

Practical 8

PROPAGATION THROUGH CUTTINGS, LAYERING, RUNNERS, SUCKERS, GRAFTING AND BUDDING

EXERCISE 8.1: PROPAGATION OF HORTICULTURAL CROPS THROUGH CUTTINGS

Objective :

- To acquaint the student with some of the basic techniques used in propagating horticultural plants using cuttings.

Delivery schedule : 01 period

Student expectations/learning objective:

- Basic techniques used in propagating horticultural plants through cuttings

Pre-learning required: Knowledge about different types of cuttings, treatment of cuttings with rooting hormones and planting of cuttings

Handouts/material required/equipment's & tools: Appropriate plant material, Propagation media/ material, Secateur and knives, Labels and marking pens, Rooting hormones (IBA, NAA)

Introduction:

Asexual or vegetative propagation of plants by cuttings is a very important part of horticulture. Asexual techniques allow the increase of plants so that all propagules are genetically identical to the parents. This differs greatly from sexual propagation where there remains the potential for diverse genetic variation. Seedling populations from many horticultural crops are so variable that asexual propagation affords the only way to practically maintain these individuals in order to retain their uniformity.

In propagation through cuttings, a portion of a stem, root, or leaf is cut from the parent plant, after which this plant part is placed under environmental conditions conducive to the formation of roots and shoots, thus producing a new independent plant which, in most cases, is identical with the parent plant. There are many different

ways to propagate plants using cuttings. The process involves determining which cutting type is best suited for the propagation of large numbers of plants and then using the appropriate preparation of the plant material for propagation.

Advantages of propagation through cutting: New plants can be started in a limited space from a few stock plants. The method is inexpensive, rapid and simple and does not require special techniques. There is no problem of incompatibility or of poor graft union. Greater uniformity is obtained. The parent plant is reproduced with no genetic change.

Cuttings are broadly classified as stem cuttings, leaf cuttings, leaf bud cuttings and root cuttings. Stem cuttings are of hardwood (deciduous and narrow-leaved evergreens), semi-hardwood, softwood and herbaceous plants.

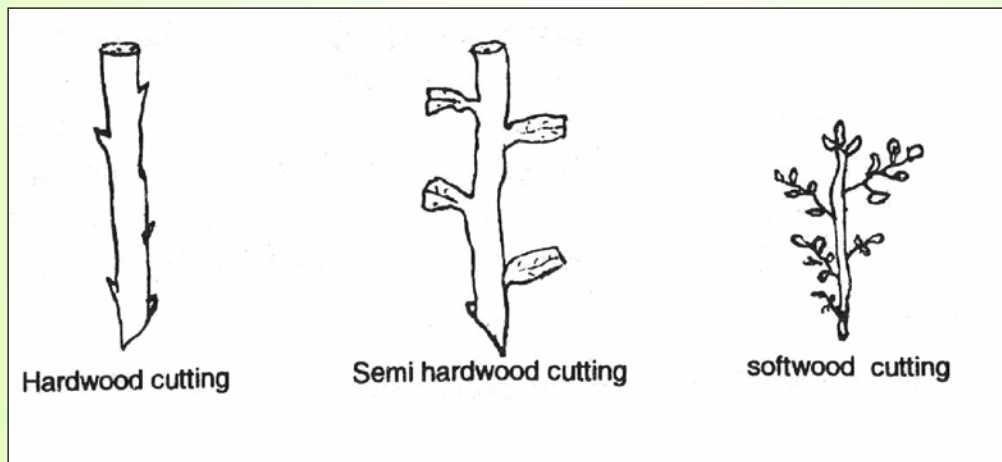
Hard wood Cuttings

Hardwood cuttings are made from mature, dormant firm wood after leaves have abscised. The use of hardwood cuttings is one of the least expensive and easiest methods of vegetative propagation. Hardwood cuttings are easy to prepare, are not readily perishable, may be transported safely over long distances and require little or no special equipment during rooting. These cuttings are prepared during the dormant season - late fall, winter or early spring - from wood of the previous season's growth. For a few species, such as the fig or olive, two year old or even older wood is used. Hard wood cuttings are often used in propagation of deciduous woody plants, although some broad leaved evergreens such as the olive can be propagated by leafless hardwood cuttings. A few fruit species such as fig, quince, olive, mulberry, grape, currant, gooseberry, pomegranate and some plums are propagated commercially by this method. Many deciduous ornamental shrubs are started readily by this type of cuttings. Some common ones are privet, forsythia, wisteria, honeysuckle, willow, poplar, dogwood, *Poinsettia*, *Sambucus*, and *Spiraea*. Rose rootstocks are propagated by hardwood cuttings.

Procedure:

- Collect one-year-old mature shoots from the fruit plants to be propagated such as fig, quince, olive, mulberry, grape, currant, gooseberry, pomegranate or deciduous ornamental shrubs (privet, forsythia, wisteria, honeysuckle, willow, poplar, dogwood, *Poinsettia*, *Sambucus*, and *Spiraea*) whichever is available in your locality during November-February.

- Discard the tip portion of the shoots because they are usually low in stored carbohydrates and often contains unwanted flower buds.
- Central and basal parts generally make the best cuttings, but there are exceptions.
- Length of cuttings should be between 10 and 45cm.
- Cuttings should contain at least 2 nodes.
- Give a straight cut just on the base of shoot below the node while a slanting cut on the top of the cutting, 1-2cm above the bud. This helps maintain the polarity of the shoot and if rain occurs, water does not accumulate on the tip of cutting.
- Apply rooting hormone (IBA/NAA).
- Plant the cuttings in well prepared beds or under polyhouses.



Semi hardwood cuttings

These are made from woody, broad-leaved evergreen species but leafy summer cuttings taken from partially matured wood of deciduous plants can also be considered as semi hardwood. Cuttings of broad leaved evergreen species are generally taken during the summer from new shoots just after a flush of growth has taken place and the wood is partially matured. Many broad-leaved evergreen shrubs such as Azalea, Camellia, Rhododendron, Euonymus, and holly are commonly propagated by semi-hard wood cuttings. A few fruit species, such as citrus and olive, can also be propagated by semi-hard wood cuttings.

Procedure:

- Collect the cuttings from the plants such as *Azalea*, *Camellia*, *Rhododendron*, *Euonymus*, and holly or fruit plants (citrus or olive) during the summer from new shoots just after a flush of growth has taken place and the wood is partially matured.
- The shoot terminals are often used in making cuttings but the basal parts of the stem will also root usually.
- Make the cuttings 7.5 to 15 cm long with leaves retained at the upper end. If the leaves are very large, these should be reduced in size to lower the water loss and to allow closer spacing in the cutting bed.
- Give a straight cut just on the base of shoot below the node while a slanting cut on the top of the cutting, 1-2cm above the bud.
- Obtain the cuttings in the cool, early morning hours when leaves and stems are turgid.
- Keep the cuttings out of the sun until they can be stuck and propagation is initiated. Therefore, cuttings should be placed in large containers, which are covered with clean moist burlap to maintain high humidity or put in large polythene bags.
- Apply rooting hormone (IBA/NAA).
- These cuttings are commercially rooted under intermittent mist or fog.

Soft wood cuttings

Cuttings prepared from the soft, succulent, new spring growth of deciduous or evergreen species may properly be classed as softwood cuttings. Many ornamental woody shrubs can be started by softwood cuttings. Typical examples are the hybrid French lilacs, *Magnolia* and *Forsythia*. Some deciduous ornamental trees such as the maples also can be started in this manner. Although fruit species are not commonly propagated by softwood cuttings, those of apple, peach, pear, plum, apricot and cherry will root, especially under mist. *Hydrangea*, *Fuchsia*, *Forsythia*, *Lilac*, *Magnolia*, Scented Geraniums, deciduous azaleas, assorted herbs and *Sedum*, etc. are also propagated by softwood cuttings.

Softwood cuttings generally root easily and more quickly than other types but require more attention and sophisticated equipment. This type of cuttings is always

made with leaves attached. They must be handled carefully to prevent desiccation and be rooted under conditions which avoid excessive water loss from the leaves. Temperature should be maintained during rooting at 23-27 °C at the base of the cuttings for most species.

Procedure:

- Collect the cuttings from the soft, succulent, new spring growth of deciduous or evergreen species such as *Hydrangea*, *Fuchsia*, *Forsythia*, Lilac, *Magnolia*, Scented Geraniums, deciduous azaleas, assorted herbs and Sedum, etc. or fruit species like apple, peach, pear, plum, apricot and cherry.
- Collect the cutting material early in the day. Keep them moist, cool and turgid at all times since keeping the cutting material or preparing cuttings in the sun even for few minutes will cause serious damage.
- It is important to obtain proper type of cutting material. The best cutting material has some degree of flexibility but is mature enough to break when bent sharply.
- Make the cuttings 7.5 to 12.5 cm long with two or more nodes.
- Remove the leaves on the lower portion of the cutting while those on the upper part are retained.
- Large leaves should be reduced in size. All flowers and flower buds should be removed.
- Apply growth regulator (1000 or 3000 ppm IBA)
- Plant the cuttings under intermittent mist.

Herbaceous cuttings

Procedure:

- Collect the cuttings from succulent herbaceous plants such as geranium, chrysanthemum, coleus, carnations and many foliage plants.
- Prepare cuttings 7.5 to 12.5 cm long with leaves retained at the upper end while remove the leaves on the lower portion of the cutting.
- Herbaceous cuttings of some plants that exude a sticky sap, such as pineapple and geranium do better if the basal ends are allowed to dry for a few hours

before they are inserted in the rooting medium. This practice tends to prevent the entrance of decay organisms.

- These cuttings are rooted under the same conditions as softwood cuttings. Bottom heat is also helpful. Under proper conditions, rooting is rapid and in high percentage.
- Although rooting hormones are usually not required, they can be often used to get uniformity in rooting and the development of better root system. Apply growth regulator (1000 or 3000 ppm IBA)

Leaf Cuttings

In this type of cutting, the leaf blade, or leaf blade and petiole are utilized in starting a new plant. Adventitious buds, shoots and roots form at the base of the leaf and develop into the new plant. 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. Only a limited number of plant species can be propagated by leaf cuttings. African violets, begonias and peperomea are routinely propagated by leaf cuttings.

Procedure:

- Leaf cuttings of African violets can be made of an entire leaf (leaf blade plus petiole), the leaf blade only or just a portion of the leaf blade. The new plant forms at the base of the petiole or midrib of the leaf blade.
- In Sansevieria, long tapering leaves are cut into sections 7.5 to 10 cm long. These leaf pieces are inserted three-fourth of their length into sand, and after a period of time, a new plant forms at the base of the leaf piece.
- For propagation of plants by leaf cuttings with thick, fleshy leaves such as Begonia rex, the large veins are cut on the undersurface of the mature leaf, which is then laid flat on the surface of the propagating medium. The leaf is pinned or held down with the natural upper surface of the leaf exposed. After some time under humid conditions, new plants form at the point where each vein was cut. The old leaf blade gradually disintegrates.
- In fibrous rooted Begonias, large well matured leaves are cut into triangular sections, each containing a piece of a large vein. The thin outer edge of the leaf is discarded. These leaf pieces are then inserted upright in sand with the

pointed end down. The new plant develops from the large vein at the base of the leaf piece.

- Leaf cuttings should be rooted under the same conditions of high humidity as those used for softwood or herbaceous cuttings.
- Cuttings are commercially rooted under mist or high humidity.
- Most leaf cuttings root readily but the development of adventitious bud and shoot is the limitation. Therefore, cytokinins can be used to induce buds to form.



Leaf cutting of Kalanchoe



Leaf cutting of Sansevieria



Leaf cuttings of Peperomia



Leaf lamina cuttings of Iron cross Begonia



Leaf lamina cuttings of Rex begonia

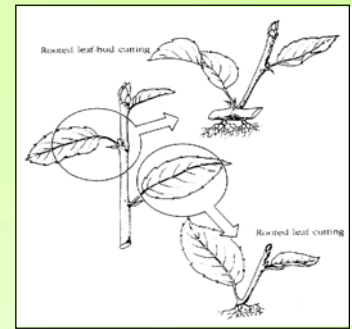
Leaf bud cuttings

This type of cutting consists of leaf blade, petiole, and a short piece of the stem with the attached axillary bud. Such cuttings are of particular value for species that are able to initiate roots, but not shoots, from detached leaves. In such cases, the axillary bud at the base of the petiole provides the essentials of shoot formation. A number of plant species such as black raspberry (*Rubus occidentalis*), blackberry, boysenberry, lemon, camellia, and rhododendron can be readily propagated by leaf bud cuttings.

This method is particularly valuable when the propagating material is scarce, because it will produce at least twice as many new plants from the same amount of stock material as can be started from stem cuttings. Each node can be used as a cutting.

Procedure:

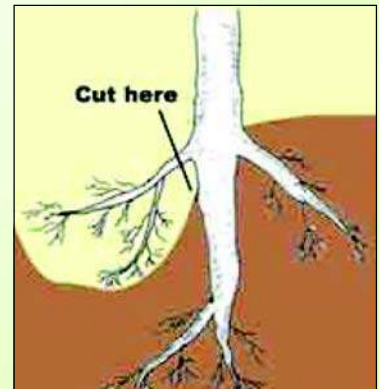
- Prepare leaf bud cuttings only from material having well developed buds and healthy, actively growing leaves.
- Remove section of stem. Cut stem into sections, each with a leaf attached
- Insert the cuttings into rooting media, with the bud about 1.3 - 2.5 cm below the surface.
- High humidity is essential and bottom heat is desirable for rapid rooting.
- Clean quartz sand and peat moss (1:1) are also satisfactory rooting media for such cuttings.



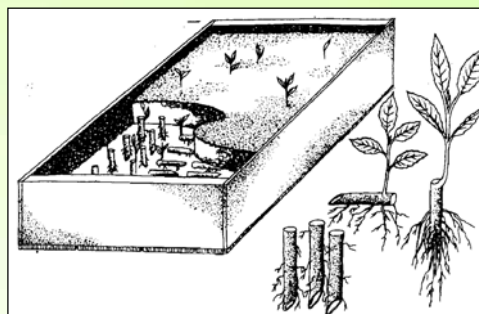
Root cuttings

These are applicable for the propagation of more woody plants than is commonly realized. They are also beneficial as a means of propagating rootstocks of fruit crops. They also play a particularly important role in the propagation of herbaceous perennials. Root cuttings are usually obtained during the dormant season from young stock plants when the roots are well supplied with carbohydrates. Once the soil is removed from the root system by shaking or then prepared by cutting to a length of about 4 in, although cuttings from plants such as phlox, anemones, and gaillardias may be smaller. Blackberry and raspberry are commercially propagated by this method. This method is also advocated in pecan nut, apple, pear and peach.

- Take root pieces preferably from young stock plants in late winter or early spring when the roots are well supplied with stored foods but before new growth starts.



- Securing cutting material in quantities for root cuttings can be quite laborious unless it can be obtained by trimming roots from nursery plants as they are dug.
- Correct polarity should be taken into consideration when planting is done. To avoid planting them upside down, the proximal end may be made with a straight cut and the distal end with a slanting cut. The proximal end of the root piece should always be up.
- While planting, insert the cutting vertically so that the top is at about soil level. With many species, however, it is satisfactory to plant the cuttings horizontally 2.5 - 5.0 cm deep.
- The size of root cuttings depends upon the nature of the roots. In plants with small delicate roots, the roots are cut 2.5 - 5 cm long. In plants with fleshy roots, the root size may be 5-7.5 cm, whereas in plants having large roots, the root cuttings are made 5-15 cm long.
- Place the cuttings under mist.



Precautions: Take cuttings only from healthy plants. To prevent the spread of disease, use clean tools and pots (clean with 10% bleach, rinse, and let dry thoroughly). Use fresh soil less potting mixture since garden soil can harbor plant diseases.

Exercise 1: Prepare the cuttings of various types from available plant material and plant them. Observe the rooting patterns for the next few weeks. Remove and keep plants which rooted successfully.

Exercise 2: Enlist the horticultural crops grown in your area propagated through various types of cuttings in the given data sheet.

Type of cuttings	Examples of horticultural crops	Remarks, if any
Hard wood cuttings		
Semi-hard wood cuttings		
Soft wood cuttings		
Herbaceous cuttings		
Leaf cuttings		
Leaf bud cuttings		
Root cuttings		

EXERCISE 8.2:

PROPAGATION OF HORTICULTURAL PLANTS THROUGH LAYERING, RUNNERS AND SUCKERS

Objective :

- To demonstrate and prepare the various types of layering that can be used to propagate horticultural plants.

Delivery schedule : 01 period

Student expectations/learning objective:

- Basic techniques used in propagating horticultural plants through layering
- To develop skill in the art of layering

Pre-learning required: Knowledge about different types of layering.

Handouts/material required/equipment's & tools : Appropriate plant material; Secateur and grafting knives; 15 x 20 sq. cm sheet of polyethylene film, rubber bands or pieces of twine, and a 15 x 20 sq. cm sheet of either craft paper, cloth or aluminum foil; Labels and marking pens.

Introduction:

Layering is a method of vegetative propagation by which a good stem is induced to produce roots while it is still attached to the parent plant. After proper rooting, the stem is detached and becomes a new plant for growing on its own roots. In this manner a new plant usually can be developed in a relatively short time and with less trouble than other methods of propagation. It can be used successfully on many fruit trees and woody ornamental shrubs grown.

The high success of layering is obtained by ringing or wounding, etiolation (absence of light), use of rooting hormone (IBA, NAA) and favourable environmental condition (temperature and humidity).

The layering can be natural means of propagation as in black raspberries and

trailing blackberries or can be artificially created by different means. The layering techniques generally employed in horticultural plants are:

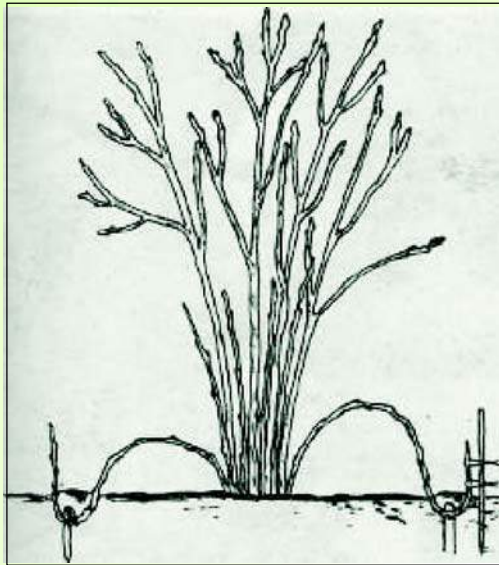
Simple Layering :

Simple layering is the bending of an intact shoot to the ground and covering a single portion of the stem between the base and shoot tip with soil or rooting medium so that adventitious roots form. The method can be used to propagate a wide range of plants, indoor or outdoor, on woody shrubs that produce numerous new shoots annually or on trees that tend to produce suckers, such as filberts (*Corylus* sp.). The usual time for layering is early spring.

Procedure:

- Select flexible, dormant, one-year-old shoots, which can be bent easily.
- Bend these shoots over to the ground during early spring or fall.
- Make a second bend in the branch at a location 15 to 20 cm (6 to 9 in.) from the tip, forming a "U".
- Hold it in place with wire hooks or wood stakes.
- Injure the stem at the underground section to stimulate rooting. Injury can be imparted through notching, bending, twisting, cutting, or or girdling at the bottom of the "U"
- Cover the base of the layer with soil leaving the tip exposed.
- Roots will form on the buried part of the shoot near the bend.
- Shoots layered in the spring will usually be rooted by the end of the growing season and remove them either in the fall or in the next spring before growth starts.
- Mature shoots layered in summer should be left through the winter and either removed the next spring before growth or left until the end of the second growing season.
- The rooted layer is detached from the parent plant. When the rooted layer is removed from the parent plant, it is treated essentially as a rooted cutting.

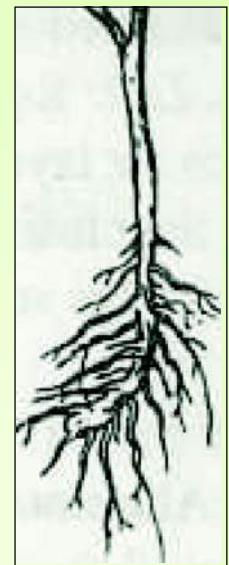
- New shoots growing from the base of the plant during the rooting year are used for layering during the next season. With this system a supply of rooted layers can be produced over a period of years by establishing a layering bed composed of stock plants far enough apart to allow room for all shoots to be layered.



Bending of shoots



*Formation of roots
near the bend*



Rooted layer

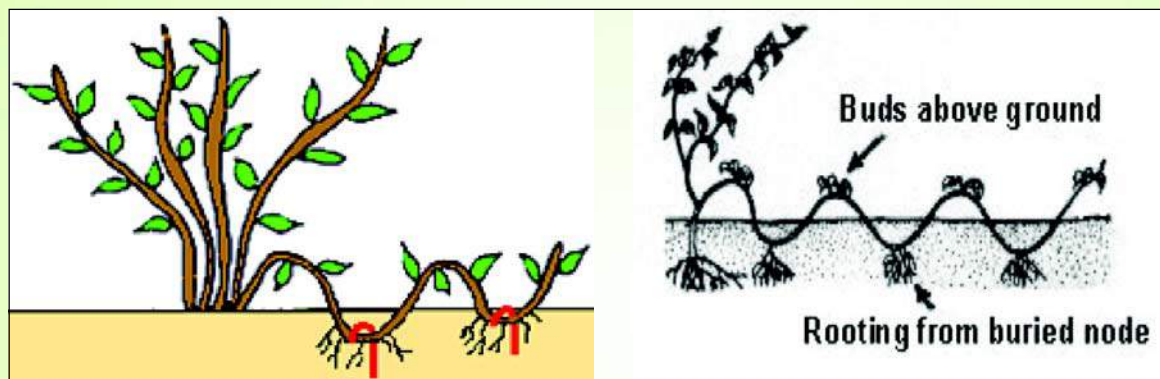
Compound layering:

It is similar to simple layering, except that the branch to be layered is laid horizontally to the ground and numerous shoots for rooting develop from various nodes rather than just one. A variation of this method (sometimes called serpentine layering) is used for propagating plants that have long, flexible shoots; for example, the Muscadine grape (*Vitis rotundifolia*) and ornamental vines such as Wisteria and Clematis. The horizontal shoots are alternately covered and uncovered to produce roots at different nodes. Several new plants are thus possible from a single branch.

Procedure:

- Permanent layering beds are established with plants spaced 1.8 to 3 m (6 to 10 ft) apart and grown for several years to establish a good root system.
- The vegetative top is then cut back to 2.5 cm (1 in.) from the ground and shoots are allowed to grow for the following season.

- Bend long shoots over horizontally to the ground before the beginning of the season, and held down with wire pegs.
- Once new shoots grow about 10 cm (4 in.), the pegs are removed, a shallow trench is dug adjacent to the stem, and the shoots are laid in the bottom of the trench with additional pegs applied to hold them in place.
- Soil or other media is filled in as the shoots grow.
- Roots will form on the buried part of the shoot near the bend.
- The rooted layer is removed from the parent plant.



Compound Layering

Tip-layering:

- Tip layering occurs naturally in trailing blackberries, dewberries, and black and purple raspberries (*Rubus*).
- In tip-layering, rooting takes place near the tip of current season's shoot which is bent to the ground.
- The stem of these plants complete their life in 2 years. During first year, vegetative growth takes place while in the second year fruiting takes place.
- After harvesting plants are heavily pruned which give rise to number of lateral shoots. The tips of these shoots are buried 5-10cm deep in soil.
- Roots will form on the under ground part of the shoot near the bend.
- Rooted layers are detached from the parent plant and planted in soil during spring.

Mound (Stool) Layering or Stooling:

Mound layering is a method where the shoots are cut back to the ground and soil or rooting medium is mounded around them to stimulate roots to develop at their bases. Apple and pear rootstocks and guava are commercially propagated by this method. However, this method is also advocated in other fruits like plum, cherry, hazelnut, pecannut, mango, jackfruit and litchi. It is also useful for quince, currants, and gooseberries.

Procedure:

Establishing the Stool Bed

- The establishment of the mother stool bed is achieved during the first year.
- The planting of the mother stocks is done during the months of December-January when the plants are fully dormant.
- The field should be thoroughly cultivated and the soil of the plot should be loose, fertile and well-drained.
- Plant healthy stock plants of suitable size (8 to 10 mm) in diameter and 60-75 cm (24-30 in.) long with well developed roots.
- Keep plant to plant distance as 30 to 37.5 cm (12 to 15 in.) apart in a row.
- Keep a minimum row spacing of 2.5 m (8 ft). Width between rows should allow for cultivation and hilling operations during spring and summer.
- At planting, the plants are cut back to 45 to 60 cm (18 to 24 in.) and allowed to grow for one year.

Annual Operations:

- Allow these mother stools to grow unchecked for one year.
- In the second year, cut back plants to 2.5 cm (1 in.) above ground level before new growth starts in the spring.
- Two to five new shoots usually develop within two months from the crown the first year, more in later years.

- Girdling of these shoots can be done near base and rooting hormone (IBA), made in lanolin paste is applied to the upper portion of cut with moist soil. These shoots are left as such up to two days for proper absorption of rooting hormone (IBA) before they are covered. The concentration of rooting hormone varies from plant-to-plant but in general 3,000-5,000ppm is most commonly used.
- When these shoots have grown 7.5 to 12.5 cm (3 to 5 in.), cover each shoot to one-half of its height with loose soil, bark, sawdust, or a soil- sawdust mixture.
- When shoots have grown 20 to 25 cm (8 to 10 in.), a second hilling operation (a horti-cultural term that refers to the mounding up of soil or other media around the base during layering) should be done by adding additional rooting medium around the bases of the shoots to cover about half of its height.
- A third and final hilling operation is done in midsummer (July) when the shoots have developed approximately 45 cm (18 in.). The bases of the shoots will then have been covered to a depth of 15 to 20 cm (6 to 8 in.).
- During the next winter, sufficient roots will form on the stool shoots by the end of the growing season.
- After natural leaf fall, the soil is forked away from the earthed shoots carefully.
- Rooted shoots are cut close as possible to their bases and utilized either for nursery production by grafting/budding or for establishing additional stool beds.
- After the shoots have been cut away, keep the stool beds exposed until new shoots have grown 7.5 to 12.5 cm (3 to 5 in.). At this time, the stooling cycle is repeated annually.
- A stool bed can be used for 15 to 20 years with proper handling, providing it is maintained in a vigorous condition and diseases, insects, and weeds are controlled.



Stool bed started by planting a rooted layer in a small trench



Established mother stool after one year growth



Top is removed to 2.5 cm above ground just before growth begins



Mother stool during 2nd year of establishment



The final earthing with fine soil to the height of 15-20 cms above the ground level



In the following winter the soil is forked away and the rooted shoots are harvested during December-January when all the leaves have dropped.



Rooted layer are cut off and are lined out in the nursery

Trench Layering

Trench layering is a layering method in which the mother plants are established in a sloping position such that shoots can be layered horizontally in the base of a trench. Soil, bark, sawdust, or other rooting material is filled in around the new shoots as they develop so as to bring about etiolation. The method can be used for clones of woody species that are difficult to root by mound layering (stooling), including cherry, quince, apple, mulberry, and walnut etc.

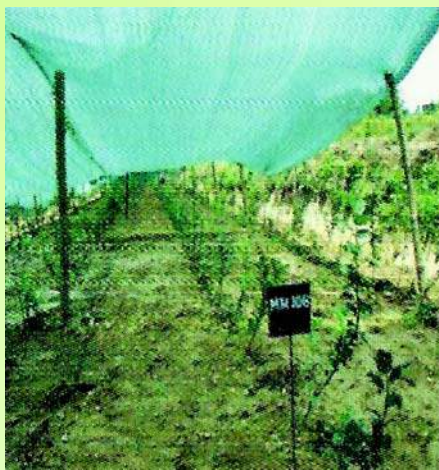
Establishing the Layer Bed

- The establishment of the mother stocks is achieved during the first year.
- The planting of the mother stocks is done when the mother stock material is dormant.
- The field should be thoroughly cultivated and the soil of the plot should be loose, fertile and well-drained.
- The mother stocks should be planted about 30-35 cm apart and 10 cm deep.
- The distance between two trenches should be kept about 1-1.5 m.
- The mother plants are planted at an angle of 30 to 45° along the row and are usually pointed southwards.
- The plants are allowed to grow during the first year to establish a good root system.

Annual Operations:

- The steps during cultivation in the first season are same as described for mound layering.
- By the end of the growing season or during that winter a shallow trench 5 X 23 cm (2 X 9 in.) is dug down the row.
- Bend the main mother plant as horizontally along the bottom of the trench as possible. This is done by using pegs or hinged wooden pegs.
- Select two-three suitable side growths on either side of the main mother stock plant and bend the same down in the trench alongside the main stem so that the trench is evenly filled with the mother plant.

- Care should be taken not to pin down too much material causing over crowding and making the mother plant too wide.
- The best time to pinning down the side shoots is late autumn. However, this operation can be taken at the same time when bending and pinning down of the main mother plant is done in winter when the growth has ceased.
- After bending and pinning down, these shoots should be shortened back to even, strong wood removing the thinner tip growth.
- Shorten back the remaining shoots on the mother plants, which were not required for pinning down. These shoots should be pruned back to the main stem in the mother plant leaving a stub of approximately 1.5 to 2 cm.
- Successful layering depends on etiolation. Buds are covered with about a 2.5 cm (1 in.) of soil before they emerge.
- Subsequent applications of rooting medium such as sawdust are added periodically to etiolate 5 to 7.5 cm of the developing shoots. Final depth should be 15 to 20 cm.
- Rooting should take place by the end of the season.
- In the following winter, the soil is forked away and the rooted shoots are cut off close to the original branch, leaving a small stub for next year's growth.
- The shoots that have not formed the roots are left to be laid and pegged down as before.
- If all the shoots have rooted, care must be taken to leave at least one shoot at every one foot distance in the trench. During the first year, cut off each rooted shoots leaving a stub of 1.5-2 cm and in the subsequent years, it should be cut back to the crown created by initially left stubs.
- The process is repeated in subsequent years. A well-cared-for stock bed should last 15 to 20 years.



Mother plants after one year's growth which were planted in the row at an angle of 30°-45°



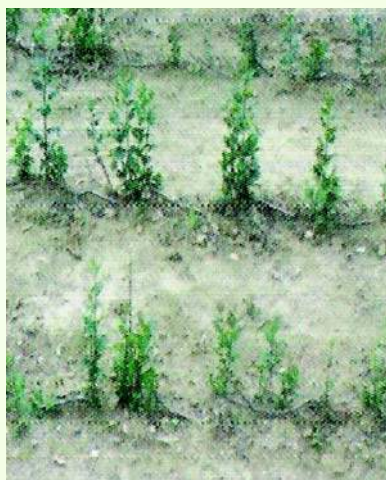
Established mother plant after 1 year of growth



Laying of plant in the bottom of trench before the start of growth



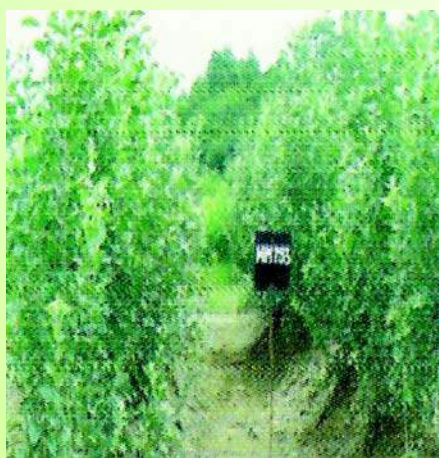
The plants are kept completely flat with the help of pegs



Even bud break across the whole bed



Shoot ready for first earthing up when the new shoots are 35 in. high



The final earthing with fine soil should be 15-20 cms above the ground level at the centre of the trench



In the following winter the soil is forked away and the rooted shoots are harvested. During December-January) when all the leaves have dropped.



Rooted layers are cut off and are lined out in the nursery

Basic steps in trench layering

Air Layering

Air layering is a type of layering in which an aerial stem is girdled and enclosed with rooting media to produce rooted layers in the upper part of the plant. This method is commonly known as goottee. It is also called pot layering, circumposition and marcottage. Plants commonly propagated by air layering include litchi, kagzi lime, jackfruit, guava and cashewnut as well as *Ficus* species, litchi, lime, lemons, guava, jackfruit, cashew nut, *Croton*, *Monstera*, Rubber plant, Hibiscus, Calliandra, Gardenia, Bougainvillea and philodendron are propagated through air-layering. February-March and June-July are the ideal periods for air-layering.

Procedure:

- Select young, vigorously growing healthy shoots 0.5 to 2 cm in diameter. Generally, shoots from the previous season's growth are preferred. However, shoots older than one year can be used in some cases, but rooting is less satisfactory and the larger plants produced are somewhat more difficult to handle after rooting.
- Remove leaves and twigs on the selected shoot 7 to 10 cm above and below the point where the cut is to be made.
- Girdle the shoot at a point 15 to 30 cm back from the tip just below a node by completely removing a ring of bark 2 to 3.5 cm wide all around the shoot by making two circular cuts with a knife.
- Scrape the exposed surface to ensure complete removal of the phloem and cambium. This will prevent callus formation and allow roots to be initiated.
- In difficult-to-root species, treat the girdled portion with the recommended growth regulator (IBA) to induce better rooting.
- Cover the girdled portion with a ball of moist sphagnum moss as soon as possible. Make sure that the excess moisture is squeezed out before applying it to the cut surface. If the moisture content of the sphagnum moss is too high, the shoot will decay.
- Place a wrapping of transparent polyethylene film (200-300 gauze) 20 to 25 cm (8 to 10 in.) square, around the sphagnum moss. The ends of the sheet should be folded with the fold placed on the lower side and tie at each end. Tying should be perfect so that no water can enter the treated part.
- Roots develop on air layers generally within 25-30 days which can be observed through the transparent polyethylene sheet and layers are ready for transplanting within 3 months.

- At this stage, remove the layer from the parent plant and transplant the layer appropriately. Removal of the layer for transplanting is best when growth is not active.
- Pruning to reduce the top in proportion to the roots is usually advisable.



Basic steps in air layering

Runner:

- It is a specialized stem which is produced from the leaf axil at the crown of plant and prostrate horizontally.
- The roots appear at one of the nodes having contact with soil.
- After root formation in the new plant, the contact with the mother plant is automatically detached and new plant can be separated and planted.
- Strawberry is the typical example which is commercially propagated through runners.



Suckers:

- A sucker is a shoot which arises on a plant below the ground.
- However, in practice, shoots which arise from vicinity of the crown are also referred to as suckers.
- Banana is usually propagated through suckers.
- In banana, 2 types of suckers are produced-water sucker and sword sucker.
- Water suckers are broad leaved while sword suckers are pointed and in the shape of a sword.
- For propagation purpose, sword suckers are preferred over water suckers.



Exercise: Practice and perform air layering in pomegranate/litchi and mound layering in guava.

EXERCISE 8.3:

PROPAGATION OF HORTICULTURAL PLANTS THROUGH GRAFTING

Objective :

- To demonstrate and prepare the various types of grafting that can be used to propagate horticultural plants.

Delivery schedule : 01 period

Student expectations/learning objective:

- Basic techniques used in propagating horticultural plants through grafting
- To develop skill in the art of grafting

Pre-learning required: Knowledge about different types of grafting.

Handouts/material required/equipment's & tools : Appropriate plant material; Secateur and grafting knives; Tying material (polythene sheet-150gauge/ paraffin wax etc.); Labels and marking pens.

Introduction:

Grafting is a method of asexual plant propagation widely used in agriculture and horticulture where the tissues of one plant are encouraged to fuse with those of another. It is most commonly used for the propagation of trees and shrubs grown commercially. In most cases, one plant is selected for its roots, and this is called the rootstock. The other plant is selected for its stems, leaves, flowers, or fruits and is called the scion. The scion contains the desired genes to be multiplied in future production by the compound stock and scion combined plant.

For successful grafting to take place, the vascular cambium tissues of the stock and scion plants must be placed in contact with each other. Both tissues must be kept alive until the graft has taken, usually a period of a few weeks. Successful grafting only requires that a vascular connection take place between the two tissues. A physical

weak point often still occurs at the graft, because the structural tissue of the two distinct plants, such as wood, may not fuse.

Grafting and budding terminology

Before discussing grafting methods further, some of the key terms involved need to be clarified.

- The **scion** is the part of the stem that develops into a shoot system following successful grafting.
- The **stock or rootstock** is the part that develops into a root system following successful grafting. A rootstock may be grown from seed or from rooted cuttings.
- An **interstock** is sometimes grafted in between a stock and scion to impart certain important characteristics to the unified plant. Interstocks are useful for dwarfing, to overcome stock-scion incompatibility, impart winter hardiness, and reduce disease problems. (The interstock may be only a thin section of wood, a short section of trunk in a fruit tree, or the trunk and lower portions of scaffold branches.) This is often referred to as "double working."
- **Topworking** applies to the process of changing the top of a plant from one cultivar to another by grafting or budding. This procedure may sometimes involve a series of multiple grafts.
- The **cambium** is a layer of dividing cells in a stem that is responsible for increasing the stem diameter. Plants lacking cambium (example: monocots such as corn) cannot be grafted. The cambium of a stock and scion must be in close contact to form a union. Cambial activity during spring facilitates easy separation of bark from the wood.
- **Callus** is a mass of cells produced from the cambium. The newly formed mass of cells grows over the wound and unites the plant parts. Thus, callus plays a crucial role in uniting the stock and scion.
- **Bench grafting** is uniting container-grown or bare-root rootstocks with scion indoors, often on a bench.
- **Sap** is the fluid transported via conductive tissues such as **xylem** and **phloem**. While **xylem** transports water from roots to the aerial parts of the plant,

phloem conducts sugars, nutrients and hormones from the leaves to the roots and storage organs (fruits).

Selecting and Handling Scion Wood

The best quality scion wood usually comes from shoots grown in the previous season. Scions should be severed with sharp, clean knives and placed immediately in moistened plastic bags. It is good practice to clean the cutting tools regularly. This may be done by flaming or immersing them in a sterilizing solution. Ethyl alcohol also works well as a sterilant, although it evaporates quite readily. An alternative sterilizing solution may be prepared by mixing one part household bleach with nine parts water. However, this bleach solution can be highly corrosive to certain metals.

For best results, harvest only as much scion wood as can be used for grafting during the same day. Select only healthy scion wood that is free from insect, disease or physical damage. Be sure the stock plants are of good quality, healthy, and true to type. If large quantities of scion wood must be harvested at one time, follow these steps:

- Cut all scions to a uniform length, keep their basal ends together, and tie them in bundles of known quantity (for example, 50 scions per bundle).
- Label them, recording the cultivar, date of harvest, and location of the stock plant.
- Wrap the base of the bundles in moistened burlap or sphagnum moss. Place them in polyethylene or waterproof paper bags, and seal the bags.
- Store the bundles for short periods, if necessary, either iced down in insulated coolers or in a commercial storage unit at 0o to 1.1oC.
- Never store scions in refrigerated units where fruits or vegetables are currently kept or have been stored recently. Stored fruits and vegetables release ethylene gas, which can cause woody plant buds to abort, making the scions useless.
- The scions should not be frozen during storage.

In grafting, as well as budding, the vascular cambium of the scion or bud must be aligned with the vascular cambium of rootstock. In woody plants the cambium is a very thin ribbon of actively dividing cells located just below the bark. The cambium produces conductive tissue for the actively growing plant. This vascular cambium

initiates callus tissue at the graft and bud unions in addition to stimulating tissue growth on the basal end of many vegetative cuttings before they have rooted.

Procedure:

1. Veneer grafting:

- This method of propagation holds promise for large scale commercial propagation. The method is simple and can be adopted with success.
- Eight months to one year old seedlings are used as rootstocks.
- A downward and inward 3-4 cm long cut is made in the smooth area of the stock at a height of about 20 cm.
- At the base of cut, a small shorter cut is given to intersect the first so as to remove the piece of wood and bark.
- Proper selection and preparation of scion are of utmost importance.
- The scion should be of matching thickness with the stock, preferably a terminal non-flowered shoot of 3 to 4 months maturity.
- Remove the leaf blades from the selected scion shoot on the mother plant keeping the petiole intact, about 7 to 10 days prior to detaching.
- This helps in forcing the buds to swell and in increasing the grafting success.
- The scion stick is given a long slanting cut on one side and a small short cut on the other so as to match the cuts of the rootstock.
- The scion is inserted in the rootstock and the graft union is then tied with polythene strip.
- The rootstock should be clipped in stages when the scion takes and remains green for more than 10 days.
- It is used widely for grafting plants such as Avocado, Mango etc.

2. Epicotyl (Stone) Grafting:

- This method of grafting is done on the epicotyl region of the young seedlings; hence the name epicotyl grafting.
- This method is simple, economical and useful for multiplication of mango plants in large number in a less time.

- Fresh mango stones are sown in the nursery beds.
- Germinated seedlings of 10-15 days old with tender stems and coppery leaves are lifted along with stones.
- The roots and stones are dipped into 0.1 per cent Carbendazim solution for 5 minutes after washing the soil.
- The seedling stems are headed back about 6-8 cm above the stone.

Preparation of scion



The scion is prepared with a long cut along one side



A short cut is given at the base of the scion on the



Steps involved in performing side veneer grafting in mango

- A vertical split (about 3-4.5 cm longitudinal cut) is made into the middle portion of the seedlings.
- A wedge shaped cut is given on the lower side of scion.
- The scions should be 4-5 months old and 10-15 cm long containing plumpy terminal buds.
- The scion is then inserted in the cleft of the seedlings and tied with polythene tape.
- Immediately thereafter, the grafts are planted in polybags filled with the mixture of soil and farmyard manure (1:1).
- The polybags are watered and then kept in the shade protecting from sun and heavy rain.
- The successful grafts should be shifted to open space or may be planted in nursery beds when their leaves become green.
- The most suitable time for stone grafting is July.
- Examples are Cashew, mango etc.

3. Soft wood grafting:

- This method is similar to that of cleft or wedge grafting.
- In the past, this technique has been used for in situ orchard establishment under dry land conditions as the grafting operation is performed using cleft/ wedge method on the newly grown top portion of the plant one year after the establishment of rootstock in the field.
- In this method, 3 to 8 months old seedlings are used as rootstocks.
- The scion shoots of the thickness equal to that of rootstocks are defoliated 7-10 days prior to grafting.
- The graft should be secured firmly using 1.5 cm wide, 150-gauge polythene strip.
- The best time for the success of softwood grafting is July and August.

4. Cleft grafting:

- This method is employed in the nursery when the rootstock is quite thicker than the scion.

- It can be done successfully in the rootstock having a diameter of 3-10 cm. A vertical split (5 cm) is made in the rootstock with a sharp knife.
- The scion should be one year old, about 15-20 cm long and having 3-4 buds above the slanting cuts.
- For preparing the scion, two slanting cuts (5-6 cm) each are given on the opposite sides.
- The scion is inserted into the split of the rootstock in such a way that the cambium of both stock and scion coincides.
- Careful tying is necessary to avoid displacing the scion and separating the cambiums.
- The graft union is then tied with the help of 150 gauge polythene strip.
- Sprouting of scion shoots starts within 3 weeks of grafting.
- The polythene strip is removed after about 6-8 weeks of grafting.
- The sprouts arising below the graft union should be removed periodically.
- The best time for cleft grafting is December- February in temperate fruits.

5. Tongue Grafting

- This method is highly effective and widely employed for the propagation of temperate fruits.
- The diameter of the scion and the rootstock should be equal.
- A flat slanting cut, about 5 cm long is given at the base of the scion so that the lowest bud is about midway along the cut but on the opposite side.
- A downward pointing tongue is made in the upper half of the slanting surface.
- A slanting cut, corresponding in length to that of the scion, is made upwards through the stock 15-20 cm above the ground.
- An upward pointing tongue is made in the upper half of this slanting surface.
- The cut surfaces of the scion and stock are now placed together so that the tongues interlock and the cambial regions are in close contact. This interlocking of tongue gives greater surface for the root stock and scion come into contact with each other to make the strong union.
- Careful tying is necessary to avoid displacing the scion and separating the cambiums.

- The graft union is then tied with the help of 150 gauge polythene strip. Sprouting of scion shoots starts within 3 weeks of grafting.
- The periodical removal of sprouts below the graft union should be carried out.
- The polythene strip is removed after about 6-8 weeks of grafting.
- The best time for tongue grafting is December- February in temperate fruits.
- Examples are apple, pear, peach, plum, apricot, almond, cherry, kiwifruit, pecan nut etc.

Preparation of root stock



The top of the stock should be cut off



This split is made by pounding the knife



a vertical split of 5-8 cm down the center of the stock

Preparation of scion



At the basal end of each scion a smooth long, sloping wedge cuts of 5 cm is made

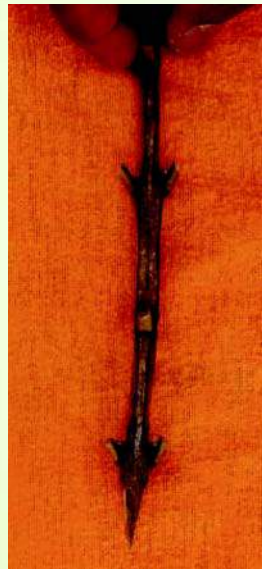


Placement of scion with proper contact of cambium layer of scion and stock

Scion and stock are firmly tied together with a plastic strip

The scion are inserted in a stub into the vertical split





Steps involved in performing wedge grafting in guava

Preparation of rootstocks



Rootstock



Slanting Cut on rootstock



Upward pointing tonque is made in the upper half of this slanting surface



Preparation of scion



Scion stick



Slanting Cut Made on scion



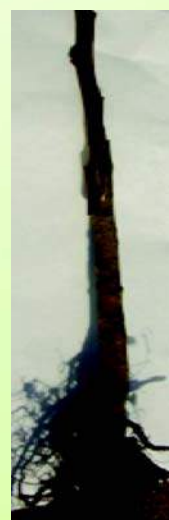
Downward pointing tanque is made in the upper half of the slanting surface



The cut surfaces of the scion and stock are now placed together so that the tongues interlock



Cambial contact



Scion and stock are firmly tied together with a plastic strip



Exercise 1: Practice and perform veneer grafting and soft wood grafting in mango, tongue and cleft grafting in apple/pear/peach and wedge grafting in guava etc. under the supervision of your resource person.

Exercise 2: Visit any well established private nursery unit/University or Government nursery. Enlist the fruit plants grown and supplied to the public. Discuss with the owner and prepare a list of methods of propagation being used for the multiplication of available fruit plants.

Exercise 3: Enlist the fruit crops grown in your area and their methods of propagation.

EXERCISE 8.4:

PROPAGATION OF HORTICULTURAL PLANTS THROUGH BUDDING

Objective :

- To demonstrate and prepare the various types of budding that can be used to propagate horticultural plants.

Delivery schedule: 01 period

Student expectations/learning objective:

- Basic techniques used in propagating horticultural plants through budding
- To develop skill in the art of budding

Pre-learning required: Knowledge about different types of budding.

Handouts/material required/equipment's & tools : Appropriate plant material; Secateur and grafting/budding knives; Labels and marking pens; Tying material (polythene sheet 150 gauge).

Introduction:

In contrast to grafting, in which the scion consists of a short detached piece of stem tissue with several buds, budding utilizes only one bud and a small section of the bark, with or without wood. Budding is often termed 'bud grafting' since the physiological processes involved are the same as in grafting.

The commonly used budding methods depend upon the bark's "slipping". This term indicates the condition in which the bark can be easily separated from the wood. It denotes the period of year when the plant is in active growth, the cambium cells are actively dividing, and newly formed tissues are easily torn as the bark is lifted from the wood.

In propagating nursery stock of the various fruit and ornamental species by budding, a root stock plant is used. It should have the desired characteristics of vigour, growth resistance to soil born diseases and pests and should be capable of being easily propagated. This root stock plant can be a rooted cutting, a rooted layer, or, more commonly, a seedling.

Procedure

1. T-Budding

This method of budding is known as T-budding (because of T-like appearance of the cut in the stock), as well as shield budding (because of shield like appearance of bud piece when it is ready for insertion in the stock). The procedure for T-budding is as follows:

- Make a vertical cut about 2.5 cm long in the stock.
- Make a horizontal cut through the bark about one-third the distance around the stock. Give the knife a slight twist to open the two flaps of bark.
- Starting about 1.2 cm below the bud, make a slicing cut under and about 2.5 cm beyond the bud.
- Make a horizontal cut about 2 cm above the bud through the bark and into the wood permitting the removal of the bud piece.
- Insert the shield piece by pushing it downward under the two flaps of bark till the horizontal cuts on the shield and the stock are even.
- Tie the bud union tightly with polythene strip but leaving the bud exposed.

2. Inverted T-Budding

- In rainy localities, water running down the stem of the root stock may enter

the T-cut, soak under the bark, and prevent the shield piece from healing into place.

- Under such conditions an inverted T-bud may give better results, since it is more likely to shed excess water.
- In citrus budding, the inverted T-method is widely used, even though the conventional method also gives good results.
- In species that bleed badly during budding, such as chestnuts, the inverted T-bud allows better drainage and better healing.
- In the inverted T-budding method, the incision in the stock has the transverse cut at the "bottom rather than at the top of the vertical cut, and in removing the shield piece from the bud stick the knife starts above the bud and cuts downward below it.

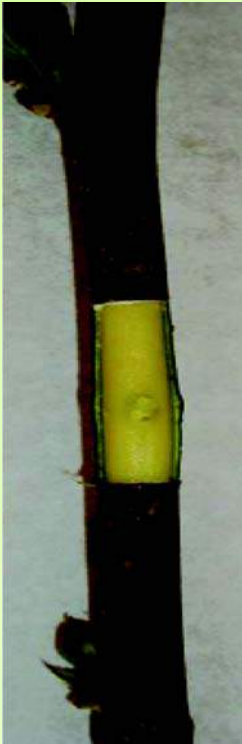
3. Patch Budding

Patch budding is quite successful when the plants are in active phase of growth. It is slower and more difficult to be done than T-budding but it is widely practiced in thick barked species like pecan nut and walnut. The best time to perform patch budding in pecan and walnut is May- June. In this method a rectangular patch of bark is removed completely from the stock and replaced with a patch of bark of the same size containing a bud of the desired cultivar. The procedure is as follows:

- Remove a rectangular patch of bark approximately 2.5 cm x 1.5 cm, with a bud in its centre from the scion by making two parallel horizontal cuts above and below the bud and two vertical cuts connecting the transverse cuts on either side of the bud. Remove the bud patch by sliding it off to one side.
- Then remove a patch of the bark of same size from the smooth place on the stock and then the scion patch is fitted in its place.
- It is more important that the bark piece fits tightly at top and bottom than along the sides. Trim along one side for a tight fit, if necessary.
- Wrap the patch with polythene strip taking care to cover all the cuts but leaving the bud exposed.



Preparation of root stock



Top is removed to 2.5 cm above ground just before growth begins



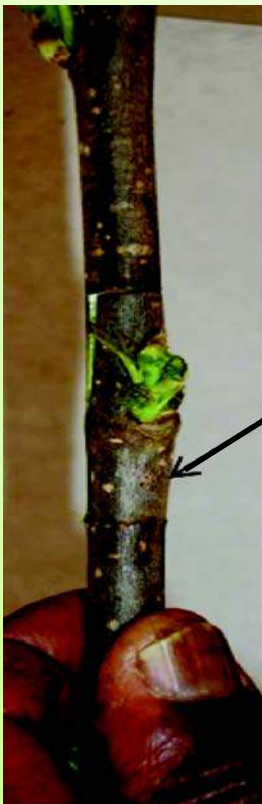
Preparation of scion



Scion bud



A rectangular patch of bark approximately 2.5 cm × 1.5 cm, with a bud in its centre is removed from the scion



The patch of bark containing the scion bud is fitted tightly on the stock



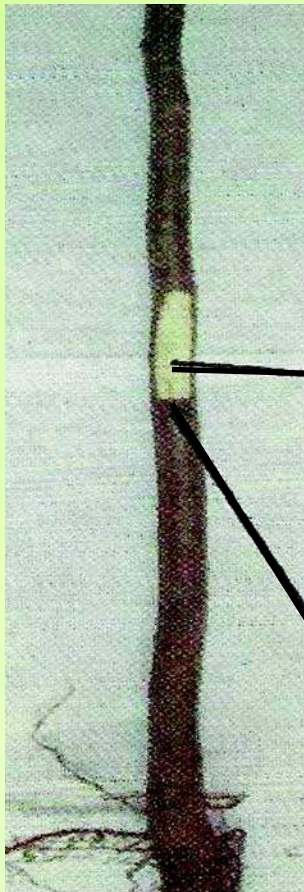
The budded portion is tied tightly with polythene strip leaving the bud naked

4. Chip Budding

A method which overcomes the problems faced in traditional T-budding is chip budding in which cambium of scion and rootstocks are placed opposite one another and unite quickly in a week following budding. Chip budding can be used at times when bark is not slipping, that is early in the spring before growth starts or during the summer when active growth has stopped prematurely. This is commonly used for the propagation of apple and pear. Chip budding also give good percentage of bud take in walnut when performed during June-July. The procedure is as follows:

- A chip of bark along with wood is removed from the smooth portion between nodes.
- On the bud stick, the first cut is given 0.5 cm below the bud down into the wood at an angle of 30-40° to a depth of approximately one quarter of the rootstock diameter.
- A second cut starts about 2.5 cm above the bud and goes inwards and downwards behind it until meets the first cut.
- The sequence of the cut may be reversed.
- In the rootstock a similar chip is removed in a similar manner.
- The cambium of bud stick and rootstock should be opposite to each other, at least at one side of the union. To obtain a good success, both chips should be cut to the same size and shape.
- The chip is lifted between thumb and knife blade and placed on the rootstock.
- Tying must be done very soon after budding as in case of T- budding.
- The polythene tie over bud should be released after about 3 weeks in summer and a month in autumn.
- In June budding, the rootstock is headed back at about 10 cm above the bud after removal of polythene, whereas in autumn budding the rootstock is only headed back in spring as growth starts.

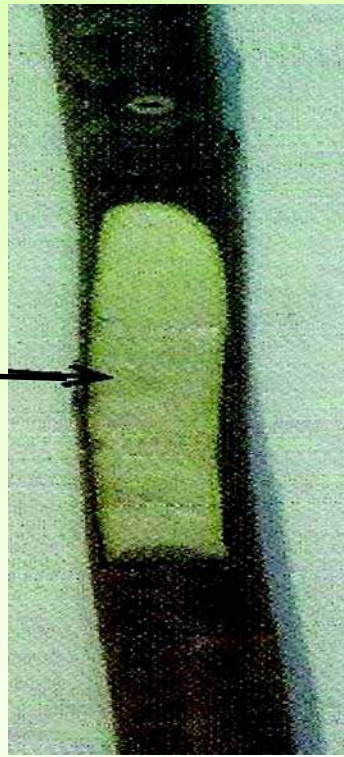
Preparation of root stock



Trim the rootstock to give the clean stem beyond the budding height

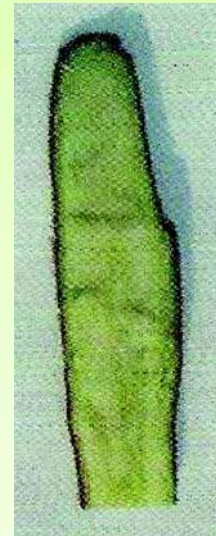


The chip is lifted between thumb and knife blade and fitted tightly on the rootstock



A chip of bark along with wood is removed from the smooth portion between nodes

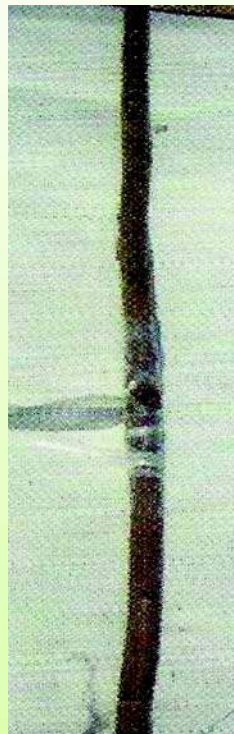
Preparation of scion



Similar size chip of bark along with wood containing bud in its center is removed from the scion stick



The budded portion is tied tightly with polythene strip leaving the bud naked.



Steps involved in performing chip budding

5. Annular Budding

Annular budding gives a very high percentage of bud take in walnut and pecan nut when performed during the month of July.

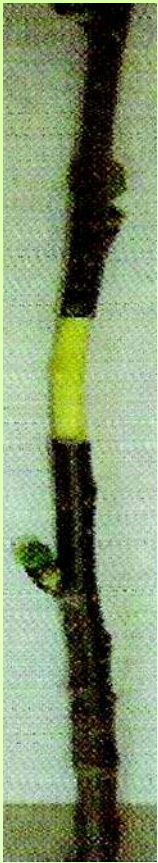
Procedure:

- Remove a complete ring of bark about 3.5 cm wide from the stock by giving two transverse cuts and a vertical cut to connect the two horizontal cuts permitting the ring of bark to be removed.
- Then remove a similar ring of bark containing a healthy bud in the centre from the scion-stick by giving two transverse cuts above and below the bud and a vertical cut through the width of ring opposite to the scion bud.
- Place the ring of bark containing the scion bud on the stock
- Tie the budded portion tightly with polythene strip leaving the bud naked. In order to match the two, both stock and bud stick should be of almost same size otherwise it may be necessary to shorten the circumference of the bud by removing the surplus bark. Similarly, for the removal of rings of bark of identical width from the stock and scion, double/parallel bladed knife should be used.

Exercise 1: Practice and perform T-budding in rose/citrus, patch and annular budding in walnut and chip budding in apple and kiwi.

Exercise 2: Enlist the horticultural crops grown in your area being propagated through various budding methods.

Preparation of root stock



Root stock

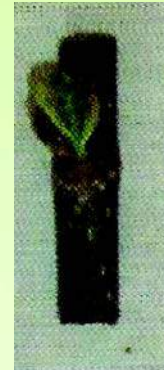


A complete ring of bark about 3.5 cm wide is removed from the stock by giving two transverse cuts and a vertical cut to connect the two horizontal cuts

Preparation of scion



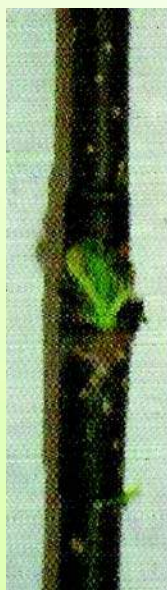
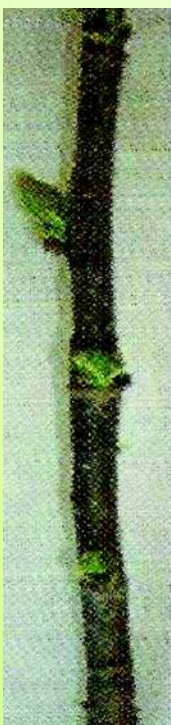
A similar ring containing a healthy bud in the centre, is then removed from the bud stick



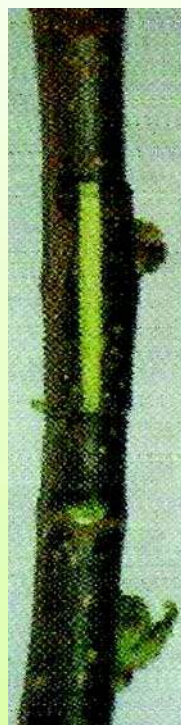
The ring of bark containing the scion bud



A vertical cut through the width of ring opposite to the scion



The ring of bark containing the scion bud is fitted on the stock



The budded portion is tied tightly with polythene strip leaving the bud naked.

Steps involved in performing annular budding