Institutional Development Plan (IDP),SKUAST Jammu

Strengthening Institutional Capacities for Delivering Competent Skilled Professionals

REMEDIAL CLASSES OF FACULTY OF HORTICULTURE

Organised by NAHEP-IDP SKUAST-JAMMU

HORTICULTURE

CHAPTER I

INTRODUCTION TO HORTICULTURE

Definition of Horticulture:

Horticulture may be broadly defined as the Science and art of growing fruits, vegetables and flowers and crops like spices condiments and other plantation crops.

It is a science of cultivation of Garden plants.

The word Horticulture in derived from the Latin word Hortus meaning enclosure (garden) and culture - meaning, cultivation, thus Horticulture man's culture or cultivation of garden crops.

Branches of Horticulture:

Horticultural Science is the most distinct branch of Agricultural Sciences and call be divided into four different branches as follow.

A) Main Branches:

Sr. No.	Branch	Description
1.	Pamology	It deals with cultivation of fruit crops.
2.	Olericulture	It deals with cultivation of vegetable crops
3.	Floriculture	It deals with cultivation of ornamental flowers and land scaping.
4.	Fruit and vegetable preservation	It deals with the principles of fruit and vegetable preservation.

B) Sub Branches:

1. Plantation and Medicinal plants.
2. Ornamental Gardening
3. Landscape gardening and
4. Nursery plant production

Importance of Horticulture

1. Per Unit Area Yield is High:

As compared to the field crops per hectare yield of horticulture crops is very high. From a fruit area of land more yield is obtained e.g. paddy gives a maximum yield of only 30 q/ha, while Banana gives 300 to 500 q/ha, Pine apple 450 q/ha and Grapes 90 - 150 q/ha. In present shortage of food and scarcity of land by growing fruits more food can be produced.

2. High Returns per Unit Area:

From one unit area of land more income will be obtained e.g. well-kept orchard of apple, grapes and sweet orange can give as much as Rs. 25,000 per ha as net income.

3. A Free Grower/Labour Remains Engaged for the Whole:

An opportunity for maintaining labours throughout the year like the cereals where one cannot keep himself and employ the labours during the slack season.

4. Best Utilization of Waste Land:

Some fruit crops can offer best utilization of waste land crops like wood apple, custard apple, karonda, litchi etc. can be grown in such areas.

5. To meet the annual calories requirements of food per year one would have to cultivate about 0.44 ha of wheat or 0.03 ha of banana or 0.06 ha of mango for satisfying once need. Thus, mango produces about 9 times more food energy than the wheat produced per unit area.

6. Raw Material for Industries:

Fruit farming is the base for several industries like canning, essential oils etc which in turn provide work for more people.

7. Use of Undulating Lands:

Fruit growing can be practiced in places where the gradient is uneven or where the land is undulating and agronomical crops cannot be cultivated. In Konkan region, mango and cashew are cultivated on large scales on hilly and hill back area.

8. Fruits and vegetables are the important energy giving material to the human body.

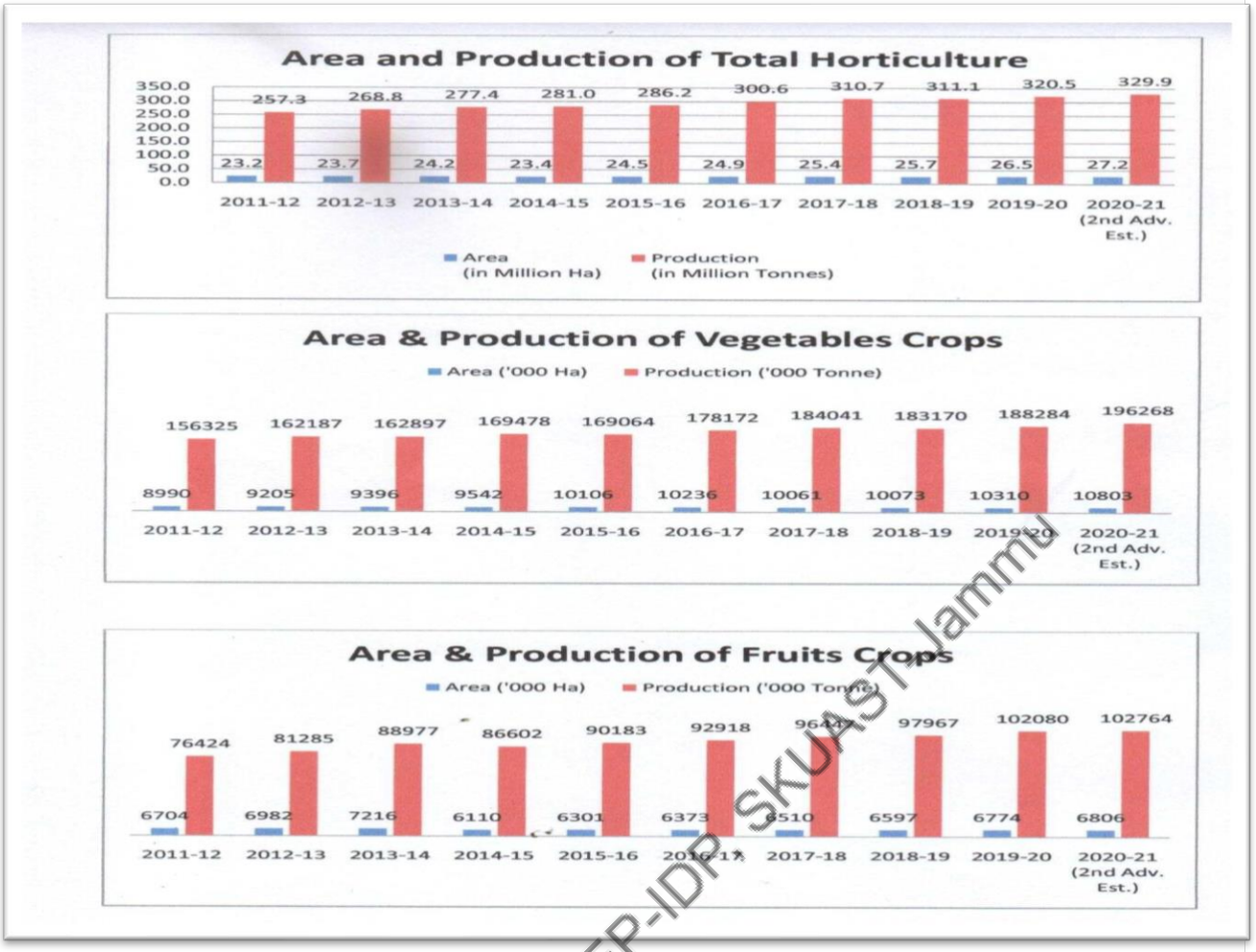
Scope of Horticulture

There is a great scope of Horticulture. Horticulture production is less as compared and hence very high demand in market.

Present Status:

(Area in Million Ha, Production in Million Tonne)

Total Horticulture	2019-20 (Final)*	2020-21 (1st Adv. Est.)	2020-21 (2nd Adv. Est.)
Area	26.48	27.08	27.23
Production	320.47	326.58	329.86



1. Increasing Investigation Facilities:

The agricultural sectors getting priority in the new five-year plan outlay. There is definitely positive factor in keeping hope for bringing area under irrigation, many irrigation projects, major and minor are in progress and many would be undertaken in near future. Number of percolation tanks is being constructed and new schemes.

2. Area Under Rain Fed:

Horticultural crops are not required the perennial irrigation.

3. Transport and Marketing Facilities:

It is obvious that horticultural produce is perishable and mostly consumed as fresh and need quick disposal after harvest.

4. Cold Storage Facilities and Preservation:

During peak period of a particular crop there is glut in market and prices realized are very low. This can be overcome by storing the fruits in cold storage. Many preserved products have export potential e.g. Jam, Jelly, Juices syrups etc.

5. New Techniques for Maximization of Production:

This helps in increasing the yield.

i) Use of Growth regulator and girdling increasing yield by 50% in grapes.

ii) Use of growth regulators.

6. Availability of Cheap Labour:

In India because of large population man power is easily available and as compared to other countries the labour is cheap which definitely help in keeping down the production cost.

7. Loan Facilities:

Many Commercial Banks and Government provide loans at low interest for the promotion of Horticultural Industry.

8. Sloppy, undulated land can be brought under cultivation by growing rain fed horticultural crops.

9. The average production of the Horticultural crops is more than the agronomic crops and therefore, the net returns are also more.

Nutritive Value of Fruits and Vegetables

As said earlier fruits and vegetables is the important energy giving material to the human body. Importance of the fruits and vegetables in the human diet is universally recognized. They are the major sources of vitamins without which the human body cannot maintain proper health and resistance to diseases. Besides they also contain minerals, salts, protein, cellulose which protects human body against various disorders, Extent of the Vitamins in various fruits / vegetables and how they are important can be judged by the following information.

A. Vitamin C (Ascorbic acid):

It is responsible for sever pains in the joints, blooding of gums, tooth decay and the humanisms, Ascorbic acid, loss in energy, delay in wound healing, increased susceptibility to disease enlargement of heart and damage to heart muscles.

Anona 600, Guava 299, Citrus 63 - 68 mg/100 gms is the richer source of Vitamin C in case of fruits. Vegetables like Methi, Palak, Lettuce, Cabbage, Green pepper, Chillies contain appreciable quantity of Vitamin C. Potato and Sweet potato also supplies ascorbic acid.

B. Vitamin B -1 (Thiamine):

Deficiency of this causes Beriberi, loss of sensitivity of skin, paralysis, loss of appetite, loss of weights, and fall in body temperature fruits like Banana (150 mg / 100 g), Apple (120 mg/100 gms) and Cashew nut (630 mg/100 gm), Almond (240 mg/100 gms) are the good source of this Vitamin B - 1.

Apart from this Methi, Cabbage, Onion, Green vegetables, Lettuce, green chillies, carrot, peas and beans (in seeds) are also rich in Vitamin B.

C. Vitamin B -2 (Riboflavin):

This vitamin is important for growth and health of skin, its deficiency causes loss of appetite, loss in weight, sore throat, swollen nose etc. Papaya (200 mg/ 100 gms), Bael (191 mg/100 gms), Pomegranate (100 mg/100 gms), pineapple (120 mg/100 gms) More or less vegetables listed above are the major suppliers of this Vitamin.

D. Vitamin - A (Carotene):

Absence of this Vitamin in diet results cessation of growth in young ones, night blindness, drying up tear glands of eyes, eruption of skin, brittleness of teeth and susceptibility to disease.

Mango (4800 i.e., per 100 gm), Papaya (2020 i.e. per 100 gms), Jack fruit (540 per 100 gms) are the richer source of this vitamin. In vegetables carrot, peas, turnip, beats, tomato, Sweet potato green vegetables, cabbage are observed to be very good supplier of this Vitamin.

Though the Vitamins are quite important in maintenance of the human body, the role of minerals cannot be ignored also. Minerals like Calcium, Phosphorus, and Iron are required for living body.

Calcium:

Calcium is badly lacking in Indian diets. It is needed for healthy bones and for resistance to infections. In its absence children suffer from rickets, pigeon chest, ignitability and retarded growth. Their teeth become bad. It also acts as an coordinator among the mineral elements and helps to correct proportion of other elements.

Fruits viz. Litchi, wood apple, dried grapes, oranges, straw berry, are the source of Calcium. However, vegetables like cabbage, carrot, cauliflower, lettuce, onion, spinach, tomato also supply Calcium in minor quantities.

Phosphorus:

Regarding Phosphorus, which is essential for all active tissues of the body. It is actually required for cell multiplication of both bones and soft tissues the for the maintenance of proper liquid content of the tissues. It also plays an important role in oxidation of carbohydrates which liberates energy. Phosphorus in enough quantities in vegetables like potatoes, carrot, tomatoes, cucumber, pinch, cauliflower, lettuce than most of the fruits. However, almonds, cashewnut and litchi are the more suppliers of the Phosphorus.

Iron: Vegetables are richer in iron than fruits and found in green leaves. Iron is essential part of the red blood capsules and is the best known oxygen carrier in the body. It is essential element in the body and can be had from Spinach, truce, Cabbage, Peas, Bean and Tomatoes. In fruit crops karonda, Dates, cashewnunt, Raising etc. are the major suppliers of this element.

Still Area under Fruit Cultivation is not increasing at Faster Rate Why?

The question arises as to why the development of fruit industry is slow in our country of vegetarianism in spite of above advantages over agronomical crops. The answer lies in the facts that,

1. Fruit growing is a long term venture requiring a high initial investment and high recurring expenditure.

2. Most of the fruit trees are woody perennials with deep roots, which take several years to bear fruits.

3. They require intensive cultivation including specialized methods of propagation.

4. Lack of technical knowledge such as pruning training etc.

5. Poor transport and irrigation facilities.

6. Availability of guanine, planting material.

7. The low purchasing power of the consumers.

8. Lack of cold storage facilities, packing as the fruits and vegetables are perishable in nature.

9. Defective marketing system. Lack of co-operative marketing societies, Middlemen are getting more profit than the growers.

Importance of fruit growing

Cultivation of fruit crops plays an important role in the prosperity of any nation. It is generally stated that the standard of living of the people can be judged by per capita production and consumption of fruits.

Fruits crops are capable of giving higher tonnage of yield per unit area than other field crops. For example, a wheat crop produces on an average 12-15 tonnes from an area of one hectare in two crops per year. Even a hybrid rice variety can giv e only a maximum of 24 tonnes from one hectare land in three crops per year while a banana crop can yield 35-40 tonnes per hectare. Papaya gives 100-150 tonnes per hectare in 2 ½ years which works out of 40-60 tonnes per year and mango gives 25 tonnes from a hectare. From grapevine, a quantity of 60-80 tonnes per hectare in tow harvests per year can be obtained under tropical climate.

Fruits are found to be a rich source of vitamins and minerals. For example, mango, papaya and jack have the important constituent the beta carotene which is actually the precursor of vitamin A.

Mango and papaya fruits have been estimated to be very good sources of readily available beta-carotene, 1990 ug per 100 g in mango and 880 ug per 100 g in papaya. While bajra supplies only 132 ug of beta-carotene per 100 g, wheat supplies hardly 64 ug per 100g. According to recent research results many phytochemicals found in fruits act as powerful antioxidants protecting cells and organs from damage caused by free radicals, neutralizing their damaging effects. They are the biologically active substances in plants that give them colour, flavour, odour and protection against not only diseases affecting the plants but also human being.

Consequently, hundreds of such plant substances are being investigated now for their role in preventing cancer and other degenerative diseases. Some of the promising phytochemicals which act as antioxidants are bioflavonoids (Vitamin P), phenolics, lycopene, carotenoids, antioxidant vitamins (C and E) and glucosinolates.

Oranges, lemons, limes and grape fruits besides being principal sources of vitamin C and folate are rich in a class of phytochemicals called limonoids. This antioxidant has been found to be very effective against cancer.

Sweet orange is the most common food recommended for a patient suffering from very high fever. It has a cooling effect as well as it is easily assimilated. Peyan, a variety of banana fruit is administered to patients suffering from chicken pox as it brings down the high temperature of the body.

The potential of fruit crops in the growth of national economy is noteworthy. Being a country having varied climatic conditions ranging from tropical to subtropical and to temperate, India has very immense potential for the production of different fruits and their export. During 1998-99, 1.18 lakh tonnes of fruits and nuts valued at Rs.24,714 lakhs were exported from India. During 2002 India ranked second in annual production of fruits with 48.57 million tonnes accounting for about 10.3% of total world fruit production.

Recent policies of the Government of India to encourage export of fruits and their products by announcing concessions to the fruit industry such as reduced air freight charges and exemption for storage charges for refrigerated air cargo at international airports have encouraged a number of private entrepreneurs / corporate bodies and NRIs to go in for planting larger area under fruit crops with an aim to export fruits and fruit products. The foregoing account is given with a view to emphasize the growing importance of the fruit industry. As could be seen from the details given therein, the fruit culture in vital to the health and economy of the nation, from the stand point of increased food production, nutrition, trade and fruit based industries.

CHAPTER II

PROPAGATION METHODS

Propagation-Themultiplicationofplantthroughseedorvegetativemeansisknownaspropagation.There are two methods of producing new plants-

1. **Sexual method-** The multiplication of plant through seed is known as sexual method of propagation.
2. **Asexual or vegetative method-** The multiplication of plant through vegetative means is known as asexual method of propagation. It may be through division reseparation /division, cutting, layering, budding and grafting.

There are certain plant modifications which are used for vegetative propagation of plants. These modified plant parts may be stem, root, or leaves and are usually specialized for food storage. Two principal methods are used for propagation of plants by using these modifications.

A- Separation: naturally detachable structures, such as bulbs or corms are separated and planted individually.

B-Division: The plants modification such as rhizomes, tubers etc., are cut into sections to obtain new plants from each section.

1- **Bulbs:** Bulbs are produced by monocotyledonous plants in which the stem is modified for storage and reproduction. Bulb is a specialized underground organ consisting of a short freshly, usually vertical stem axis bearing at tip apex or growing points and

enclosed by thick freshly scales. Bulb scales morphologically are the continuous sheathing leaf base. Growing points develop in the axils of these scales to produce miniature bulbs known as bullets/ daughter bulbs. These daughter bulb scan separated from the mother plant at the end of growing season and used as propagating material.

Ex: Tulip, Daffodils, Tuberose, Onion, Garlic(cloves)

2- **Tubers:** A tuber is the short terminal portion of an underground stem which has become thickened because of accumulation of preserved food material eg: Potato. Propagation by tuber can be carried out either by planting the whole tuber or by cutting into sections each containing bud or eyes.

3- **Tuberous roots:** Certain herbaceous perennials produce thickened roots which contain large amount of stored food. The tuberous roots differ from the tubers in that hey lack nodes and internodes. Adventitious buds are present only at stem end or proximal end; fibrous roots are produced towards the distal end. These fleshy roots are separated and used for propagation. For example- sweet potato, Dahlias. Tapioca(Cassava).

Rhizomes: The horizontal, thick and fleshy or slender and elongated stem growing underground are known as rhizomes. Rhizomes have no de sand internodes and readily produce adventitious roots. The rhizomes are cut into pieces, each containing vegetative bud and transplanted. Eg: Banana, Ginger, Ferns, Turmeric, and Cardamom.

4- **Corms:** A corm is solid underground base of a stem having node sand internodes and is enclosed by a dry scale like leaves. After flowering one or more corms may develop just above the old one, which disintegrates. In addition, several new corms called caramels develop below each new corm. These may be separated and grown for 1-2yearstoreachfloweringstage. Eg: Gladiolus, Amorphophallus.

5- **Runners**: Runners are specialized arial stems (stolon's) arising in the leaf axils of plant having rosette crowns. New plants arise from nodes at interval. From these runners' newer runners may arise thus developing natural clonal multiplication methods. The typical runner producing plant is straw berry which is photo sensitive with regard to its runner production. Long days favour runner production whereas short days prevent runner formation. Eg: Strawberry.

6- **Suckers**: Adventitious shoot from the underground portion of the stem or from their horizontal root systems are known as suckers and when these strike roots, they may be utilized as propagation materials. Well-developed suckers are dugout and separated from them other plant and planted in the nursery for further growth. Suckers are usually treated like rooted layers. Eg: Pineapple, Chrysanthemum, Curry leaf, Banana.

7- **Offsets/ offshoots:** An offset is a shoot or thick stem of rosette like appearance arising from the base of the main stem of certain plant such as date palm, pineapples, Date palm cultivars are propagated vegetatively by separating away the off shoots and replanting them. However, these are girdled and layered for about a year prior to separation, because offshoots do not root easily when directly separated from the mother plant and planted in the field.

Study on Propagation by Cutting

Cutting- It is a detached method of propagation in which any vegetative part of the plant is separated and planted to regenerate the missing parts and develop itself into a new plant. This method is commonly used in plants which root easily and readily, thus, multiplication of plant is very quick and cheap.

Purpose- Multiplication of plants by cuttings includes stem, root and leaf cuttings. The stem cuttings are of four types i.e., hard, semi hard, soft wood and herbaceous cutting. The success in propagation by cutting depends upon factors such as conditions of mother plant, parts of the tree where cuttings are made, time of year, care while planting and aftercare.

Materials required- Secateur, rooting media, nursery bed/pots, khurpi.

A. Stem cutting

Next to seed, the stem cuttings are the most convenient and popular method of plant propagation. A stem cutting is any cutting taken from the main shoot of a plant or any side shoot growing from the same plant or stem. It is essential for the cuttings to have a sufficient reserve food to keep tissue alive until root and shoot are produced. The shoots with high carbohydrates content roots better. Cuttings from new shoots (less than one year age) root better as compare to older shoot of the plant. Based on maturity of shoots, the stem cuttings are classified as-

1.Hardwood cutting- Hard wood cuttings are made from the mature and lignified stems of shrubs and trees.

Procedure-Selectoneyearoldshootscurrentyearorofpreviousseason'sgrowth about lead pencil thickness from healthy, vigorous and young plants. The length of cuttings varies from 10-25 cm in length depending upon species. Each cutting should have at least two or three buds. While preparing the cutting, a straight cut is given at the base of shoot about 0.3 cm below the node while a slanting cut 1-2 cm above the bud is given at the top. Remove the leaves from the cuttings. Treating the cutting with100-5000ppmIBAbeforeplantinggivesbetter results Make holes in the rooting media/nursery bed and burry the 2/3basal portion of cutting in the holes at 45-degree angle facing slant portion to sun in the east. Press the soil around cutting firmly. Sprinkle water as and when necessary. Record the data as per technical programme. It is commonly practiced in Grape, fig, pomegranate, mulberry and phalsa.

2.Semihardwoodcutting

Semi hardwood cuttings are prepared from semi matured 6–9-month-old, slightly woody shoot. The sea resucculent and tendering nature and are usually prepared from growing wood of current season's growth. The length of cutting varies from10-20 cm. The cuttings are prepared by trimming the cutting with straight cut below a node. However, it is better to retain two to four leaves on the top of cuttings. Treating the cutting with IBA before planting gives better results in guava, lemon etc.

3.Softwood/Green woodcutting

Softwood cutting is prepared from soft, succulentandnon-lignified3–6-month-old shoots which have not become hard or woody. Usually, the cutting size is 5-15cm but it varies from species to species. Usually, few leaves are retained and before planting, treatment with auxin (IBA) is beneficial. This is commonly used for root stocks of apple, peach, plum and cherry in mist condition.

4.Herbaceous cutting- The cuttings are prepared from terminal soft, succulent and tender portion of 1–3-month-old shoots of current growth under mist condition ensuring warm and humid condition. This is commonly used in ornamental plants.

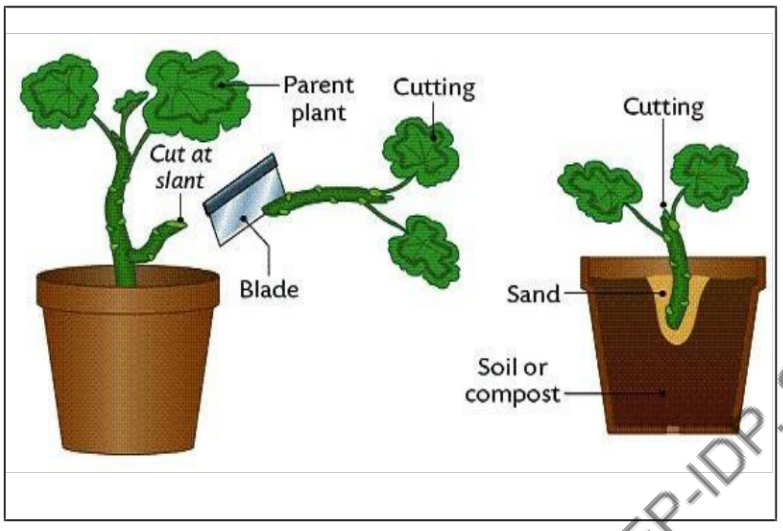
B. Leaf/Leaf bud cutting

Leaf cutting should preferably be prepared during growing season because buds if intern dormancy may be difficult to force to active stage. A leaf bud cutting consists of a leaf blade, petiole and shoot piece of stem with attached axillary bud of active growing leaves. In this cutting, 1-1.5 cm stem portion is used when propagating material is small. Leaf bud cutting are best made from material having well developed bud and healthy actively growing leaves. High humid condition is essential for better success in leaf cutting. eg. black berry, lemon, rasp berry.

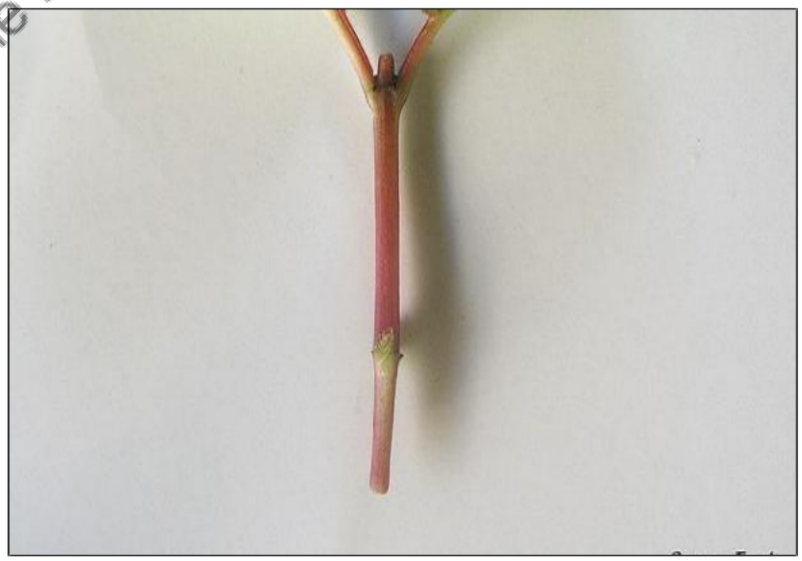
C. Root cutting- This is commonly used in apple, pear, cherry, guava, black berry, fig,

raspberry, wood apple etc. The root cuttings should be taken from root pieces of young stock plants in late winter or early spring when the roots are well supplied with stored foods but before new growth starts. It is important with root cuttings to maintain correct polarity when planting as the new shoots develop from the proximal end ie. from the part close to the crown. The proximal end of the root piece should always be up.

D. Others- Some different kinds of cuttings are also used by propagators like Basal cuttings, Heel cuttings, Bud cuttings, Eye cuttings, Inter nodal and nodal cuttings, Irishman's cuttings and Piping cuttings.



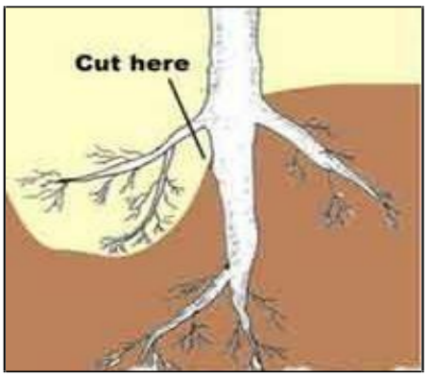
Herbaceous Cutting



Soft Wood Cutting

Semi Hard Wood Cutting

Hard Wood Cutting



Root Cutting

Leaf Cutting with petiole

Leaf cutting without petiole

Propagation by Layering

Layering- The layering is the development of roots on a stem, while it is still attached to the parent plant. The rooted stem is then detached to become a new plant growing independently on its roots.

Purpose- Layering is the oldest technique used by nurserymen to propagate many horticultural plants. Plant multiplication through layering includes several forms of ground and aerial layering (Goottie). When branches running parallel to the ground are utilized, then the method is known as ground layering. When rooting is encouraged on the aerial part of the plant after girdling, then the method is called as air layering or goottieormar cottage.

Classification of layering-

A. Ground layering

1. Tip layering
2. Simple layering
3. Compound or serpentine layering
4. Trench layering
5. Mound or Serpentine layering

B. Air layering (goottieormar cottage)

Materials required-Secateur, budding knife, rooting media, nursery bed/ pots, khurpi, sphagnummass, polythene strip, sutali etc.

Propagation by layering

1. Tip layering

In tip layering, the tip of shoots is bend to the ground and the rooting takes place near the tipof current season's shoot. The tips of shoot buried 5-6 cm deep in the soil. Keep the soil wet where cane is buried for developing the roots. Rooting in the buried shoots takes place within a month. The new plants may be detached and transplanted in the nursery duringspring.eg. Black berry, raspberry and gooseberry.

2. Simple layering

In simple layering, the flexible shoots of a plant are bent downwards over to ground in early spring or in rainy season. Remove a ring of bark or make a notch at a distance of 20-25 cm away from the tip to encourage rooting. The girdled portion is buried up to 7-10cm depth and covered with soil leaving the terminal end of the branch open. It is necessary to hold the cane/shoot in place with wire or wood stakes. Keep the soil wet where cane is buried for developing the roots. Rooting in the buried shoots takes place within a month. Eg. Grape, lemon etc.

3. Trench layering

In this method it is important to establish a permanent row of plants to be propagated. The mother plants are planted at the base of a trench at a angle of 45 ^{0} in rows. The long and flexible stems of these plants are pegged down on the ground to form a continuous line of layered plants. The young shoots that arise from these plants are gradually mounded up to a depth of 15-20 cm in autumn, winter or end of the season, depending upon the species. Eg Apple rootstocks (M16 and M25), cherry, plum

4. Compound or Serpentine layering

It is suitable for plant producing long, slender, and flexible shoots. It is modification of simple layering in which one year old branch is alternatively covered and exposed along its length. The stem is girdled at different point in the underground. However, the exposed portion of the stem should have at least one bud to develop a new shoot. After rooting, the section are cut and planted in the field. Jasmine, American grapes etc.

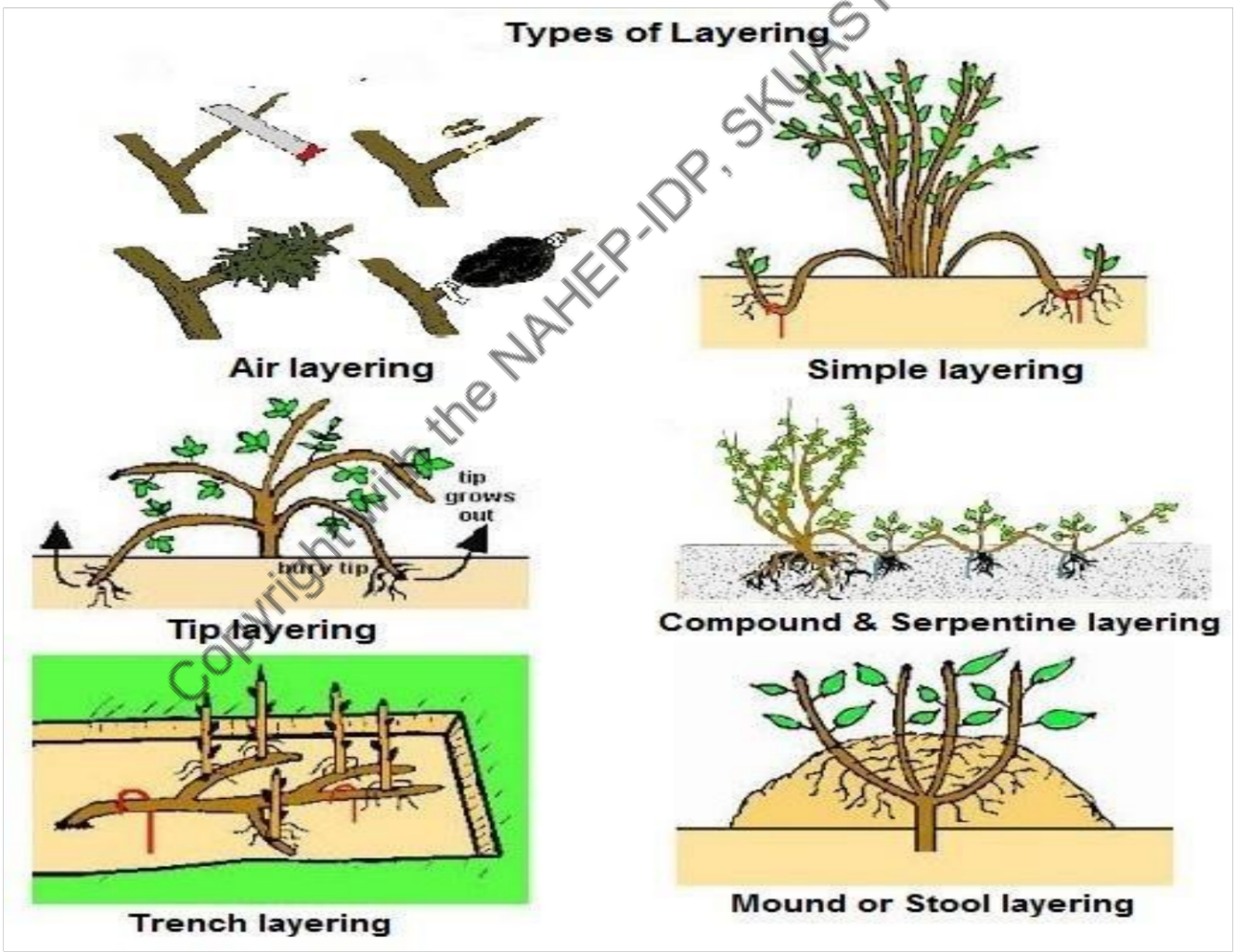
5. Air layering

Generally, one to two years old, healthy and vigorous shoots having pencil thickness are used for air layering. First the leaves are removed near the basal – inter nodal portion which is away from 35 to 45 cm from apex of the selected shoots then the stem is given a notch or is girdled by removing a ring of bark about 2-3 cm wide. Root promoting substances may be applied as powder or in lanolin or as a solution. IBA or a combination of IBA + NAA, both at the rate of 500ppm may be applied for better results. After application of hormones, ringed or girdled portion is covered with moist moss grass or handful of moist clay soil. This ball of earth may be again covered with sphagnum

moss and wrapped with a 200-gauge polythene sheet. Air layering should be done either inspiring or in monsoon. The rooted layers are either planted in pots or in the nursery beds in a shady place until they are fully established. Litchi, guava and pomegranate, lemon and Lime can be propagated by air layering.

6. Stooling/mound layering

In this method the mother plants are headed back to 10-15 cm above ground level during dormant season. The new sprout will arise within two months. These sprouts are then girdled and rooting hormone made in lanolin paste is applied to the upper portion of the ring. The concentration of rooting hormones are varies from plant to plant but in general 3000 to 5000ppm is most commonly used. These shoots are left for two days for proper absorption of hormone before they are covered with soil. Care must be taken to keep the soil moist all times. The roots from shoots may emerge within 20-30 days depending on species. These rooted stools should be separated from the mother plant only after 60-70 days and then planted in then nursery beds. Eg. Guava, Apple root stocks, quince, currants, raspberry etc.



Propagation by Grafting

Grafting

Many horticultural plants are propagated by grafting. In grafting, the desired cultivar can be raised on other plants (rootstocks) for achieving the desired benefits.

Grafting is an art of joining the stock and scion in close contact with each other in such a way that they will unite and continue to grow as single individual/composite plant. The upper part of the composite plant is termed as 'scion' and the part which forms the root is termed as 'rootstock'. Sometimes, when scion and rootstocks are not compatible with each other, another piece of wood is used in between the stock and scion, which is compatible with both; this is called as 'inters tock'.

Principles of Grafting- The principal steps involved in healing process and formation of the graft union are-

i. Establishmentofdirectcontactbetweenthecambialregionofbothstockandscion.

ii. Production and interlocking of parenchymatous cells.

iii. Production of new cambial cell.

iv. Formation of new vascular tissues.

Different methods of grafting-

A-Attached method of grafting- Inarching, bridge grafting

B-Detached method of grafting–Whip, tongue, cleft, veneer, softwood, epicotyl grafting.

1. Inarching

It is generally used for repairing or replacing damaged root system and hence also called as repair grafting. Selection of parent tree for taking the scion is an important factor for its success. The scion plant should be healthy, vigorous and high yielding. The stock is brought close to the scion. A thin slice of bark (6-8 cm long and about 1/3 inch in thickness at height) at about20cmabovethegroundlevelisremovedfromthestockwitha sharp knife. A similar cut is made in the scion. Thus, the cambium layers of both stock and scion are exposed. These cuts are brought together and tied firmly with the help of polythene strip. After successful union, stock above and scion below the graft union are looped of gradually. It is done soon after rainy season provided that temperature of the localities does not fallbelowthe15 0C.eg Mango, sapota, guava, litchi.

2. Veneer grafting

It is simple method of propagation and can be used in one year old rootstock seedlingshavingadiameterof1.0-1.5cm. Forveneergrafting,3-6monthsoldscionshootsareselected. Usually, the terminal and next to terminal shoots are most ideal. The shoots aredefoliated5-10dayspriorthegraftingleavingthepetioleattached.Therootstockisprepared by making a slating cut (5cm long) and an oblique cut is made at the base of first cut so that a piece of wood along with bark is removed. The base of the scion wood is then fitted into the rootstock in such a manner that the cut surface including the cambium layers of scion and rootstock face each other. The rootstock and scion are tied together with polythene tape. When scion growth begins the shoot of rootstock is removed above the graft union. Eg. Mango

There are some other methods of grafting used for propagation of fruit plants.

3. **Whip grafting**

It is simple and popular method of grafting. In this method of grafting, it is essential that both stock and scion should be of equal diameter1-1.5 cm. About one year old rootstock is headed back at a height of 20-25 cm from the soil and a diagonal cut is made at the distal end of the rootstock. A similar slanting cut of 2-4 cm is made on the proximal end of the scion. The cut surface of both rootstock and scion are bound together and tied firmly with polythene tape or banana fiber. Many fruits plant are propagated by whip grafting eg. apple and pear etc.

4. **Tongue grafting-** This method is practiced as whip grafting except one additional reverse cut is made on both scion and rootstock, so that cambial contact will be more with more success percentage.

5. **Cleftgrafting**

It is particularly suitable in rootstock having diameter greater than the scion. Rootstock with 5-7 cm or more girth is selected for this purpose. The rootstock is cleft grafted after decapitating the stock 20-40 cm above the ground level. The beheaded rootstock is split to about 5cm deep through the center of stem. After that a hard wooden wedge is inserted to keep open for the subsequent insertion of scion. The scion of 15-20 cm size is taken from a terminal shoot, which is more than three month old and then it is wedge securely (6-7 cm).The cleft of the scion then slipped into the split of the stock. In thicker rootstock more than one scion should be inserted. The graft should be thoroughly waxed to prevent wilting. Eg Avocado, apple, pear, plum, mango.

6. **Bark grafting**

It should be done in spring when bark of the stock slips easily. It is important that scion used in bark grafting should be dormant. The stock is first sawed off at a point, where bark is smooth. Bark is split downward, about 5 cm from the top. Scion of 10-12 cm long, containing 2- 3 buds are collected from the dormant wood and are preparing by giving slating cut (5cm) downward along one side of the base. The prepared scion then inserted in the center of split between the bark and wood of the stock. The scion is kept firmly byusingadhesivetape.eg Many fruit plant.

Special Grafting Techniques

7. **Epicotyl /Stone grafting-** This method is commonly practiced in mango. It is simple method of wedge grafting where the current season's scion shoot of the desired variety is inserted into the tender part of the stem of the sprouted stone (15-30 days old seedling) and tied with polythene sheet

8. **Top working-** This is commonly practiced to convert an old/ unproductive orchard of in ferior variety in to productive one by grafting with desirable variety after head back of unproductive plant eg. Mango, cashewnut, mulberry

9. **Soft wood grafting-**This technique is commercially used for raising Cashew nut, Mango, Jamun, Tamarind, Custard apple through wedge grafting. In this technique, grafting is done with mature, procured scion on the emerging soft, coppery red shoot of the rootstock, which is 60-70 days old.

10. **Bridge grafting**- Bridge grafting is done with objective of repairing of damaged fruit plant.

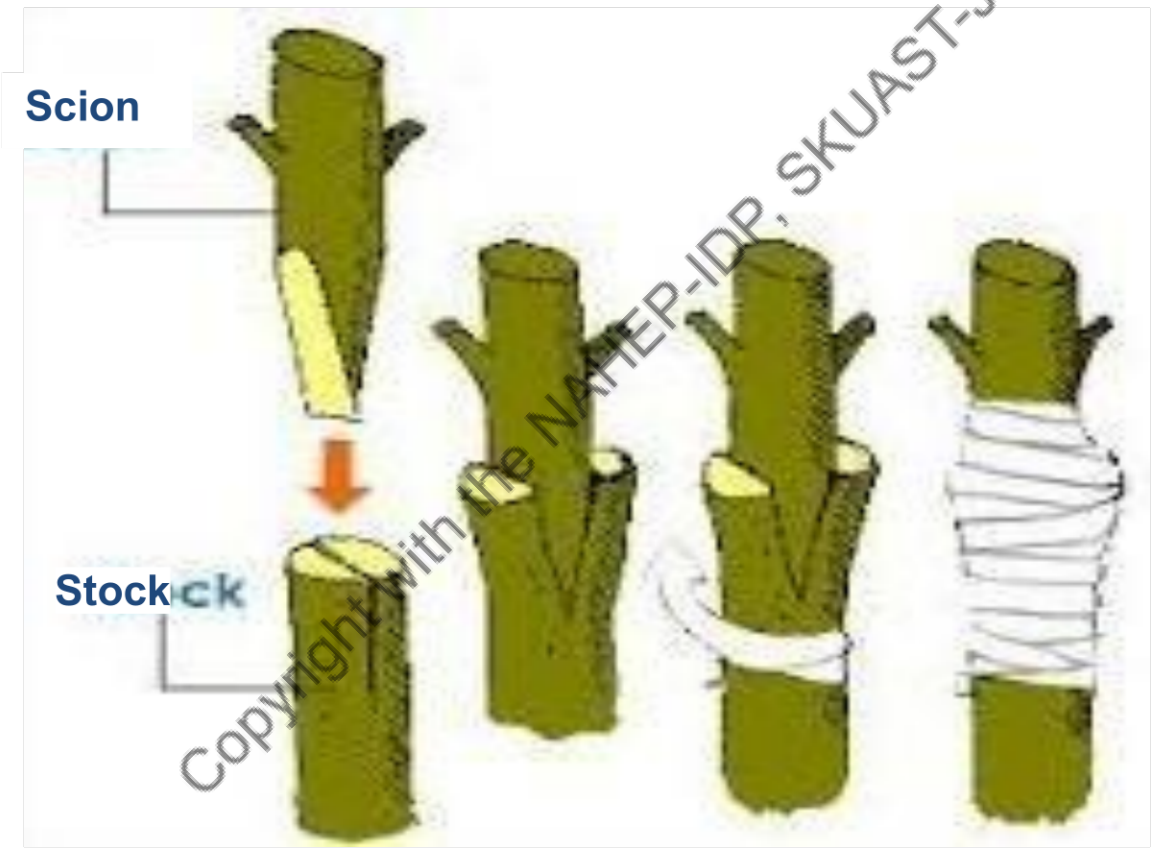
The scions are prepared by giving slanting cuts on one side of the top and base.

11. **Double working-** Double working is a specialized technique of grafting in which the composite plant has three different components, the root stock, inters tock and the scion i.e. the desired variety or cultivar. Thus, the double worked plants have graft joints, one between the rootstock and interstock and other between the inters tock and scion. It is done to overcome the in compatibility between the desired cultivar and stock.

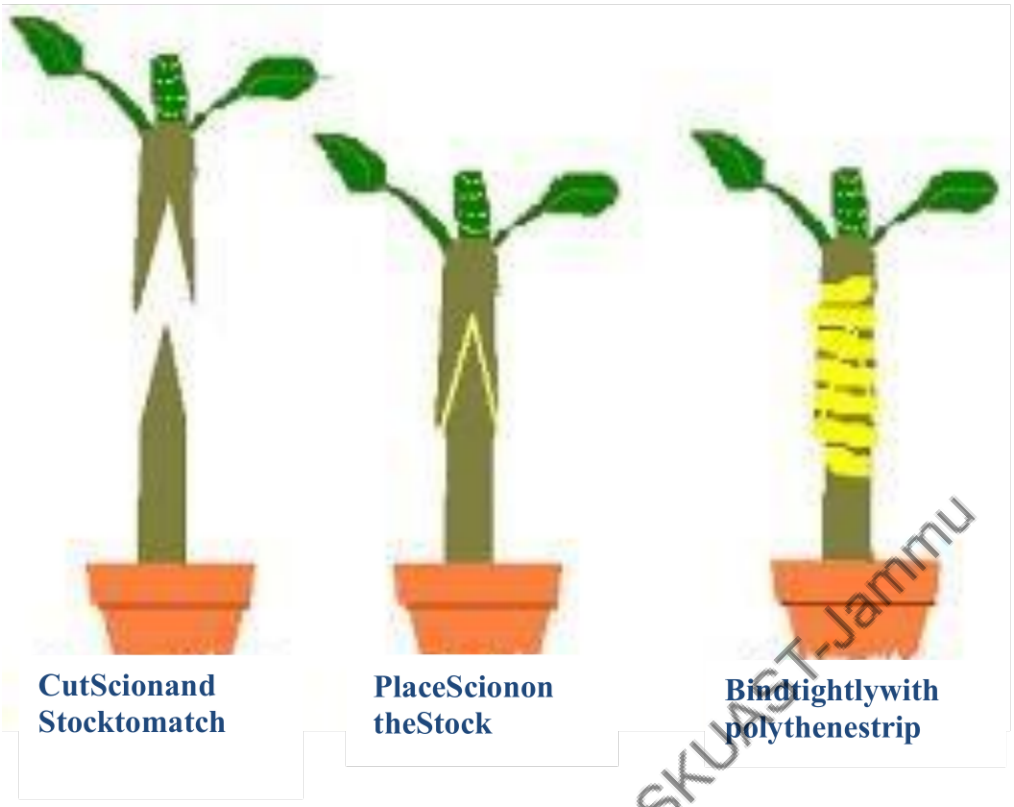
12. **Micrografting-**Thegraftingoftinyplantpartsunderascepticandcontrolledenvironmental condition is called micrografting. Micrografting has been mostly used in citrus, apple and plum top reduce virus free plants.

Inarchin

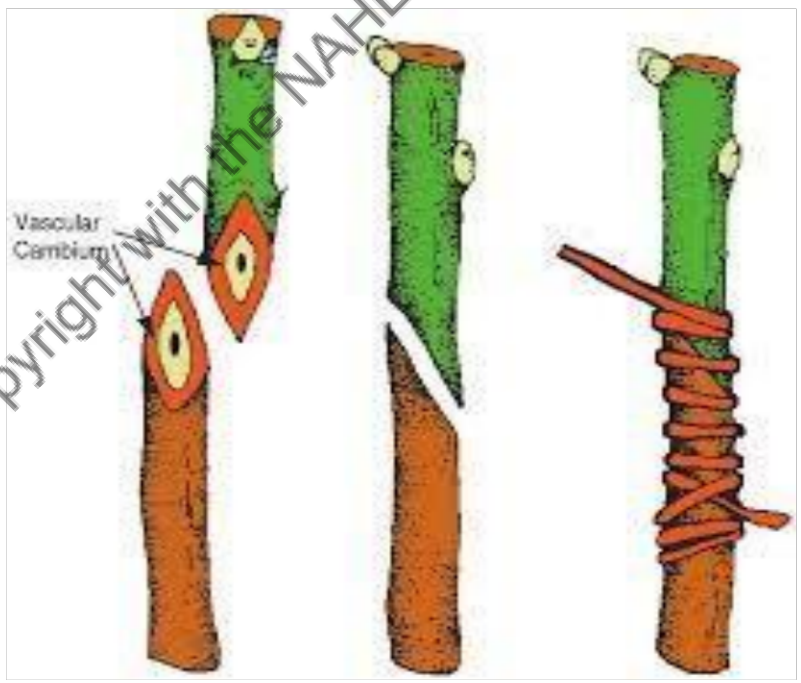
Veneer Grafting



Cleft/Wedge Grafting



Saddle Grafting Inarching



Whip Grafting

Tongue Grafting

Epicotyl Grafting

Bridge grafting to repair damage

Propagation by Budding

Budding- Budding is also a method of grafting, wherein only a single bud with a piece of bark with or without wood is used as a scion material, which develops into plant after successful union of the stock and bud. Budding is generally done when the stock plant is in active growth and more cambial activity.

Bud Union- Like graft union, a series of changes takes place in the formation of successful bud union also. In general, four stages viz. pre- callus, callus, formation of cambial bridge and healing process etc. takes place for the formation of successful bud union.

Nurserymen employ various method of budding but according to convenience in performing the operations and percentage of success, the following methods are the commercially advocated in propagating various horticultural crops.

1. **Shieldor T-budding**

A'T'shapedcutismadeontheselectedportionofthestockwiththehelpofsharpbudding knife on one–year-old rootstock seedling having 2-2.5 cm thickness at 15-20 cm height. The bark of seedling should slip easily. The two flaps of bark are then loosened slightly with the help of budding knife. From the bud wood, which is selected from a healthy shoot of a current season's growth, the buds of middle portion are selected. These are removed from the bud wood by cutting shallowly about 5-6 mm below and 2-3 cm above the bud. This shield piece containing a bud is inserted carefully in 'T' shaped incision made on the stock. This bud then presses firmly and tied with polythene strip. After the bud has sprouted, the stock is cut to about 10-15 cm above the bud. eg citrus, aonla, custard apple, jamun, bael, plum, peach, cherry, ber, rose etc.

2. **Inverted 'T' budding-** As the name indicates, the cut is to be given on the root stock is reverse to that of 'T' i.e. inverted 'T' cut is given on the stock. This is widely used in high rainfall areas.

3. **Patch budding**

A rectangular patch of bark is removed completely from the one-year-old seedling stock and replace with a similar patch of bark containing a bud of desired variety. It is successfully used in species having thick bark such as aonla, bael, jamun, guava, walnut, peanut.

4. **Ring budding**

In ring budding, a complete ring of bark is removed from the stock and it is completely girdled. A similar ring of bark containing a bud is removed from the bud stick and is inserted on to the rootstock. In this budding both scion and stock should be of same size. It is utilized in peach, plum, ber, mulberry etc.

5. **Modified ring budding.**

In modified ring budding, complete ring of bark from the both scion and stock is removed by making one vertical cut on the opposite side of the bud, so that bud can be removedeasily,eg. aonla, beretc.

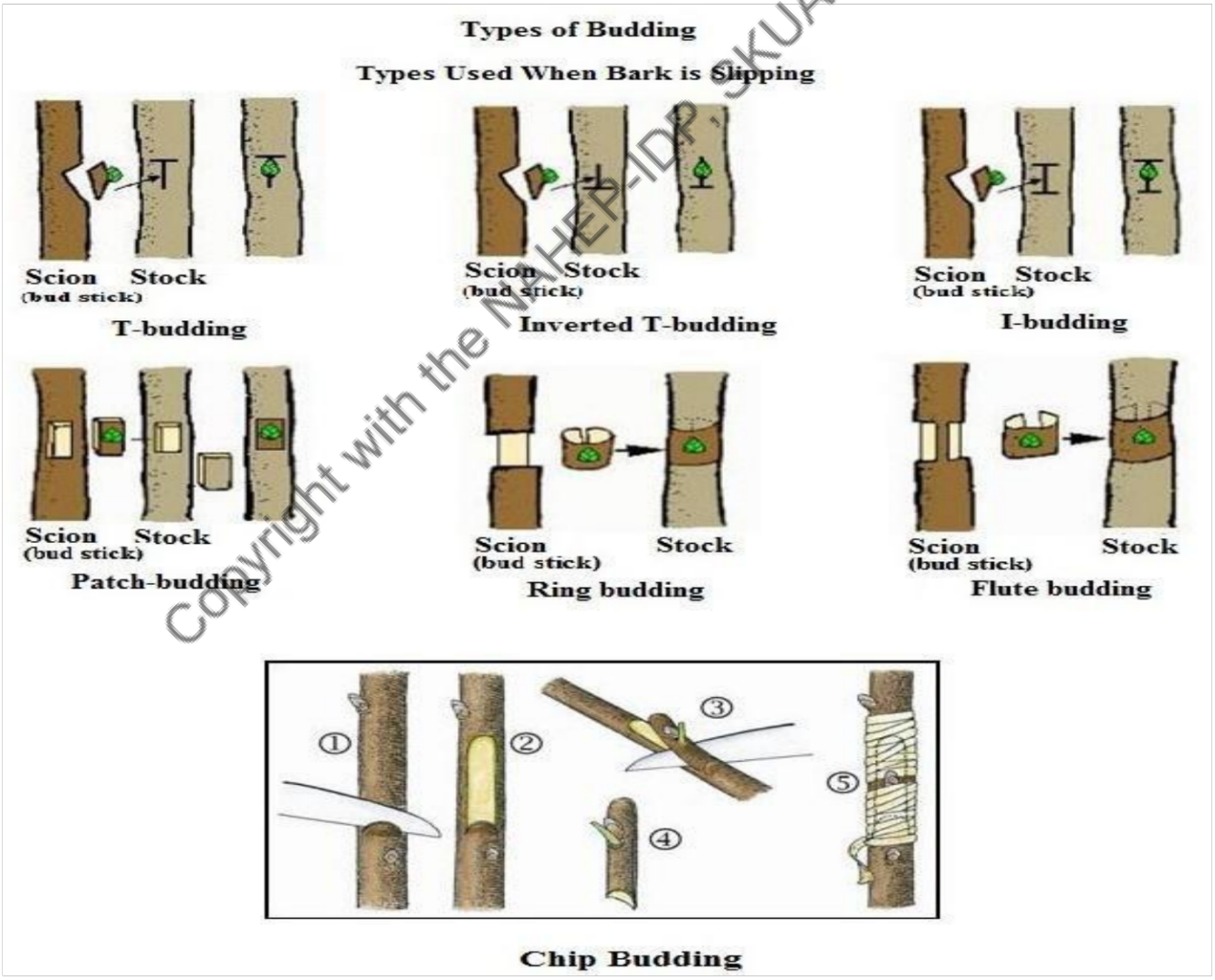
6. **Chip budding**

Chip budding is successful method of budding when the bark of the stock does not slip easily. A chip of bark and wood is removed from the smooth surface between the nodes of the stock. A chip of similar shape and size is then removed from the bud wood of desired cultivar. For which, a 2-3 cm long down ward cut is made through the bark and slightly into the wood of the stock. Then a second cut of about 2.5 cm is made so that it bisects the first cut at an angle of 30-45 0.in this way the chip of wood is removed from the stock. The bud chip then slipped in the place of rootstock from where chip has been removed. egg rape.**7.Flute budding**

In flute budding a patch of bark (Flute) encircling the stock is removed leaving a narrow strip thereon. A similar patch of bark containing the bud is taken from the scion plant and placed on the cut surface of the rootstock followed by tying as usual when the bud exhibits the signs of growth, the top footstock is cut back.

6. Forkert method of budding

It is modified method of patch budding, in which the bark flap of the patch is not removed from the stock plant but used to cover the bud on the stock plant. The bud is inserted in tithe flap. It is covered with flap of bark on the stock plant and tied firmly with alkathenestrip. Example-Aonla, berbael and guava.



Micro propagation

Micro propagation refers to the production of plants from very small plant parts, tissue or cells grown aseptically in a test tube or containers under controlled nutritional. Micro propagation is an advanced vegetative propagation technology for rapidlymultiplyingalargenumberofgeneticallysuperiorandpathogen-freeplantsorgeneticallymodifiedplants in a limited time and space throughout year.

Basic requirements for micropropagation-

1.A well-equipped

laboratory

2.Asepticcondition

3.Culture Medium (Nutrient

media)

4.Controlled culture environment

5.Acclimatization/Hardening chamber

Principle-Allthebiologicalprincipleofmicro-propagationtechniquearebasedonthephenomenon of *totipotency* of a cell, which is the capacity of a plant cell to regenerate in to a complete plant having different organ. German Plant physiologist, Haberlandt (1902) is known as the father of plant tissue culture technique, who for the first time coined the term *to tipotency*.

Process-The process of tissue culture consists of five important steps: Initiation, Multiplication, Shooting & rooting, Primary Hardening in green houses and Secondary Hardening in shade houses. Strict adherence to aseptic standards and micro-climatic conditions and care during the hardening process alone can ensure success.

Stages of micropropagation

A) **Stage-1Establishment-**Itincludesselectionofanelitemotherplant-Explant-Surfacesterilizationand Washing-Inoculation in culture medium.

B) **Stage-2Proliferation-**Transferinproliferationmedium–shootandembryoidformation.

C) **Stage-3RootingandHardening-**Transferofshootstorootingmediumandafterrootingtransferinartificial medium or sterilized soil by gradual weaning process

Banana propagation through tissue culture

Purpose-The main method of vegetative propagation in banana is by means of daughter suckersformedatthebaseofthepseudostem(5to10innumberdependingonthevariety).
Traditionally, sword suckers with narrow leaves, weighing approximately 500-1000 gm are the preferred planting material for vegetative propagation. The major constraint for conventionally propagating banana is the lack of ready availability of large quantities of sword suckers at any given time. Besides, suckers generally may be infected with some pathogens and nematodes. Similarly, due to the variation in age and size of sucker, the crop is not uniform, harvesting is prolonged and management becomes difficult. Therefore*, in vitro* clonal propagation i.e. tissue culture plants (properly hardened secondary seedlings) are recommended for planting as they are healthy, disease free, uniform and authentic. The

sterile operational nature of tissue culture procedures excludes fungal, bacteria, viral and pests from the production system. Banana plants produced from tissue culture are free from diseases at the time of supply. Since they are produced under controlled laboratory conditions using selected nutrients, they usually give yields.

Advantages of Tissue Culture in banana:

1. Initiationandestablishmentofrapidlymultiplyingasepticshootculturescaneliminatetheproblem of low sucker multiplication rates effectively and economically.
2. Largenumberofuniformpropagulescanbegeneratedinarelativelyshortperiodoftime.
3. Variability encountered in size and propagules density can be minimized.
4. Itcouldallowforrapidbulkingofnovelcloneswhenusedinconcertwithbreedingprograms.
5. Itwouldfacilitatetranscontinentalexchangeofdiseasediagnosedplantingmaterial.
6. With refinement in preservation techniques, *in vitro* culture of bananas can be of immense evaluating germplasm conservation.
7. Pest and disease-free seedlings. Round the year planting possible as seedling saremade available throughout the year.
8. Uniform growth, early maturity of crop -maximum land use is possible in lowland holding country like India.
9. Two successive ratoonsarepossibleinashortdurationwhichminimizescostofcultivationincreasesyield
10. 95%-98%plantsbearbunches.Nostaggeredharvesting, higher yield.
11. New varieties can be introduced and multiplied in a short duration.

Process involved in Micro-propagation of Banana

The tissue culture process involves the micro-propagation of a sucker growing point under sterile conditions. A sucker is detached from the nursery parent plant and brought to a laboratory where the outside tissue is pared away until only the growing point remains inside a plug of $10mm^3$.This is placed in a jar on agar containing a nutrient solution in a sterile environment and under controlled conditions of temperature and light. The growing point subdivides into several shoots. This process, called sub-culturing. The sub culturing, continues about five or eight times (one month per sub-culture) until approximately 1000 plants are produced from one original growing point These plants are then transferred to a rooting medium and when fully rooted, they are transferred from *in vitro*conditions(sterileunderglass)to*invivo*conditions(seedlingtraysinagreenhouseenvironment). After 6 to 8 weeks, the 5 cm plants are relocated from the greenhouse trays to nursery bags in a netted shade house. After another6to8weeks, the20cmplantsareready for two leaf initials. Meristem cultures have the disadvantage that they may have a higher mortality rate and poor initial establishment.

For banana micro propagation, MS based media are widely adopted. Generally, they are supplemented with sucrose as a carbon source at a concentration of 30-40g/L. Usually two types of growth regulators used, a cytokinin and an auxin, are added to the banana growth medium. Their concentration and ratio determine the growth and morphogenesis of the

banana tissue. In most banana micro propagation systems, semisolid media are used. As a gelling agent, agar (5-8g/L) is frequently added to the culture medium. Media are poured in a glass bottle where suckers are propagated.

Banana shoot tip cultures are incubated at an optimal temperature of 26±2ºC in a light cycle of12-16 h with a photosynthetic photon flux(PPF) of 60µE/m^2s.After 2 weeks, the suckers will become greenish in colour and the multiple shoots will arise from the base of the suckers. The shoots are cut at the base, separated and placed in a fresh medium. In each bottle, three-five shoots were inoculated. After 2-3 weeks, multiple shoots arise from the inoculated shoot. Again, they are separated and placed in afresh medium. The sub culturing is done until the required quantity of plants is needed. The shoots are every day checked for contamination and the contaminated shoots are transferred to a fresh medium. Meanwhile a set of well grown healthy shoots are taken for rooting.

Mass Multiplication

Contamination free explants are further cultured on multiplication media supplemented with plant growth hormones (cytokinins) which help in proliferation of auxiliary buds into multiple shoots.

Rooting:

Plantletsfromshootingmediaareseparatedandsingleplantletsaretransferredtomediacontainin g charcoal and auxins or medium without any growth regulators. It will take 2-3 weeks for rooting and fresh roots arise at the base of the shoot. In this stage, roots will develop and plants will be ready for dispatch from laboratory.

Agar Weaning of Plants

Well-developed single plantlets need to be removed from the culture incubation room and exposed to ambient conditions in the culture vessel for four to five days. The plantlets are then carefully removed and the roots washed in running tap water. The plants after being removed from nutrient media should preferably be trans planted within 72 hours.

Primary hardening will take at least 4 weeks depending upon the climatic conditions. In final week, these trays are gradually exposed to 50% shade by removing plastic sheets. These plant lets are sprayed with fungicides, bactericide, and water-soluble fertilizers as per schedule.

Secondary Hardening

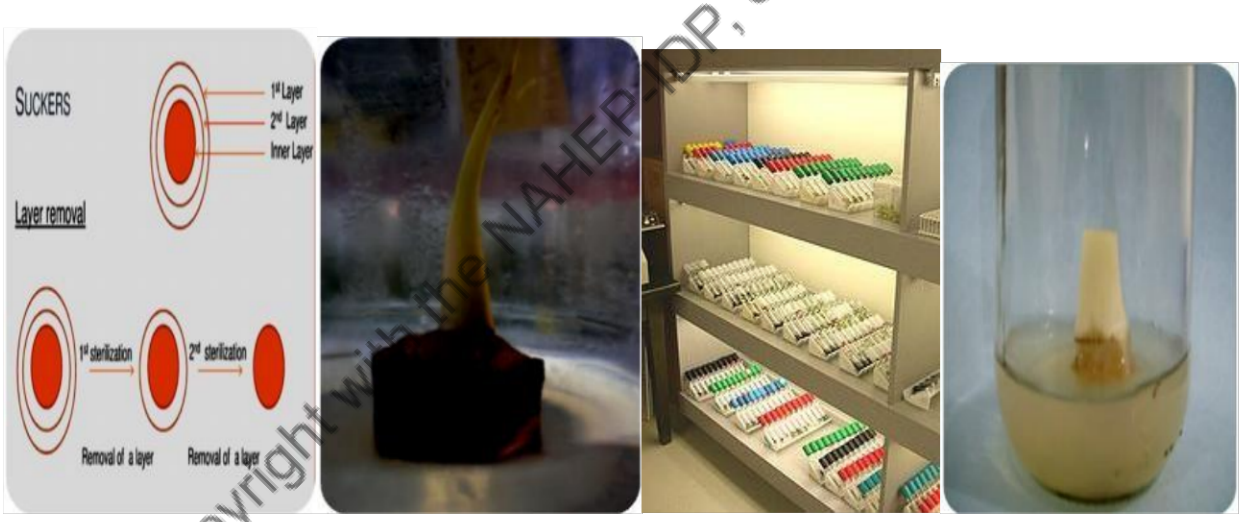
Primary hardened plants after 4 to 5 weeks are transferred to Poly bags (Nursery Bags) of suitable size. Soil mixture is prepared by mixing sand, soil and farmyard manual into 1:2:1ratio. The plants are kept in these Poly bags for 6 to 8 weeks under 50% shades. Humidity is maintained around 60% to 70% and regular foliar sprays of plant protection chemicals and water-soluble fertilizers are given regularly. Any possible variation if observed is discarded at this stage. Normal transportation is done where the plants are placed and grown in plastic bags. Well grown plants are removed to provide space in green house for the next cycle of plants and also to lower the cost of storage. Polybags is separated from the plant without disturbing the root ball of the plant and then plants are planted in the pits keeping the pseudo-stem 2cm below the ground level. Soil around the plant is gently pressed. Deep planting should be avoided.

Problem of Banana Micro Propagation

Banana tissues often suffer from excessive blackening caused by oxidation of polyphenolic compounds released from wounded tissues. Therefore, duringfirst4-6weeks, fresh shoot tips

are transferred to new medium every 1-2 weeks. Alternatively, freshly initiated cultures can be kept in complete darkness for one week. Anti-oxidants such as ascorbic acid or citric acid inconcentrationsrangingfrom10-150mg/L, are added to the growth medium to reduce blackening or the explants are dipped in anti-oxidant solution (Cysteine 50 mg/L) .

Banana Vegetative Propagate

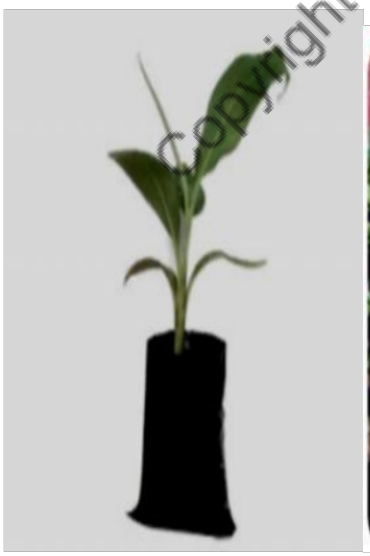


Trimming Explant For Propagation

Initiation Of Banana Micro propagation

Multiplication **Shoot Elongation**

Invitro rooting **Weaning of Agar**



Banana Hardening

CHAPTER III

TRAINING OF FRUIT CROPS

Definition: Physical techniques that control the shape, size and direction of plant growth are known as training or in other words training in effect is orientation of plant in space through techniques like tying, fastening, staking, supporting over a trellis or pergola in a certain fashion or pruning of some parts.

Objectives of training

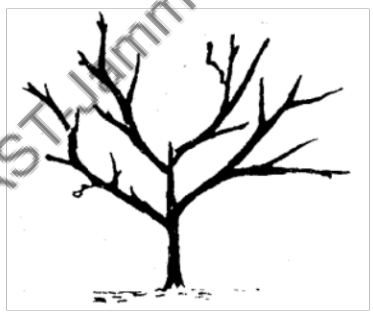
- To admit adequate sunlight and air to the center of the tree and to expose maximum leaf area to the sun.

- To limit the growth and spread of the tree so that various cultural operations such as spraying and harvesting are performed at minimum cost.
- To build the frame work and arrangement of scaffold branches.
- To build the structure of the tree to such heights at which the trees are less exposed to sunscald and wind damage.

SYSTEMS OF TRAINING OF FRUIT CROPS

The woody perennials, which are widely spaced and remain on a place for a long duration, are trained for develop strong framework for sustainable production of quality produce and for ornamental beauty in different shapes (topiary). In these plants following types of training are followed.

(i)Open center system (Vase shaped):



In this system the main stem is allowed to grow to a certain height and the leader is cut to encourage lateral scaffold from near the ground giving a vase shaped plant. This results in a low head and as such bulk of crop is borne closer to the ground. This is common in peaches, apricots and ber.

Advantages: The trees are more fruitful and shape of the tree greatly facilitate the operations like spraying, thinning and harvesting.

Disadvantages: The branches of trees trained to this system form weak crotches and branches arise close to one another almost from the same point. So, there is certain amount of risk of splitting of the branches when there is a heavier fruit load on the tree branches. In areas of high light intensity, trees trained to open center are susceptible to sun scald injuries.

(ii) Central leader system (closed centre):

In this system the central axis of plant is allowed to grow unhindered permitting branches all around. This system of training is adopted in such type of trees which have a pronounced apical dominance. On account of vigorous and rapid growth of main trunk, the tree develops a close centre and grows to great heights. This system of training is more common in use in apple, pear, mango and sapota.

Advantages: The tree branches are less exposed to sunscald.

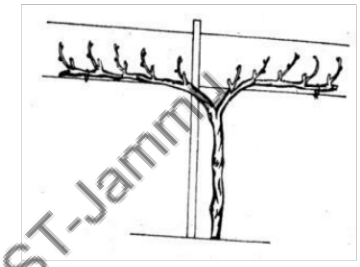
Disadvantages: The lateral branches are low in vigour and productivity. The plants grow very tall, the spraying and harvesting operations become difficult.

(iii) Modified Leader System

This system is in between open centre and central leader system wherein central axis is allowed to grow unhindered upto 4-5 years and then the central stem is headed back and laterals are permitted. This system combines the advantages of both open centre and central leader.

It is common in apple, pear, cherry, plum, guava

(iv)Cordon system



This is a system wherein espalier is allowed with the help of training on wires. This system is followed in vines incapable of standing on their stem. This can be trained in single cordon or do uble cordon and commonly followed in crops like grape. Now-a-days it is being used in apples also

(v) Pergola

To support perennial vine crops pergola is developed by a network of criss-cross wires supported by RCC/angle iron poles on which vines are trained.

While training a fruit tree following points should be kept in mind.

1. Height of the head: This is the height from ground to first branching or scaffolding. Depending on the height the trees could be divided in three groups.

a) **Low head**: 0.7—0.9 m. This is common in windy areas. Such plants are easy to maintain.

b) **Medium head**: 0.9—1.2 m. This is the most common height which combines both effects, ability to stand against wind and easy management.

c) **High head:** More than 1.2 m. Common in tropics in wind free areas. Operations under the canopy are easy to perform.

2.Number of scaffold branches: It refers to allowing of number of scaffolds on the primary axis of the tree which vary from 2 to 15 but extremes are undesirable. In fruit trees 5 to 8 scaffolds are preferred to make the tree mechanically strong and open enough to facilitate cultural operations.

3.Distribution of scaffolds: Scaffolds should be distributed in all the directions spaced at 45-60 cm allowing strong crotches through wide angles of emergence.

A well-trained tree is an asset to the farmer and therefore, efforts should be made for training trees appropriately in formative years for sustainable production. In fact the process should have begun from nursery itself.

Pruning

Definition: It refers to removal of plant part like bud, shoot, root etc. to strike a balance between vegetative growth and production. This may also be done to adjust fruit load on the tree.

Objectives:

1. To maintain the growth and vigour of the trees and to have a balance between the vegetative vigour and fruitfulness, so as to be conductive for production of optimum crop of best quality.

2. To shape the tree to make the best use of the space between trees while allowing the necessary access.

3. To regulate the size and quality of the fruits by way of proper distribution of the fruiting area.

4. To regulate the succession of crop and to have the crop where it can be managed easily and cheaply.

5. To spread the trees for economic orchard management.

6. To remove the dead, diseased and over aged wood.

7. For effective spraying of pesticides to the crop.

8. To minimize biannual bearing and consequent risk of die back.

9. To get maximum plagiotropic shoots/stems.

Types of pruning:

Basically, there are three types of pruning with definite purposes.

(i) Frame pruning.

(ii) Maintenance pruning.

(iii)Renewal pruning.

1. **Frame pruning**: This pruning is done to provide shape and form to a plant in its formative years so that tree develops strong framework and a shape for ease of operations. This process begins from nursery itself and continues up to fruiting stage. This is done continuously irrespective of the season.

2. **Maintenance pruning**: To maintain status- in production level and for uniform performance this pruning is done. In some plants like grapes, apple, pear, peach etc. (deciduous trees) it is

an annual feature and in others (evergreen like mango, sapota) it is rare confining to removal of water sprouts and unproductive growth and opening of the tree.

3. **Renewal pruning**: This pruning is done in old trees like mangoes which shows decline. In this case severe pruning is required.

Factors to be considered in pruning:

- In some of the tree species pruning as a regular feature in bearing trees is done to strike a balance between vegetative growth and production so that farmers get sustained production uniformly with optimum quality of produce.
- To achieve this one should consider the following factors.
- Time at which buds are differentiated in relation to blooming.
- The age of the wood that produces the most abundant and highest quality of fruit buds.
- In consideration of these factors our knowledge about bearing habit of the tree/plant should be complete.
- Bearing habit means relative position of a fruit with reference to its potential bud giving rise to flower or inflorescence in the shoot. This habit varies from plant to plant.

Principles of pruning:

1. Excessive pruning should be avoided as it affects the growth of the plant by dwarfening and may induce more of water suckers, fasciation's (union of a number of parts side by side in a flat plane) and thus affect the bearing potential.

2. In pruning, only that wood which is not necessary for the tree should be removed.

3. Pruning of larger limbs should be avoided as far as possible.

4. Pruning of young trees should be done more carefully than the yielding trees, since severe pruning of young trees delays the cropping and much more of yield area will be removed than what is desired.

TOP WORKING

It is a technique or method of rejuvenation where in the objective is to upgrade seedling plantations of inferior varieties with superior commercial cultivars or hybrids suitable for domestic or export market or the desired variety of the grower.

The technique involves grafting with procured scions of desired variety on shoots emerged on pruned branches by adopting softwood grafting during monsoon season (Season of top working

slightly varies from species as it also depends on availability of good shoot and scions). The scion shoots and the emerged shoots should be of same thickness.

Advantages of top working:

1. Increase the tree productivity /orchard productivity.

2. Conversion of old and senile orchards into productive orchards.

3. Conversion of seedling or inferior variety plantation /orchard into new orchard with desirable variety or varieties through top working.

4. Possibility of grafting several varieties on the same plant.

5. Increasing the fruit set of orchards by grafting few shoots with pollinizer varieties.

6. Additional income by selling the pruned wood during non-bearing season or period.

Disadvantages: 1. Chances of death of plant if not done properly or on severe pruning. 2. Need good management post pruning period. 3. Loss of crop for 2-3 years 4. Chances of pest and disease occurrence (stem borer, anthracnose etc.). 5. Needs skilled labour for thinning of shoots, removal of side shoots etc.

Top working technique can be successfully followed in crops like mango, sapota, aonla, cashew, guava, tamarind, jackfruit, etc.

CHAPTER IV

ORCHARD

An orchard is one where different fruit crops have been planted in an orderly manner and are managed for production of successive yield for economic return.

Orchards are also sometimes feature of large gardens, where they serve an aesthetic as well as productive purpose.

Establishment of Orchard

- Establishment of an orchard is a long-term investment and deserve a very critical planning.

- Before going to establish a full-fledged orchard, one should keep the following principles underlying the orchard establishment:
    1. **Location and site selection**
    2. **Planning of orchard**
    3. **Layout of orchard**

1. Location and site selection

- Market should be close to that area.
- Climate should be suitable to grow the chosen fruit crops.
- Adequate water supply should be available.
- Transport facilities either by road or railway.
- Availability of labour.

2. Planning of orchard

- Optimum Spacing to accommodate maximum number of trees per unit area.
- Stores and office building in the orchard should be constructed.
- Stores and office building in the orchard should be constructed at the centre for proper supervision.
- Wells should be located at convenient places in different parts.
- Each kind of fruit should be assigned in a separate block.
- Fruits ripening at the same time should be grouped together.
- Roads should occupy minimum space for the economy of transport. The clearance between wind break and first row of trees is advantageous for the road.
- Short growing trees should be allotted at the front and tall at the back for easy watching and to improve the appearance.
- Evergreen trees should be in the front and deciduous ones behind.
- Fruits attracting birds and animals should be close to the watchman's shed.
- Irrigation channels should be laid along the gradients for most economical conduct of water.

3. Layout of orchard

An orchard's layout is the technique of planting the crops in a proper system. There are different methods of planting and thus different layouts. Some of these layout types include:

1. Square method
2. Rectangular method
3. Quincunx method
4. Triangular method
5. Hexagonal method
6. Contour method

Each of these systems are discussed in detail.

1. Square Method

In this system, trees are planted on each comer of a square whatever may be the planting distance. This is the most commonly followed system and is very easy to layout. The central place between four trees may be advantageously used to raise short lived filler trees. This system permits intercropping and cultivation in two directions.

2. Rectangular Method

In this system, trees are planted on each corner of a rectangle. As the distance between any two rows is more than the distance between any two trees in a row, there is no equal distribution of space per tree. The wider alley spaces available between rows of trees permit easy intercultural operations and even the use of mechanical operations.

3. Quincunx system

This is the square method but with one more plant in the centre of the square. This will accommodate double the number of plants, but does not provide equal spacing. The central (filler) tree chosen may be a short lived one. This system can be followed when the distance between the permanent trees is more than 10m. As there will be competition between permanent and filler trees, the filler trees should be removed after a few years when main trees come to bearing.

4. Triangular method

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

5. Hexagonal method

In this method, the trees are planted in each comer of an equilateral triangle. This way six trees form a hexagon with the seventh tree in the center. Therefore, this system is also called as 'septule' as a seventh tree is accommodated in the center of hexagon. This system provides equal spacing but it is difficult to layout. The perpendicular distance between any two adjacent rows is equal to the product of 0.866 x the distance between any two trees. As the perpendicular distance between any two rows is less than unity, this system accommodates 15% more trees than the square system. The limitations of this system are that it is difficult to layout and the cultivation is not so easily done as in the square system.

6. Contour Method

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.

MANAGEMENT OF ORCHARD:

Orchard management refers to the management of the orchard soil in such a manner that the fruit trees give higher yield of quality fruits in successive years for sustainable economic returns. The following points must be considered in management practices of an orchard:

- Soil management
- Planting season
- Transplanting
- Intercropping
- Mulching

1. Soil management

The following points should be considered in soil management:

- Clean cultivation
- Ploughing
- Weeding
- Mulching
- Pruning and training

2. Planting season

The season of planting varies with different fruits and local conditions. There are two seasons of planting in vogue in India.

i) Monsoon (June - August)

ii) Spring (February - March)

Monsoon season is considered to be the best for planting evergreen fruit trees like citrus, mango, sapota and guava. If the trees are planted early in the rainy season, they soon establish themselves and grow vigorously. Deciduous trees may be planted during the dormant period without shock. Care should be taken that planting is done before the growth starts, otherwise trees suffer severely and will be in poor condition to withstand the next hot weather.

3. Transplanting

The trees should be planted approximately where the original pegs were placed. This is achieved by replacing the planting board in position with the help of the guide pegs and the stem of the trees is brought to the central notch with the help of a hand hoe.

One of the most common mistakes is that of planting the trees too deep. The plants should be sent in such a way that the bud union remains slightly above the ground level. The trees in the field should be planted as deep as they stood in the nursery. The trees are irrigated soon after planting This consolidates the soil and helps the roots to establish contact with it and to secure a supply of water quickly. A small basin may be made around the tree for this purpose. Planting if taken up during the rains, this basin should be demolished within a day or two so that water will not collect around the tree. This is more dangerous on heavy than light soils.

4. Intercropping

In the case of long duration horticultural crops like tapioca, turmeric, ginger and banana some area between adjacent plants will be remaining unoccupied by the main crop for few months. It naturally appeals to the grower to get some return from this vacant land especially when he is getting no return in the early periods. The practice of growing any economic crop in alley spaces of the fruit trees in the first few years or in the' unoccupied spaces of the long duration crop in the early periods is referred as intercropping. They also act as a cover crop and the land benefits by the cultivation, irrigation, manuring given to the intercrops.

5. Mulching

Mulching is one of the simplest and most beneficial practices that are most commonly adopted in temperate fruit orchards.
It is a recognized practice that saves soil and moisture, and is used in most orchards.
It is simply a protective layer of a material that is spread on top of the soil.

CHAPTER V

MANURES AND FERTILIZERS IN FRUIT IN FRUIT CROPS

Manures

- The perennials are different from annuals in their nutritive requirements.
- The annuals require fewer nutrients when gradually falls as the crop matures.
- Whereas, in perennials there are often two or three peak period of uptake owing to the occurrence of more than one vegetative flush and crop.
- Manaurial requirement of perennials gradually increased with the age of the tree till the trees reach their full growth and thereafter remains constant.
- Depending upon the requirements, we may have to supplement by applying manures and fertilizers at the appropriate time.

Inorganic fertilizers

- Industrially manufactured chemicals.
- Contains higher nutrient than organic manures.
- Nutrient input is lost through leaching, runoff, volatilization, fixation by soil or consumption by weeds etc.

Organic fertilizers

- These are plant and animal wastes that are used as nutrients after decomposition.
- Improves the soil tilth, aeration, water holding capacity and activity of micro-organism.

Where to apply manures?

- In fully grown trees, the manures and fertilizers should be given over the area, where their active roots are spread.
- Fertilizer should be given in restricted area i.e., in the surrounding area of about 1 to 1.5 m away from the trunk of the trees.

Time of Fertilizer Application

- It must be applied when the plants need it.
- Timing depends on the type of fertilizer and climate.
- Fruit trees require more nutrients at the emergence of new flushes and differentiations of floral buds.
- Utilized more during the course of fruit development.
- Nutrients should be available to them in February –March.
- So, it would be better to apply them in October-November to be available to the trees in February to March.

Nutrient Contents of Organic Manures

Bulky organic manures			
Organic Manure	**N %**	**P2O5 %**	**K2O %**
Cattle dung	0.40	0.20	0.17
Poultry manure	3.03	0.63	1.40
Farmyard manure	0.50	0.25	0.50
Rural compost	0.75	0.20	0.50
Urban compost	1.75	1.00	1.50
Vermicompost	3.00	1.00	1.50

Concentrated organic manure			
Castor cake	4.37	1.85	1.39
Coconut cake	3.00	1.80	1.90
Neem cake	5.22	1.08	1.48
Blood meal	12.00	2.00	1.00
Groundnut cake	7.30	1.50	1.30
Pressmud	2.10	4.40	0.80

Nutrient Contents of Inorganic Fertilizers

Fertilizer	**N (%)**	**P2O5 (%)**	**K2O (%)**
Sodium nitrate	16	-	-
Calcium nitrate	15.5	-	-
Potassium nitrate	13.8	-	-
Anhydrous ammonia	82	-	-
Urea	46	-	-
SSP/ double SP/Triple SP	-	16/32/46-48	-

Methods of fertilizer Application:

Broadcasting

- Fertilizer in solid state or granular or dust are spread uniformly over the entire field.
- Leaching loss may be more.

Disadvantages

- Some of the elements like phosphorous and potash do not readily move in the soil. Therefore, surface application may not be available to the trees especially in drier tracks.
- Leads to accumulation of potassium in surface soil beyond detrimental levels causing injury to plants.
- Surface application always stimulates weed growth.

Band placement

- Application of fertilizer on the sides of rows.
- Fertilizer in solid and liquid forms can be applied.
- Quantity of fertilizer may be economised.

Ring Placement

- Commonly followed in fruit trees.
- Fertilizers are applied in a ring encircling the trunk of the trees extending the entire canopy.
- It is more labour intensive and costly.

Foliar Application

- Fertilizers are applied in liquid form as foliar sprays.
- They are easily absorbed by leaves.
- Fertilizers are applied in a very low concentration tolerable to the leaves.
- Recommended when the nutrients are required in small quantity.

Starter Solution

- Liquid form of fertilizer application.
- Seedlings and propagules are kept emerged up to their root system for varying duration in starter solution.
- The starter solution is prepared either by dissolving concentrated fertilizer mixture at a concentration not exceeding 1%.

Fertigation

- Application of fertilizers in irrigation water in either open or closed systems.
- Nitrogen and sulphur are the principal nutrients applied.
- Phosphorous fertigation is less common because of formation of precipitates takes place with high Ca and Mg containing water.

Advantages

- Nutrients especially nitrogen can be applied in several split doses at the time of greatest need of the plant.
- Nutrient is mixed with water and applied directly near the root zone, as such higher use efficiency.
- Cost on labour is saved.

Best results of fertigation are noticed when the fertilizer is applied towards the middle of the irrigation period and applied towards the middle of the irrigation period and their application terminated shortly before completion of irrigation. Use of soluble fertilizer improves use efficiency.

Note: The grower must consider the economics and advantages before deciding for using fertigation.

Tree Injection and Tree feeding

Tree Injection

- Direct injection of essential nutrients into the tree trunk.
- Iron salts are injected into chlorotic trees that are known to suffer from iron deficiency.

Feeding Needles

- Several types of feeding needles or guns are available.
- With these fertilizers either in dry form or in water solution placed in holes.

Factors favouring nutrients absorption and transport

- High humidity, proper temperature and incident radiation.
- Good CHO supply and vigorous growth.
- Chemical and physical properties of nutrient spray solution.
- Leaf characters like leaf thickness, hairiness and wax coating on the leaf.
- Generally, more vigorous plant and young growing leaves have good capacity to absorb nutrients.
- Nitrogen- applied in the form of urea (1%) is readily absorbed.
- Sodium and potassium (Kcl) - readily absorbed by leaves and they are among the highly mobile Elements.

Note

- Foliar application proves to be most effective where problems of nutrient fixation in soil exits. So far, the most important use of foliar sprays is in application of micronutrients.
- Foliar sprays should be applied either with pressure sprayer or with specially designed spray guns. The trees should be sprayed until the nutrient solution begins to drip from the leaves.
- Foliar application of urea has been found effective in many fruit crops like citrus, guava, apple, etc.
- Potassium spray (3-5g/lit)- Papaya, Pineapple, Citrus and Guava.

Precautions

- While applying foliar sprays, care should be taken to ensure correct concentration of spray solution.
- Apply in the morning or evening hours on a clear sky day.

CHAPTER VI

UN-FRUITFULNESS

Fruit: Fruit is a structure which arises from an ovary or fusion of several ovaries after fertilization and may or may not carry associated floral parts.

Fruit development: Fruit passes through 4 important phases during their development.

1. First phase include ovary development, anthesis and dehiscence of anthers. It involves slow division of cells.

2. During post fertilization period when fruit starts growing rapidly due to rapid cell division.

3. Cell division almost ceases and the fruit growth is attributed to cell enlargement. Food reserves are accumulated and fruit attain their final shape and size.

4. Final phase of fruit development involves ripening of the fruit which is followed by shedding.

Un-fruitfulness/Barrenness: Conditions where a plant is unable to bloom or set fruit or unable to carry fruits upto their maturity. Unfruitfulness is a major problem in many fruit crops and their varieties result in huge loss to growers and make fruit cultivation less profitable. Unfruitfulness in fruit crops refers to the state where the plant is not capable of flowering and bearing fruit. However, the causes of unfruitfulness can be broadly grouped into two categories: Internal and external factors. Fruits may be completely barren, fully self-fruitful or partially self-fruitful. Self-fruitful varieties need no pollinizers like self-unfruitful varieties.

Causes of Unfruitfulness

External factors:

1. Environmental factors (Temperature, rainfall, wind frost, hailstorm, cloudy weather, light intensity): Low temperature stops the activity of pollinators and very low temperature kills the developing flower buds. High temperature also limits the pollinator activity and may lead to desiccation and flower drop. High temperature may also cause non viability of pollen

grains and stigma surface dries at quiet faster rate which lowers down the effective pollination and fertilization period. Frost is a state of environment where temperature of air falls to 0°C or below 0°C. Moisture in air changes into ice and falls on the plant surface; results in irreversible damage to the plant. It may damage flowering or sexual parts of flowers making plants unfruitful. Rainfall at flowering causes damage in several ways- It washes off pollen from anther and stigma, decreases pollen viability, reduces activity of pollinating insects, reduces fruit set or no fruit set. Heavy rains can result in heavy fruit drop. Cloudy weather favors spread of diseases like powdery mildew which usually appear immediately after cloudy weather, delays dehiscence of pollen, adversely effects on pollen germination and growth and has devastating effect on flowers and fruit set. Wind is most important agent for transfer of pollen from stamen to pistil. Important in both insect (Entomophilous) and wind (Anemophilous) pollinated plants. Bees and other pollen carrying insects work more effectively in still atmosphere. A reasonable wind speed helps pollination by carrying pollen and is necessary for good fruit set. High wind velocity at flowering hinders movement of insects and affects pollination. Strong and desiccating winds adversely affect fruit setting. Frost is a state of environment where temperature of air falls to 0°C or below 0°C. Moisture in air changes into ice and falls on the plant surface; results in irreversible damage to the plant. It may damage flowering or sexual parts of flowers making plants unfruitful.

2. Disturbed water relation: Deficit and excess of moisture at the time of fruit set are harmful. Moisture deficit is more harmful as it leads to flower shedding post fertilization. The excessive atmospheric moisture or rainfall limits the pollination and pollinator activity thus pollens may not be available for pollination at the proper stage.

3. Nutrient supply: Poor nutritional status affects vegetative growth, production of defective pistil and impotent pollen. Excessive N fertilization results in excessive vegetative growth at the cost of flowering and disturbs C/N ratio. Best C/N ratio is CC/NNN. Disturbed soil and plant water relations may lead to abscission of flowers and fruits. During early stages of fruit development, shortage of water is quite harmful. Moisture stress causes disturbance in Carbon-

Nitrogen ratio (C/N ratio) and other physiological activities leading to fruit drop. Judicious water supply results in best performance. Abundance of water may cause flower and fruit drop e.g. apple and olive.

4. Rootstock: Rootstocks have mechanical and physiological influence on scion. Grafted plants bear early crops compared to seedlings and influence fruitfulness e.g. Malling series rootstocks in apple induced precocity; Troyer citrange rootstocks in citrus hastens fruit maturity; SohSarkar rootstocks in citrus delays maturity.

5. Pruning: Improper pruning, very heavy pruning, and pruning at wrong time can result in poor flower and fruit set.

6. Age & vigour of plant: Most plants have long juvenile phase and bear only after certain maturity is attained. Young and vigorous trees fail to set fruit. Less vigorous trees set fruit freely.

7. Insect-pests and diseases: Flowers are subject to attack of various insects, pest and diseases; result in serious reduction in fruit set. Insects are both helpful (housefly and honeybee) and harmful (mealy bug, anthracnose and mango hopper) for fruiting. Adopting suitable preventive measures before attack greatly increases fruit set. Useful insects act as pollinators; Plan cultural operation not to harm beneficial insects. Harmful insects like mealy bug suck sap of flowers and developing fruits resulting in drop of flowers and fruits. Hence it is necessary to reduce their threshold level, by adopting suitable preventive and timely control measures.

Internal factors:

A. Evolutionary Tendencies

1. Defective Flowers (Imperfect flowers, heterostyly and pollen impotency)

- **Monoecious (Uni-sexual):** Flowers are imperfect; either staminate or pistillate occurring on same plant, same inflorescence or separate inflorescence; often wind pollinated. Pollination is possible but less likely, ensures out crossing by spatial separation. Common in temperate

regions. Few examples are chestnut, hazelnut, walnut, jackfruit, pistachio nut, date palm, papaya, coconut and areca nut.

• **Dioecious (Uni-sexual):** Male and female flowers are borne on separate plants. For proper pollination, fertilization, fruit set and seed development a number of male plants are required to be planted in the vicinity of female plants; otherwise there will be poor fruiting. Commonly found in tropical region. Examples are papaya, date palm, strawberry, Muscatine grape. Japanese persimmon some varieties are monoecious, some dioecious.

• **Psuedohermaphroditism:** Plants produce morphologically perfect flowers having both male and female parts but functionally unisexual (either stamen or pistil is non-functional and behave like either male or female) e.g. grape, plum, pomegranate, persimmon

2. Structural peculiarities: Certain minor peculiarities are observed in normal appearing flower either in floral structure or functions preventing self-pollination and making cross pollination a rule; absence of cross pollination results in self or cross incompatibility and unfruitfulness. e.g., heterostyly, dichogamy, pollen impotence, abortion of pistil or ovules.

3. Dichogamy: In hermaphrodite plants, stamens and pistils mature at different times or receptivity does not coincide with pollen viability/maturity and prevents self-pollination in perfect as well as monoecious flowers.

• **Protandry:** Stamens mature and anthers shed before the pistil is ready to receive pollen (stigma receptivity doesn't coincide with pollen viability and maturity); common in insect pollinated plants, more common than protogyny, ensures out crossing by temporal separation. E.g. walnut, coconut, macadamia, custard apple, sapota and passion fruits.

• **Protogyny:** Stigmas are receptive before anthers release pollen. All monoecious plants and majority of dioecious plants are protogynus. e.g. banana, plum, pomegranate, avocado, chestnut, pistachionut.

4. Impotence: Impotence means when one or both the sex organs fail to develop adequately to the required stage so there is complete failure of the formation of flowers or abortiveness of the male and female organs or abortiveness of the embryo.

• **Impotence from abortive flowers:** In perfect flowers, reflexed stamens partially defective pollen, or quantity of pollen produced is small, non-viable (e.g. European varieties of Grape) resulting in failure to set and mature fruit. Abortive flowers are more common in plants having indeterminate inflorescence. High pollen viability is necessary to ensure good fruit set and yield.

• **Impotence from degenerated or abortive pistil or ovule:** Any factor that hinders the process of fertilization results in unfruitfulness or sterility. Complete: no flower or no sex organs are formed or fail to attain full development; Partial: either stamens or pistils abortive, sometimes looking normal; Abortion of ovules: e.g. mango; multiple ovules and anthers result in both female and male sterility.

5. Sterility: This phenomenon is common in polyploids containing an uneven multiple of the basic chromosome number especially in triploids. Such pollen grains either fail to germinate or if pollen tubes are formed these usually burst easily or after reaching the ovary, they give rise to unbalanced embryo.

6. Incompatibility: Incompatibility is due to physiological reactions occurring in between the pollen tube and the style and ovarian tissues. In black currants, the post-bloom fruit drop is mainly due to the auto-incompatibility of the varieties. Incompatibility

7. Abortion of embryo: It may arise from genetical and unfavourable nutritional conditions and usually results in shedding of fruits. Sweet cherries of late maturity shows higher rates of fruit drop, which is attributed to the abortion of the embryo. In the super early cherries, embryo abortion occurs often during the second phase of pericarp growth, which is due to the competition for resources between the seed and the pericarp.

CAUSES OF ABORTION IN DIFFERENT FRUIT CROPS:

Fruit plant	Causes of abortion
Apple	Defective embryo, defective ovules
Almond	Defective embryo sac, gynoecium abnormality
Grapes	Degeneration of nucleus
Kiwi fruits	Pollen degeneration
Strawberry	Lower bud abortion, defective pistil
Sour cherry	Defective embryo
Mandarin	Abnormal pistil
Pecan nut	Defective pistil
Plum	Degeneration of pistil
Peach	Degeneration of nucleus, embryo abortion
Olive	Pistil abortion
Litchi	Embryo abortion