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Before going into the details of different methods of grafting, it becomes very important to know about the basic terminology related to grafting methods.

Grafting: Grafting is a process by which two living parts are joined together in such a manner that they would unite together and subsequently grow into a composite plant. Usually graft has two parts, the scion and rootstock.

Scion: Scion refers to that part of a graft combination that becomes the top of the plant. Scion is the short piece of detached shoot containing 3 or more dormant buds, which when united with the rootstock or inter-stock, comprises the upper portion of the graft and from which will grow the stem or branches or both. It should be of the desired cultivar and free from diseases.

Rootstock: The rootstock is the lower portion of the graft, which develops into the root systems of the grafted plant. It may be seedling, a rooted cutting, or a layered or micro-propagated plant.

Inter-stock: Inter-stock is a piece of stem inserted by means of two graft unions between the scion and rootstock. Inter-stocks are used to avoid an incompatibility between the rootstock and scion, to produce special tree forms, to control diseases or to take advantage of its growth controlling properties.

Vascular cambium: Vascular cambium is a thin tissue located between the bark and the wood. Its cells are meristmatic i.e. they are capable of dividing and forming new cells. For successful graft-union, the cambium of the scion is placed in the close contact with the cambium of the rootstock.

Callus: Callus is a term applied to the mass of parenchymatic cells that develop from and around wounded plant tissues. It occurs at the junction of a graft union, arising from the living cells of both the scion and rootstock. The production and interlocking of these parenchymatic cells (callus) constitute one of the important step in callus bridge formation between the scion and rootstock in a successful graft.

Reasons for grafting and budding

- Perpetuating clones that cannot be readily propagated by cutting, layers, division or other asexual methods
- Obtaining the benefits of certain rootstocks

- Obtaining the benefits of certain plants (double working)
- Changing cultivars of established plants (top working)
- Precocity in bearing
- Reduction in juvenility
- Obtaining special forms of plant growth
- Repairing the damaged parts of trees
- Study and elimination of viral diseases
- Studying the developmental and physiological processes

Elements for successful grafting

There are five important elements for any successful grafting operation. These are:

- The rootstock and scion must be compatible.
- The vascular cambium of the scion must be placed in intimate contact with that of the rootstock.
- The grafting operation must be done at a time when the rootstock and scion are in the proper physiological stage.
- Immediately after completion of grafting, all cut surfaces must be protected from desiccation.
- Proper care must be given to the grafts for some period of time after grafting.

Types of Grafting

1. [Detached scion grafting](#)

A. Apical grafting

Whip-and –tongue grafting

Splice grafting (whip grafting)

Cleft-grafting (split grafting)

Wedge grafting (saw-kerf grafting)

Saddle grafting

Four flap graft (banana grafting)

B. Side grafting

Side-veneer grafting

Side-tongue grafting

C. Bark grafting

Bark graft (rind grafting)

D. Root grafting

Whole-root and piece root grafting

2. [Approach grafting](#)

Spliced [approach grafting](#)

Tongued [approach grafting](#)

Inlay [approach grafting](#)

3. Repair grafting

Inarching

Bridge grafting

Bracing

With increasing labour costs, only a few of the more efficient [grafting techniques](#) are utilized, such as side veneer, tongue and whip-tongue grafts. In automated and manual grafting of herbaceous vegetable crops, the splice graft is one of the most important. The description of some of the methods used in fruit crops, ornamental or vegetable crops is as under.

Detached Scion Grafting

A. Apical grafting

Splice or whip grafting:

- In this method, it is essential that both the stock and scion should be of equal diameter. The various steps involved in splice grafting are shown in.
- For this, about one-year-old rootstock is headed back at a height of 20-25 cm from the soil and a splice (diagonal) cut of 2.5 to 6 cm long is made at the distal end of the rootstock with the help of a sharp knife.
- A similar slanting cut is made on the proximal end of the scion. The cuts should be smooth and the cut surface of both the rootstock and scion are bound together and tied firmly with polythene strip.
- After the union has taken place, the rootstock above the union is lopped off gradually. Sprouts arising below the grafting union must be removed at regular intervals to divert flow of metabolites for the growth of scion only.

Whip and tongue grafting:

- It is modified form of whip grafting. It differs from whip grafting that a reverse cut is made downward at a point about 1/3rd of the distance from the tip and should be about ½ the length of first cut.
- The various steps involved in splice grafting are shown in Plate 7.2. To obtain a smooth-fitting graft, the cut should not split.
- The rootstock and scion is then inserted into each other, with the tongues interlocking. It is important that vascular cambium layer match along at least one side, preferably along both sides.
- The lower tip of the scion should not overhang the stock as there is a likely hood of the formation of large callus knots.
- The use of scions larger than root stock should be avoided. After the scion and rootstock are fitted together, they should be securely held by tying with budding/grafting tape or polythene.
- This method gives better success than splice grafting because of better cambial contact between stock and scion due to formation of tongue.
- Regular de-shooting of sprouts on stock is required to obtain better growth of scion.

Cleft grafting:

- It is one of the oldest methods of field grafting. It is used to top work trees, either in the trunk of a small tree or in the scaffold branches of a bigger tree.
- The various steps are shown in Plate 7.3. In making the cleft-graft, a heavy knife is used to make a vertical split for a distance of 5 to 8 cm down the center of the stub to be grafted. This split is made by pounding the knife in with a hammer.
- The branch is sawed off in such a way that the end of the stub is smooth and free from knots for at least 15 cm.
- In this method, two scions are inserted, one at each side of the stock where the vascular cambium layer is located. The scions should be 8 to 10 cm long and 10-15 mm in thickness and should have two or three buds.
- The side of the wedge, which is to go to the outer side of the rootstock should be slightly wider than the inside edge. When the knife is removed, a hard wooden wedge is inserted to keep it open for the subsequent insertion of the scion.
- The graft should be wrapped with a polyethylene strip properly to prevent wilting of the scion. The scion starts growing after 2 to 3 months of grafting. The right time for cleft grafting is the later part of the dormant season or just before the start of active growth.
- Pear, walnut, hazelnut, pecan nut and grapes are propagated by this method.

Wedge grafting (saw-kerf grafting):

- It is performed in late winter or early spring before the bark begins to slip. A sharp, heavy, short bladed knife is used for making a V-wedge in the side of the stub or stock about 5cm long.
- Two cuts are made, coming together at bottom and as far apart at the top as the width of the scion. These cuts extend about 2 cm deep into the side of the stub.
- The base of the scion is trimmed and a wedge shape cut exactly the same size and shape as the opening. With the two vascular cambium layers matching the scion is tapped downward firmly into place and slanting outward slightly at the top so that the vascular cambium layers cross.
- After all scions are firmly tapped into place, all cut surfaces including the tips of the scion, should be waxed thoroughly. It is called saw-kerf grafting because the cuts in the side of the rootstock can be made with a saw rather than the sharp knife.

Saddle grafting:

- The saddle grafting can be bench grafted by hand or machine. The rootstock and scion should be of the same size. The scion is prepared by cutting upward through the bark and into the wood opposite sides of the scion.
- The knife should penetrate more deeply into the wood as the cuts are lengthened. Before the scion piece, and the saddle shape is gradually formed by removing pieces of the wood.
- The rootstock is cut transversely and then two upward cuts are made on either side. The apex of the rootstock is carved to fit the saddle so that vascular cambium of both stock and scion match.
- The graft is tied and cut surfaces are sealed by polythene until the graft-union is formed.
- It is used for the propagation of grape and rhododendron cultivars.

B. Side grafting methods

Side veneer grafting:

- This method is used for grafting small potted plants such as seedling of deciduous trees, shrubs and fruit crops. A shallow downward and inward cut from 2.5-3.5 cm long is made.
- At the base of this cut, a second short inward and downward cut is made, inserting the first cut, so as to remove the piece of wood and bark.
- The scion is prepared with a long cut along one side and very short one at the base of the scion on the opposite side.
- These scion cuts should be of the same length and width as those made in the rootstock so that the vascular cambium layers can be matched as closely as possible. After inserting the scion, the graft is tightly wrapped with polythene strips.
- After the union has healed, the rootstock can be cut back above the scion in gradual steps. This method is commercially used for raising mango and walnut plants.

Side-tongue grafting:

- In this method, the cut is made at the base of the scion, like the cut made in whip-and-tongue graft. Then, a thin piece of bark and wood from stock and scion is completely removed.
- Then a reverse cut is made downward in the cut on the rootstock starting 1/3rd of the distance from the top of the cut. This second cut in the rootstock should be of the same length as the reverse cut in the scion.
- The scion is then inserted into the cut of the rootstock, the two tongues interlocking, and the vascular cambium matching. The graft is wrapped tightly, to avoid desiccation.
- The top of the graft union is left intact for several weeks until the graft union is healed and may be cut afterwards above the scion gradually so that the buds on the scion are forced into active growth.

C. Detached scion grafting methods

Bark Grafting (Rind grafting):

- It is very simple method of propagation and some nurserymen prefer it, because it can be done without splitting the stub, which prevents the entry of pathogens.
- It can be done in branches, which are 25 to 30 cm long. It should be done in spring when the bark of the stock slips easily.
- It is important to note that the scion used in bark grafting should be dormant. The rootstock is first sawed off at a point, where bark is smooth. If the stock is thick many scions can be inserted.
- For each scion, bark is split downward, about 5 cm from the top of the stub. Scions of 10-12cm length containing 2-3 buds are prepared by giving a slanting cut (5cm) downward along one side of the base.
- On the other side, a small cut is made. The scion is then inserted in the centre of split between the bark and wood of the rootstock. The longer cut of the scion is placed against the wood.
- The scion is held firmly by using adhesive tape. Afterwards, all the exposed portions of the stub and scion should be tied with polyethylene strip tightly. The scions will start sprouting after 6-8 weeks in case of successful grafts.

D. Root grafting (Whole root and Piece-root grafting):

- In this method, the seedling rootstock, rooted cuttings or layered plant is dug up and the roots are used as the rootstock for the graft.
- The entire root system may be used (whole-root graft) or the roots may be cut into small pieces and each piece is used as a rootstock (piece-root graft). As the roots used are relatively small (0.5-1.5 cm) in diameter, the whip and tongue graft is generally used. Root grafting is usually bench grafted indoor during the late winter or early spring.
- In preparation of root-grafts, the root-pieces should be 7.5 to 15.0 cm long and the scions of about the same length containing two to four buds are used.
- After the grafts are made and tied properly, they are bundled together in groups of 50 to 100 and stored for callusing in damp sand, peat moss or other packing material.

Approach Grafting

The characteristic features of approach grafting are that two independent, self-sustaining plants are grafted together. After the formation of union, the top of rootstock plant is removed above the graft union and the base of the scion plant is removed below the graft union.

- Generally, it is performed with one or both of the plants to be grafted, which are growing in a container. Rootstock plants in containers may also be placed adjoining to an established plant, which is to furnish the scion part of the new grafted plant.
- It must be performed in the season when plants are in active growth because under such conditions, rapid healing of the graft-union will take place. The important methods are:

Spliced approach grafting:

- In this method both scion and stock should be of same thickness. A splice of 4-5cm bark and wood is removed both from stock and scion (Fig.7.3).

- The cut on both the partners should be of the same size and should be smooth too. The cut surfaces of stock and scion are bound together with some suitable tying material and waxed properly.
- The stock above the union and scion below the union are cut after sometime, when proper union has taken place. It may be necessary to reduce the leaf area of the scion if it is more than the root system of the rootstock.

Tongue approach grafting:

- The tongue approach grafting is the same as the spliced approach grafting, except that after the first cut is made in each stem to be joined, a second cut downward on the stock and upward on the scion is made, by providing a thin tongue on each piece.
- By interlocking these tongues tightly, a closely fitted graft union can be obtained.

Approach grafting:

- The inlay approach grafting may be used if the base of the rootstock plant is considerably thicker than that of the scion plant. The various steps involved are shown in.
- A narrow slot, 7.5 to 10 cm long is made in the bark of the rootstock plant by making two parallel cuts and removing the strip of bark between. This can be done only when the rootstock plant is actively growing and their bark slipping easily.
- The slot should be exactly as wide as the scion to be inserted. The stem of the scion plant, at the point of union, should be given a long shallow cut along one side, of the same length as the slot in the rootstock plant and deep enough to go through the bark and slightly into the wood.
- This cut surface of the scion branch should be laid into the slot cut in the rootstock plant and held there by nailing with two or more small, flat headed wire nails. The entire union must then be thoroughly covered with grafting wax.
- After the union has healed, the rootstock can be cut off above the graft and the scion below the graft.

Inarching:

- Inarching is similar to approach grafting as rootstock and scion plants are on their own roots at the time of grafting.

- It differs in that the top of the new rootstock plant usually does not extend above the point of the graft-union as it does in approach grafting. Inarching is used to replace roots damaged by cultivation equipments, rodents or diseases.
- It is very advantageous in saving a valuable tree or improving its root system.
- In this method seedlings (or rooted cuttings) planted beside the damaged tree, or suckers arising near its base are grafted into the trunk of the tree to provide a new system to supplement the damaged roots.
- The seedlings to be inarched into the tree should be spaced about 10-15 cm apart around the circumference of the tree if the damage is extensive.
- The seeding of compatible species is planted around the tree during dormant season and grafted when active growth commences in them during early spring. Inarching will enhance growth of uninjured older trees.

A thin slice of bark (6-10 cm in length) at about 20 cm above the ground level is removed from the stock with a sharp knife. A similar cut is made in the scion. Thus, the cambium layers of both stock and scion are exposed. These cut are brought together and tied firmly with the help of a polythene strip.

After the successful union, stock above and scion below the graft union are lopped off gradually. In low rainfall areas, it should be done with the onset of rains, while in regions of heavy rainfall; it should be done soon after the rainy season is over, provided temperature does not fall below 15⁰C.

Other Grafting Methods

3. Repair Grafting

Bridge grafting:

- Bridge grafting is basically not a method of propagation but a form of repair grafting only in plants, which have been damaged either by frost, rodents or insects. The various steps involved are shown in.
- It may, however, be kept in mind that bridge grafting is only helpful if the trunk is damaged but the root system of the plant is healthy.

- In this method, first the damaged portion of the stock is cleaned and the irregular edges of the girdled area are cut evenly.
- The scion of desired variety is inserted in such a way that it is attached at both upper and lower ends into the living bark. Similarly, it is important that scions should be inserted right side up to ensure the polarity.
- The exposed injured wood must also be covered otherwise; it may serve as an entry channel for decaying organisms.

Bracing:

- Bracing is a form of natural branch grafting that is used by fruit growers to strengthen scaffolding limbs of a tree in order to support the load of the fruit crop. In this method two strong, young lateral shoots from the limbs are to be braced.
- A rope or electrical cord is used to temporarily brace the larger limbs. The weaved smaller shoots, which will naturally graft, are tied with waxed string or poly tape to keep them together.

4. Softwood grafting

- This technique of grafting is commercially used for raising mango, sapota, tamarind and cashewnut in western India. In this technique, grafting is done with mature, procured scion on the emerging soft, coppery-red shoot of the rootstock, which is 60-70 days old.
- The basic technique involves the beheading of rootstock with a sharp knife. Then, a slit is made on the beheaded stock to insert the procured scion. The lower portion of scion is made in wedge shape so that both the faces of scion fit with the stock. Both stock and scion are tied with help of a polyethylene strip.
- The scion is then covered with a polythene bag (100 gauge) and tied with thread to keep the scion fresh till the complete union is formed (Fig.7.9). After sprouting, the bag is removed. To have better success, the leaves on the stock must be retained.
- This technique is effective in dry hot weather or in areas of low precipitation where mortality of nursery raised grafts is very high.

5. Epicotyl grafting

- It is also called as stone grafting. In this method, germinating seeds of less than two weeks old are wedge or splice grafted with mature scion. Moderate temperature and high

relative humidity are major factors related to success of epicotyl grafting. For splice grafting, germinating seeds less than 2 weeks old are used as rootstock.

- A 2-3 cm long slanting cut is made in the epicotyl with a matching cut on the proximal portion of the scion and then these are tied firmly with polythene strip. In wedge grafting, the selected 2 weeks old seedlings are headed back, by retaining 6-8cm long stem with the stone.
- The longitudinal transverse cut running 4-6 cm centrally down on the beheaded rootstock is made with the help of a sharp grafting knife. A wedge shaped cut, slanting from both sides is made on the lower side of scion stick.
- The scion stick is then inserted into the saddle-like structure made on the rootstock and press properly so that cambium tissues of the rootstock and scion stick firmly and overlap each other

The union is then tied with the help of 150 gauge-polyethylene strip. This technique has been commercialized for rapid multiplication of mango in Konkan area of Maharashtra.