Soma	Anab-e-ShahiXQueen of Vine Yard	Suitable making good quality wine making
Arka Trishna	Bangalore BlueXQueeen of Vineyard	Suitable for wine making
Arka krishna	Bangalore BlueXConvent large Black	Suitable for juice
Arka Urvashi	HurXBeauty seedless	Suitable for juice and wine.tolerant to Anthracnose
Pusa Navarang	MadeleineAngavineXRuby Red	Tenturier,suitable for juice and wine

Commercial classification of grape varieties: Depending on the use, the grape varieties may be classified into five categories, viz, .Table, Resin, Wine, Juice and Canning.

Table grapes: The grapes are used as fresh fruit. These grapes must be attractive in appearance and must have pleasing eating quality and good keeping and shipping qualities. Grapes with Muscat flavour, thin skin, firm flesh and without seeds are preferred. The grapes should also possess the characteristic colour of the variety. **Important varieties** are Thompson seedless, Pusa seedless, Perlette, Beauty seedless, New perlette, Anab-e Shahi, Bhokri, Cardinal, Black Muscat, Early Muscat, Fakhri, Kandhari, and Kale-Sahebi etc.

Raisin grapes: Seedless grapes posessing soft texture, a marked and pleasing flavour, large or very small size after drying and a little tendency to become sticky during storage are classed as good raisin grapes. For safekeeping, the raisins should not have more than 17% moisture. **Important varieties** are Thompson seedless, Pusa seedless, Kishmish, Black Corinth and Sultana, Muscat, Alexandria etc.

Wine grapes: Two types of wines can be prepared from grapes i.e. **table wines** and desert wines. Table wines are produced from grapes of moderately high sugar content and of moderate or high acidity. The desert wines are produced from grapes having high sugar content and low acid content. **Important varieties** are Gross Column, Red Prince, Black Champa, Beauty seedless, Cheema Sahebi etc.

Sweet - juice grapes: These grapes produce acceptable beverage when it is preserved by pasteurization, germ proof filtration or other means. The juice must be able to retain fresh grape- flavour. **Important varieties** are Bangalore Purple, Bangalore Blue, Gulabi, Concord, and Pearl of Csaba.

Canning grapes: Seedless grapes are used in canning with other fruits, in fruit salad and fruit cocktail.Important varieties are Thompson seedless, Pusa seedless, Perlette, Canner etc.

Propagation: Grape can be propagated both by sexual and asexual methods. Sexual propagation is encountered with a no. of hazards like poor germination and long period for germination etc.Asexual or vegetative propagation on the other hand has high percentage of success and it ensures genetical purity.

Vegetative propagation in grape is practiced through cuttings, grafting, layering and budding depending on the varieties used and the growing conditions.

Propagation through hardwood cuttings is the most popular method of propagation in grape. Cuttings made from well matured one season canes from productive vines which are of medium in thickness (0.7 to 0.8 cm), with an internodal length of 8-10cm and 25-30cm in length with at least 3-4 buds and dormant should be selected preferably from the October prunings. In making the cuttings the lower cut should be given immediately below the bud and the upper cut should be about ½" above the bud. They are planted in well prepared flat beds, leaving two nodes above the soil surface. In North India these cuttings are planted in the nursery after allowing them to form callus by burying them in moist soil or sand for 4-5 weeks. To control insect pests like termites in the nursery beds, at periodical intervals, treat the soil with Aldrin or Heptachlor dust. The rooted cuttings will be ready for planting in the main field only after one year.

In India grape is planted on its own roots. However, use of resistant rootstocks is necessary under infestation by nematodes and other pests and diseases and also for saline soils. The scion variety can be chip budded on suitable root stocks.

Phylloxera (Aphid) resistant root stocks—St.George and Riparia.

Nematode and soil salinity-- Salt creek

Resistant to nematode-- Harmony and Dog ridge

Spacing: The spacing that is given between the vines will depend on soil, climate, and vigour of the variety, method of training, pruning and cultivation practices.

Region	Training method	Spacing
Bombay-Deccan	Single stake	2.5X2.5m
Punjab-Haryana	Kniffin	3X3m
Bangalore region (Bangalore Purple)	Pendal / Bower / Over head / Arbour / Mandwa	5X6m
Madurai region	Pendal / Bower /Over head / Arbour / Mandwa	8X9m
Hyderabad region	Pendal /Bower / Over head / Arbour / Mandwa	5X9m

Planting: Preparation of the land before planting grape vine is essential. The land is prepare thoroughly by deep ploughing and follow up by tillage and the land should be leveled. Pits of $1m^3$ are dug at required spacing. October is the ideal time for planting unrooted cuttings directly in the filed. Rooted cuttings are planted in January or February. When rootstocks are planted, budding or grafting is done in July-August. Either chip or wedge grafting is followed.

Training and Pruning: Proper methods of pruning and training contribute towards higher production of better quality fruits in grape.

Training mainly concerns with giving the form and the direction of the trunk and arms and the position of the shoots. Training determines the form while pruning effects the functioning of the vine. It is done to concentrate the activity of the vine to the parts left after pruning.

Pruning is the most important operation for the maintenance of fruitfulness and quality along with vigour of the vine.

Before actually discussing the subject of training and pruning it is necessary to understand the various terms commonly used in these operations to make the subject more intelligible.

Trunk	-- The main stem of the vine which is vertical
Arms/Cordons (Primary)	--The main branches arising from the trunk or extensions of the trunk usually grow vertically
Arms/Cordons (Secondary)	-- The branches arising from primary arms or extensions of the primary arms or cordons.
Head	--The region of the trunk from which the arms or canes arise
Shoot	--The young growth(herbaceous) of the current season developing from a bud situated on the arm or trunk
Cane	--The matured shoot of the past season
Spur	--The shortened cane or part of the cane left after pruning
Fruiting spur	--The spurs having a few buds some of which (usually the apical ones) sprout and grow into fruiting shoots.

Training: In the natural habitat, a grape vine is robust climber but it can be trained on any fashion. Although a no. of training systems are known only four namely bower, kniffin, telephone trellis, and head system are followed in India.

The choice of a training system depends upon many factors such as:

- Apical dominance
- Vine vigour
- Variety
- Bearing zone
- Sun scald problems
- Easiness to cultural operations
- Land use
- Climate
- Capacity of the grower to invest

An ideal training system is one which

- Facilitates different operations like pruning, culture, plant protection, harvesting etc.
- Spreads the fruits in the entire area provided for the purpose
- Provides good leaf exposure
- Avoids bigger wounds to the permanent parts of the vine
- Maintains the vitality of the vine over a longer period.

Head System: This is the cheapest and easiest system of training grape vines. In this system the vines are trained like dwarf bush. Less vigorous varieties and varieties producing fruitful shoots from the basal buds are suitable for this system. Ex. Beauty seedless, Perlette, Delight and Gold.

In this system the plants are spread very closely to accomodate2000-2500 plants per acre. The vine is allowed to grow to a single stem with the help of stakes. After attaining a height of 3' the plant is topped and two lateral branches are encouraged. The plant is again topped at 4' height by which two or more laterals are developed. After keeping 4 laterals, 4' above the ground in all directions, the rest of the shoots are thinned out. These later cut to two buds at the first dormant pruning, will produce secondary arms. Generally two arms of about 20-30cm are kept on each lateral. At the time of second pruning, normally 1-2 fruiting spurs are kept on each secondary arm. After 3-4 years, the vine becomes like a dwarf bush and needs no stake.

Advantages:

- Simplicity in shape
- Ease in training
- In expensive to establish
- Possibility of cross cultivation

Dis-advantages:

- The vines are slow to come to full production
- Increased possibility of bunch rot and poor colour
- The bud and flower drop is maximum compared to other systems.

Pendal System: This system is also called as Arbour, Pergola, Mandwa, Over head or Bower system. Owing to the vigorous growth of the vine and pronounced apical dominance in the tropics, this system is most suitable for many of the commercial grape cultivars. This is more popular system for Anab-e-shahi in A.P.This is best suited for vigorous varieties, which don't perform well on other systems.Inspite of being the most expensive; this is being adopted on a large scale almost in all the grape growing regions of India.

In this system the vines are spread over a criss cross net work of wires usually 7' (2.1m) above the ground supported by pillars(Concrete, stone or iron).Galvanized wires of 5,8 and 10 gauge thickness and turning buckles are used. Only the best growing shoot from the plant is allowed to grow upright along the stake provided up to the bower height. When the vine reaches the wires, it is pinched off 15cm below the pendal level to facilitate production of side shoots close to the wires. Two vigorous shoots in opposite direction are selected and allowed to grow in opposite directions on the wires overhead. These two shoots develop into primary arms. On each primary arm three laterals on either side at a distance of 60cm (2') (along the wires) are kept as secondary arms. Thus, there will be 12 secondary arms on each, which after maturity form fruiting canes. These primary and secondary arms for the permanent frame work of the vine. The vines are allowed to trail straight along the wires by tying intermittently with banana fibre.

Advantages:

- Greater spread of the vines.
- Better exposure of the foliage to the sun, resulting in better maturity of the canes**.**
- Higher production.
- More uniform bunch colour
- Superior quality of fruits, which are free from sunscald.
- The vines in general give uniform performance
- It gives good protection to the canes against hot desiccating winds with ease in bird scaring.

Dis advantages:

- It is the most expensive than all other systems
- Pruning, training and spraying operations become difficult
- The spraying material cannot reach effectively the leaves and shoots.

Telephone system (Over head trellis / Telephone trellis system): This system is suitable for moderately vigorous varieties with more apical dominance. The chief

demerit of kniffin system, where the lower arms are rendered unproductive, is modified in this system by wires, stretched at one height like telephone wires. It is also an improvement over bower system in respect of ventilation and light penetration. It is relatively less expensive than kniffin system. The usual spacing provided for each vine is 3x3m.

Trellies are erected by using the granite stone pillars of 8' length and 6"x6" thick at the ends and 8"x4"x4" in the middle of the lines. The middle pillars may be spaced at 20' distance. Cross arms of 41/2' length are fixed on each pillar at a height of 5'.These can be iron blades of 4" width and ¼" thick or the angle iron pieces of 2"x2" width and¼" thick. Three wires of 8 gauge thick galvanized iron are pulled horizontally over the cross arms at a regular spacing of 2' using turning buckles at the end of pillars are supported side ward.

In this system the vines are allowed to grows straight up to a height of 1.5m (5') and then trained over head on a canopy of usually 3or 4 wires (45-60cm apart) fixed to the cross angle arms supported by vertical pillars or posts. The young growing vines are supported by bamboo sticks. After reaching the height of telephone (5') the tip should be pinched off to encourage side shoots close to wires. Two vigorous side shoots (cross to wires) are selected as primary arms from which four vigorous laterals on each side along the wires are allowed to develop on secondary arms. Each complete secondary arm can carry 6-8 fruiting units.

Advantages:

- Greater spread of the vine
- Better exposure of the foliage to the sun resulting in the better maturity of canes.
- Higher production
- More uniform bunch colour
- Superior quality of fruits free from sunscald
- Vines in general give more uniform performance.

Dis advantages:

- Cost of establishment is high. At present rates it may cost 60-70 thousand rupees.
- It is a system difficult to develop i.e. vine training needs a lot of skill and effort.
- The bunches are not as well exposed to light as kniffin system.
- Not suitable for vines making low to moderate growth.

Kniffin System: It is also called as **espalier** system. It is a system of training grape vine in which the arms of the vine are tied to horizontal wire at the same level above the ground. This system is not as common as the bower system. It is suitable for the moderately vigorous varieties with less apical dominance. Closer planting is adopted for this training system with in the row and 3m (10') between the rows. Galvanized iron wire of 8 gauge thickness is stretched parallel to the ground at a height of 75cm above which two or more wires are stretched at successive heights of 60cm.when the plant

crosses the first it is topped leaving a bud above the wire. Two laterals are developed on either side of the plant along the wire and the terminal shoot is allowed to grow vertically. Similarly, a pair of laterals is developed along the second and third wire. Thus each vine will have six arms.

In some cases only two pairs of laterals are developed at a height of 41/2' (1.35m) and 61/2' (1.95m) from the ground level and in such cases it is called four arm kniffin system.

This system is suitable for Beauty seedless, Early Muscat, Bhokri and Delight.

Advantages:

- ✓ This system is cheaper when compared with bower system.
- ✓ It is a good system for obtaining full crop on vines, the basal buds on the canes of which are sterile and which require long cane pruning.
- ✓ It is good for small clustered varieties which require fruit thinning for improved quality.
- ✓ The system allows more lateral spread of fruit bunches than cordon system.
- ✓ The average yields are 10-15kg per vine when planted at 3.0 mx3.0 m spacing.

Dis-advantages:

- ✓ Cultivation is possible in one way
- ✓ The lower arms become unproductive after some years.
- ✓ The arms produce fruiting wood mainly at the extreme ends only.
- ✓ From the pruning point of view, it is very difficult and exacting system. Since the retained fruiting units are very few, they must be perfect and pruner must have a thorough knowledge for their appropriate selection.
- ✓ Its cost of establishment is about 50-60 thousand rupees per hectare.

This system is mainly confined to research institutes and it is not popular with the farmers in any of the regions of the country.

Pruning: In grape pruning is done only once in North India during the month of January to make the fruitful buds to sprout but in south India, pruning is done twice in a year, once in summer and again in winter. Grape vines in these regions grow continuously without any dormancy (due to tropical climate).Hence by pruning in April (summer) the vines are forced to have a rest period, which helps in fruit bud differentiation. Pruning time mainly depends on rainfall and temperature. Pruning is adjusted so that there is no coincidence of rainfall with fresh growth and flowering and also winter doesn't set in with in 8-10 days after pruning.

Pruning refers to the judicious removal of any plant part

- To establish and maintain desired vine shape
- To increase productivity
- To facilitate various cultural operations
- To distribute proper amount of bearing wood over the vein
- For consistent productivity

Summer pruning: It is done during March-April in the states of A.P. and Karnataka, but in July in Tamil Nadu.In this pruning the canes are cut back to one or two bud level for building up the fresh vegetative growth. Hence it is called **back pruning** or **growth pruning**.

Winter pruning: This is done during the last week of November in A.P. and Maharastra, during the second and third weeks of October around Bangalore, but at any time of the month of October in the interior northern districts of Karnataka and in December in Tamilnadu. The mature canes (about 6 months old) are pruned. Entire foliage and immature shoots are removed. Levels of pruning differs with varieties.Anab-e-shahi and Bhokri are pruned to 5 bud level, Thompson seedless to 10 buds, Bangalore Blue to 4 buds and Gulabi to 9 buds. This pruning is also called as **forward pruning**.

Some of the varieties like Perlette, Beauty seedless, Bangalore blue, Bhokri etc. produce fruits on the shoots arising from the basal buds on the cane. In such varieties the canes are headed back to 4-5 buds. Such varieties are called **Spur pruned** varieties**.** On the other hand the Pusa seedless, Thompson seedless varieties in which the fruits are produced on the shoots arising from terminal buds, the canes are headed back to 8-12 buds. Such varieties are called **Cane pruned** varieties**.**

In the varieties like Bangalore Blue in Karnataka, Pacha Draksha and Anab-e-Shahi in Tamil Nadu, the vines are pruned for cropping twice. Instead of back pruning forward pruning is done in summer. Particularly in Bangalore blue, the vine yard is usually divided into blocks and the pruning time is staggered in such a way that the fruit is available almost throughout the year.

Points to be borne in mind while pruning: Pruning is a very crucial operation in viticulture. So, much care and precession are to be exercised in pruning a vine. A wise pruning envisages less depressing effect on the vine but more concentration of activity in the parts left after pruning. Severe pruning i.e. retention of fewer canes results in light crop. A vine in a given season can properly nourish only a certain quantity of fruit. Hence, while pruning the vigorous vines, more canes are retained, but in less vigorous vines less no. of canes are retained. If a vine has given a heavy crop during the previous season, it has to be pruned severely during the present fruiting season.

All the canes in a vine cannot be equally fruitful. Canes that are away from the trunk are more fruitful than the ones nearer the trunk. Hence, the former are pruned lightly than the latter. The thicker canes are pruned lightly as compared to thinner canes.

Main principles covering successful pruning:

- Cut back only current seasons growth
- Don’t prune when the vine is young. Prune only when the stem has attained 15cm girth (thickness) which occurs after a year.
- Fruit branches are borne only on fresh wood called” **fruiting spur**” of the current season. This spur arises from the previous season’s pruned spur or ripened shoots.
- A vine should be allowed to have only a limited no. of spurs.

The shoots borne on spurs should be kept checked retaining 10-20 leaves per spur depending upon the variety.

Manuring: Grape is a heavy feeder of fertilizers**.** The following manurial schedule is adopted in different years of growth.

At the time of planting: Fill the pit with50 kg of FYM,3kg of super phosphate,5 kg of castor cake or neem cake and two baskets of wood ash with top soil or silt.

After the establishment of the vines: The following manures and fertilizers should be applied every season of six months up to two years and properly irrigated after each application.

100kg of FYM, 2-3kg of castor cake or neem cake, 2-3kg of super phosphate, 250g of Ammonium sulaphate, and 125g of Urea.

From the **3rd year** onwards the following manures and fertilizers are applied thrice in a year

Manure/Fertilizer	After summer pruning (Growth pruning)	After winter pruning (For fruiting)	One moth after winter pruning
FYM	200-250 kg	200-300 kg	---
Castor or Neem Cake	10-12 kg	10-12 kg	---
Amm.Sulphate	½ to 1 kg in 2 splits at monthly intervals	1kg in 2 splits at 20 days interval	250g
Super phosphate	2-3kg	2-3kg	---
Urea	--	125-250gmIn two splits	---
Potassium sulpahate	--	3 kg &1kg at 15 days interval from flowering to fruiting.	500g

Potash plays an outstanding role in grape cultivation. From the time of October pruning, flowering commences in a period of 90 days, the vine has to produce a crop of 10-15 tonnes.The application of potash even in rich silt, and black clay loams at 1-2 kg per vine at least in split doses has recorded good yields.

Repeated sprays of magnesium sulphate and borax at 0.05% to 0.2% strength have helped to over come most of the deficiency. Due to regular use of Dithane Z-78 in the spray schedule for control of fungus, ample supply of zinc is ensured.

Irrigation: Vine yard irrigation is chiefly governed by the nature of soil, its drainage, the rainfall and its distribution and temperature in the locality.

Grape vine requires judicious irrigation for optimum growth and yield. During initial year of planting, vine may be irrigated frequently. While stagnation of water around the

root zone leads to mortality of the vine. The excess water from frequent irrigations is conducive to excess and rapid vegetative growth at the cost of the fruiting of the vine.
Grape requires 6-8 irrigations after April pruning till the south West monsoon begins. Vines are not irrigated from June-October.
8-10 irrigations may be given at 7-10 days interval after October pruning till March. Each adult vine needs 200 liters of water in winter and 300 liters of water in summer per irrigation. Watering the vine just before pruning may increase the flow of plant sap.Hence; the vines are not irrigated after harvest and allowed rest for 15 days in April before pruning is taken up. This practice of withholding water for a fort night helps in controlling the flow of plant sap. The flow of plant sap inside the tissue at the time of pruning should be at the minimum, as otherwise, the plant may be get drained off the plant sap through the cut surface after pruning. This draining of plant sap through cut surface is called"**Bleeeding".**Hence; vines should not be pruned when the plant shows bleeding. Again while the berries are ripening, the irrigation of the crop may make the berries less sweet.Hence, withholding of water before pruning and also while the fruits are ripening is a sound practice.

Inter- culture: It is not feasible to grow any inter crop and frequent shallow tillage is desirable. The vineyard should be kept free from weeds by shallow digging of 8-10cm depth in 15-20 days interval with spade by manual labour and weeds hand picked. Owing to shade the crop is susceptible to two mildews and anthracnose disease against which a schedule of three prophylactic sprays of bordeaux mixture sprayed after pruning, at flowering and when fruits are developing.
Fruit thinning: Thinning of berries at pea stage increases the berry size by 20%,fruit quality with high sugar content in Anab-e-shahi and lowered the acidity in sub-acid varieties like Bhokri. Improvement in colour of berries and earlier maturity are the other advantages due to thinning. It also means to remove diseased, misshapen and shot berries.

Use of Plant growth regulators: Encouraging responses were observed both in seeded and seedless varieties of grape by the use of growth regulators.
Effect on fruit set: A good fruit set was obtained by spraying the flower cluster thoroughly 4-6 days after full bloom with **100ppm Gibberellic acid** or **20ppm Parachloro phenoxy acetic acid**. This increased set in current grapes, Thompson seedless and black Corinth.
Effect on berry size: Increase in berry size in Anab-e shahi, Kishmis and Bhokri varieties was reported when **GA** was applied at **40ppm** at bud and flower stages. Higher concentrations resulted in the increase in the length of berries.
Effect on cluster size: Use of **GA, TIBA and PCPA** resulted in lengthening the cluster parts especially the pedicles.

Effect on maturity: with the application of **Benzothiozal A-Oxyacetic acid (BOA)** maturity can be regulated. Maturity can be delayed by 15 days with the application of this **Benzothiozal A-Oxyacetic acid.**

Harvesting: Grapes should be harvested when they are fully ripe as they don't ripen any further after harvest from the vine. The criteria for maturity are:

- The bunches should be fully developed and every berry should attain a uniform size, shape and colour.
- The bunch is ready for harvest when the lower most berry of the bunch is soft and sweet.
- The berries should develop translucent look of colour peculiar to the variety. Anab-e-Shahi develop amber or light honey colour.
- The seeds of the ripened berries becomes dark brown
- Total soluble solids also give the indication of ripening. Anab-e-shahi is harvested when it records a brix of 15^{O}-16^{O} and Thompson seedless 21^{O}-22^{O}
- The bunches should be harvested when they are ripen on the vine as they are not subjected to post-harvest ripening process.

The bunches are harvested with secature or scissors. Then the immature and rotten berries are removed with the help of scissors. Then they are packed in wooden or card board boxes or bamboo staked baskets. The paper strips are used to avoid damage to the berries.

Yield: Bangalore blue and Patcha draksha--5000 kg/ha, Bhokri - 4500 – 9,000kg/ha, Anab-e-shahi-1000--15000kg/ha and Bangalore blue -30,000kg/ha.

Grapes are long lived and may yield up to a century with a good care. But on a commercial scale they may be replaced after about 30 years with advantage.

GUAVA

Botanical Name: *Psidium guajava, linn* **Family:** Myrtaceae

Origin: Tropical America (from Mexico to Peru)

Guava is a subtropical crop. It is one of the most common and major fruits of India and is considered the fourth most important fruit in area and production after mango, banana, and citrus. It is a hardy and prolific bearer and highly remunerative fruit.

Guava is native to tropical America and seems to have been growing from Mexico to Peru. It is believed to be introduced in to India during early 17^{th} century.

In A.P it is commercially grown in Telengana, North coastal districts and Ananthapur in Rayalaseema.

Guava is the rich source of Vitamin C, and a fair source of Vitamin A and B_2 and minerals like calcium, phosphorus and iron. The vitamin C content of Guava is 2-5 times higher than oranges. Guava fruits are used for making jam, jellies and various culinary purposes. The fruits can be canned in sugar syrup. The leaves yield dye and tannin and also have medicinal value of curing Diarrhea.

Climate: Guava cultivation can be extended to varying agro-climatic regions owing to wider adaptability. Guava can be successfully cultivated both under tropical and subtropical conditions. It does well up to an altitude of 1,000-1,500 meters. It grows best with an annual rainfall below 100cm restricted between June-September. Places having more than 250cm rainfall are not suitable for guava. Under heavy rains and high relative humidity brings down the quality of fruits. Optimum temperature requirement is 23-28^{O}C.

The areas having distinct winter season, is considered best for increasing yield and improving quality. The humid conditions lead to luxuriant growth of the trees and yield fruits of poor quality. It can be grown as rain fed as well as irrigated crop depending upon agro climatic conditions. At the time of flowering and fruiting, it requires dry climate. High temperature and high velocity winds at fruit development period lead to heavy fruit drop.

Soil: Guava adapts well to a wide range of soils. Well-drained, light sandy loam to clay soils is good. Since it is a hardy fruit crop, it can be grown on alkaline soils wastelands etc. It is sensitive to waterlogged conditions. It tolerates a wide range of pH from 4.5 to 8.5.If the soils are having a pH of 7.5 and above there are more chances of getting guava wilt. Some varieties like Lucknow- 49 can be grown in saline soils also.

Varieties: Basically basing on seed content in guava there are two types-- Seedless and seeded varieties. Seedless guavas are triploids with irregular shape and low productivity and plants are very vigorous in growth.Hence, unfit for commercial

cultivation. Seeded guavas are more commercial, high yielder's with excellent quality. The seeded guavas are diploids. Seeds range from 250-500 / fruit. Basing on colour of the flesh again there are two types—White fleshed and red fleshed. Among these two, white fleshed are more common and red-fleshed are less common.

Important seeded, seedless and hybrid varieties commercially grown are:

Seeded varieties- 1. Allahabad safeda, 2. Lucknow-49, 3. Arka Mridula 4. Red fleshed and 5.Allahabad Surkha etc.

Seedless varieties: Two types of fruits, completely seedless and partly seeded, are borne on a plant of seedless variety. The completely seedless fruits develop on the shoots arising from the stem and these are bigger in size and irregular in shape. The partly seeded fruits are borne on normal shoots at the periphery and are small in size and round in shape. The important seedless varieties are-Nagapur seedless, Saharanpur seedless

Hybrids:

Saefd jam: This is a hybrid variety released from Fruit research station, Sangareddy (A.P.). It is a cross between Allahabad Safeda and Kohir. Fruit size is bigger with less seed and vitamin C is more in comparison to their parents.

Kohir Safeda: It is cross between Kohir and Allahabad safeda. Fruit is large in size, slightly acidic. Yield 300 fruits per tree.

Other varieties like Nasik, Dharwar, and Apple colour, Banarasi, Hafsi, Anakapalli, Harijha and chiitdar etc. are also considered as good cultivars.

Propagation: Guava can be propagated both by seed and vegetaively.

Seed Propagation: It is still common to raise commercial orchards by propagation from seeds. This practice is not advisable because this would lead to lot of variation among trees in fruit size, yield and quality. Hence, it is very important to plant an orchard only with vegetaively propagated plants of known variety.

Vegetative methods of propagation —Air layering or ground layering can be practiced for multiplication of guava plants and the best time for doing this is rainy season. It is more commonly practiced in S.India. It is very convenient, cheap and easy method. The layered plant being on its own roots grows more vigorously and establishes quickly even in difficult soil conditions. Pot layering is practiced in Telengana area.

Regarding budding shield or patch budding is generally practiced and the best time is May-June.

Inarching is another common method of vegetative propagation and it is good to do it in the month of July-August for high success.

Propagation of Guava by cuttings under ordinary conditions is not successful. It is only successful under intermittent mist conditions with the aid of rooting hormones like IBA and NAA. Hence, propagation through cuttings is not generally followed.

Some times stooling is practiced but the success is very poor, so it is not generally followed.

Guava can also be propagated through root suckers but it not possible to obtain large no. of suckers to raise orchards.

The commercial method of propagation for guava is air layering / pot layering or inarching.

Planting: The field should be deeply ploughed and properly leveled before planting. Pits of 75-100 cm^3 size are dug well in advance to the onset of monsoon. The pits are filled with a mixture of tank silt, FYM Or Compost and soil in equal proportions .To avoid termite problems dusts like lindane are also mixed in the soil mixture. Guava may be planted from June to December in South India and June to August in N.India.

Spacing generally adopted is 5-6 meters in square system of planting. In highly fertile soils it may be increased to 6-8meters.

Flowering and fruiting: The guava bears flowers solitary or in cymes of two or three flowers, on the current seasons growth in the axils of leaves. The bearing twigs grow a few centimeters long, putting forth 4-5 pairs of leaves. The blooming period varies from 25-45 days depending on the cultivar, season and region. The initial fruit set is quite high and approximately 80% of flowers set fruits. Afterwards due to severe fruit drop only 34 - 56 per cent of fruits reach maturity. In cultivars like seedless, the final retention is as low as 6 percent.

Under natural conditions, guava tree produces flowers and fruits twice in a year in North India, but in South and Western India it is thrice i.e. almost throughout the year, which results in no rest period and ultimately guava tree bears small crops at different times of the year. The pattern of flowering and fruiting periods in guava are:

Ambe-bahar: When guava tree flowers during February-March or spring season, this flowering period is known as Ambe-bahar.The fruits ripe from July-September in rainy season. The fruits obtained during this season are insipid, watery and poor in quality i.e. taste and keeping quality.

Mrig-bahar: When guava produces flowers in June-July or monsoon, this- flowering period is known as *Mrig-bahar.*The fruits ripe from November-January in the winter. The fruits obtained during winter are excellent in quality and therefore, the guava trees are made to produce the *Mrig-bahar* flowering only.

Hasth-bahar: Some times, guava tree produces flowers in October is known as *Hasth-bahar*. The fruits ripe from February-April. The quality is good, but yield is very low. However, it fetches good price. This bahar in guava is not very common. It is mostly a chance crop. Hast-bahar is observed in western and southern India.

Crop regulation (Bahar Treatment): Throughout India, *Mrig-bahar* is preferred over ambe and Hast-bahars.Therefore, it become necessary to regulate flowering, so that *Mrig-bahar* can produce heavy flowering and fruits are available in winter. The practices followed for taking *Mrig-bahar* are:

Restricting irrigation water: The trees should not be given irrigation from February to middle of May. Doing so, the tree sheds its leaves during hot season (April-May) and goes to rest. During this rest period, tree can conserve food material in its branches. In the month of June tree is well cultivated and manured followed by irrigation. After about 20 -25 days the tree blaze in to profuse blossoms. The fruits mature during winter.

Exposing roots: Carefully upper soil around the trunk about 45 - 60 cm radius is removed, so that the roots are exposed to the sun which results in reduction in supply of soil moisture from the soil to the top and therefore, the leaves begin to shed and the tree goes to rest. After about 3-4 weeks the exposed roots are again covered with the soil. Manuring and watering may be followed.

De-blossoming: It can be done with the use of growth of regulators. Among many chemicals NAD (Naphthalene acetamide) at 50 ppm is the most effective. Deblossming can also be done manually on small scale.

When flowers of *Ambe-bahar* are de-blossomed or thinned, the tree become more potential to produce more flowers and fruits in *Mrig-bahar.*

Irrigation: Guava is a hardy plant and generally it doesn't require much irrigation. But the yield and quality improve markedly by irrigation in summer. The young guava plants need irrigation at weekly interval during summer months and 2-3 irrigations during winter months. Just after transplanting, watering is necessary in the absence of rains. For bearing trees irrigations are needed for flowering and better fruit setting. Fruit size is reduced, if sufficient soil moisture is not maintained. Irrigation is also required to check excessive fruit drop during summer months.

Manures and fertilizers: The requirement for manures and fertilizers to give guava crop varies with the varieties, age of the crop, fertility status of the soil climatic conditions and management practices. The fruit of guava are borne on current seasons growth, therefore, manures and fertilizers encourages vegetative growth and fruiting.

Manures	One year after planting (Kg)	Add every year (Kg)	Bearing trees (Kg)
Compost	20	20	100
Ammonium sulphate	1.0	0.5	3.0
Super phosphate	1.0	0.25	2.0
Muriate of Potash	1.0	0.25	2.0

Guava is a surface rooted tree and therefore the manure should be evenly spread all over the surface of the tree basin and lightly dug in. In case of zinc deficiency, spraying trees with 450g of zinc sulphate and 300g of slaked lime in 73 litres of water

twice in a year, once in June-July and second in September-October corrects the deficiency. Zinc deficiency is serious in waterlogged areas.

Interculture : The orchard should be kept clean by ploughing twice or three once in the beginning of monsoon to improve the infiltration of rain water into the soil and the second ploughing in the middle of the rainy season to control the weeds. The third one at the end of the monsoon to conserve the moisture. The basins should be kept weed free by digging occasionally and the basins around the trees should be kept enlarged as the trees get older. They should be kept a little bigger than the spread of the largest branch.

Inter cropping: In the early stages of establishment of guava orchard till the commercial bearing, the interspaces can be utilized by growing suitable intercrops. Vegetable crops like bhendi, brinjal, beet root and fruit crop like papaya can be grown as intercrops. However, intercropping is not desirable in orchards with full grown plants.

Training and pruning: The main objective of training a guava plant is to provide a strong framework and scaffold branches suitable for bearing a heavy crop with out damaging the branches. Training guava trees to open centre system is good. Care must be taken to prevent criss- crossing of the primary branches in the initial years of planting. Incase of varieties having spreading habit, primary branches are allowed at least 75cm above ground level. It is better to shape the tree canopy to a limited height into a rectangular shape, allowing more spread in East-West direction. Dead, diseased, intercrossing branches and suckers coming up from the base and sides of framework should be pruned back annually.

In guava, the flowers and fruits are borne on current season's growth in the axils of leaves arising from the old ones, hence, a light annual pruning is considered necessary to encourage new shoots after the harvest. Seedling trees grow vertically high up producing fruit bearing new growths at their top ends. They don't produce much fruits lower down.On the other hand grafts or layers remain dwarf and their branches grow horizontally and drooping producing enormous number of fruit bearing shoots. This suggests that seedling trees can also be made more productive by bending the upright branches horizontally.

Pruning in guava results in large fruits of higher value, early flowering, protection of fruits from birds, rats etc. due to cover by vigorous foliage. Severe pruning reduces yield largely, light pruning is always desirable.

Pollarding or Dehorning: When the trees are aged and don't give good yields, their branches may be pollarded or dehorned. In this method the branches are cut leaving 30 cm in length at their origin. The cut branches produce enormous shoots and flowers and ultimately give high yields.

Bending: It is a common feature that in the guava trees branches growing upright and tall don't bear at all. In such cases, straight-growing branches may be bent and tied on the pegs driven on the ground. In bent branches dormant buds are activated and induced to bear flowers and fruits heavily. This method is successful especially in varieties, which grow erect and bear little fruits.

Harvesting: Seedling guava trees require 4-5 years to bear, while vegetatively propagated plants start bearing from third year after planting. The fruits turn greenish yellow with the approach of maturity are considered ready for harvesting. Guava fruits mature for harvesting after 4-5 months of anthesis. However it depends upon the climatic conditions and variety. Fruits on ripening give excellent taste and flavour characteristic of a particular variety. The fruits should be harvested immediately when it is mature, because it cannot be retained on the tree in ripe stage. Mature or half ripe fruits are preferred for consumption. Hand picking at regular intervals is suggested to avoid possible damage to fruits instead of shaking the tree. The fruits should not be allowed to over ripen on the trees as they deteriorate in quality and are more liable to be damaged by birds. Individual fruits are picked when they are still hard and firm at regular intervals.

Yield: The yield of guava varies due to different varieties, age of the plants, fruiting season and orchard management practices etc. Seedling tree of guava of 10 years old yields about 400-500 fruits. Grafted tree yields 1000-2000 fruits where as good orchard yields about 25-30 tonnes per hectare.

SAPOTA

Botanic name: *Achras zapota* (*Manilkara achras, Manilkara zapotilla*)

Synonyms: Chiku, Sapodilla, Dilly, Naskerry

Family: Sapotaceae **Origin:** Tropical America

It is a delicious fruit introduced from tropical America. Sapota is mainly cultivated for its fruits in India while in other countries; it is mainly cultivated for the milky latex produced from the bark and fruits, which yields a commercial product called "**Gutta parcha"** which is the base for the manufacture of chewing gum (Chicle).

Sapota is a native of tropical America and is believed to have originated in south Mexico or Central America and from there, it spread to India and other countries where it adopted very well.

Sapota, when fully ripe, is delicious and is eaten as dessert fruit. The pulp is sweet and melting. The sapota fruits are good source of sugar which ranges between 12 and 14 per cent.

Climate:

Sapota is a tropical fruit and It prefers a warm and moist weather and grows in both dry and humid areas. Coastal climate is best suited. In South India it is grown on the hills up to a height of 1000m. At higher altitudes fruit quality and tree health suffers. Areas with an annual rainfall of 125-150cm are highly suitable. The optimum temperature ranges between 11^{O}C and 34^{O}C. A high temperature above 41^{O}C during summer causes drying up of stigmatic fluid, flower drop and fruit scorching. In severe cases, leaves and fruits undergo scorching. Dry and strong winds also cause damage to flowers, leaves and fruits.

Soils: Sapota is a hardy tree and can be grown on a wide range of soils, but in sandy soils, the plants are uprooted by strong winds. The soils having very high percentage of calcium are not suitable. If the soil is not well drained or a hard pan is present in sub-soil, the sapota tree doesn't make good growth. It can with stand presence of salt to some extent. Drainage is most important for sapota growing. Alluvial soils, sandy loams, red laterite soils are suitable.

Varieties: The important and widely adopted varieties are Cricket ball, kalipatti, Kirthibatti, Pala, Baramsi, Guthi, CO2, PKM-1 etc.

A good table sapota should have 2-4 seeds with melting sweet pulp. Thick skinned, hard-fleshed varieties with sandy texture are considered inferior.

Hybrids:

CO-3: It is hybrid between Cricket ball and Vavivalasa.Trees are intermediate in stature. Bearing commences fourth year of planting. Fruits are dull brown, oblong sweet and yield annually about 157 kg fruits per tree.

PKM-2: Hybrid between Guthi and Kirthibarthi. A high yielder with a yield performance of 1500-200 fruits per tree per year weighing 80-100 kg. Fruits are bigger in size and oblong to oval shaped. The average fruit weight is 95g.TSS ranges from 25-27^{O}B.

PKM-3: Developed at Horticulture College and Research institute, Periyakulam, TNAU.It is a hybrid between Guthi and Cricket ball. It has vertical growth habit and hence lends itself for high density planting. Fruits are big sized with oval shape and have a cluster bearing habit. The fruit yield is 14 tones/ha.

Other varieties: Baramasi, Chhatri, Jonna valasa, vavivalasa, Bangalore, Thagarampudi,

Propagation: Sapota is propagated both by seed and also by vegetative methods.

Seed propagation: In the earlier days, seedlings were used for planting, but they have some disadvantages such as slow growth, very long pre-bearing period of about 8-10 years and growing to a huge size or height and showing too much variation or not being true to type.

Vegetative propagation: This method has many advantages such as being true to type; earliness in bearing, dwarf or easily manageable size of the trees, favourable rootstock may influence and improve bearing. Among the vegetative methods, the most important are air layering, ground layering / pot layering, inarching and soft wood grafting. However; commercially followed method is inarching and now this method is replaced by softwood grafting

For grafting in sapota various rootstocks are used. Use of proper rootstock is important in grafting. Since the slow growth of the seedling rootstocks become a limiting factor for rapid multiplication. The use of rootstock also posesses certain problems such as incompatibility and undesirable or adverse effects. Often the incompatibility affects fruit quality after several years.

The different rootstocks used are:

- Sapota seedlings: (*Achras zapota*)
- Rayan or Khirni or pala: (*Manilkara hexandra* or *Mimusops hexandra*)
- Adams Apple: (*Manilkara kasuki or Mimusops kauki*)
- Mahua: (*Madhuca latifolia)*
- Mee tree :*(Bassia longifloia)*
- Star apple: *(Chrysophyllum cainito)*
- Miracular fruit :*(Sideroxylon dulicifolium)*)

Among the different rootstocks rayan / pala is the most vigorous and productive rootstock.

Planting: The land is ploughed twice and leveled properly to avoid water stagnation. Pits of 90cm size are dug at a spacing of 8X8 m or 9X9m. System of planting generally adopted is square system. The pits are allowed to weather for 15 days before planting. Planting is done preferably during early monsoon period.

Each pit is filled with a mixture of 30 kg. FYM, 500 g. Neem cake with top soil. Then the plant is planted in the center. Care should be taken to see that the graft joint is at least 15cm above the ground level. After planting, the plants are watered properly and protected from scorching sun as well as from dry and hot wind. The plants are trained properly up to 3-4 years. The lower most branches up to a height of 60-90cm may be removed. The root stock sprouts are removed periodically.

Irrigation: Though sapota can tolerate drought conditions to some extent, yet it responds well to irrigation. Young plants are watered regularly during dry season and at long breaks in the monsoon, winter and summer at an interval of 6-12 days. In areas where there is water scarcity, drip or pitcher irrigation systems can be effectively practiced.
Insufficient irrigation results in dropping of a large no. of flowers leading to a loss in yield up to 40%.

Manuring: The following doses of manures and fertilizers have been found beneficial for obtaining higher yield of sapota in Andhra Pradesh.

Age of the tree	**FYM (Kg/Plant)**	**N**	**P (Grams/Plant)**	**K**
1-3 years	50	50	20	75
4-7 Years	50	100	40	150
7-10 Years	50	200	80	300
11 and above	50	400	160	450

Manures and fertilizers are applied twice in year. The first half is applied in the beginning of the monsoon (June-July) and the remaining half the dose at the end of the monsoon (September-October).
Fertilizers are applied in a shallow circular trench 15-22cm deep, 15cm wide and 60-90cm away from the trunk. After application, the fertilizers are covered with top soil and irrigated.

Interculture: Frequent weeding or mulching is necessary for first few years. In established orchards, pre- monsoon and post-monsoon intercultivation is recommended fro better aeration and effective weed control

Intercropping: Sapota has long pre-bearing age and till the trees cover the entire area with canopy, inter crops can be grown. This period may be as long as 10 years. Short duration fruits like banana, papaya, or vegetables can be profitably grown. Legume vegetables and pulses benefit in several ways.

Training and pruning: In Sapota, a strong central stem is necessary. The Sapota, in general, has a well balanced distribution of branches and the crown assumes a

uniform shape. There is no necessity of pruning every year. All the growths those appear on the rootstock below the graft joint must be removed. After 3-4 years of planting, the lower most branches up to a height of 1 m may be removed. In Sapota, new growth and flowering occur simultaneously and it has a mixed type of bearing habit. Flowers and fruits appear in the leaf axils in the new growth and hence pruning of branches should not be done. Pruning in sapota is confined to open the tree to light, and removal of dead and diseased branches over shaded and crowded branches.

Flowering and fruiting: Sapota starts bearing small crops from second or third year of planting but economical yields can be obtained from seventh year onwards. Flowers appear in leaf axils on new growth. Under tropical conditions, flowers are seen almost through out the year. However, there are two main seasons of flowering i.e. March-April and September-October and hence, two harvesting seasons.

Harvesting: Sapota is a climacteric fruit and it ripens properly and improves in its quality after harvesting. It matures in about 4-6 months after fruit set depending upon cultivars and available heat units.

The fruit harvested earlier than physiological maturity takes too long to soften and has poor quality. On the other hand, fruit harvested late soften quickly resulting in spoilage during handling and transportation.

Great difficulty is expressed in determining maturity because of continuous flowering and fruiting.

The fruits to be harvested must be fully mature and maturity can be judged by several external symptoms as mentioned below.

- Fruits at full maturity develop a dull orange or potato brown colour.
- A mature fruit when scratched shows light yellow streak instead of a green streak, which is a sign of immature condition.
- Brown scaly material disappears from the fruit surface as the fruits approach full maturity.
- As the fruit matures, the milky latex content is reduced.
- The dried spine like stigma at the tip of the fruit falls of easily when touched.

The matured fruits are harvested with stalk intact individually by giving a twist and collected with out bruising. The fruits thus harvested are spread in a thin layer on a bamboo mats under shade for an hour or two. To avoid bruising of fruits they are collected in gunny bags and lowered to the ground carefully.

Continuous flowering and fruiting observed in sapota, though there are two distinct periods of harvest viz; September-November and January-March. At some locations a third crop during June-July is also obtained in small quantity.

Yield: The yield depends upon several factors such as age of the tree, variety, agro-climatic conditions of the locality, nutritional and plant protection measures. Bearing starts from 4th year onwards and economical yields can be obtained from 7th year. It

takes 4-6 moths from flowering to fruit maturity. March to May and September to October are the two distinct seasons of harvest.

S.No	Age	Yields
1.	4-5th year	250 fruits per plant.
2.	6-7th year	800 fruits per plant.
3.	8th-20th year	1200-1500 fruits per plant.
4.	By 30th year	2500-3000 fruit per plant.

PAPAYA

Botanical name: *Carica papaya* L. **Family:** Caricaceae.

Origin: Tropical America

Introduction: Papaya is one of the important fruit crops of tropical and subtropical regions of the world. It has originated in tropical America and was introduced from Philippines through Malaysia to India in the latter part of 16th century by Portuguese. It is one of the few fruit crops that flowers and fruits throughout the year giving early (9-10 months after planting) and high yields (about 100 tones per hectare).

Besides its use as a fresh fruit, Papayas can be processed as Jam, Syrup, Preserves, Papaya candy, canned fruits, salad, and jelly. Papya is also a commercial source of protease enzyme, "**Papain**".

Papaya fruit is highly nutritive and is very rich in Vitamin A. It improves digestion and said to cure chronic constipation, piles and enlarged liver and spleen.

Normally papaya plants are Dioecious which bears male and female flowers separately on different plants. There are Gynodioecious forms also which bears female (Pistillate) and Hermaphrodite (Bisexual) flowers separately on different plants. Male flowers are borne on long stalks and female and perfect flowers in small clusters in leaf axils.

Climate: Papaya is essentially a tropical fruit crop and grows best in sunny places. It is very sensitive to frost but withstands extremes of temperature. Temperatures below 10^{O}C will affect the growth and fruit set. It grows well in regions where summer temperature doesn't exceed 38^{O}C but it can stand up to 48^{O}C.It also flourishes well in regions up to an elevation of 1100m. It is adapted to a wide range of rainfall conditions ranging from 35cm to 250cm annually; however, excessive moisture adversely affects the crop as well as fruit quality. It does not stand strong (80Km/Hour) or hot winds. Dry climate during flowering often causes sterility while the same conditions during fruit maturity add to the sweetness of the fruit.

Soils: It can be grown on a variety of soils provided the soils are well drained. Under water stagnated conditions and in soils with poor drainage foot rot disease may cause heavy mortality. Hence, heavy soils should be avoided as papayas cannot withstand water stagnation for more than 48 hours. A loamy soil with a pH of 6.5 to 7.2 is considered ideal. Medium black and alluvial soils are also suitable. Calcareous and stony soils with poor organic matter are not suitable. It can be grown in poor soils also provided with heavy manuring and irrigation.

Varieties: As the crop is grown entirely almost from seed, varieties are not well defined. Varieties with medium sized fruits are generally preferred to those with very large fruit. Since papaya is a highly cross-pollinated crop, seeds taken from a fruit would rarely breed true to type. If a variety is to be maintained pure, controlled pollination between selected female and male progenies of the same parent.i.e.

sibmating (i.e. crossing of sister and brother) has to be done. This consists of collection of pollen from the male parent and applying it on the previously bagged female flower. Seeds from such crossed or sib-mated fruit should be used for further multiplication .Seeds from open pollinated fruits should not be used. Failure to observe this precaution leads to the deterioration of the variety resulting in the progeny being a mixture of all kinds of types with in a few years.

Based on the sex expression, papaya varieties can be either classified as **dioecious** or **gynodioecious**. The dioecious varieties produce male and female plants in 1:1 ratio where as gynodioecious types produce plants of female and bi-sexual (**Hermaphrodite** form) in 1:2 ratio.

Some of the commercially grown improved varieties of papaya are: CO1, CO-2,CO-3,CO-4,CO-5,CO-6,CO-7,Washinton,Coorg Honeydew, Honeydew, Pusa dwarf, Pusa delicious, Pusa giant, Pusa majesty, Surya, Red lady etc.

Propagation: It is mainly propagated by seeds. Since it is a highly cross-pollinated crop, the plants raised from seeds have a mixed inheritance, which makes the highly variable. So, genetically pure seeds should be collected from the sib mated or selfed fruits**.**

Vegetative methods of propagation like cuttings, layering, grafting and budding are not possible on a commercial scale due to the hollow and fragile nature of its stem.

Raising of seedlings: Freshly extracted seeds germinate better and grow quicker. The fresh seeds are cleaned of the pulpy material adhering them, dried in shade. About 400 -500 grams of seed is required for raising crop in one hectare. Seedlings can be raised in nursery beds or in polythene bags .Among these, the seedlings raised in polythene bags are found good. Seeds are sown at a spacing of 5cm with in the row and 15 cm between rows. Seeds germinate with in 15-20 days. In about 2 months, seedlings grow to a height of 15 to 20 cm and are ready for transplanting. It is essential that large ball of moist soil containing the entire root system is lifted from bed and transplanted in the field without mutilating the roots in any manner. Hence, raising seedlings in polythene bags is more desirable for better establishment, after transplanting.

Planting: The land should be ploughed deep, harrowed and leveled. Pits of size 45cm X 45cm are dug and spaced about 2.5 m apart each way. This would accommodate 1666 plants per hectare or 680 plants per acre. The pits after weathering are filled with top soil mixed with 5 kg. of FYM, 100 grams of neem cake and 40 grams of super phosphate. Four seedlings should be maintained per pit till the identification of female and male progenies. Finally one female plant per pit and one male plant for every 10 female plants should be retained in dioecious type. Normally male plants flower earlier than female on pendulous hanging inflorescence with branched stalk.

The best time for planting in most parts of India is the beginning of the monsoon in the light rainfall tracts and close of the monsoon in the heavy rainfall tracts.

Manuring: Papaya is a quick grower and heavy feeder. To maintain vigour and continuous fruiting manures and fertilizers are required. Doses differ with variety, soil, rainfall etc.

While planting, along with top soil 5 kg. of FYM, 100 grams of neem cake and 40 grams of super phosphate should be mixed and pits are filled. After thinning of male and female plants first dose of 50 grams each of N, P and K per plant (110 g of urea, 310 g of super phosphate and 80 g of muriate of potash) should be applied. The same dose should be applied at 2 months interval from second month of planting.

Irrigation: Papaya is very specific in its irrigation requirements. Fruitfulness depends on its vigour which in turn depends on irrigation and manuring.For high and successful production regular irrigation is needed. Lack of moisture results in stunted growth and poor fruiting. During summer, irrigations are to be given at 5-6 days interval and during winter 8-10 day's interval. Ring system of irrigation is better. This method prevents water coming in contact with the trunk. So, it prevents collar rot disease.

Interculture: Land should be ploughed and harrowed cross wise at least twice in a year. Frequent weeding around the stems is necessary. When the entire area is covered by the foliage the weeding may not require.

Intercropping: When papaya is grown as a pure crop. Vegetables can be profitably grown as intercrops for about 6 months from planting of papaya seedlings.

Flowering and fruiting: Starts flowering in 5-6 months after planting. Fruit setting commences a fortnight after flowering. Fruit takes 4 to 5 months to reach full maturity. Fruiting continues through out its life.

Harvesting: Starts in about 9-10 months after planting. The maturity is well indicated by colour change and the consistency of latex. The latex of mature fruits becomes watery. Fruits for local consumption should be picked when the green colour is half way changed into yellow; for export it is necessary to pick sooner, after the blossom end has turned colour Individual fruits should be harvested by twisting by hand without damage.

Yield: Average yield is about 75-100 tones per hectare. Peak yield during 2nd year and decline by third year. Economic life of papaya is 2 to 3 years.

Papain: The cultivation of Papaya for producing papain will be a profitable proposition. Substantial quantities of papain can be extracted by adopting correct techniques. Papain is the proteolytic enzyme present in the milky latex obtained from green fruits of papaya. This enzyme is exclusively exported and there is great demand in the

international market. Papain is used in breweries, especially for clarification of beer, medicines, cosmetics, tanning industry, tenderization of meat and fish, extraction of animal and plant protein from various animals and plants etc. In the medicinal field, papain finds use in the treatment of insect bites, itching of skin, cancer,displaced disk in the spinal cord, dyspepsia and other digestive ailments, ring worm infection, skin lesions and disorders of kidney. Several proprietary pharmaceutical preparations using papain are available in the market now.

Papain extraction: The latex should be tapped from 75 to 90 days old immature papaya fruits early in the morning up to 10.00am. On the selected fruit, four longitudinal incisions should be given using a razor blade attached to bamboo splinter. The depth of the cut should not be more than 0.3cm.The tapping has to be repeated four times on the same fruit at an interval of 4 days. The latex should be collected in aluminum trays and shade dried. The dried latex is then packed in polythene bags. Before drying, potassium meta-bi-sulphate (KMS) 0.05% has to be added to the latex for better colour and keeping quality. The latex can also be dried in oven at a temperature range of 50-55 ^{O}C.

Papain yield ranges from 1.23g to 7.45g per fruit and the cultivar. Washington variety recorded the highest mean yield of 7.45g per 100-150g of dried latex / tree / year.

Varieties suitable for Papain: CO-2, CO-4, CO-5, Coorg honeydew, Pusa majesty and Pusa delicious.

Time for papain extraction: Cool and wet period–gives more papain. July to August is the best period.

POMEGRANATE

Botanical name: *Punica granatum* **Family:** Punicaceae

Origin: Iran (Persia)

Pomegranate was introduced into India from Persia or Afghanistan. It is a favourite table fruit in tropical and subtropical regions of the world. In India it is a well-known and widely grown fruit.

The fruit is liked for its cool and refreshing juice besides its use as a table fruit. It also possesses a no. of medicinal properties. The juice is considered to be useful for patents suffering from leprosy. The bark and rind of the fruit are commonly used against dysentery and diarrhoea. The rind of the fruit is also a source of dye, which gives yellowish brown colour and is used for dyeing wool and silk. Flowers yield a light red dye used in dyeing clothes. Tannin also occurs in all parts of the fruit and is used in tanning leather.

The fruits are a good source of sugars (14-16%), minerals (0.7-1.0%) and a fair source of Iron (0.3-0.7 mg/100 g.)

In A.P it is grown in Ananthapur, Rangareddy, Medhak, Mahaboobnagar and Adilabad districts.

Climate: pomegranate is mainly subtropical fruit However; it can adopt itself to wide range of climatic conditions and can grow up to **1800m** above sea level. The tree grows best in semiarid climate where cool winter and hot dry summer (Which is present in Baluchistan, Afganisthan and Iran) prevail. The tree requires hot and dry climate during the period of fruit development and ripening. The optimum temperature for fruit development is **38^{O}C**.The tree can not produce sweet fruits unless the temperature is high for a sufficient long period. Under subtropics it is deciduous in nature while in tropics it is evergreen. Under humid conditions, the sweetness of the fruit is adversely affected. Therefore it is considered that pomegranate is a hardy fruit and can thrive well under drought conditions though the yield is low.

In areas of low temperature, the tree behaves as deciduous in nature and sheds its leave during winter months. Aridity and frequent anomalies of the climate cause leaf shedding and fruit cracking.

Soils: It can be grown on varied types of soil. The deep loamy or alluvial soils are ideal for its cultivation. It can tolerate soils, which are slightly alkaline. It can thrive well

on comparatively poor soils where other fruits fail to grow. It can also be grown in medium and black soils. It is rated as salt-hardy fruit plant.

Propagation: Pomegranate plants raised from seed vary widely and are undesirable. Thus they must be raised vegetatively. Among the vegetative methods of propagation hard wood stem cuttings, air layering and root suckers are the important methods. Among these methods, **stem cuttings** are universally used for raising plants on commercial basis**.**

Stem cuttings: Mature wood is used for making the cuttings. Cuttings of 20-25cm. long are prepared from high yielding plants of 1-year-old wood. The best time for making the cuttings is December-January when the plants shed leaves.

Treatment of cuttings with IAA 200 ppm or soaking basal part in 50 ppm solution for 18 hours improves rooting markedly. During monsoon season in S.India the cuttings are planted directly in the nursery beds or in polythene bags. Rooting starts in 15-20 days after planting. The plants are usually ready for transplanting with in 8-9 months.

Air layering: Pomegranate can also be propagated by air-layering or goote. Treatment with 10000 ppm Indole Butyric acid in lanolin paste was found to improve rooting. The best period for air layering is rainy season. The survival of rooted layers is poor in the field. Simple layering can also be practiced.

Root suckers: Healthy root suckers are taken out carefully and planted in the beginning of monsoon season. This method of propagation is possible on a very small scale because the availability of root suckers in large number is very difficult.

Varieties: Initially many cultivars of pomegranate were introduced in to India from Afghanistan, Iran and Iraq, but they failed to establish because of disorders caused by non-availability of chilling requirement during winter season.

Several types of pomegranate cultivated in India are distinguished by the shape of the fruit, the colour, thickness of the rind, taste and colour of the seeds. The rind may be thick or thin; colour may vary from pale yellow to crimson. The seed pulp in superior types is thick; flesh is very juicy, while in inferior types it is thin. The seed coat varies in hardness. Some of the soft seeded types are known as seedless. Lack of lignification of the testa is the main cause of seedless ness in pomegranate.

Good taste, flavour and attractive seed colour (Aril) are favoured by the consumers, but all these characters are not found in any single cultivar. However on the basis of yield and other quality characteristics various varieties have been recommended for commercial cultivation. The important commercially grown varieties are-Bhagwa, Bedhana, Jodpur, RedDholka, Ganesh, Alandhi, Musket Red, Jalore seedless, jyothi, Papershell

The edible part of pomegranate fruit is the juicy outgrowth of the seed called the **aril**.

Hybrids:

Mridula: MPKV Rahuri, Maharastra, developed this variety. A seedling selection from an open pollinated progeny rose from F1 progeny of a cross Ganesh X Gul-e-sha Red. Fruits are medium sized, rind smooth, and dark red in colour. Arils are blood red with very soft seed, juicy and sweet taste. It is significantly superior to other commercially grown pomegranates. The fruits weigh between 230-270g.The TSS of the fruit is 17-18^{O}Brix and acidity of 0.47%.

Ruby: This was released from IIHR-Bangalore. This is a complex hybrid between Ganesh, Kabul, Yercaud and Gul-e-sha Rose pink varieties. The fruit weighs between 225-275g.The-rind colour is red, seeds are soft with dark red coloured arils having TSS of 17^{O} Brix and 0.64% acidity.

The other important varieties are Spanish Ruby, Vellodu, Kabul, Khandhari, and Arakta

Land preparation and planting: Land is prepared thoroughly prior to pit digging It should be well leveled. Pits are dug 60-75 cm^3 before the on set of monsoon. The pits are filled with 20-25 kg of FYM or Compost, 1 kg. Of super phosphate and 25 grams of phorate granules with the good soil mixture. The plants are planted usually in the beginning of the monsoon in S.India and January to mid February i.e., during dormant period in N.India, in square or hexagonal system of planting. The distance of planting in case of many improved varieties is **5.0 X 4.0m.** It was also recommended that for higher yields for the first 4-5 years after planting, a distance of **5X2m** may be adopted and alternate plants may be removed afterwards maintaining a planting distance of 5X4m. However planting distance of **3.0 X2.5 or 4X2 m** has been reported to produce high and economic yield of good quality fruits.

Irrigation: The newly set plants require regular irrigation so that the roots become well established and the plants can start growth. The plants may be individually watered daily or about a week after planting. In northern India where planting is done during the spring, regular watering may be given every 7 to 20 days till the start of the monsoon. In areas where planting is done during the monsoon, irrigation may be given whenever there is no rain for a prolonged period of time. After the plants are well established, in about 6 months, they can stand considerable amount of drought and irrigation may be given at intervals of 2 to 4 weeks depending upon the soil, climate, weather conditions and intercrops grown. Regular irrigation is essential from flowering to ripening of fruits, as irregular moisture condition results in dropping of flowers and small fruits.It may also development of cracks on mature fruits, which reduces market value and consumer acceptance.

Manures and fertilizers: It is a hardy fruit plant, growing successfully in low fertile soils. Its productivity can be increased by application of manures and fertilizers. Both macro and micro nutrients affects its growth, development and productivity. One year old plants should be manured with about 10 kg.of FYM and 150 to 200 grams of Ammonium sulphate.This amount is increased every year, so that a five year old plant

gets 50 kg FYM and 1 Kg of Ammonium sulphate.The adult bearing trees are applied with 675g of Nitrogen, 250g each of Phosphorous and Potash. In case of zinc deficiency Zinc sulphate @ 5 g per litre of water is dissolved and sprayed twice on the new foliage. For controlling boron deficiency, application of Borax @ 12.5 g per plant to soil or borax @ 2 g per litre is dissolved in water and sprayed.

Training: Pomegranate may be trained as multi-stemmed tree or single stemmed tree.

(ii) **Single-stemmed tree:** The single stem is left by removing all the side shoots at the time of planting. The main stem is headed back at a height of about one metre results in the formation of branches. Four or five well distributed branches on all sides above 60 - 75 cm from the ground level are allowed to grow. In the third year of planting one can maintain desired shape of the pomegranate. Single stemmed tree has tendency to produce less number of shoots.

The single stem system has its own disadvantages. The plants have a tendency to produce ground suckers, making the plant bushy. As such it is rather difficult to train the plant to a single stem. The crop is highly susceptible to stem borer and shoot hole borer. More over this system is hazardous. Thus single stem system of training is uneconomical for commercial cultivation. Therefore multi stem system of training is more prevalent in the country.

(i) **Multi-stemmed tree:** In this method 3 - 4 stems are left at hill and remaining shoots are removed. In Maharashtra, the growers prefer multistem training by retaining all stems. But yield has not been found to be affected by number of stems per plant.

Pruning: Pomegranate plants don't require pruning except removal of ground suckers, water shoots and criss cross branches, dead and diseased twigs and giving a shape to the tree. In pomegranate fruits are borne terminally on short spurs arising from matured shoots, which have the capacity to bear fruits for 3-4 years. With the advance in age they decline. Limited pruning of exhausted spurs to encourage the growth of new ones is practiced.

Flowering and crop regulation: Depending on climatic conditions of a particular location, pomegranate has different flowering and fruiting seasons in India. Under tropical climate of S.India, with mild winter, the growth and flowering continues through out the year. Similar pattern is also observed in sub-tropical, central and Western India. In the above areas there are three seasons of flowering. In N.India two seasons of flowering have been reported. In temperate climate the flowering is seen in one season i.e.during April. The flowering period of different cultivars is also quite variable. Under Delhi condition, depending on cultivar grown, the flowering may be once or

twice.Dholka, Khandhari, Muskat and Patiala flowered only once in a year, while Ganesh and Japanese dwarf flowered twice.

Pomegranate produces flowers on previous season's growth as well as on one year to two years old spurs. Flowers are borne in clusters or in single depending upon the character of the variety. Flowers are borne on leaf axils and also some times terminally. These flowers are hermaphrodite, male and or intermediate.

The three distinct seasons of flowering in Pomegranate have been named as:

1. Ambe bahar (February-March)

2. Mrig bahar (June-July)

3. Hasta bahar (September-October)

Bahar Treatment for crop regulation: A fully grown pomegranate has a tendency to bear flowers and fruits through out the year. Owing to this, higher yield is not obtained during any period. Therefore, to obtain higher fruit yield during a particular period, pomegranate plants are given a resting period by which the natural tendency of trees is altered with artificial means. Manipulation of flowering in a desired direction is called bahar treatment. This treatment also helps in getting uniform and good quality fruits with a maximum production with fewer incidences of pests and diseases.Bahar treatment include root pruning, root exposure, use of chemicals, with holding water for about two months before flowering.

Selecting a bahar at a location depends on:

- Availability of water for irrigation
- Occurrence and extent of fruit damage by insect-pests and diseases affecting fruit quality.
- Climate of the area
- Availability of fruit in the market
- Comparable yields

Normally only two bahar treatments are followedi.e.Ambe- bahar and Mrig-bahar. Hastha-bahar is seldom selected. For practicing Hasth-bahar, the trees have to be forced to go in to dormancy by with holding water during August-September. This is rather uncertain because of the rains that occur during this period.

Ambe-bahar is practiced by with holding water after the end of monsoon. When the trees shed their leaves in October-November, subsequent land operation, manuring and irrigation induce the plants to flower during December-January and the fruits mature during July-August. This bahar is economical wherever irrigation facilities are available.

For Mrig-bahar, the growth of plants has to be suppressed during December-April by withholding water. The trees shed their leaves in March and remain dormant till May. Subsequent soil operation followed by application of manures and fertilizers and irrigation till the rainy season, induce flowering and fruiting where the fruits are harvested during October-November.

Harvesting: Generally the fruits ripen in about 5 to 7 months from the time of flowering stage. Mature fruits should be immediately picked from the plants after maturity stage, as delay in harvesting leads to fruit cracking.

Fruits are harvested in the morning and evening times. Fruits should not be twisted and harvested. Fruits should be harvested with the help of clippers retaining 1 cm of the stock. All the fruits should be harvested in 2 to 3 pickings with in a span of 1 month. Immediately after harvesting the fruits are kept in plastic crates and taken to a cool place. Afterwards the fruits are cured in shade. This will make the skin harder and will stand better in transportation

Maturity indices:

a) Fruits are ready for harvesting in about 150 to 170 days.
b) External colour of fruit changes from green to yellow or red yellowish brown.
c) Fruit becomes soft.
d) Ridges on the fruit become flat.
e) Floral parts on the fruit dry out.
f) Fruits when tapped produce a metallic sound or cracking sound.
g) Acidity of the fruit should be less than 1.85%.
h) Basal beak shaped portion shrinks at the time of maturity.

Fruits harvested at a premature stage show poor keeping quality and are prone to damage during handling and transport.

Physiological disorder:

Fruit cracking: It is a serious problem and is more intense under dry conditions of the arid zone. The fully grown mature cracked fruits though sweet loose it's keeping quality and becomes unfit for marketing. They are liable to rot qualitatively. The cracked fruits show reduction in their fruit weight, grain weight and volume of juice. It is mainly associated with fluctuation of soil moisture, day and temperature, relative humidity and rind pliability. This disorder may also develop due to boron deficiency in young fruits and moisture imbalance in mature ones.

Prolonged drought causes hardening of peel. If this is followed by heavy irrigation or rains the pulp grows and peel cracks. Cracking of fruits is also due to rise in air temperature during fruit growth and development. It is also a varietal character, since the rind thickness and texture are related to proneness to cracking. The percentage of cracked fruits is also related to season. Mrig-bahar (June-July) crop is more susceptible to fruit cracking because of variation in humidity. Ordinarily regular rains are received up to August, so that

the fruit continues to develop. If there is a break in rains the growth of the fruit is arrested. As a result of this dry period the skin looses its elasticity and becomes hard. When there is a rain again the growth restarts resulting in cracking of fruits because of lack of elasticity of fruit rind.

Control :

- Adequate and regular irrigation and interculture throughout the bearing period.
- Cultivating tolerant/less prone types like Karkai, Guleshah, Bedana, KHog and Jaloreseedless and avoiding cultivation of susceptible varieties like vellodu, Kabul and Khandhari.
- Spraying Borax@ 0.1 to 0.2%
- Spraying of GA_3 in the month of June at 250ppm
- Planting wind breaks around the garden.

Annonaceous Fruits

Annonaceous fruit include **custard apple or sithapahal** (*Annona squamosa*), **Bullock's heart or Ramaphal** (*Annona reticulate*),**cherimoyer or lakshman phal** (*Annona cherimola*) and **sour sop**(*Annona muricata*).Among these fruits, sithaphal is available on a fairly large area and hence is of commercial importance. The other fruits mentioned above are not available or cultivated on a large scale and so are of not commercial importance.

Custard apple

Botanical name: *Annona squamosa* **Family:** Annonaceae.

Origin: Tropical America.

Custard apple has been growing in India from time immemorial. It is found growing wild in tropical and subtropical parts of India in forest areas and on hill slopes. Andhra Pradesh is the major custard apple growing state in India.

In A.P it is being grown on a large scale in Mahaboobnagar district in Balanagar area and in the uplands of Rajhamundry and Peddapuram taluks of East Godavari district.

The custard apples are rich source of carbohydrates, protein, fibre, minerals like calcium, phosphorus and iron and VitaminC.They are considered as good energy source.

Custard apples are mostly consumed as table fruits. They can be preserved as jam, jelly and are also used in ice creams. Baked fruits are also commonly eaten in A.P.
The edible portion of the fruit is creamy, granular with excellent blend of sweetness and acidity.
Besides high nutritive value, it has also a high medicinal value. Oven dried kernels of seeds contain about 30% oil which is used for making soaps and cake is used as manure. Due to the presence of **Annonaine**, the leaves stem and other parts of the plants are bitter. Because of this bitterness goats or cattle do not attack the plant. The leaves of sithaphal yield a tetra hydro isoquinoline alkaloid, which is a cardio tonic active principle. It was identified as **higenamine.** An alcohol **Ancorin** has been extracted and this is considered to possess insecticidal property. Traces of Hydrocyanic acid (HCN) have been found in the leaves, bark, root and seeds.

Climate: Annonas are mostly sub tropical fruits. They prefer warm climate and moderate winter and humidity. The tree remains dormant for a short period during cold season i.e. the months of December to February and shed their leaves. The prolonged cool weather and frost adversely affect its growth. High temperatures affect fruit growth and yield due to soil moisture stress. Custard apple can thrive well to an elevation of 1000 meters above sea level. Annual rainfall of 50-75 cm is considered adequate for its growth and fruiting. Moist climate is favourable for proper growth and development. Mild summer and evenly distributed rainfall is favourable for its higher yield. Warm temperature with high humidity and occasional rains are required for good set and development of custard apple fruits.

Soils: Custard apple grows well on sandy, rocky, gravely and even on heavy soils. The tree is rather shallow rooted. So, it does not require a deep soil but drainage should be proper, as it suffers from water- logging. Sub-soil with hardpan or having high water table needs to be avoided. It can tolerate salinity to a great extent but doesn’t withstand alkalinity.

Varieties: Custard apple is a seed propagated crop. Custard apple seedlings are found growing wild in India. Since custard apple is a cross-pollinated crop wide variation in form, size, colour of the pulp, seed number, quality and yield. This natural variability available with in the species is often exploited to identify superior genotypes which are usually named after the place of collection like Balangar, Washington, colour of the fruit like red custard apple, crimson custard apple, yellow custard apple and size of areoles like Mammoth.
Some of the varieties grown commercially in different agro-climatic regions of the country are-Lalsithapal, Mammoth, Balanagar, British Guinea, Pinks Mammoth, Island gem, Washington, Arka Sahan, Atemoya

Propagation: Both sexual and asexual methods are employed for propagating the annona plants. However to maintain the genetic uniformity for obtaining higher yield of better quality fruits, the clonal propagation is a must. Diffrent methods of vegetative propagation are-cuttings, grafting and budding.

Cuttings: A very high rooting success (90%) has been recorded when custard apple cuttings were etiolated 15 days before planting treated with NAA 5000ppm and rooted under intermittent mist. Root cuttings of custard apple have given only 2-5% success.

Budding: Custard apple can be successfully propagated through budding. Among the budding methods shield, patch, modified forket and chip budding, shield budding is most successful. Sithaphal on its own rootstock and on cherimoyer has given 60-80% success. Budding is done in early spring when the sap starts flowing or in the autumn. For taking bud wood, dormant, last year's shoots should be preferred. The seedling rootstocks, however exhibit wide variability in growth and yield of scion.

Grafting: It can be propagated successfully by grafting. Among the grafting methods like tongue, cleft, veneer, inarching, splice, inarch grafting on *A.cherimola* and *A.reticulata* is more sucessful. The latest technique of custard apple propagation is by veneer grafting. This method is being adopted on a commercial scale at FRS Sangareddy.

Variability in seedling rootstock performance is a major cause of scion with regards to yield and fruit quality reduction. It is suggested that clonal propagation of cultivars or rootstocks would eliminate most of this variability.

Planting: There are hardly any commercial plantations of custard apple in India except a few orchards in Saurastra region of Gujarat. The fruits come in the market from semi-wild forests in Deccan plateau.

About 6months to one year old seedlings and grafts are considered quite suitable for transplanting when they are not raised *in-situ*.

The pits of 45-60cm^3 are dug on deep soil where as dimension of pit increases on poor soils to 75cm^3 to 90cm^3. Pits are filled with a mixture of top soil, Farm Yard manure (15-20 kg) and 300 grams fertilizer mixture of urea, super phosphate and muriate of potash in equal proportion. This promotes excellent growth of newly set plants.

The distance of planting on poor soil is 4m and on good soil is from 5-7m both ways in square system. Closer planting is recommended in rain fed regions with a view to improve pollination by maintaining more humidity.

The best time of planting for custard apple is in the beginning of rainy season to avail the advantage of rainwater.

Training and pruning: Newly planted custard apple plants are trained with wooden sticks fixed near the stem. It will help to grow plants straight. The plants are trained to single stem up to 1m height.

The custard apple is very slow growing plant. It forms a small bush with large no. of branches of various sizes and ages. The fruits are borne on new as well as old wood. Light pruning of old wood induces better branching of the plant. Pruning can best be done to avoid over crowding and to promote well spread branches. In budded plants the growth is uniform and there is very little need for any pruning. The custard normally goes to dormancy from **November to December**. The leaves gradually turn yellow at the time of harvest of fruits and drop with the approach of winter. The plants remain in leafless condition for about two months in the winter season and new growth emerges with the onset of spring. Pruning should be carried out when the plant is to put forth new growth in early spring after dormancy.

Manuring and fertilization: The custard apple is mostly cultivated on poor soils, thus manures and fertilizers should be applied for better growth and yield. Fertilizer application checks decline and extend longevity of trees. The flowering can be advanced by 10-15 days with high doses of nitrogen and phosphorous, but low nitrogen delayed flowering by over two months. High nitrogen rates resulted higher flower production while high N, P and K enhanced the fruit set.

For bearing plants 50 kg of FYM, 1 kg of Castor cake, and 1 kg.of bone meal are to be applied during June-July. 250g of N, 125 g of SSP, 125 g of potash should be applied in two splits when there is moisture in basins i.e. during June-July, and August-September. The fertilizer dose for young plants has been recommended as 250g of N, 125g each of P_2O_5 and K_2O.The fertilizers should be applied on the commencement of rainy season.

Irrigation: The fruit set and development of Annonas occurs during rainy season, thus they produce a fair crop even without any irrigation. Therefore, annonas are considered drought tolerant. Two to three irrigations before the onset of monsoon to promote fruit set and one to two irrigations after the monsoon to increase fruit size should be given to Custard apple.

Water stagnation during heavy rains causes tree decline. Such trees shrivel and drying of old branches takes place and sometimes they may die suddenly.

Intercultural operations: For good health of the plants it is necessary to keep the weeds under control. One harrowing during August - September checks the growth of the weeds and also conserves moisture.

Custard apple bears flower on the current season growth and very rarely on older wood. The early completion of leaf fall is essential for the initiation of the new growth. Therefore manual defoliation during mild summer is recommended.

Inter cropping: Intercropping is not generally practiced in Custard apple orchards. However growing of legumes as inter crops, up to the period of full development of plant canopy, helps in improving the soil texture and fertility, and it directly affects

plant growth and productivity. Crops like groundnut, black gram etc. in rainy season and gram, pea etc. in winter can successfully be grown as intercrops.

Flowering and fruiting: Custard apple has a short juvenile period. The plants begin flowering within 4 years of planting. *Annona* species bears flowers on old and current season's growth. The flowering period of custard apple is very long commencing from March-April and continues up to July-August. The peak flowering is observed in April and May. From initiation, a floral bud develops in to flower in 27-35 days depending on the species. No fruit set occurs during the entire spring and summer and it commences only during the rainy season, leaving little period for the late set fruits to develop before the onset of winter season. The setting of fruits early in the season is important because immature fruits instead of developing become inedible in winter season and turn in to stone fruits.

Factors affecting fruit set: A custard apple tree may bear 1500-2000 flowers but hardly 2-3 percent sets fruit. This low fruit set is due to Dichogamy, high temperature and low humidity at the time of flowering and lack of pollinating agents.

The setting of fruit early in the season is important, but in India the early flowers produce no pollen and hence artificial pollination is difficult. It is possible to increase the set of fruits during the rainy season. By hand pollination of flowers 85% set can be obtained compared with 30% in natural pollinated ones

Another factor, which may affect the fruit set, is dichogamy. Some custard apple trees shed pollen in the morning and others in the afternoon. The stigmas are not receptive when the pollen is shed and the receptivity also remains for a short period. Hence it is cross-pollinated. Pollen grains are sticky; the wind pollination is very less effective. There are no insect pollinators in Annona.

Increase in fruit set is possible by application of NAA at 20 ppm during flowering for 3-4 times at 8-10 days interval and spraying with GA_3 at 50 ppm.

Harvesting: If the fruits are left on the plant unduly long they split up and damaged. Custard apple fruits are climacteric; therefore they are harvested when they are mature, firm and plumpy. Fruits are harvested when the segments become conspicuous and the colour between the segments changes from white to light yellow or orange. Fruits also changes colour from green to light green. The skin between the segments turns into light yellow colour when the fruits have fully matured. It ripens within a week after fruits are harvested. If the fruits are harvested before maturity the segments held together and the fruits become hard, the pulp ferments and the quality is poor.

Yield: In custard apple seedling plants start fruiting in 4-5 years while grafted or budded plants give fruits in 3-4 years. After 15 years reduction in fruiting has been

noted. The period of fruit development from flowering to harvesting covers about 4 months.

A good bearing tree of custard apple gives about 100-150 fruits. Each fruit weighs about 80-120 grams and contains 30-60 seeds. Well-managed crop produces about 8-10 tones of fruits per hectare depending on the variety grown.

Disorder in Sithaphal:

Stone fruits: The sithaphal plants go to dormancy immediately after the harvest of the crop. In neglected trees the dormancy starts very early. At this junction the fruits on the tree suddenly turn brown. Such fruits are known as stone fruits. These fruits continue to stay on the tree even after the fruits have shed or even after new growth commenced in spring.

The occurrence of such fruits is common in sithaphal during November-December. The formation of stone fruit may be due to physiological disorder or malnutrition.

Application of super phosphate and bone meal improves crop yield and reduce formation of stone fruits. When trees are cultivated and attended properly fruits reach at harvest earlier than the dormancy period and thus escape development of stone fruits.

Pineapple

Botanical Name: *Ananas comosus* / *Ananas sativus* **Family:** Bromeliaceae

Origin: Brazil

Pineapple is one of the commercially important fruit crops of India and most delicious of the tropical fruits. It is known as "**queen of fruit crops"**. The name pineapple is derived from Spanish name **'Pina',** given to the plant based on the appearance of its fruits, which resemble a pine cone. The name **'ananas'**, which later became the generic name, is derived from Tupi Indian name **'nana'**. In Gurani language, **'a'** means fruit and nana means**'excelling'**.The generic name,'**Ananas'**,thus stands for the excellent edible quality of this fruit.

The fruit is a good source of Vitamin A and B and is very rich in Vitamin C and calcium. It contains phosphorous and iron. The fruit contains a special enzyme called 'Bromelin' which digests protein. It provides adequate roughage to prevent constipation. Fruit is used for table purpose, preparations of juices, slices, tit bits, squash, jam, mixed jam, candy etc. The fruit juice is also canned. Dried waste after extraction (pomace) is valuable cattle feed. Pineapple juice is also utilized in the manufacture of alcohol, calcium citrate, citric acid and vinegar.

Fruit of pineapple is botanically called, 'Sorosis'. Botanical name of pineapple is *Ananas comosus* and family is Bromeliaceae.

Pineapple has spread to other tropical parts of the world from its origin of Brazil. In 1548 it reached to India.

Climate: It is a tropical fruit crop. It thrives well in mild tropical climate. It grows well near the coasts well as in the interior, so long as the temperatures are not extreme. The optimum temperature ranges from21-23^{O}C. At low temperature, no fruit bud differentiation takes place. It can be grown up to an elevation of 1100m above the sea level; provided they are free from frost. It requires an optimum rainfall of 150cm which should be well distributed. Where the rainfall is less, supplementary irrigation must be provided.

Soil: Pineapple can be grown on any type of soil (except heavy clay).However, Sandy loams, laterites and slightly acidic soils with pH 5.5 to 6.00 are suitable for crop cultivation. The soil should have a depth of at least 60cm with out hard pan beneath or water logging. Soils should have low calcium content.

Varieties: There are many pineapple varieties, which are divided into three groups, according to Hume and Muller's (1904) classification. They are Cayenne, Queen and Spanish.Some cultivars grown commercially in India are-Giant Kew, Kew, Queen, Mauritius, Jaldhup and Lakhat, Charlotte Rothschild etc.

The varieties of Cayenne and Spanish group are dual purpose (fresh fruit and canning) ones, where as varieties of queen group are grown exclusively for fresh fruit purpose as they are not suitable for canning owing to deep eyes.

Kew is more suitable for canning because of its shallow and broad eyes and it is shy suckering where as queen is not suitable for canning because of its prominent eyes irregular and deep set and it shows high suckering habit.

Propagation: Pineapple is mainly propagated by vegetative methods. It can be propagated by shoot suckers, ground suckers, slips, crown, and stem bits and from splitted crowns. However, suckers and slips are usually preferred for planting since they flower comparatively earlier than crown. Propagation by crowns is very limited. Use of stumps or discs for planting in India is very rare.

Suckers: Suckers are the shoots arising either from the leaf axils on the main stem below the fruit or from the base of the plant near the ground. The suckers are preferable for planting, since the plants bear the first crop earlier than the slips in 14-18 months.

Slips: The slips or the gills are the shoots borne on fruiting stem ie.shoots arising from immediately below the fruit. Plants from the slips give large sized fruits though late in production ie.20-22 months for the first corp. Slips are used for planting commonly in shy suckering varieties like giant Kew and Kew.

Crowns: Crowns are often used as propagating material in Kew variety because of its shy suckering habit. These are late fruiters and take about 20- 24 months.

Stumps: Stumps are the stocks of the fruits. These are also some times used to make up shortage of planting material. Stumps are cut into bits known as discs and they are first planted in furrows and are allowed to sprout. Later the new shoots are separated and planted. This should be avoided since the resulting plants produce irregular plants with low production.

Preparation of the land - The selected site of land for planting should be prepared very thoroughly by ploughing and cross ploughing. If the land is undulating terracing should be practiced. The land should be dug up to a depth of 40-50cm. till a fine tilth is obtained. At the last round of ploughing or digging FYM or compost is applied. After leveling, the land is laid out into trenches alternating with mounds for planting the suckers. For double row system of planting, two shallow furrows about 10-15cm depth are to be opened.

Suckers of uniform size (400-450g) should be selected for planting as they give best yields compared to higher or lower size categories of suckers. Planting material should be collected from high yielding well maintained gardens, which are free from pests and diseases.

Preparation of the planting material-At the time of planting few basal scaly leaves of the suckers should be stripped off to encourage the formation and entry of roots into the soil. Before planting, the suckers should be dried for one or two days, by

spreading them upside down. Fresh suckers should not be planted in moist soil, otherwise they decay. The suckers should be dipped in Bordeaux mixture (1%) or Dithane Z-78(0.3%) and Difoltan (0.2%) to avoid mealy bugs and heart rot.

Planting methods: The popular method of planting pineapple is the double row system. The two rows are spaced at 60cm apart and in each row the plants are planted at 45cm apart in such a way that no two plants are exactly opposite each other. The double rows are spaced at 1.5 to2.0 meters. In this method15,000 to 20,000 suckers can be accommodated per ha. When it is desired to have more than two ratoon crops, the above method can be adopted. Otherwise close spacing may be chosen. In this method, early and higher yields are obtained from a unit area. In this method a spacing of 25X60X105cm or 25X60X90cm is adopted. This accommodates 49,000 to 53,000 suckers per hectare.

Planting: Planting may be done normally during the rainy season, avoiding periods of heavy rainfall. July and August are the best months.However, where irrigation facilities are available, planting can be taken up all-round the year to ensure supply of fruits throughout the year.

Interculture: After planting, wherever weeds appear interculture should be done without digging of the soil deep. Mulching with dry grasses, straw, saw dust, coir dust, rice husk etc. will also help to suppress weed growth, conserve moisture, and maintain the humus status of the soil.

To achieve good fruit size and uniform cylindrical shape, the crowns of fruits may be removed with a sharp knife, when they are 5-10cm long. In hot weather, the fruits may be covered by wrapping with the leaves or dry grass or straw or banana leaves or paper covers for protection from sun scorch.

Manuring: After plants have established apply 35g.of Urea, 13g.of Super phosphate and 6-8g. of Muriate of potash per plant two to three times.

FYM	-20-25 tonnes
Nitrogen	-350kg/ha
P_2O5	-130kg/ha

K_2O	-40kg/ha

FYM and P_2O_5 may be applied as basal dressing at the time of last ploughing or digging. Nitrogen and K_2O are to be applied in three split doses i.e.60th, 150th and 240th days after planting. Nitrogen may be supplied in the form of ammonium sulphate.Immediately after manuring the crop should be irrigated and then earthed up to provide better anchorage to the plant.

Irrigation: Though pineapple is a drought resistant crop, for getting high yields, it should be irrigated, at least during the dry periods. Irrigations are given for getting better sized fruits. Therefore 4-5 irrigations in hot months at an interval of 15-20 days will ensure a good crop.

Flowering: One of the major impediments in successful cultivation of pineapple is its erratic flowering behaviuor.Evenafter 15 to 18 months of growth under ideal management less than 40 to 50% of the plants normally flowers leading to overlapping of operations and irregular supply of fruits to canning factories. Therefore, it is of utmost importance to regulate flowering for better returns as well as to have regular supply to canners. Regulation of flowering will also be beneficial in economizing labour requirement.

To achieve uniform flowering in pineapple NAA in the form of **'Planofix'** at 10-20ppm (1ml planofix in 9 litres of water) or a mixture of 10ppm of **Ethephon(Ethrel)**+2%**urea**+0.045% **sodium carbonate** may be poured (50ml) in the heart of the plants 15-16 months after planting on a clear sunny day. The ethephon solution should be used immediately after preparation.

Cropping: The plats generally flowers12 months after planting from February to April. The fruits take about 135 to 165 days to mature and ripen. The fruits ripen from June to September depending on the variety in our state.

Harvesting: The plats generally flowers12 months after planting from February to April. The fruits take about 135 to 165 days to mature and ripen. The fruits ripen from June to September depending on the variety in our state.

When at least 2 or 3 rows of eyes at the base have turned yellow, the fruit is ready for harvest. However for distant markets the matured fruits are to be harvested. Harvesting may be done with a long, sharp knife, cutting the fruit stalk few centimeters below the base of the fruit. The fruit with the crown can be kept without damage for 3-4 days after harvest.

Yield: The yield per hectare varies from 40-60 tonnes depending upon the variety.

Ratoon crop: Ratoon cropping is common in pineapple. After the harvest of the first crop, all the suckers borne on the plant should be removed leaving only one sucker on the mother plant. Similarly all slips should be removed. Then the plants are fertilized, irrigated and earthed up so that the plants have good anchorage for the ratoon crop. The crop is retained like this for four or five years and then removed.

BER
(JUJUBE)

Indian Ber : *Zizyphus mauritiana*

Chinese ber: *Zizyphus jujuba*

Family: Rhamnaceae

Origin: Indo-China region

The ber is an ancient fruit of India and China. It is being grown, since 4000 years in China. It is found growing wild, semi- wild and cultivated farms practically all over the country.

Although ber is often referred as poor man's fruit, yet it is not a poor fruit. It excels many important fruits in vitamins and minerals. The ber fruits are rich in nutritive value. They contain considerable amounts of protein, minerals, vitamin 'C' and carotene. Vitamin 'C' content of ber fruit is more than that of citrus fruits.

Climate: It grows under varying conditions of climate all over India even at an elevation up to 1000 m above mean sea level. For its successful cultivation, it favours a hot and dry climate. It can withstand extremely hot conditions but it is susceptible to frost. The trees shed leaves and enter into dormancy during summer. Under moderate climate of south India, however, the trees continue to grow throughout the year. It is extremely drought hardy owing to its deep root system and other xerophytic characters. The tree prefers dry atmospheric conditions for development of good quality fruits. High atmospheric humidity is distinctly disadvantageous particularly during fruiting.

Soil: It adapts to a wide variety of soils, varying from shallow to deep and from gravelly and sandy to clayey. Ber can also withstand alkalinity and slightly waterlogged conditions. It can also be grown on marginal lands which are unfit for growing other fruit crops. However, deep sandy loam soils which are neutral or slightly alkaline provide best media for its excellent growth and fruiting. The ber tree is drought hardy and can grow under the most hazardous conditions of soil, water and climate.

Varieties: Numerous horticultural varieties of ber are grown all over India. Some of the most popular varieties are - Umran, Kaithli, Banarasi karaka, Gola, Seb Dandan, Meharun

The other important varieties are Sanur-2, Meharun, Dandan etc.

Propagation: The Ber was commonly propagated by seeds during earlier period. But main disadvantage of this method is of heterozygosity and variability in seedling progeny. Therefore, propagation of superior varieties by budding is recommended. Among the different methods of budding adopted, the most common method is shield budding on a suitable rootstock. For raising a budded plantation, it is considered best to sow ber seeds in the field itself at proper distances and use the seedlings thus raised for budding in *situ*.

The commercial method of propagation of ber in India is by budding. Among the different methods of budding adopted, the most common method is shield budding on suitable rootstock.

Rootstock: Two species of Zyzyphus namely *Zizyphus rotundifolia and Z.nummularia* are growing wild in India and are known for their extensive root system and hardiness. The ber plants should be budded on *Zizyphus rotundifolia* for higher fruit yield. The seedlings of *Z.nummularia* are slow growing and become buddable after a long period than *Zizyphus rotundifolia.* On the rootstock *Z.nummularia*, budding forms inverted bottleneck formation.

Planting: The ber plants can be planted in February-March and again in August September, but the latter season of planting gives a better success.

Before the plants are put in the field, the orchard site should be properly laid out according to the system of planting to be adopted. $1m^3$ pits should be dug and left exposed for one month before actual planting. Pits should be refilled with a mixture of top soil, about 20 kg well rotten FYM and 1 kg super phosphate per pit. To avoid the attack of white ants 30 g of carbaryl or aldrex dust is added to each pit. The refilled pits should be about 5 cm higher than the ground level and irrigated thoroughly, so that the loose soil settles down firmly. The plant may be set in the center of the pit with the help of a planting board, maintaining the same level of soil at which it stood in the nursery. The budding point should remain 15-20 cm high from the ground level. The plants should be immediately watered after planting.

The grafted ber plant is spreading in habit and grows in to a big tree. The tree requires proper spacing for its healthy growth and fruiting. For obtaining good yields, ber plants should be spaced at 7.5 m apart in square system thus accommodating 180 trees per ha.

The young bud lings should be stalked to avoid the breakage at the bud union.

Training: The ber is a spreading type of tree. If it is uncared and left to nature, it tends to remain bushy and take spreading form creating management problems. So, training and pruning of ber trees are highly desirable to build a strong framework and to obtain regular and profitable yields.

For developing a strong framework, it is essential to train them right from the nursery stage. When the scion buds sprouts only one upright growing shoot should be retained at the time of planting and the others should be removed. Training of ber is carried out during the initial three years after planting. During the first year, an upright and vigorous main trunk is developed up to a height of one meter from the ground level by removing all the sprouts. From this trunk 3-4 well-spaced and favorably located main branches should be allowed and the rest are removed. These form the mainframe work of the tree. On these primary branches 3-4 upright growing secondary branches are allowed. In the second year, the secondaries should be trained to carry tertiary branches. During the third year, final balancing and correction of the tree framework is done, along with first pruning. All the criss-crossing, dead, diseased and weak shoots should be removed.

Pruning: Pruning is an essential operation in ber production as fruits are borne in the axil of leaves on the young shoots of current season. Pruning is therefore, done every year to induce maximum number of new healthy shoots which bear good quality fruits.

Pruning consists of heading back of 1/4th of previous seasons growth (branch lets and shoots) together with the removal of diseased, broken and criss cross branches is also necessary to avoid crowding. The ber trees shed their leaves and enter into dormancy by the end of May. The best time of pruning is end of May or beginning of June when the trees are in dormant condition.

Spraying of Thio-urea once i.e. 2 days before pruning induces bud sprouting from maximum no of nodes.

Manures and fertilizers: Ber orchards are seldom manured. However, productivity of trees can be improved if manuring is done every year. The dose depends on fertility status of the soil. The manurial schedule varies from place to place.

Age	FYM (Kg)	Nitrogen (g)	Phosphorous (g)	Potash (g)
1 year after planting	10	125	40	75
2 years after planting	15	250	80	150
3 years after planting	20	250	120	225

4 years after planting and then onwards	25	500	160	300

The manurial dose can be split in to two equal halves and applied one during June after pruning and the other at the fruit set i.e. September-October.

Irrigation: Though ber is drought resistant, it responds well to irrigation. To improve the productivity, irrigation is a must. However ber trees need not be irrigated during most part of the year. But irrigation during the period of fruit development (September—December) is very essential and beneficial. Irrigation is given at 7-10 days interval depending on the prevailing climatic conditions.

Interculture: Area around the young plant is kept clean by weeding and hoeing. Stirring the soil under the tree canopy after rains provides better aeration around roots and helps in conserving soil moisture and weed control. One ploughing in September-October is desirable to keep the weeds under control.

Intercropping: The ber takes about 5 years to occupy the interspaces in the orchard. Till then, the interspaces can profitably be utilized by growing intercrops. Leguminous intercrops are preferable as they enrich the soil.

Flowering and fruiting: In ber, the flowering period lasts for about two and half months from June – August and it slightly varies from place to place. The time of flowering varies in different parts of India. Flowers are borne in the axils of the leaves of mature as well as current season's shoots.Flowers are hermaphrodite and pollination is mediated by insects. Fruit setting starts in the second week of October and continues up to first fortnight of November. Fruit of ber is a drupe.

There is a great variability in the extent of fruit set (2-18%) in ber.This can be increased by the application of GA20ppm and 2, 4, 5-T 20 ppm at full bloom. After fruit set, large numbers of fruits drop due to various reasons. Extent of this drop varies from cultivar to cultivar and management practices. It varies from 50-95% of initial set. Spraying of 2, 4-D at 10-20ppm is most effective in controlling this fruit drop.

Harvesting: Ber trees are regular and heavy bearers. Bud lings start bearing with in three years of planting. Thereafter it gives regular yields. Under the prevailing conditions of our state, ber flowers in the months of June to August and the harvesting of fruits begins by November on wards and lasts up to the end of January.

All the fruits on the tree don't ripen at one time and therefore, 4 or 5 pickings have to be done in the season. Application of 750 ppm of ethephon at colour turning stage induces early ripening and reduces number of pickings. Fruits are harvested with hand or a pole with a hook. The fruit should be harvested at right stage.i.e.neither under ripe nor over ripe. It should be picked when it has acquired normal size and characteristic

colour and softness of a particular variety after the fruit has attained full size. At maturity its colour changes from green to yellowish and golden yellow to brownish. The fruit requires about 120 days to reach maturity. Under ripe fruits are acrid and don't have satisfactory sweet ness, over ripe fruits on the other hand lose their attractive colour and become red, loosing their crisp and juicy texture.

Yield: The average yield per tree varies with the variety. It ranges from 100-200 kg.

FIG (Anjur)

Botanical name: *Ficus carica* **Family:** Moraceae

Origin: Southern Arabia

Fig (Anjur) is beloved to be one of the oldest fruits. It is a deciduous small to medium tree with short and twisted trunk. The edible fruit is a multiple fruit Syconium (a form of inflorescence in which flowers are borne on the inner wall of a hollow receptacle). Fruit consists of a fleshy hollow receptacle with a narrow aperture at the tip and numerous small flowers lining in the inner surface. The fruits are tiny drupelets inside the cavity of the fused peduncle.

Fruits are extensively used in fresh and dried forms. It is a nutritious fruit with a high sugar content (26%) and low in acidity. The fresh fruit is rich in calcium, iron, and vitamin A and C. and it is also more alkaline containing high mineral matter. Dried figs contain 50-65% sugar. They stimulate blood production and useful in preventing anemia.

Poona, Bangalore, Srirangapatnam, Bellary, Ananthapur and Lucknow are the growing centres in India. However, the commercial cultivation of fig is centered around Poona region.

Climate: It is a deciduous sub-tropical plant but does not require chilling to break dormancy and can withstand low temperatures (-12^{O}C) in western India. It can be grown in tropics and subtropics, but doesn't do well in the low wet tropics and can be grown at higher elevations and in areas of low rainfall during flowering and fruiting. Fig enters dormancy during rainy season (August-September) in western India. In N.India,

it remains dormant during winter and puts up new growth in October. For high quality fruits, climate should be slightly warm during fruiting. Irrigated arid and semi-arid regions are considered better for fig. Temperature above $39^{O}C$ causes burning of fruits and they become insipid with tough skin and premature ripening of fruits will also occur. At very low temperatures fruits split and produce poor quality fruits. It can be grown up to 1500m elevation.

The essential conditions for success of fig cultivation are:

- High temperature
- Low humidity
- Absence of rains during fruit development and ripening period
- A dry locality with irrigation facilities

Soil: Fig trees grow well on a wide range of soils but do best in deep, non-alkaline clay loams. Alluvial clay loams / medium black soils, which are well drained but retain enough moisture, are good for fig cultivation. Soils with high lime content produce better quality fruits and are suitable for drying. It is sensitive to sodium carbonate and boron salts. On high alkaline soils fig develops high sugar content.

Varieties: The fig fruit as one sees immediately after emergence, is an inflorescence containing large no. of flowers on the inner side. At the apex of the fig is a small opening known an eye, which is usually covered by bracts.

There are four types of fig:

Capri fig: It bears both male and female flowers. The male flowers are located near the opening, which is usually covered by bracts. The female flowers with short styles are present inside. These short styled female flowers are adopted for the laying of eggs by the wasp ***Blastophaga psenes***. Hence, they are in edible. The other three types are edible figs and they bear only female flowers with long styles. Capri figs give three crops viz; profichi (April-June), mamnoni (November) and manme (November-April).

The important varieties of this group are: Stanford, Crosic, Samson, Roe ding etc.

Adriatic fig or Common fig: The fruits develop parthenocarpically. Fruits won't produce viable seeds. The fruit is hollow without kernel and embryo. However, when pollination is done with the pollen from Capri fig by wasps, the seeds may be formed.

Varieties: Black Ischia, Turkish white, Marseilles, Kadota, Mission, Adriatic, Brown turkey, Celeste, Conardia etc.

Smyrna fig: Trees generally produce main or summer crop only, although a few breba may reach maturity by parthenocarpy. Main crop is non-parthenocarpic and needs pollination and fertilization. It won't develop fruits without pollination. Develop fruits when the flowers are pollinated with pollen from the male flowers of Capri fig through blastophaga wasp. If not pollinated the ovaries shrivel and drop off.

Varieties: Zide, Taranimt.Calimyrna.

White Sanpedro: It combines in itself the characteristics of both Smyrna and Adriatic types. This type has spring crop without the stimulus of flower pollination. However main crop needs fertilization**.**
Varieties**:** San Pedro, dauphine, Gentile, Blanguette, king and Lampeira.

In South India Marseilles, Black ischia, Kabul etc are the popular varieties grown at an elevation of 1500m.

Propagation: Fig is commercially propagated by hard woodcuttings. In India, the cuttings are taken from matured terminal branches, which are one year old with 11/2 to 2cm thickness and shorter internodes. Rooted cuttings of one year old are planted in the field.
Propagation by air layering, ring budding and side grafting on ***F.glomerata***,a nematode resistant is also possible.

Planting: Planting is done in pits of 60cm cube in square system prepared at 6m spacing from June to October in the monsoon season. The spacing varies from place to place, soil to soil, variety-to-variety etc. Spacing varies from 3x3m to 8x8m but 6x6m looks appropriate.

Training and Pruning: Young plant should be trained properly to give proper head and scaffold branches. It can be trained to single stem or multy stem. In Mysore, the plant is trained into a bush by cutting the trunk near the ground level and selecting 6-7 main branches.
Fig plants are headed back every year in Jan-February to about two buds on each shoot of previous season's growth to obtain fruits in July-October. It is best performed in December-January. Notching is practiced to stimulate production of laterals on vigorous upright branches (done on at least 8 month old shoots).

Inter cropping: Fig trees start bearing in 2-3 years and come into full bearing at 5-6 years age. Therefore, for good use of interspace green manuring and amenable vegetable crops could be taken during rainy season.

Manures and fertilizers: Fig plants should be manured from the very beginning. One-year-old tree should be given 10 kg of FYM and 170 g of Ammonium sulphate, and about 7 kg of FYM and 170g of Ammonium sulphate should be increased progressively every year up to 5 years.
In N.India, the application of manures is done before the growth starts in spring and fertilizers in March. In western and southern parts of India, manure is applied in November. While applying manure in fig plant, care should be taken to avoid exposure of roots, as it is harmful.

Manures and fertilizers are spread around the trunk between radial distance of 45-60cm and mixed with the help of a spade by digging.

Irrigation: Fig is fairly drought tolerant, but during summer, when the fruits are developing and ripening, irrigation twice a month is beneficial. This gives large and sweet fruits. Excess of irrigation makes the fruit insipid. Some times excess of irrigation during ripening of fruits causes cracking of fruits, therefore judicious watering is desirable for high quality crop.

Fruiting: The fig bears two crops in a year. The spring crop breba is borne on the previous years shoots. The second crop is borne on the current season's growth and is the main crop. In N.India the spring crop ripening in May is taken as main crop. In Central and South India, the fig crops in July to September and February to May. The latter crop is sweeter and more valuable.

Harvesting: Trees may start fruiting at 3 years of age but commercial bearing starts from 5 years onwards and continues to bear up to 40 years of age.
Fig fruits are harvested when mature, which can be judged on the basis of colour development. The mature fruit is of light green colour and little soft to touch. In N.India the spring crop ripening in May is taken as main crop. Some times fruits are allowed to fall from the tree of their own and allowed to dry and then collected.

Yield: A good harvest may give 300-500 fruits per tree per year and 12 tones/ha in well managed orchards, which depends on the size of the tree and methods of training. The fruits are harvested by twisting the neck at the stem end.

PHALSA

Botanical Name: 1. Bush Phalsa: *Grewia subinaequa*lis

2. Tree Phalsa: *Grewia asiatica*

Family: Tiliaceae **Origin:** India

Phalsa is a subtropical fruit and native to India. It is a successful crop of arid and semi-arid regions. Being a hardy fruit, can be grown successfully even on inferior and marginal lands.

Phalsa fruits are a good source of Vitamin A and C. Fruits also supply phosphorous and iron. Fresh fruits have cooling effect. Fruits are used for making juice, squash and syrup. Fruit contains 55-65% juice, which makes an excellent refreshing drink.

Fruits are eaten when they are fully ripe. They are astringent, cooling and stomachic. Fruits contain seeds; hence they are not liked much as table fruit.

In India it is cultivated on a large scale in U.P, Punjab, Haryana, Rajasthan and Madhya Pradesh. It is cultivated on a very limited scale in Maharastra, Gujarat, A.P., Bihar and West Bengal, in South India along the Western Ghats along the Malabar Coast.

Climate: Phalsa can be grown all over the country except at higher altitudes. It relish distinct winter and summer for best growth, yield and quality. In regions having no winter, the plant doesn't shed leaves and produce flower more than once, thus yield

poor quality fruits. Full-grown plants can tolerate freezing temperature for a short period. The plants can tolerate as high as 45^{O}C.High temperature during fruit development favours ripening of fruits. At flowering time, clear weather is needed, where as rains at that time affect fruit setting adversely. For raising profitable crop of phalsa, satisfactory arrangements for irrigation need to be made.

Soils: Phalsa can be grown on a wide variety of soils even on moderately sodic soils. It grows well in well-drained loamy soils. The plant is sensitive to water logging, which makes it chlorotic. So, soils which have poor sub surface drainage and water logged should not be selected for commercial cultivation of Phalsa.Iron chlorosis is a common problem in calcareous soils i.e. it is sensitive to lime. The ideal soil for growing phalsa is the rich loamy type.

Varieties: There are no improved varieties of phalsa. Some local selections –local and sharbathi are popular. However, Haryana agricultural university, Hissar has recognized two distinct types **Tall** and **Dwarf**. Dwarf type is commonly grown. It is quite productive.

Propagation: Phalsa is **commercially propagated through seeds**, which is the easiest and most commonly used method of propagation. Propagation by cuttings (hard wood) and layers is also possible with the help of growth regulators (IBA 2500ppm –30,000ppm). In layering, air layering and simple layering are mostly followed.

Planting: Land is prepared well before the plants are set in the field. Pits of size 50cmX50cmX50cm are dug and re- filled with a mixture of top soil and well rotten FYM in the ratio of 1:1.To save the plants from the possible attack of white ants add 30g of BHC 10% dust to each pit. After that the plants are planted in the pits. Eight to twelve months old seedlings are better for planting in the field. Phalsa plants should preferably transplant in the field during January-February before they start new growth. The plants being dormant at that time, they can be lifted from the nursery with bare roots. However for transplanting during August-September, the seedlings are to be lifted from the nursery along with the ball of earth. Transplanting in the rainy season is therefore a little more cumbersome and riskier than that done in the spring, when plants are dormant.

Phalsa plants can be planted at a distance of 2.5 to 3.0m from plant to plant and 3.0 to 4.0m from row to row. Phalsa is well suited for close planting. Increase in plant density may increase the yield. The plants can be planted at 2X2m apart in square system accommodating 2500 plants per hectare.

Manures and fertilizers: Being a hardy crop, phalsa is hardly fertilized. The fruits are borne on new growth; hence application of fertilizer definitely encourages vegetative

growth. In order to get profitable crops of good quality, full-grown phalsa plants should be given10-15 kg of well rotten FYM, soon after planting. Nitrogenous fertilizers should be applied preferably in two split doses one at the time of flowering and second after fruit setting @ 1 kg of CAN or Ammonium sulphate per bush. Higher yield of phalsa can be obtained by application of 100 kg N; 40kg P_2O_5 and 25 kg K_2O per hectare respectively. Of the micronutrients, Zinc and iron are beneficial for juice content and berry size. Spraying of Zinc sulphate @0.5% and Ferrous sulphate @0.4% can be done at pre-bloom and post-bloom stages.

Irrigation: Phalsa is drought tolerant crop but irrigation is essential for higher yield of quality fruits. First irrigation is needed in February after application of fertilizers. Irrigation during summer (March-April) at 2-3 weeks interval is desirable.

Inter- culture and inter- cropping: One or two ploughings after pruning the plant is desirable to control weeds and to incorporate FYM or compost. It is desirable to grow green manure crop such as green gram, Cowpea or black gram during the rainy season in early life of the orchard (First or second year of planting). The green manure crop should be turned into the soil towards the end of rainy season or earlier.

Flowering and Fruiting: Flowering in phalsa starts from February-March and continues till May. The first flower to open is at the base. The flowers are borne in the axils of the leaves. The flowers are mostly cross-pollinated and honeybee seems to play a major role in pollination.

Training and Pruning: The phalsa fruit is borne in clusters in the axil of leaves on the new growing shoots produced during the current season. Annual pruning is therefore very essential to have new vigorous shoots to ensure regular and heavy fruiting. Phalsa plant is allowed to develop as a bush; hence, no initial training is practiced. Pruning is an essential annual operation for obtaining better quality fruits. Both severe and very light pruning affect the crop yield. The desirable height of pruning varies from 50-100cm from ground level. The phalsa plants are rather slow in shedding their leaves in winter. The best time for their pruning is during December-January, when the plants have shed their leaves and in all cases the operation should be finished well before the start of the new growth.

Harvesting: The phalsa begin to bear fruits in the second year. A good commercial crop is usually obtained during third year. In Punjab and Haryana, the harvesting season of phalsa fruit start by the end of May and lasts till the end of June and in South India it is March-April.

Fruits should be harvested at the right stage of maturity. Phalsa fruits become fully mature in 55 days after the fruit set. Maturity is judged by colour. The phalsa fruit should be picked when the colour has changed to deep reddish brown and the pulp

tastes sweet. Fruits are individually picked by hand and collected in bamboo baskets cushioned with polythene sheet or newspaper cuttings. Several pickings are necessary, as all fruits don't ripen at one time. The fruit picking is usually done on alternate days.

Pre-harvest application of Ethephon or Ethrel @500ppm when few fruits start to change their colour reduces the no. of pickings from 7 to 3 and improves fruit quality in terms of TSS,VitaminC content and colour development due to an increase in anthocyanin pigment.

Yield: On an average a mature plant provides 2-4 kg of fruits.

JACK FRUIT

Botanic Name: *Artocarpus heterophyllus* **Family:** Moraceae

Origin: India.

It is medium to large sized tropical fruit tree. It gives the largest fruits, which are borne on small leafless stalks arising from the trunk and main branches of the tree. The fleshy carpel (Perianth) is the edible portion. Jack is rarely grown as a plantation but preferred very much in home stead and as a shade tree or as a mixed crop. It occupies a considerable area in coffee gardens and roadside plantations. It is popularly known as poor man's food in the eastern and southern parts of India.

Uses:

- It is a rich source of vitamin A, C and minerals and it also supplies carbohydrates.
- Tender jackfruits are popularly used as vegetable.
- The skin of the fruits and its leaves are excellent cattle feed
- Its timber is valued for furniture making since it is rarely attacked by white ants.
- The latex of the bark contains resins
- Pickles and dehydrated leather are its preferred delicacies.
- Canning of flakes can be done. They can be bottled and served after mixing with honey and sugar.
- Nectar is prepared from its pulp.
- The rind is rich in pectin
- The flakes, seeds, sterile flowers, skin and core contain calcium pectete. They are considered as good sources of pectin.

Assam, Bihar, kerala and Tamilnadu are the main Jack growing states in India. Nearly, it is cultivated in an area of 13,200 ha in India.

Climate: It grows well and gives good yield in warm humid climate of hill slopes and hot humid climate of plains. It can be grown successfully from sea level to 1200m.Ideal temperature range is 22-35^{O}C. Jack is often used as a shade tree in coffee plantations.

Soils: Jack can be grown on a wide variety of soils but it grows well in a rich, deep, alluvial and well-drained soil. It can also be grown on light textured sandy loam or lateritic soil provided sufficient nutrients and moisture supplies are available. Drainage is the most important criterion for selecting the soil as the tree is highly sensitive to water stagnation.

Propagation: Jackfruit is commonly propagated through seeds. Seeds should be sown immediately after extraction, since; they loose their viability during storage. **Seventy** percent of the seeds germinate up to 15 days after extraction. But after 30 days storage the germination is declines to **thirty** percent. Soaking seeds in **NAA** 25 ppm or 500 ppm of **GA_3** for 24 hours improves their germination and seedling growth. Generally seedlings are raised in pots or polythene bags and after 1-2 years the seedlings are planted at site. Air layering, grafting (Inarching and epicotyle) and budding (Forket, chip and patch) are means of its vegetative propagation. **Inarching is normally practiced.** Inarching is done on **Jack seedlings** or ***A.hirsuta*** rootstocks and also on **Rudrakshi**. The plants attain planting size in one year. Occurrence of **Vivipary** is not uncommon in Jackfruit.

Certain varieties are capable of maintaining their individuality even after propagation by seeds.

Varieties: Being a cross-pollinated crop and mostly seed propagated, its innumerable types of fruits differ widely in **density of spines, rind, bearing, size, shape, quality and period of maturity**. Such variations among clones offer great scope for clonal selection.

There are two broad groups of cultivated types—**soft-fleshed** and **firm fleshed**.

Soft fleshed: When fully ripe, the fruit yields to the thrust of finger easily. The pulp is very juicy and soft. The taste varies from very sweet-to-sweet and acid to insipid.

Firm fleshed: The rind doesn't yield to thrust easily .The pulp is firm and crispy. The taste is variable in degree of sweetness.

Rudrakshi and Ceylon Jack are the important jack varieties.Rudrakshi is mostly grown for root stock purpose

Other varieties:

Jack fruit varieties **NJT1, NJT2, NJT3 and NJT4** collections from Faizabad(UP) have large fruits of excellent quality and bulbs having low fibre. They are suitable for table purpose.

NJC1, NJC2, NJC3 and NJC4 have small to medium sized fruits with thin rind and soft flesh. They are suitable for culinary purpose.

Planting: The land is ploughed in two directions, after clearing of the filed .The plot is then laid out according to the spacing. In fertile soils spacing adopted is 12mX12m on either side accommodating 70 plants per hectare. On average soils spacing can be reduced to 10mX10m or 11mX11m. June to August is the best time for planting.

Irrigation: It is not normally irrigated. The tree is sensitive to drought. Irrigation during dry period is essential in arid regions for normal growth.

Manuring: Jack needs adequate nutrition for regular and good cropping. Apply 80 kg FYm to a tree annually along with chemical fertilizers. For obtaining higher productivity, the following fertilizer schedule is recommended.

	Age of the plant		
Nutrient	**1-3 years**	**4-7 years**	**7 years and above**
Nitrogen (g)	200	400	600
Phosphorous(g)	120	240	300
Potassium(g)	60	120	240

Full dose of FYM plus P_2O_5 and K_2O and half of the Nitrogen may be applied in the end of June and the rest half Nitrogen in February-March.

Flowering: It is a monoecious tree. The male and female flowers of Jack are borne on separate drooping catkins (Spikes). Male catkins don't develop in to fruits. Female spikes are borne on footstalks and also on primary and secondary branches (Cauliflorous), while the male spikes appear both on the foot stocks and on the terminal branches.

Fruits are multiple types, very large with sharp protuberances, thick endo carp fused with the meso carp, aromatic and rich in latex. The outer part of the perianth is fleshy and edible.

It starts flowering from 7-8 years after planting. Flowers start appearing in December and continue up to March.

Harvesting: Jack produce fruits usually 7-8 years after planting .The fruits are in season from March to June.

Harvesting Indices:

- A dull hollow sound is produced when the fruit is tapped by the finger.

- The last leaf of the peduncle turns yellow.
- Fruit spines become well developed and wide spaced.
- The spines yield to moderate pressure.
- Development of aromatic odour.

For distant market, fruit should be harvested when still firm and with out any aroma.

The tender jackfruit, which is used for culinary purpose, is harvested before the hardening of the seeds.

Yield: It ranges from 20-100 fruits / tree. The fruit weight varies from 10-30 kg.

LITCHI

Botanical Name: *Litchi chinensis* Soun **Family:** Sapindaceae

Origin: Southern China

Litchi is an important subtropical fruit crop. It is one of the most popular fruits in India both in fresh and dried forms.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 litches are also popular. A highly flavoured squash is also prepared from its fruits.

Litchi is also an excellent source of Vitamin C, but it contains insignificant amount of protein, fat, pectin and minerals especially calcium, phosphorous and iron.

Litchi reached India by the end of 17 th century. The spread of litchi to other parts of the world has been limited and has taken place only in comparatively recent times. This is an account of its exacting requirements of climate. Even today, its original region remains the biggest producer of litchi. India ranks second in the world next to china in litchi production. Most of the litchi growing areas in India fall in North Bihar.

Litchi fruit is a single seeded nut and its edible portion is **aril**.

Climate: The litchi is exacting in its climatic requirements. This is the most important factor in the spread of this delicious fruit. It requires a moist subtropical climate without heavy frost or hot dry winds. The four essentials for litchi cultivation are said to be (I) freedom from frost (2) high humidity (3) rich deep soil and (4) abundant moisture. The plants grow luxuriantly at 30^{O}C.The maximum temperature during flowering and fruit

development varies from 21^{O}C in February to 38^{0}C in June in Bihar. The dry and hot winds in summer causes fruit cracking and subsequently damage the pulp.

Soils: It grows in variety of soils. However fairly deep, well drained loam soil rich in organic matter is best suited for its cultivation. Light sandy loam soils are ideal for its cultivation. High lime content in soil is also beneficial to its trees. If soil is deficient, lime must be added to it .A sandy loam or clay loam with a pH of 5.5 to 7.0 and sufficient soil depth is ideal for litchi cultivation.

Varieties: A large number of varieties are grown in different parts of India. Of these Saharanpur Early bedana, Dehra doon**,** Culkattia, Muzzafarpur, Late bedana, Swaran roopa are important. Swarna Roopa is an improved variety evolved through selection.

Propagation: Litchi is raised both through seed and vegetative means. Propagation by seed is not common because the plants raised from seed take 7 to 12 years to come into bearing. These plants normally don't produce true to type fruits and often produce fruits of inferior quality. More over, the litchi seeds loose their viability with in 4 or 5 days after removal from the fruit. Hence, the litchi is commercially be propagated vegetatively. The most common method of propagation is air layering or gootee.The best time for air layering is June.

Planting: Before planting, the land should be cleared and leveled. The pits of 1mX1mx1m size should be dug as per the lay out, a few weeks before planting. The pits are refilled with a mixture of FYM (20-25 kg), bone meal and sulphate of potash (400g) with a basket full of soil 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 and the spacing adopted varies from 9 to 12 m.

6-9 months old true to type plants, with fine roots should be selected for planting. Early monsoon season is the best time of planting. Planting can also be done in the spring, if irrigation facilities are available.

Training and Pruning: Training of young litchi plants for making a good frame work is necessary. Once the desired shape and a strong frame work is achieved, pruning is not required, except removing dead or diseased branches and damaged shoots. In India, this occurs indirectly when a part of the shoot bearing the cluster of fruits is removed during harvesting. However, heavy pruning of trees causes profuse vegetative growth resulting in poor fruiting. If trees becomes too old and produce small fruits, pruning heavily improves the yield and quality of fruits.

Manures and fertilizers: In India litchi is grown mostly in natural fertile soil. A little or no manure is given. The acute shortage of NP and K seems to stunt all forms of litchi growth, including floral initiation.

The fertilizer schedule recommended in Bihar where most of the litchi area exists.

Manure/Fertilizer	First year	Increasing amount every year (Up to 5-6 years)	Fertilizer dose of full bearing tree.
Compost	20 kg	10 kg	60 kg
Castor cake	1 kg	½ kg	5 kg
Neem cake	½ kg	½ kg	3 kg
Single super phosphate	2 ½ kg	½ kg	5 kg
Muriate of potash	100 kg	50 kg	0.5 kg
Calcium nitrate	--	½ kg	0.002 kg

Fertilizer should be applied just after harvesting during the rainy season. Applying fertilizers late in the season results in more vegetative growth and less fruiting. The plants grown under deficiency of NPK can flower but don't set fruits. The plants grown under magnesium deficiency don't even bloom.

Irrigation: January end to the onset of monsoon is a critical period for irrigation since vegetative growth and fruit development takes place. Four months prior to normal floral initiation period (December to January) in northern India, the plants should not be irrigated. Though litchi is a deep rooted perennial crop, the absorbing roots occur mostly in the upper topmost soil layer between 20 and 30 cm depth. Therefore, this zone should have 50% soil moisture during the critical period. Young trees should be irrigated by the basin method. 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 upon type of soil. Generally weekly irrigation is given in summer. No irrigation is required during winter in fruiting trees before fruit set.

Interculture: Maintenance of good sanitary conditions is must to keep litchi orchards healthy and disease free. Litchi is a shallow rooted tree with most of its feeding roots occurring 20-30cm deep. Therefore, deep tillage is harmful for its plants, since it may cause injury to roots. Tillage operations should be limited to upper 7-10cm depth of the soil layers. Litchi orchards should be given tillage for 3-4 times a year and must be kept of weeds. Raising of cover crops or intercrops is very beneficial. Summer cover crops are especially beneficial for maintaining humidity.

Inter-cropping: Inter-cropping of young orchards provides the much needed income during the period when litchi plants are not bearing. Leguminous crops like peas,

beans, and grams are to be preferred for this purpose. The young orchard can also be planted with filler trees of papaya and phalsa.

Harvesting: The no. of days taken by the fruit to mature varies with genotype and environment and hence cannot be the deciding factor for its maturity. Generally litchi fruits mature 50 to 60 days after fruit set. The development of colour on fruits is 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 quality. Maturity of fruit is also determined by the shape of the tubercles which on ripening becomes some what flattened and the epicarp becomes smooth. The fruits are harvested in bunches along with a portion of the branch and a few leaves. It prolongs the storage life of the fruits. Harvesting of litchi is usually done in May and June. The fruits for local market should be harvested at their full ripe stage, while for distant markets when they start turning reddish.

Yield: In India the yield varies from 80 to 150 kg fruits / tree / year depending upon variety and tree vigour.

APPLE

Botanical Name: *Malus pumila / Malus sylvestris*

Family: Rosaceae **Origin:** South West Asia

It is the most important temperate fruit. It is the premier table fruit of the world. Apple is also called as "***King of temperate fruits***". It is under cultivation since time immemorial.

It is a rich source of easily assimilable carbohydrate and it is also fairly rich in calcium, phosphorous and potassium. It also supplies vitamin B and C.

In India it is predominantly grown in Jammu and Kashmir, Himachal Pradesh and hills of Uttar Pradesh, accounting for about 90% of the total production. Its cultivation has also been extended to Arunachal Pradesh, Sikkim, Nagaland, and Meghalaya in north-eastern region and Nilagiri hills in Tamilnadu.

The apple growing areas in India don't fall in the temperate zone of the world but the prevailing temperate climate of the region is primarily due to snow covered Himalayan ranges and high altitude which helps to meet the chilling requirement during winter season extending from mid-December to mid March.

Botanically apple fruit is a false fruit **(Pome)** with fleshy thalamus as edible portion. Most of the commercial apple varieties are diploids. Triploids are rare.

Climate: Most of the apple varieties require 1000 to 1500 hours of chilling at below 7^0C during winter to break the rest period. These conditions are available at an elevation of 1500 to 2700m above mean sea level in the Himalayan ranges. By and

large the average temperature should be around 21 to 24^{0}C during active growth period. The areas with frost free spring and adequate sunshine during summer with out wide fluctuations in temperature are most suitable for apple cultivation. Low temperature, rains and cloudy weather during flowering period hamper the bee activity, affecting cross pollination adversely. Dry winds during summer desiccate flowers and hampers bee activity, resulting in poor fruit set. Well distributed rainfall of 100 to 125cm through out the growing season is most favourable for its optimal growth and fruitfulness. Long drought spells during fruit development and excessive rains and foggy conditions at fruit maturity hamper fruit size and quality.

SOILS: Soil depth, drainage and pH determine the suitability of soil. Loamy soils rich in organic matter having a pH of 5.5 to 6.5 with gentle to moderate slope, proper drainage and good aeration are most suitable. The soil should be free from hard substrata and water logged conditions. The presence of lime in the soil is good for apple cultivation.

Varieties: Apple varieties should have climatic adaptability, attractive fruit size, shape, colour, good desert quality, long shelf life, resistance to pests and diseases and tolerant to drought conditions besides high productivity.

In apple there are two types of varieties i.e. **diploids and triploids**. The diploids usually have plenty of pollen and are self fruitful. The triploids on the contrary are self unfruitful and productive only when they are pollinated by diploid varieties. Golden delicious and red gold are recommended pollenizers in apple.

Diploids : Red-delicious, Yellow delicious, Jonathan etc.

Triploids: Baldwin, Beauty, Tropical beauty.

Some of the promising cultivars recommended for important apple growing regions of the country are:

Diploids- Reddelicious, Yellowdelicious, Jonathan- **Triploids**- Baldwin, Beauty, RomeBeauty, Ambri, Sunheri, Ambstarking, Ambroyal, Ambrich, Chaubattia Princess, Chaubattia Anupam, Ambred Red.

The cultivar Ambri is Indigenous and extensively grown in the Kashmir valley.

In apple some early maturing and good quality hybrids were developed at various research stations in India.

Some of the hybrids developed and their parentage are

Lal Ambri (Red Delicious X Ambri), **Sunehr**i (Ambri X Golden delicious), **Ambstarking** (Starking delicious X Ambri 81), **Ambroyal** (Starking delicious X Ambri 84), **Ambrich** (RicharedXAmbri 15), **Chaubattia Princess** (Delicious X Early Shanburry), **Chaubattia Anupam** (Delicious X Early Shanburry), **Ambredred** (Delicious X Ambri 57)

Propagation: Apple plants are commercially raised by vegetative means, since seedling plants are not true to type**. Apple is** generally propagated by budding or

grafting on seedlings of crabapple, golden delicious etc. Shield budding is done with buds of current seasons growth in June. Among grafting methods tongue grafting is the ideal method. Grafting is done in spring. **Malling IX** root stock is popular which was introduced from East Malling research station, England. Several Malling root stocks developed in England are vegetatively propagated. They can be used to control the vigour of the plants and have resistance to wooly aphis, a pest on apple.
Crab apple *Malus baccata* is most commonly used rootstock of apple in India.

Planting: In flat and valley areas' planting is done in square and hexagonal system of layout, in slopes contour / terrace planting is preferred.
Pits of $1m^3$ size are made and kept open for a month and filled with a mixture of 40-50kg of FYM + 500g of Super phosphate + top soil. The soil is allowed to settle for a month. Planting is done late in winter after the danger of frost is over. One year old plants are planted. The planting distance varies from 7 to 10m depending on the vigour of the rootstock.

Training and pruning: The plants are trained according to growth habit and vigour of the root stocks**.** In India the apple trees are trained to modified leader system with 3-5 main branches and a clear trunk of 1.0 to 1.5m.After completion of training in 4-5 years with proper pruning the branches of the tree should make an extension growth of 25 to 50cm every year to maintain a balance between vegetative growth and fruit production. Some apple trees bear fruit on short crooked growth called spurs. These spurs bear for several years. Such spurs should be pruned to encourage vegetative growth and new spur development in only when they stopped bearing fruits.
Pruning is done when the plants are dormant i.e. in the month of December-Jamuary.

Manures and fertilizers: Application of manures and fertilizers start right from planting of an orchard. The first application should be made at the time of filling of pits. The fertilizer dose should depends upon soil fertility, type of soil, kind and age of trees, cultural practices, climate and crop load.
In an orchard of optimal fertility, N, P and K may be applied in the ratio 70:30:70 g/ year age of the tree. The dose should be stabilized (700:350:700gN: P: K per tree) after 10 years of age. These applications may be supplemented with FYM@10 kg per year age of the tree with the maximum of 100 kg. Apple trees prefer N, P and K in the form of Calcium ammonium Nitrate, Super phosphate and muriate of Potash respectively. In off years the fertilizer dose of NPK may be reduced to 500g, 250g and 400g respectively.
In bearing trees, FYM along with P and K should be applied during December-January. Nitrogen is applied during February-March, 2 to 3 weeks before bud break. The Nitrogen can be applied in two split doses, first dose 2-3 weeks before bud break and the second one, one month after flowering.

The fertilizers should be broadcasted in the tree basins 30cm away from the tree trunk up to the canopy drip line and mixed well in the soil.

Irrigation: Most of apple orchards in India are situated in rain fed sloppy areas where irrigation facilities are inadequate except in flat valley areas. Apple requires uniform distribution of rainfall throughout the year or needs to be supplemented with irrigation during critical periods. The most critical period of water requirement in apple is from April to August, the peak requirement being after fruit set. During summer months, the irrigations can be given at 7-10 days interval and rest at In3-4 weeks interval.

Harvesting: Since apple is a climacteric fruit, the maturity of fruits doesn't coincide with ripening. The fruits usually don't attain full ripe edible quality on the tree while harvesting. The fruits should be harvested at proper picking maturity to attain proper edible quality at ripening. Picking of immature fruits results in poor quality fruits lacking flavour and taste which shrivel during storage. Over mature fruits develop soft scald and internal break down with poor shelf life. There are several reliable maturity indices which can be adopted singly or in combination for proper fruit harvesting. They are:

- TSS of the fruit pulp
- Ease in separation of fruit from the spur
- Change in ground surface colour from green to pale
- Change in seed colour to light brown
- Fruit firmness
- Days from full bloom to harvest

All the fruits on the tree won't mature at a time, thus more than one picking are required.

Yield: A full bearing tree yields from 40-100 kg fruit. The bearing generally commences after 5 years of planting and continues for about 50 years. Sveral varieties of apple show alternate bearing.

PEACH

Botanical name: *Prunus persica* L.

Family: Rosaceae **Origin:** China

Peach is an important stone fruit grown in warm temperate zones of the world. The attractive colour of the fruit with excellent quality, taste and rich nutritive value make peach a most popular fruit in the world. Among temperate fruits, peach has the lowest chilling requirement and is earliest in flowering. Processed peaches like canned, dried, frozen, preserved jam, juice and beverages are also popular products. Nutrient rich baby food can also be processed by blending peach pulp with sugar syrup.

The peach fruit is rich in proteins, sugar, minerals and vitamins. The peach kernel is a good source of fats, proteins, fibre and minerals.

China is the original home of peach and recorded to be grown as far back as 2000BC from china, the peach reached the mediterranean region very early in the history and then spread to other parts of the world. Introduction of cultivated peach into India probably took place in the latter half of the 19 th century.

Smooth skinned mutants allied to peaches (*P.persica*) are called nectarines and is classified as *P.persica* var.*nucipersica* . It is a non-pubescent peach (Fuzzless) with smaller, size fruits are called nectarines.

Botanically the fruit of peach is a drupe. Its two types are worth mentioning –in first group the pulp remains clinged to stone and called clinged stone peaches and in second group pulp remains free from stone and called free stone peaches. In the genus persica there is one species “Nucipersica” whose outer appearance resembles plum but fro inside it is like peacxh.These are called nectarines.

Climate: Peaches require humid climate with cold winter and dry summer. It is moderately winter hardy and sensitive to low temperature injury. Swelling buds are injured at - 6.5^{O}C. The chilling requirement of most of the varieties is 850 hrs. Ths chilling requirement varies from variety to variety and it ranges from 75-850hr.Sites which are free from early spring frost are more suitable as peaches bloom early in the season. Deep valleys are not ideal sites because cold air settles in these areas, and frost and freeze injuries are very common. The land with gentle slope is ideal.

Soils: Deep sandy loam soil rich in organic matter is best for its successful cultivation. Peaches are highly susceptible for water logging and prefer perfect drainage. Fertile and heavy soils are hazardous as it makes heavy vegetative growth and hence results in winter injury. The pH of the soil should be between 5.8 and 6.8. Acidic and saline soils are unfit for peach cultivation.

Varieties: Peach is generally self fruitful except the variety J.H Hale, which is male sterile. On the basis of their use, peach cultivars can be grouped into table cultivars and canning cultivars.

Table cultivars: Table cultivars should be yellow fleshed, free stone and with a regular bearing habit. Eg. Alexander, Elberta, J.H.Hale, Cardinal etc.

Canning cultivars: Canning cultivars should be yellow fleshed, cling stone with a small non-splitting pit, uniform size, devoid of red colour at the pit and should mature uniformly. Eg.Certex, Halford, Fortuna, Crawfords early, Golden bush etc.

Nectarine cultivars: Smooth skinned peaches are called nectarines. These cultivars are mostly preferred for table purposes. Eg. Nectared, Sun grand, Sunlite, Sun red, Sun rise and sun ripe.

Propagation: Peach is commercially propagated by grafting and budding. Peach seedlings are generally used as rootstocks, though plum, apricot and almond seedlings can also be used. Some times Bhemi (*P.mira*) is also used as rootstock. Since wild species produce more vigorous and hardy seedlings than the cultivated varieties, wild seedlings are preferred as rootstocks.

Nemaguard, Yunnan, Nemared and Shalin are nematode resistant rootstocks of Peach.

Peaches are commercially propagated by tongue or cleft grafting and “T” budding or ring budding.

Planting: The planting in peach is carried out during winter season. In hilly areas, contour or terracing system of planting depending upon the steepness of the slope and in plains square system of planting is adopted. Pits of 1mX1mX1m size at a spacing of 6-7m in hills are dug during September-October. In high density planting a

spacing of 3X3m is followed. The pits should be refilled with fertile top soil mixed with 40 kg of well rotten farmyard manure. 10 liters of chloropyriphos solution (1ml/Liter) can be applied to each pit to avoid any damage from insects.

Training and pruning: Of the conventional training systems modified leader and open centre are usually adopted to train peach trees. If sun light exposure is a limiting factor (hills) vase or open centre system of training is usually followed.
Peaches require heavy and regular pruning because fruiting occurs laterally only on previous season's growth which bears only once in its life time. The pruning of peach has two important components –Thinning out and heading back of the shoots. Pruning should be done so as to produce 25 to 50 cm of growth annually under temperate condition, which is sufficient for maintaining optimum productivity

Manures and fertilizers: Peach requires a higher amount of Nitrogen than other temperate fruits. Non-bearing trees should be given 454g (1lb) of Nitrogen per tree for every year of age of the tree. The bearing orchard should receive 1100g (2.5lb) each of Nitrogen and potash and double this quantity of phosphorous in inorganic form and 15-25 tonhnes of FYM per ha.

Whole quantity of FYM along with P and K is given during December-January. Half of N should be given in spring before flowering and the remaining half a month later if irrigation facilities are available.
Sice active roots of peach tree are present at 0-60cm radial distance from the trunk and at depth of 0-25cm the nutrients must be applied in this area followed by mixing up to the depth of 15cm.

Irrigation: To get optimum size and quality fruits, irrigation is very much essential. There should be sufficient moisture in soil before the emergence of leaves and flowers and frequent irrigations are needed during the fruit development. Lack of irrigation, particularly during dry and hot summer result in fruit drop, reduced fruit size and quality. At least two irrigations should be given during fruit development. Irrigations should be stopped a few days before harvesting and at the time of dormancy, when the plants should become, sufficiently hardened to withstand cool weather.

Interculture: A peach orchard should be regularly cultivated. Ploughing, which should not be deeper than 10cm, is generally done in winter. A suitable cover or green-manure crop may be sown in the rainy season after the fruits are picked and ploughed-under during winter.

Intercropping: The interspaces in young orchard can be economically utilized by growing short duration crops like cowpea, soybean, turmeric and pineapple. till the

peaches come into commercial bearing. Exhaustive crops like okra and onion should be avoided as intercrops.

Crop regulation: Heavy flowering and fruiting are characteristic features of peach trees resulting in small sized, poor quality fruits and reduction of flowering in subsequent season. Hence, for production of quality fruits of good size, crop regulation through thinning is essential.

The criteria for fruit thinning in peach are based on fruit to leaf ratio, spacing between fruits, number of fruits per tree and expected fruit size. The number of fruits to be retained per tree after thinning varies with the cultivar, tree vigour and soil fertility condition. Usually 30-40 leaves per fruit are the appropriate ratio. In thinning desirable space between fruits is 15 to 20cm.

Harvesting: To get premium price and reduce the losses during packing and transporting, peaches should be harvested at optimum stage of maturity. A large no. of maturity indices are there to decide the maturity like – days to maturity, calendar date, fruit size,firmness,sense of touch, pit discolouration,freeness of pit, taste, ground colour,sugar,acidity, starch, sugar: acid ratio.

All peach fruits won't mature simultaneously. Therefore, these may be harvested in 3-4 pickings at 4 days interval. For distant markets peaches are harvested when they attain a good colour but are still hard and ripe, but where as for local consumption tree ripe peaches are harvested by twisting with hand. The peak harvesting period for peach is mid-May to mid-July.

Yield: The peach comes to bearing after 2 years of planting. The plants bear for about 20 years. The average yield of fully grown trees of different varieties varies from 50 to 125 kg in hills.

PEAR

Botanical name:

(1) French pear Or European Pear or Soft pear: -*Pyrus communis*

(2)Oriental pear or Japanese Pear -*Pyrus pyrifolia*

Family: Rosaceae **Origin:** South-West Asia

Pears are the only temperate fruit grown to any extent on the hills in South India.It is next only to apple in importance. It is a rich source of Carbohydrates as sugars and starch and cellulose and minerals like Calcium, phosphorous and sulpher.

There are two types of pear .They are (**1) European pear** (French pear) and **(2) Oriental pear or Japanese pear.** The European pear is usually characterized by persistent calyx, fleshy pedicels and pyriform shape. While the oriental pear possesses deciduous calyx, on fleshy pedicels and the shape of an apple.

The high perishability of pear is responsible for its limited cultivation. Pear is cultivated at lower altitudes than apples.

Climate: It can be grown on a wide range of climatic conditions, as it can tolerate as low as -26^{O}C temperature when dormant and as high as 45^{O}C during growing period. A large no. of pear cultivars requires a temperature of below 7^{O}C for 1,200 hours during winter to complete their chilling requirement to flower and fruit satisfactorily.

Soils: It grows best in deep, well drained, fertile, medium textured and relatively more clay soils. It is more tolerant to wet soils but less tolerant to drought than apple. Pears even do well on poorly aerated heavy soil with high water table which is heavy in texture for most of deciduous fruits. A soil depth of about 6 feet is ideal for proper root

growth and fruit production. A neutral pH of 6.0 to 7.5 is desirable because Fe (Iron) deficiency appears on highly alkaline soils.

Varieties: Most of the pears varieties are **self unfruitful** and require pollenizers.The following varieties are recommended basing on the results after adopting large no. of trials. They are: Baghu Gosha, Conference, Early china, Bartlett, Favourite, Hardy, Nashpati and Kieffer etc.

Pollination and fruit set: Fruit set, in both European and Japanese plum, is a problem. From fruit set point of view European plum can be divided in to three important groups namely (1) **Self fruitful varieties,**(2) **Self unfruitful and** (3) **Cross unfruitful.** It is therefore, safer to interplant with at least one pollenizer variety, while planting varieties of the first two groups with synchronized flowering period. Both the self-unfruitful and self fruitful varieties have good pollen and can be used for mutual cross pollination.

Japanese plum varieties are mostly self-unfruitful and some are self fruitful. It is therefore advisable to provide pollenizer varieties for both the group of plum.

The dependable pollenizer varieties are Vickson, Santa Rosa, Red Heart, and Elephant Heart.

To make the pollination of plum varieties more effective, it is recommended to plant every third tree in every third row with pollenizer. Alternatively one or two pollenizer rows may be planted after every 2 or 6 rows of a variety.

Propagation: Pears are commercially propagated by Shield (T) budding. The root stocks generally used are the wild Himalayan pears i.e.*Pyrus pashia*, *P.pyrifolia*, *P.kashiana*. To produce dwarf trees **Quince-D** root stock is used. Some commercial varieties are not compatible with **Quince-C** root stock. By double working using an intermediate rootstock like Old Home, the incompatibility can be over come. **Quince A** is a vigorous root stock

Planting: The pits of size 1m X 1m X1m are dug and filled with a mixture of soil and compost. For a crop on its own roots an initial spacing of 3mX2m is given which is changed to 6mX4m after 4-5 years. For pear on **quince-D** a planting distance of 3.5m X 1.1m is enough since, it has the effect of dwarfing the trees.

Manures and fertilizers: An optimum dose of major nutrients of 600g N, 150g P and 300g K per tree per year is sufficient to get the maximum yield. It is generally grown in poor soils. Calcium deficiency in pear causes black end and cork spot disorders.

Training and pruning: Proper training and pruning of pear trees is essential for the development of strong frame work, to maintain vigour and growth, spread of fruiting

area uniformly, secure fruits of good size and quality, encourage regular bearing and to provide convenience of pruning ,spraying and harvesting.

Pear trees are usually trained to “**Modified leader method**”. In this system 4 or 5 well spaced primaries are developed during initial years and then the leader is headed back.Ths first branch is allowed at a height of 60cm from ground and subsequent branches 10-15cm apart around the trunk.

In pruning bearing trees, a certain amount of thinning out and heading back of outward growing laterals are considered adequate. A balance is required to be maintained between fruit production and vegetative growth. Pear bears fruits on spurs on 2 year old wood and a spur continues to bear for more than 6 years. The limbs with spurs over 6-8 years old need to be removed in phased manner.

In hills, dormant season, when the danger of heavy snow fall is over, is the best time of pruning. Early pruning may result in severe cold injury.

Irrigation: In heavier soils, moisture supply representing 50% or more of the maximum available moisture in the upper 1m is essential for maximum growth of the fruit, shoot and trunk. Lighter soils or those with a gravel substratum need more frequent and heavier application of irrigation.

Harvesting: Fully mature fruits are harvested for fresh consumption, while still firm and green for canning and distant markets. The fruits are picked individually by giving a gentle twist rather than direct pull. Harvesting should be done in 2-3 pickings at 3-4 days interval rather than single picking.

Yield: The average bearing life of the pear tree in India is 60 years.30-40tonnes of fruits / ha / year can be expected.

PLUM

Botanical Name: *Prunus domestica* (European plum) **Family:** Rosaceae
Prunus salicina (Japanese plum)

Origin: European plum--Caspian Sea (Caucasus region)--Japanese plum-China

Plum is an important temperate fruit which is used both as fresh and in preserved form. Of the stone fruits, it ranks next to peaches in economic importance.

There are two types of plum: (**1) European plum** and **(2) Japanese plum**. These were introduced in 1870 into Himachal Pradesh.

European plums are cultivated at higher elevations (1300 to 2000M) and the Japanese plum at lower elevations (1000-1600M) and in the sub-mountane areas.

Plum fruits supply fair amounts of sugar and minerals like potassium, calcium, magnesium, iron, zinc and vitamins like “A” and “B” like thiamene, ribo-flavin and Niacin.

Most of the European plums are self fruitful and Japanese plums are often self fruitful.

In India Japanese plums are more popular compared to European plums. European plum is more popular world wide.

Japanese plum bears heavy crops and needs fruit thinning.

Climate: European plum requires a temperature below 7.2^{O}C for 800 – 1000 hours for winter chilling for satisfactory bud break where as Japanese plums requires comparatively lower chilling i. e. 700-800 hours below 7.2^{O}C. Areas free from spring frost are conducive to plum production. Areas receiving 100-125 cm rainfall well distributed through out the growing season are considered suitable. Areas subjected

to high wind velocities or cyclones are not suitable and can only be used for plum cultivation by providing wind breaks. Hail prone areas are to be avoided.

Soil: Deep sandy loam soils with good drainage are best suited for plum cultivation. European plums perform even better on heavy loam or clayey soil.Unfavourable soil conditions can be over come by the use of appropriate root stocks. Water logged, poorly drained, very shallow soils with excessive salts should be avoided. The depth of the soil should be at least 6 feet.

Varieties: There is large no. of varieties in India but for commercial cultivation only a few are recommended. They are: Santa Rosa, Beauty, Grand duke, Plum red, Kelsey, wickson, Bur Bank, Victoria etc.

Beauty, Santarosa and Mariposa are self fruitful cultivars and used as pollenizers for plum. Kelsey, Eldorado, Wickson, Larado and Farmosa are self unfruitful cultivars.

Propagation: Since it doesn't breed true to type from seeds, vegetative propagation by grafting and budding is commonly used for commercial multiplication of plants. Plum is raised on seedling root stocks of wild apricot (Zardalu) and Myrobalon B plum clonal root stocks. Tongue grafting, Chip budding and "T" budding are the important methods employed commercially for propagation of plum. After grafting or budding the plants take about 2 years to attain standard size plants.

Planting: Plants are planted in pits of size $60cm^3$ at a spacing of 5-6m either way. One to two year old budded plants are planted during spring before bud break under extreme winter condition.

Manures and fertilizers: Plum requires adequate amounts of nutrients for better growth and quality of fruits. Application of manures and fertilizers depends on soil fertility, type of soil, topography, age of tree, cultural practices and crop yield. For a bearing tree of 7 years and above 40 kg of FYM and 2 kg of Calcium ammonium Nitrate(500g N),1560 g of single super phosphate(250g of Phosphorous) and 1,170 g of Murate of potash(700g of potash) should be applied. Full dose of FYM, P and K should be applied during December and January. Half of the nitrogen should be applied in spring before flowering and remaining half a month later.

Training: Plum plants are generally trained according to their growth habit and vigour of the root stock. Training is done to give a proper shape and to develop a strong frame work of branches. Plum trees are generally trained to 'open centre system'.

Pruning: The bearing habit of the plum is variable. Several varieties of European plum bear on spurs so; pruning is necessary for spur renewal and 75 to 80% removal

of new growth in each season. The Japanese varieties bear a profuse crop on shoots and require more severe pruning. Bearing trees are pruned to maintain a balance between vegetative and reproductive growth. Pruning should be regulated that the tree makes 30-50cmof extension growth every year.

Irrigation: Plum requires adequate amount of water through out the growing season. In India most of the plum orchards are on sloppy land growing under rain fed conditions. Though the annual rainfall is very high, its distribution is not uniform through out the growing season. Generally, drought conditions prevail during the fruit growth and development, therefore irrigation is necessary during this period. The peak water requirement period in plum is May to June, which coincides with the rapid fruit development period.

Harvesting: Since, plum is a climacteric fruit, it does not attain full ripe edible quality on tree. So; fruits should be picked at proper stage of maturity. The various maturity indices are:

- Days from full bloom
- Firmness of the fruit.
- Total soluble solids
- Change of ground colour from green to yellow or red depending on the cultivar

Yield: Fully grown plum trees yield 60-70 kg of fruits. Harvesting time varies from variety to variety in different states. Fruits are available in the market from second week of May to third week of July.

CHERRY

Botanical Name: **(1) Sweet Cherry:** *Prunus avium* **Family:** Rosaceae
(2) Sour Cherry: *Prunus cerasus*
Origin: South Central Europe and Asia Minor

Cherries are one of the important temperate fruits. There are two types of cultivated cherries. They are Sweet cherry and Sour cherry. Sweet cherries are used as desert and the sour cherries are used for cooking and canning.

Climate: Though sweet cherry is grouped under temperate fruit, it can not tolerate frost. It can not tolerate warm climate too. But sour cherries comparatively tolerate frost but don't tolerate warm climate.

Soil: A well drained deep gravelly or sandy loam soil will be ideal for growing cherries.

Varieties: About 120 varieties are available. Most of them belong to sweet cherry group. All varieties are divided in to 2 groups.
Sweet cherry: Emperor Francis, EarlypurpleBlackheart, Compact Lambert, Jubilee, Sam, Summit, Sue, Sunbrust e, English morello etc.
Sour cherry: Mont morency, North Star, English morello
Most commercial varieties are self incompatible and some are even cross incompatible.

Propagation: Cherry is propagated commercially by '**T' budding or Inverted 'T' budding**. The rootstocks mostly used are *Prunus cerasoides*, *P.mahaleb*, *P. padus*

etc. Diffrent states are using different root stocks depending on their merits and demerits

Planting: In India cherry cultivation is confined to hilly areas on sloppy lands. The planting is done on contour or terrace system. The planting distance depends on the soil fertility and the root stock used. For sour cherries the planting distance adopted is 6mX5m and for sweet cherries it is 7mX6m.Pits are filled with top soil and FYM in the ratio of 1:1.Grafts of less than two years are planted.
In establishing cherry orchard, the varieties planted should be able to pollinate one another.

Training: Cherry trees are trained on '**modified leader system'**. Plants are headed back at about 60-80cm at the time of planting The central leader is retained and 3-5 wide-angled branches,20-25cm apart are selected spirally on around the plant in the first dormant pruning. The lowest branch should be 40-60cm above the ground level. The selected scaffold branches are headed back to minimum and only one fourth of the growth is pruned off. In second dormant pruning, 3-4 well spaced main branches are selected whose one fourth growth is pruned off and on each main scaffold well spaced 3-4 secondary branches are selected. After 3-4 years, central leader is headed back and lateral branches are allowed to grow, resulting in the development of a strong and moderately spreading tree.

Pruning: Cherry plants require more corrective pruning rather than too much heading back of the branches. Bearing trees need some pruning to keep the centre of the tree open. Pruning is restricted to eliminating the dead, diseased and inters crossing branches. Fruits are borne laterally on spurs of one year old shoot .The average productive life of these spurs is 1-12 years, requires less renewal pruning.

Manuring: Cherry requires all the essential nutrients for better growth and quality of fruits. Since, fruit development and vegetative growth occurs simultaneously, it has high demand for mineral nutrients. The amount of manures and fertilizers to be applied is influenced by the age or size of the tree, soil type, fertility status, management practices and anticipated fruit yield.

Irrigation: Due to sloppy lands and non-availability of irrigation water, cherry is grown under rain fed conditions in our country. The distribution of rainfall throughout the year is uneven and owing to less rainfall during April-May, its plants should be watered frequently. Irrigation at weekly intervals during fruit growth and development is recommended for better fruit size and quality.

Harvesting: Cherry starts bearing from the 5^{th} year and reaches full bearing after 10 years. It continues to bear up to the age of 50 years. The yield and quality of cherry is

appreciably affected by the stage of maturity at which the fruits are harvested. The fruits are borne in clusters on long stems should not be harvested when wet. If there are rains when the fruit is maturing, fruits crack and rot. Early picking results in flat fruits with less yields as cherries usually develop rapidly in the last few days before maturity is reached. Harvesting of over ripe fruits result in loss of weight, volume and quality. Determination of degree of maturity should be employed as a guide for harvesting of fruits. Colour development; TSS and flavour are the best standards for judging the optimum time of harvest**.**

Fresh fruits are picked with stem when the surface colour changes from green to red. While for processing, fruits are picked with out stem.

Yield: The average yield is 15 to 20 kg /tree/ year**.**