18BBO6EL- NONMAJOR ELECTIVE PAPER –II PLANTS AND HUMAN WELFARE

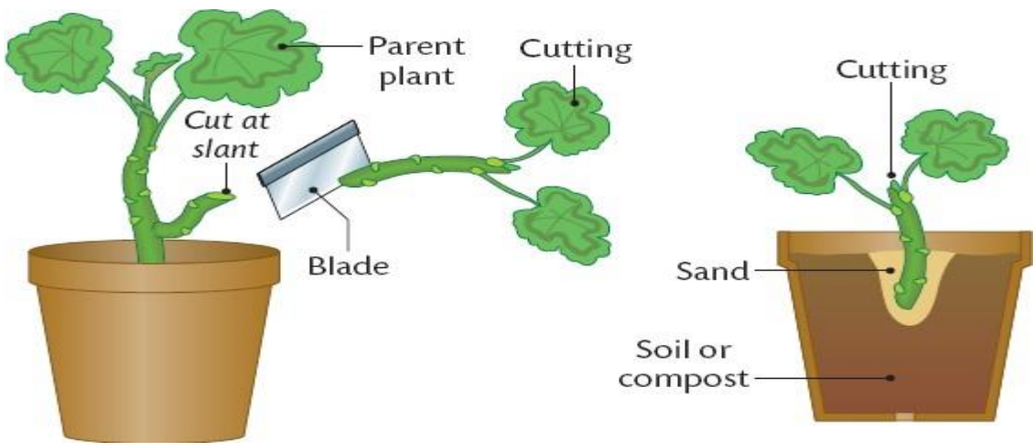
UNIT -II

Plant propagation methods, cutting, layering, grafting, budding, stock-scion relationship. Use of plant regulators in horticulture

PLANT PROPAGATION METHODS

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.

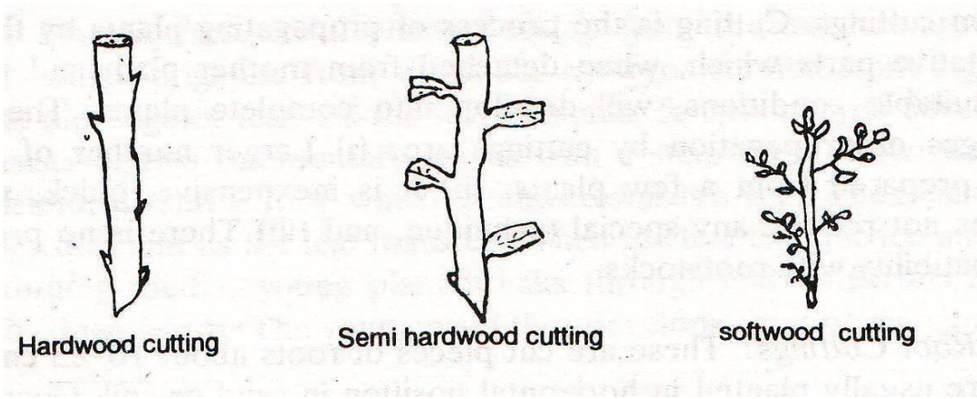
Classification of cuttings:

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



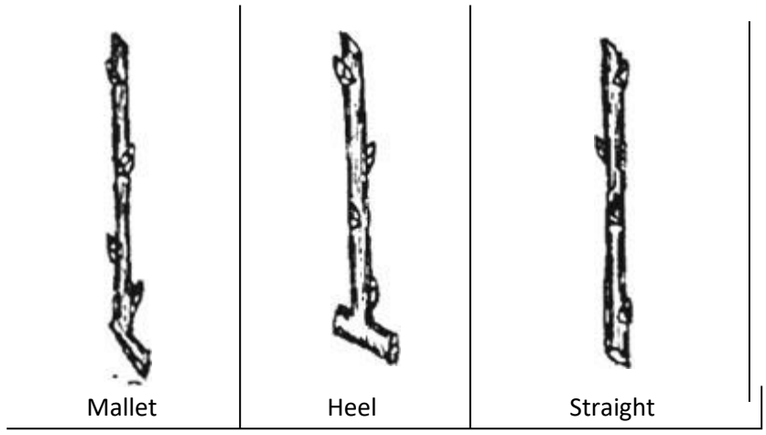
Hard wood stem cuttings: These cuttings are made from the past seasons growth or wood that has matured and lignified are known as hardwood cuttings.

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 without

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, Cranthemum, 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:

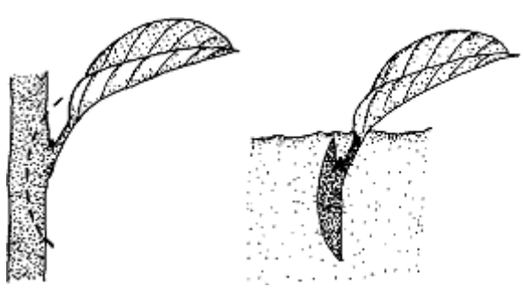
Preparation and planting: Select a healthy leaf and Give a slanting cut towards the base of the leaf. Measure a length of about 7 to 10-cm and give a horizontal cut towards the terminal end. Prepare as many cuttings as possible from the selected leaf. Insert up to ¾ of the prepared leaf cuttings in to 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

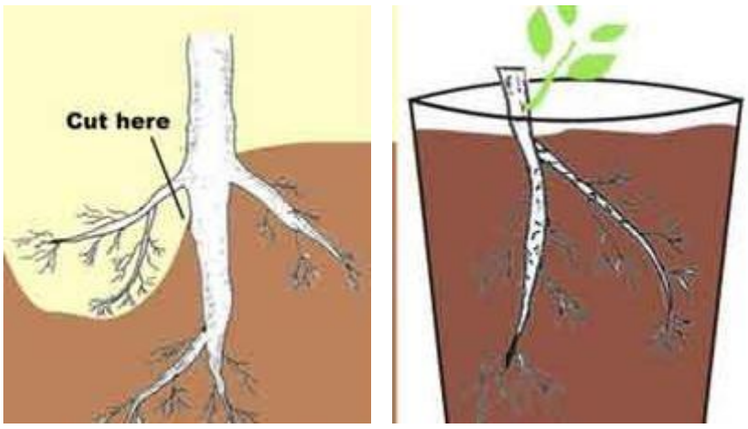
and a small portion of the stem. Repeat the process until possible number of leaf bud cuttings are made.Treat if necessary the cut surface of the prepared cuttings with the recommended root promoting substance to stimulate rapid root formation. Insert the prepared cutting in the rooting medium so that 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.*

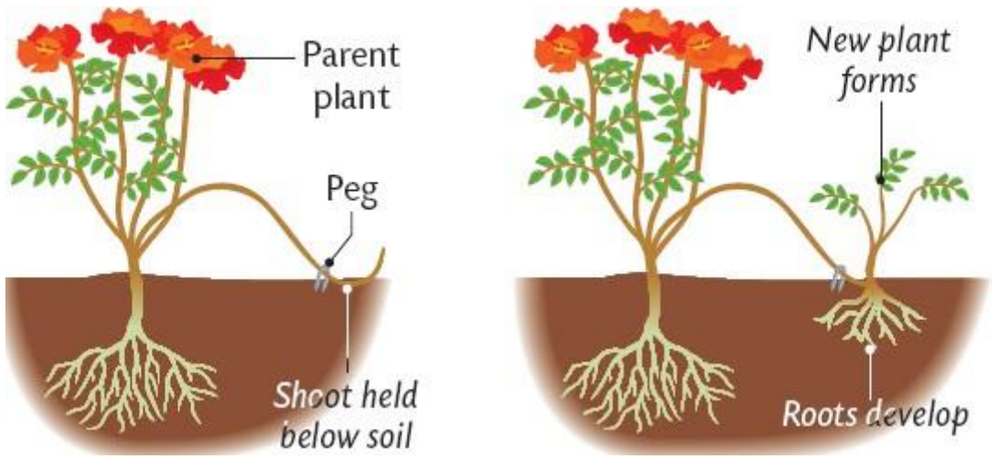
Root cuttings: Plants which give rise root suckers freely are propagated by root cuttings.



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

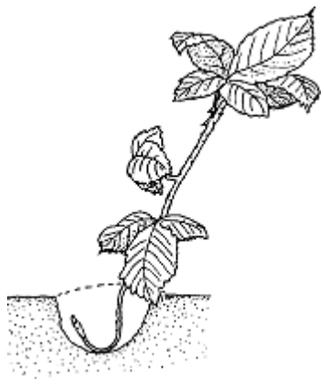
vii. The beneficial effect of root stock cannot be exploited.

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

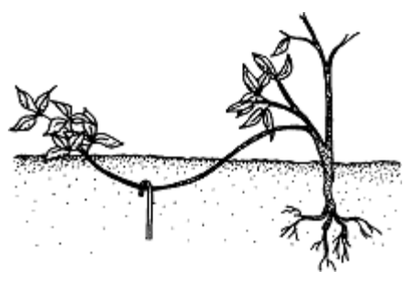
II.Air layering. (Gootee or Marcottage).



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

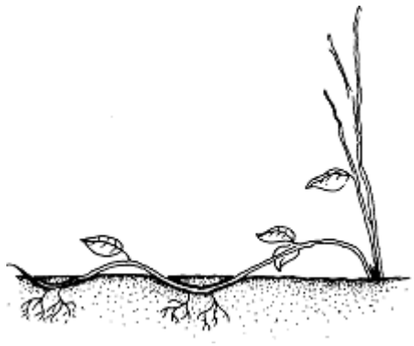


Simple layering

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.

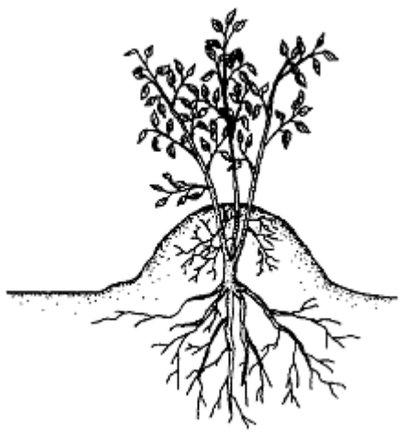
Procedure: Select a healthy, flexible and sufficiently long (50 to 60cm) branch towards the base of the plant. The selected branch should be closer to the ground. At a distance of about 15 to 30cm back from the tip give a sharp, slanting inward and upward cut 1.5 to 2.5cm below a node and insert a small 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.

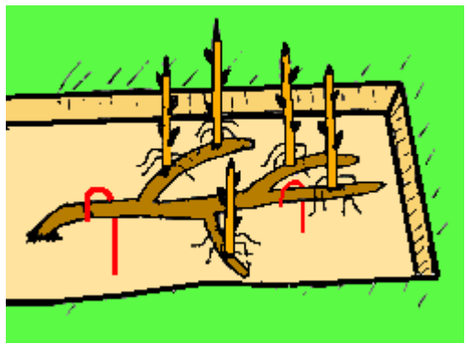
Procedure: Select a healthy, flexible and sufficiently long (100 to 250 cm) basal branch that is close to the ground. Give a sharp slanting, inward and upward cut 1.5 to
2.5 cm below a node at 30cm interval starting from the tip leaving 3 to 3 buds in between two such cuts. Bend the shoot gently to the 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,

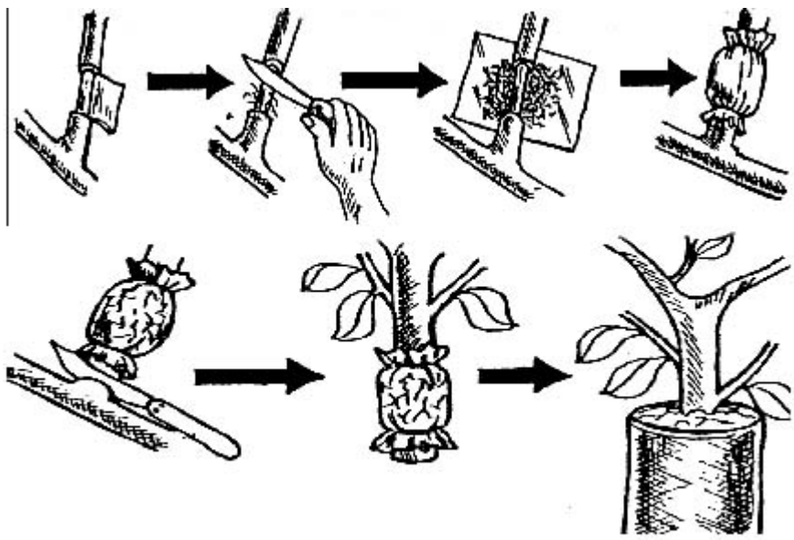
Procedure: Select the plant to be mound layered or plant a rooted layer in a trench and allow it to grow for a year. Cut back the plant to 2.5 cm from the ground level just before growth begins. Allow the new shoots to develop. When these shoots have grown 7 to 15 cm tall, girdle them at the base and 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.



Stages of preparing an Air layer- piece of bark removed, scraping the exposed wood, wrapping with moist rooting medium, tying, separating the branch from the mother plant, separated air layer, planted air layer

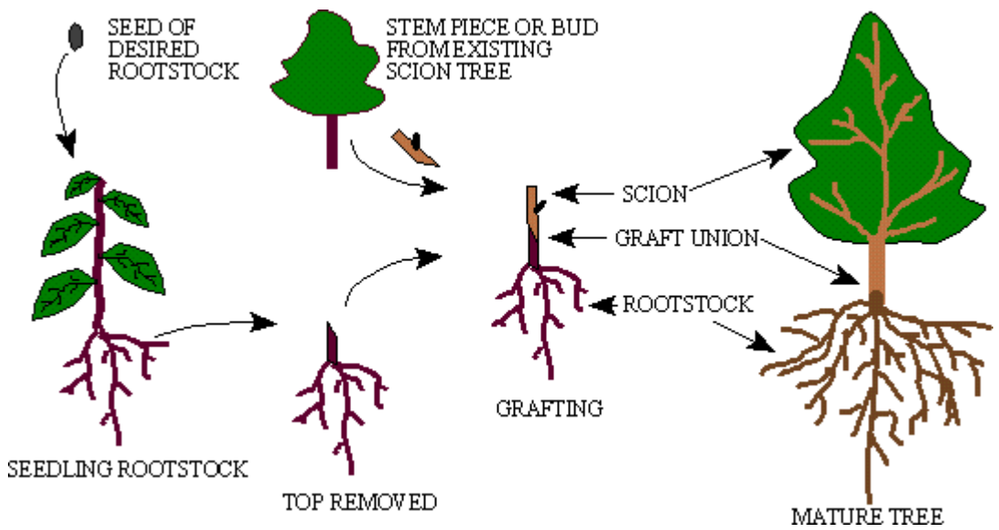
Air Layering

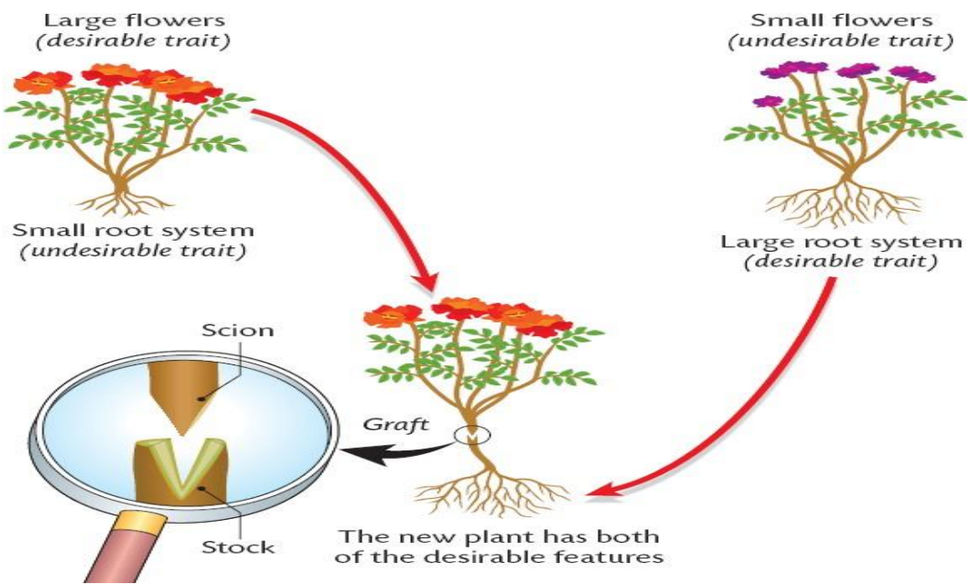
II. **Air Layering:** In air layering roots form on an aerial shoot. The rooting medium is tied to the shoot for getting root initiation. Sphagnum moss is the best rooting medium for air layering as it holds large quantities of water till root initiation and through the root initiation and through the 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**.



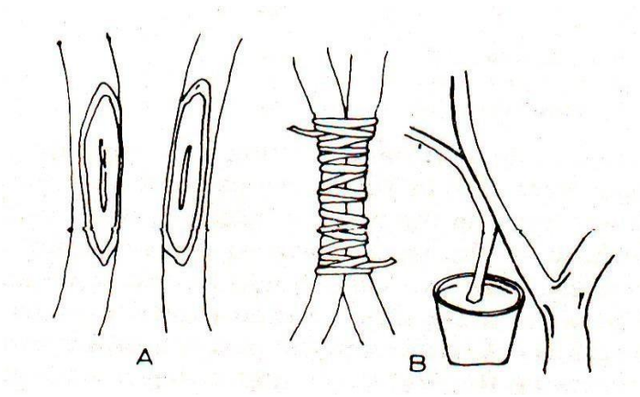


Methods of grafting: Mainly in grafting there are two types. ***Attached scion methods of grafting*** *and* ***detached scion methods of grafting.***

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.

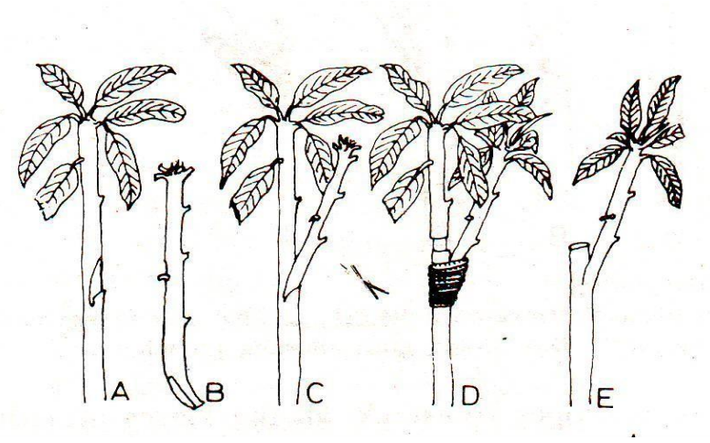
Procedure: Select a healthy shoot of having a 3.5cm girth on the selected mother plant which is to be used as a scion source. Select a root stock (raised in pot) having approximately the same size as that of the selected shoot on the mother plant. On the internodal region, where the union is to occur, 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.

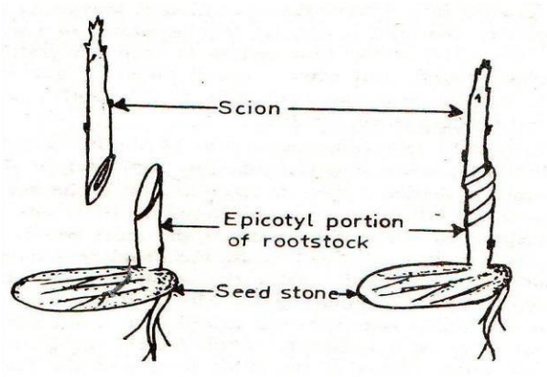


A-Prepared root stock, **B-**prepared Scion, C-Scion inserted, **D**-Girdled stock and tied graft joint, **E**-Sucessful graft, the stock being removed

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

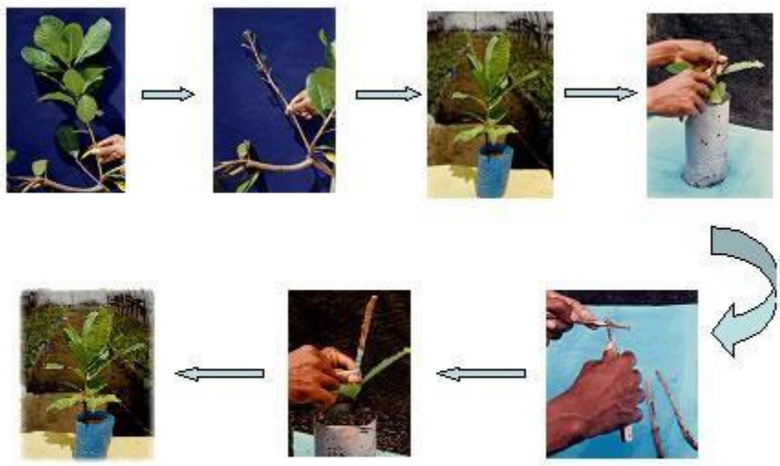
Epicotyl (Stone) Grafting: This method of grafting is done on the epicotyl region of the young seedlings; hence the name epicotyl grafting. Eg. Cashew, mango etc.

Procedure: Select very young seedling about 10days 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.



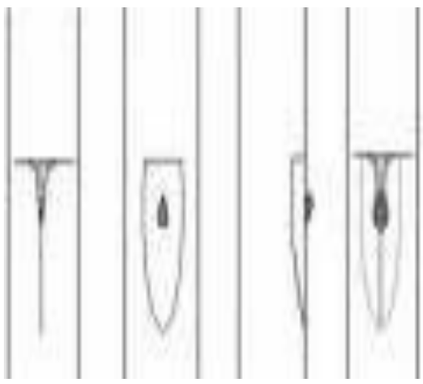
Softwood grafting

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

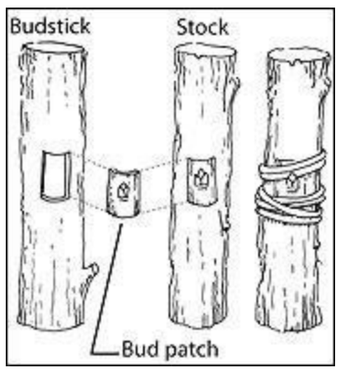
that the horizontal cut of the shield matches the horizontal cut on the stock. Wrap the bud stick tightly with polythene strip exposing only the bud.

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.

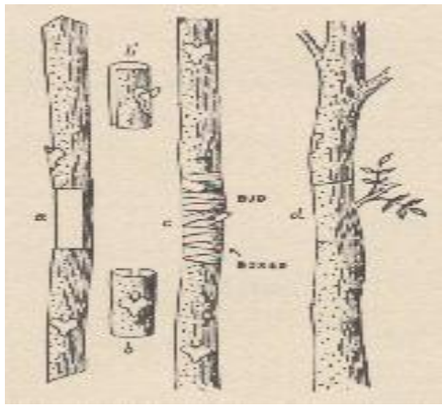
Patch Budding: In this method a regular patch of bark is completely removed from the stock plant and is replaced with a patch of bark of the same size containing a bud from the desired mother plant. For this method to be successful, the bark of the stock and bud stick should be easily slipping .The diameter 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.



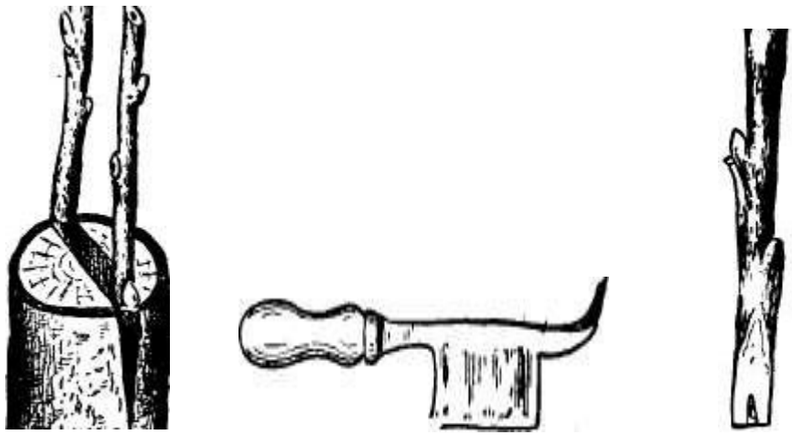
Ring budding

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.

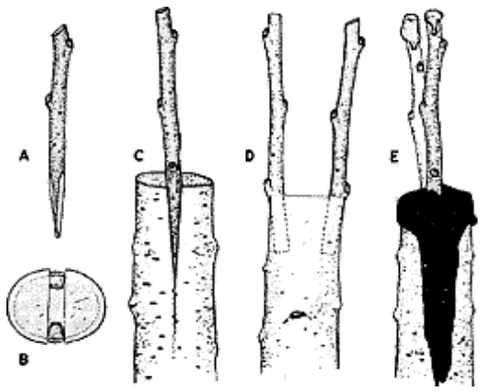
Double working: It is practiced for several purposes (1) to overcome incompatibility between the stock and scion. (1)incompatible stock and scion may be united by means of a piece of interstock that is compatible to both (2) to secure resistance to drought or cold by providing a disease or cold resistant trunk by means of double working.(3) To resistance to pest and dwarfing effect by using a pest resistant stock and a obtain 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.

USE OF PLANT GROWTH REGULATORS

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. 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 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 different species or genera. There are mainly two types of grafting: bud grafting and 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: Parthenocarpic 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 Viz., Anab-e-shahi, Pachadraksha etc. The problem of development of seeds in Poovan plants. Application of GA at 100 ppm induced complete seedlessness in grape varieties 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 ethanol 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. Ethephon 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.