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Vegetative methods of plant propagation: I-cutting layering and budding

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Abstract
The fruit plants are propagated by two main methods, namely, sexual method and asexual method. Most of the fruit plants do not produce seedlings true-to-type. Using the asexual method of propagation the fruit plants produce true-to-type (clones) of the parent plant. Moreover, these plants also produce uniform yield, fruit size and quality. Although seedling plants produce heavy crop, the fruit size and quality is inferior and do not fetch good return in market. The seedling plants for several fruit crops have long juvenile period and have more vigorous growth habit, which creates difficulty in taking plant protection measures and harvesting of fruits. The fruits of seedling plants do not mature in one stroke and hence, affect the marketing. The asexual methods of plant propagation are of the four types, Cutting, Layering, Budding and Grafting. In this communication we present review on the Cutting, Layering, and Budding methods of plant propagation. The cutting method includes root, stem, scion and leaf cutting methods of vegetative propagation. The layering method category encompasses the Natural, Simple, Tip, Compound or Serpentine, Trench, Mound and Air layering methods. The budding method of the asexual propagation includes, T/Shield, Inverted T/Shield, Chip, I, Patch, Forkert, Flute and Ring/ Annular Budding methods.

Keywords: asexual/vegetative plant propagation, propagation of fruit plants, cutting, layering, budding

1. Introduction
The fruit plants are propagated by several methods, which can be grouped under two main heads, (i) sexual method - propagation by seeds and (ii) asexual method - propagation by grafting. Most of the fruit plants do not produce seedlings true-to-type. This problem can be overcome by using the asexual method of propagation as these fruit plants produce true-to-type (clones) of the parent. Moreover, these plants also produce uniform yield, fruit size and quality. Although seedling plants produce heavy crop, the fruit size and quality is inferior and do not fetch good return in market. The seedling plants for several fruit crops have long juvenile period and have more vigorous growth habit, which creates difficulty in taking plant protection measures and harvesting of fruits. The fruits of seedling plants do not mature in one stroke and hence, affect the marketing. Keeping these disadvantages of seedling plants in mind and to obtain uniformity in plant performance, fruit plants should be propagated through asexual methods of propagation. The asexual methods of plant propagation can mainly be divided into four groups, namely, (i) Cutting, (ii) Layering, (iii) Budding and (iv) Grafting. In this communication we present review on the former three methods, i.e., Cutting, Layering, and Budding methods of plant propagation.

2. Cutting
A plant cutting [1] is a piece of a plant that is used in horticulture for vegetative (asexual) propagation. A piece of the stem or root of the source plant is placed in a suitable medium such as moist soil. If the conditions are suitable, the plant piece will begin to grow as a new plant independent of the parent, a process known as striking. A stem cutting produces new roots, and a root cutting produces new stems. Some plants can be grown from leaf pieces, called leaf cuttings, which produce both stems and roots. The scions used in grafting are also called cuttings. Some plants form roots much more easily than others. Stem cuttings from woody plants are treated differently, depending on the maturity of the wood. Softwood cuttings are used for stems that are rapidly expanding, with young leaves. In many species, such cuttings form roots relatively easily. Semi-hardwood cuttings are used for stems that have completed elongation growth and have mature leaves. Hardwood cuttings are used for fully matured stems, and are often propagated while dormant (Figs.-2.1a, b.c).

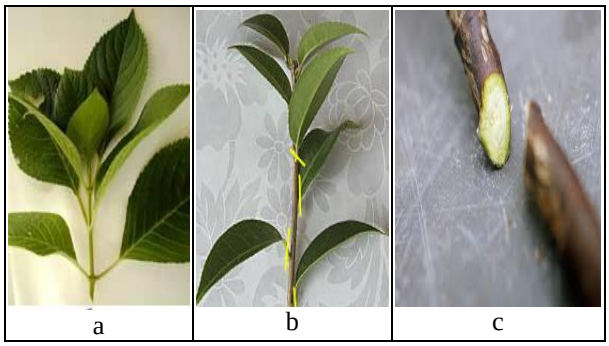

Fig 2.1: a-Soft, b-semi-hard and c-hard woods

Most plant cuttings are stem pieces, and have no root system of their own; they are likely to die from dehydration if the proper conditions are not met. They require a moist medium, which, however, cannot be too wet lest the cutting rot. A number of media are used in this process, including but not limited to soil perlite, vermiculite, coir, rock wool, expanded clay pellets, and even water given the right conditions. Most succulent cuttings can be left in open air until the cut surface dries, which may improve root formation when the cutting is later planted.

In temperate countries, stem cuttings may be taken of soft (green or semi-ripe) wood and hard wood which has specific differences in practice. Certain conditions lead to more favorable outcomes for cuttings; timing, size, location on the plant, and amount of foliage are all important. Stem cuttings of young wood should be taken in spring from the upper branches, while cuttings of hardened wood should be taken in winter from the lower branches. Common bounds on the length of stem cuttings are between 5-15 cm for the soft-wood and 20-25 cm for the hard-wood. The soft-wood cuttings do the best when about two thirds of the foliage is removed, while the hard-wood stem cuttings need complete foliage removal.

The environment for cuttings is generally kept humid—often attained by placing the cuttings under a plastic sheet or in another confined space where the air can be kept moist—and partial shade to prevent the cutting from drying out. Cuttings in the medium are typically watered with a fine mist to avoid disturbing plants. Following the initial watering, the aim to keep the soil moist but not wet and waterlogged; the medium is allowed to almost dry out before misting again.

A rooting hormone may be administered to encourage growth and can increase the success rate of plant growth. Though not essential, several compounds may be used to promote the formation of roots through the signaling activity of plant hormone auxins. Among the commonly used chemicals is indole-3-butyric acid (IBA) used as a powder, liquid solution or gel. This compound is applied either to the cut tip of the cutting or as a foliar spray. Rooting hormone can be manufactured naturally, such as soaking the yellow-tipped shoots of a weeping willow tree in water or to preparing a tea from the bark of a willow tree. Shoots or bark do better when soaked for 24 hours prior to using. Honey, though it does not contain any plant hormones, can also aid in rooting success through its natural antiseptic and antifungal properties. Cinnamon or an Aspirin tablet in water, can also aid the rooting process.

Many vegetative parts of a plant can be used. The most common methods are:

1. Root cuttings (Fig.-2.2a), in which a section of root is buried just below the soil surface, and produces new shoots.
2. Stem cuttings (Fig.-2.2b), in which a piece of stem is part buried in the soil, including at least one leaf node. The cutting is able to produce new roots, usually at the node.
3. Scion cuttings (Fig.-2.2c) are used in grafting.
4. Leaf cuttings (Fig.-2.2d), in which a leaf is placed on moist soil. These have to develop both new stems and new roots. Some leaves will produce one plant at the base of the leaf. In some species, multiple new plants can be produced at many places on one leaf, and these can be induced by cutting the leaf veins

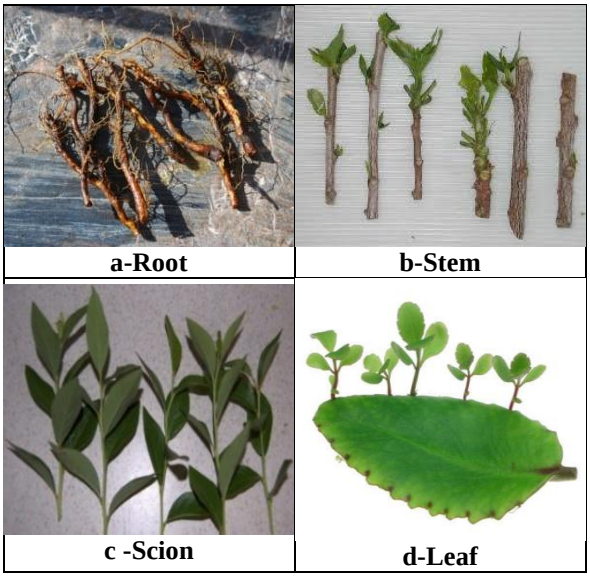

Fig 2.2: Plant Cuttings

Although some species, such as willow blackberry and pelargoniums can be grown simply by placing a cutting into moist ground, the majority of species require more attention. Most species require humid, warm, partially shaded conditions to strike, thus requiring the approach above to be followed. Particularly difficult species may need cool air above and warm soil. In addition, with many more difficult cuttings, one should use the type of cutting that has the most chance of success with that particular plant species. There are ways of improving the growth of stem cutting propagations. Intensifying light allows cuttings to root and sprout faster, though the heat thus generated could cause the propagation material distress. Azalea cuttings can be mildly heated in water to disinfect it from the fungus pathogen Rhizoctonia, and this could potentially be used for other plants. Depending on the type of soil being used, several additives may need adding to create good soil for cuttings. These additions may include:

- chalk; to increase the pH-value of the soil; a pH of 6-6.5 is to be maintained
- organic substance/humus; to increase nutrient load; keep to a bare minimum though
- sand or gravel; to increase the soil's water permeability

For example, with plain potting soil, a third of the container should be filled with sand, to make suitable soil for cuttings. Although several options can be used here, usually semi-white plastic is used to cover the cuttings. The soil below and from the cuttings themselves is kept moist, and should be aerated once in a while to prevent formation of molds. A plastic bottle can be used as a small greenhouse to provide the right humidity level.

3. Layering

Layering/layerage/marcotting [2] is a common plant vegetative propagation technique in natural environments where an aerial stem is made to grow roots prior to detachment from the parent plant. Natural layering occurs when a branch comes in contact with the ground and spontaneously grows adventitious roots. At a later stage the connection with the parent plant is severed and as a result a new plant is produced. Layering has the advantage over the cutting that the propagated portion continues to receive water and nutrients from the parent plant while it is forming roots. This is important for plants that form roots slowly, or for propagating large pieces. Layering is used quite frequently in the propagation of bonsai. It is used as a technique for both creating new roots and improving existing roots.

Layering is also utilized by horticulturists to propagate desirable plants. The horticultural layering process typically involves wounding the target region to expose the inner stem and optionally applying rooting compounds. As layering does not involve sexual reproduction, new plants are effectively clones of the original plant and exhibit the same characteristics. This includes flower, fruit and foliage. Plant selection usually involves plants with a flexible stem.

The plant layering is mainly of the following types:

(i) Natural layering, (ii) Simple layering, (iii) Tip layering, (iv) Compound or Serpentine layering, (v) Trench layering, (vi) Mound layering, (vii) Air layering.

3.1 Natural Layering

Sometimes layering occurs naturally, without the assistance of a propagator. Runners and offsets are specialized plant structures that facilitate propagation by layering. A runner produces new shoots where it touches the growing medium. Plants that produce stolons or runners are propagated by severing the new plants from their parent stems. Plantlets at the tips of runners may be rooted while still attached to the parent or detached and placed in a rooting medium. Examples include strawberry and spider plant. Plants with rosetted stems often reproduce by forming new shoots, called offshoots, at their base or in the leaf axles. The new shoots are severed from the parent plant after they have developed their own root systems. Unrooted offsets of some species may be removed and placed in a rooting medium. Some of these must be cut off, whereas others may simply be lifted from the parent stem. Examples include date palm, bromeliads, and many cacti

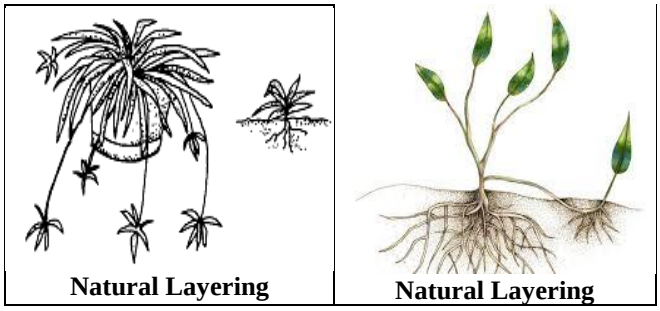

Fig 3.1: Natural Layering

3.2 Simple / Ground Layering

Simple layering can be accomplished by bending a low growing, flexible stem to the ground. Part of the stem is covered with soil, leaving the remaining 6 to 12 inches above the soil. The tip is bent into a vertical position and staked in place (Fig.-3.2). The sharp bend often induces rooting, but wounding the lower side of the bent branch may help also. Simple layering can be done on most plants with low-growing branches. Examples of plants propagated by simple layering include climbing roses, forsythia, rhododendron, honeysuckle, boxwood, azalea, and wax myrtle. Simple layering can be done in early spring using a dormant branch, or in late summer using a mature branch. Periodically the adequate moisture level and the formation of roots are checked. It may take one or more seasons before the layer is ready to be removed for transplanting

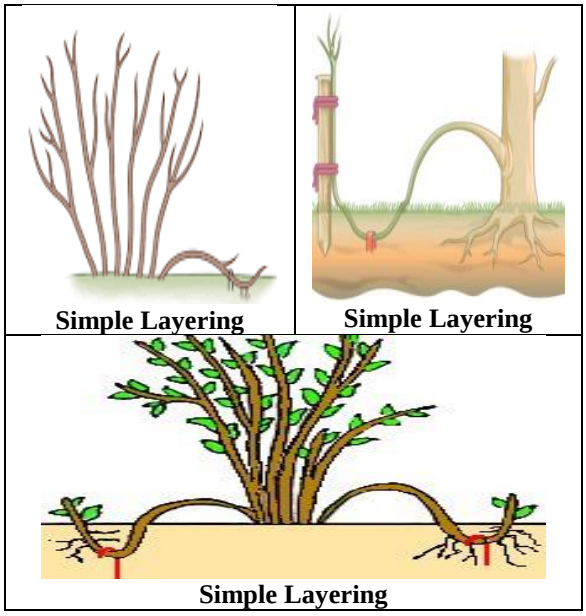

Fig 3.2: Simple/Ground Layering

3.3 Tip Layering

Tip layering (Fig.-3.3) is quite similar to simple layering. Tip layering works by pushing the very tip or point of a stem underground and holding it in place with a pin. A hole is dug 3 - 4 inches deep in the soil. The tip of a shoot of the current season is inserted in and covered with the 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. The tip layer is removed and the new plant is planted in late fall or early spring. Examples of plants propagated by tip layering include purple and black raspberries, and trailing black berries

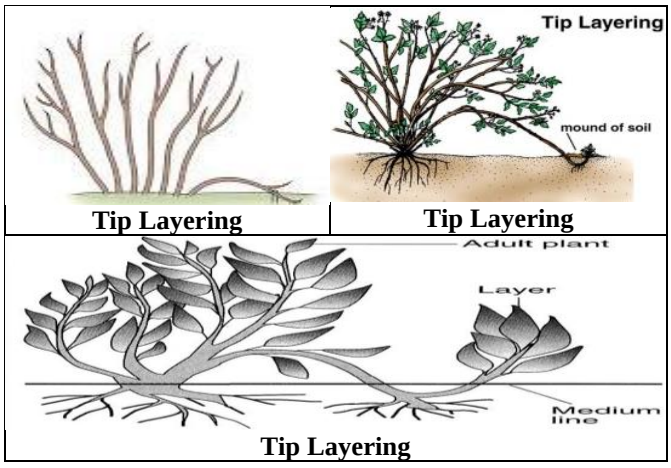

Fig 3.3: Tip Layering

3.4 Compound / Serpentine Layering

Compound / Serpentine Layering (Fig.-3.4) is similar to simple layering, but several layers are made from a single

stem. The stem is bent to the rooting medium as for simple layering, but alternately covering and exposing the sections of the stem. Each section should have at least one bud exposed and one bud covered with soil. The lower side of each stem section to be covered (Fig.-3.4) is wounded. This method gives two or more plants instead of just one. This method works well for plants producing vine-like growth such as heart-leaf philodendron, pothos, wisteria, clematis, and grapes

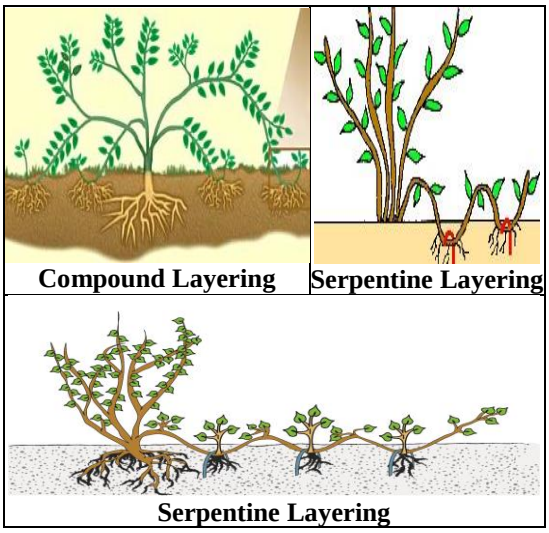

Fig 3.4: Compound/Serpentine Layering

3.5 Trench / Etiolation Layering

Trench / Etiolation layering (Fig.-3.5) is primarily used for fruit trees which are difficult to propagate by other methods, and works best with plants whose buds will break and grow under the soil, such as willows, viburnum, grapes and dogwoods. In this method the parent plant is planted at an angle of 30-40 ° to the ground so that branches may be pulled down to the soil surface more easily. A young, vigorous branch is laid horizontally in a 5 cm (2 in) trench and pegged into position. It is then covered with soil to encourage the development of several new shoots. As these shoots develop, soil is filled around them and roots eventually develop. The rooted shoots can then be detached from the original branch and planted out

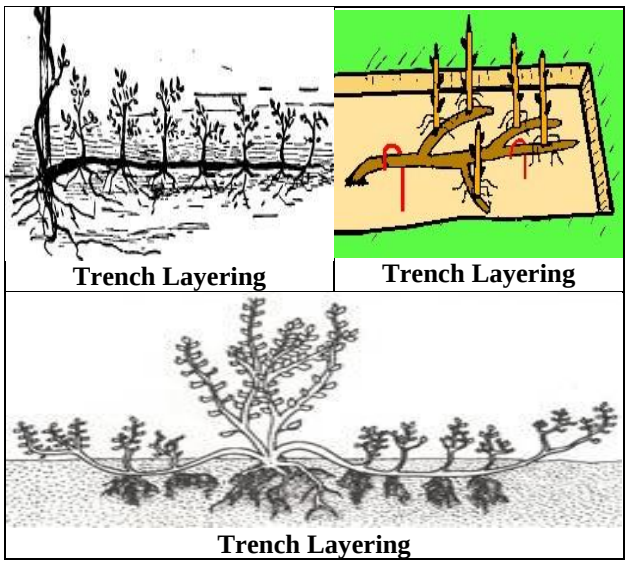

Fig 3.5: Trench / Etiolation Layering

3.6 Mound / Stool Layering

Mound layering (Fig.-3.6) is a vegetative propagation technique in which the original plants are set in the ground with the stem nearly horizontal, which forces side buds to grow upward. After these are started, the original stem is buried up to some distance from the tip. At the end of the growing season, the side branches are rooted, and can be separated while the plant is dormant. Some of these can be used for grafting rootstocks, and some can be reused in the nursery for the next growing season's crop. Ground layering is used in the formation of visible surface roots known as nebari on bonsai trees.

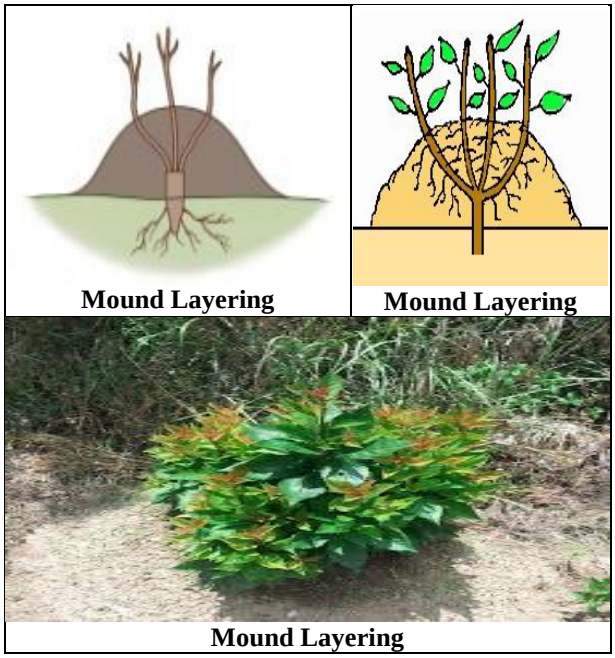

Fig 3.6: Mound/Stool Layering

3.7 Air Layering

Air layering (Fig.-3.7) is an effective propagation method for some plants that do not root readily from cuttings and which often lack low-growing shoots suitable for conventional layering, such as magnolia, hazel, *Cotinus* and flowering *Cornus species.* Other suitable plants for air layering include: acers, camellia, *Chaenomeles*, daphnes, *Ficus*, *Forsythia*, Hamamelis, jasmine, *Philodendron*, rhododendron and azalea, lilac and viburnums. Air layering can be used to propagate large, overgrown house plants such as rubber plant, croton, or dieffenbachia that have lost most of their lower leaves. Woody ornamentals such as azalea, camellia, magnolia, oleander, and holly can also be propagated by air layering.

Layering can be carried out in autumn or spring. Deciduous plants respond well in either season, but evergreens respond better to spring layering. Air layering is done by peeling the bark from the middle of a branch and covering this exposed wood with moss and plastic wrap. Roots will form inside the moss, and one can cut the rooted tip from the plant.

For optimum rooting, air layers are made in the spring on shoots produced during the previous season or in mid to late summer on shoots from the current season's growth. For woody plants, stems of pencil size diameter or larger are the best. A straight, healthy and vigorous1-2 year old stem is chosen. An area just below a node is Chosen and leaves and twigs on the stem 7.5-10 cm above and below this point are removed. This is normally done on a stem about 30 cm from the tip.

For monocots, an upward 2.5- 4.0 cm cut is made about one-third through the stem. The cut is held open with a toothpick or wooden match stick. The wound is surrounded with moist, unmilled sphagnum moss (about a handful) that has soaked in water and squeezed to remove excess moisture. The moss is wrapped with plastic and held in place with twist ties or electrician's tape. Each end of the plastic is fastened securely, to retain moisture and to prevent water from entering. If exposed to the sun, the plastic should be covered. Aluminum foil can also be used, as it does not require twist ties or tape to hold it in place.

The process for dicots is similar, except a 2.5 cm ring of bark is removed from the stem. With a sharp knife, two parallel cuts are made about 2.5 cm apart around the stem and through the bark and cambium layer. The two parallel cuts are connected with one long cut. The ring of the bark is removed, leaving the inner woody tissue exposed. The newly bared ring is scraped to remove the cambial tissue to prevent a bridge of callus tissue from forming. Application of a root-promoting substance to the exposed wound is sometimes beneficial. Using the same procedure as that described for monocots the moss is wrapped and covered. After the rooting medium is filled with roots, the stem is severed below the medium and the layer is potted. The new plant will usually require some pampering until the root system becomes more developed. Shade and adequate moisture are provided until the plant is well established.

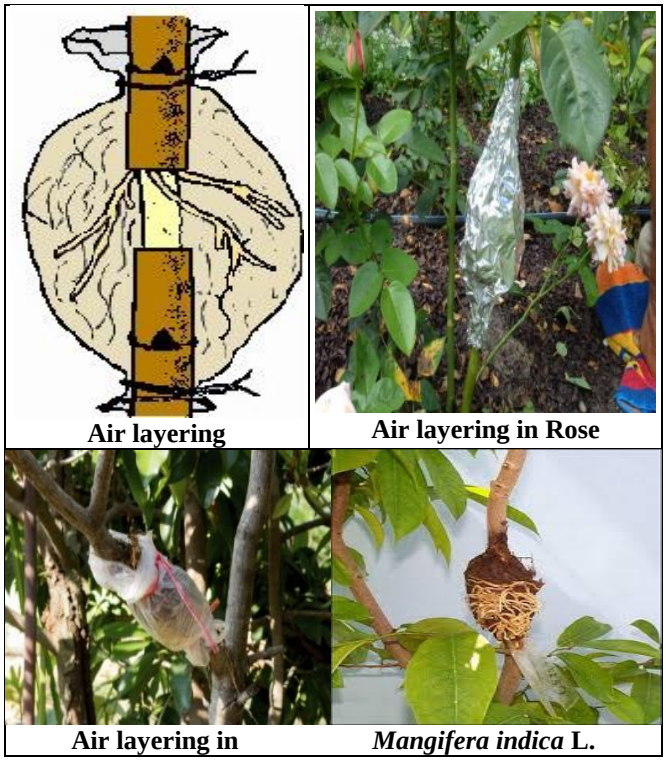

Fig 3.7: Air Layering

4. Budding

Budding [3-11] is a type of asexual reproduction in which a new organism develops from an outgrowth or bud due to cell division at one particular site. The small bulb like projection coming out from the yeast cell is called a bud. The new organism remains attached as it grows, separating from the parent organism only when it is mature, leaving behind scar tissue. Since the reproduction is asexual, the newly created organism is a clone and is genetically identical to the parent organism. The buds develop into tiny individuals and, when fully mature, detach from the parent body and become new independent individuals. In agriculture and horticulture, budding refers to grafting the bud of one plant onto another.

4.1 T Budding or Shield Budding

T-Budding or Shield Budding (Fig.-4.1) is a special grafting technique in which the scion piece is reduced to a single 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*, i.e., the vascular cambium is actively growing, and the bark can be peeled easily from the stock piece with little damage. T budding can be performed on certain fruit trees (like peaches) in June using cold stored bud sticks and field grown seedling rootstocks. Many deciduous trees are budded in late July or early August after the current seasons buds have developed fully and are dormant using field grown seedlings that have slipping bark.Bud sticks having plump, healthy buds are suitable scions. These bud sticks should be on branches that exhibited good growth during the current season. Leaf blades are clipped from the bud sticks, leaving the petiole intact. This leaves a convenient handle for holding the bud while it is cut from the bud stick. The bud and a small sliver of the wood underneath it are cut from the bud stick using an upward slicing motion. The cut should begin about 1.25 – 2.0 cm below the bud, and should go deep enough into the wood so that when the cut is finished about 1.25 – 2.0 cm above the bud, the bark and a small sliver of wood are cut off. A perpendicular cut across the top of the upward cut will separate it from the bud stick. Budding knife should be kept very sharp to keep as little damage as possible to the bud. Buds must be cut from the bud stick just prior to grafting.

A vertical cut is made on the stem of the root stock. The cut should be deep enough to insure that the bark will separate at the cambium. The T is then crossed, i.e., a perpendicular cut is made at the upper end of the vertical cut. In areas with heavy rainfall during the grafting season, or in species in which the rootstock is likely to bleed heavily, an upside down, or inverted T bud can be used to prevent water or sap from pooling in the graft. The bark is carefully slipped from the stem of the rootstock exposing a pocket into which the bud shield can be placed. Care should be taken not to tear the flaps of bark in the process of spreading them. If the bark does not slip easily, this indicates that the stock is not in active growth and the process should be conducted later when active growth has resumed.

The bud shield is carefully slipped in between the bark flaps. The top of the bark strip on the bud shield is trimmed to fit tightly against the horizontal cut (the cross of the T) so that the bud fits within the pocket snuggly. The bark flaps are held tightly against the bud as they are wrapped with a budding rubber, grafting tape or other suitable closure. This closure must either breakdown by weathering (as budding rubbers do), or must be removed in 2 - 3 weeks after the union has healed. If the material does not break down, it will girdle the rootstock.

After the union has healed, the upper part of the rootstock plant can be cut away to force the bud to grow (as would be the case for June budding). If the grafting is done in the late summer, the bud will need to overwinter prior to resuming growth. In this case, the upper portion of the rootstock is usually removed during the dormant season, either in late winter or early spring. After the upper portion of the rootstock is removed, the scion bud grows vigorously.

4.2 Inverted T-Budding

The inverted T-budding technique is exactly same as the normal T-budding method with the exception that the horizontal cut is made on the bottom end of the incision. In this case, the bud is cut from the bud stick by starting above the bud and exiting below it. Currently most fruit trees are propagated with the T-budding method. However, the use of inverted T-budding technique is much more effective due to the downward flow of hormones that are intercepted below the bud. Therefore, the union will be stronger and the healing process will be faster (as opposed to the normal T-budding method. This method of budding is used to prevent the possible entry of water from the top of the T-cut which may cause rotting of the shield piece

4.3 Chip Budding

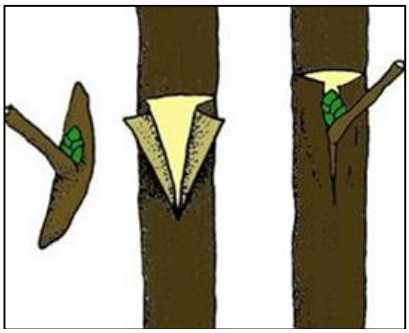

Fig 4.1: T/Shield budding

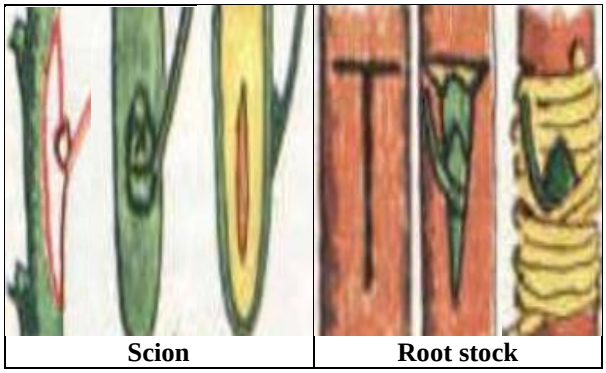

Fig 4.3: Chip budding

Chip budding (Fig.-4.3) is a technique which can be used to plants of stems with barks that do not readily separate from the woods as in *Citrus spp.*. It may be used whenever mature buds are available. In this method the bud is cut out with a chip (of the length 1.5-2.5 cm) of the underlying wood. This requires that a chip of corresponding size be cut out of the stock piece in order to align the cambia for proper graft healing. As the bark does not have to slip, the chip-budding season is longer than the T-budding season. Species whose bark does not slip easily without tearing may be propagated more successfully by chip budding than by T-budding. Though all the basics in handling bud-wood and stock are the same for chip and T-budding, the cuts made in chip budding differ radically. The first cut on both stock and scion is made at a 45- 60º downward angle to a depth of about 3mm. After making this cut on a smooth part of the rootstock, the second cut is started about 2 cm higher and draw the knife down to meet the first cut. After this the chip is removed.

Size of the cuts on both the scion and rootstock should be exactly the same. Although the exact location is not essential, the bud is usually positioned one-third of the way down from the beginning of the cut. If the bud shield is significantly narrower than the rootstock cut, one side should be lined up exactly. Wrapping is extremely important in chip budding. If all exposed edges of the cut are not covered, the bud will dry out before it can take. Chip budding has become more popular over the past few years because of the availability of thin (2-mil) polyethylene tape as a wrapping material. This tape is wrapped to overlap all of the injury, including the bud, and forms a miniature plastic greenhouse over the healing graft.

Although budding rubbers and polyethylene tape reportedly decompose and need not be removed, studies show that unless they are taken off, binding or girdling of fast-growing plants may occur within a month. On species budded in early summer, it may be desirable for the buds to break and grow during the same season. In this case, the stock tops should either be removed entirely or broken over within a few weeks of budding to encourage the scion buds to break. For plants budded in late summer, the tops should be removed just before the growth starts the following spring. To insure a top-quality plant, it is essential to remove unwanted sprouts. These sprouts should be rubbed off as soon as they are visible so that they do not reduce the growth and quality of the budded stock. If they are removed regularly and early, large scars or doglegs can be avoided.

Chip budding can be done in mid- to late summer, unlike most grafting which takes place in the early spring. The bud will usually not begin growing until the following spring, though one can determine if the grafting succeeded before that by seeing whether the bud swells or shrivels. In the next spring, all the other shots except that from the scion bud are removed, which become the source for the new top of the plant.

4.4 I – Budding

A method of budding in which incisions in the shape of an I (capital of letter i) is made in the bark of the rootstock by a single vertical cut and a horizontal cross-cuts at both the ends, is called I budding. A rectangular bud patch similar to that in patch budding is then inserted in I cut.

4.5 Patch Budding

Patch budding (Fig.-4.5) is probably the simplest to perform amongst the various methods of budding due to ease in removing or preparing rectangular patches of the bark. It is widely used in plants with thick bark that can be easily separated from the wood. The method involves the complete removal of a rectangle-shaped patch of bark with the longer sides parallel to the axis of the stem of the rootstock. It is then replaced with a bud patch of the same size from a bud stick.

Fig 4.5: Patch Budding

The patch of the bud is cut from both the rootstock and the bud stick by two parallel horizontal cuts either with one stroke of a double-bladed knife or two strokes when using a single-bladed knife. With vertical stroke of a knife, both horizontal cuts are connected at each side. The bud patch is carefully removed intact and inserted into the rootstock.

4.6 Forkert Budding
A form of patch budding in which the patch of bark in the rootstock is retained, is called Forkert budding. Incisions are made on the bark of the rootstock in the shape of Π and pulled downward as a flap which is then used to cover the inserted bud patch. This flap is later removed to expose the bud. Both Patch and Forkert methods of budding follows the same procedure in the preparation of a bud patch.

4.7 Flute Budding
Flute budding (Fig. 4.7) is similar to patch budding but the patch of bark that is removed from the stem of a rootstock almost completely encircles it except that there remains a narrow strip of bark (~1/8 the rootstock circumference) that connects the upper and the lower parts of the rootstock. The bud patch is prepared by two horizontal cuts about 2.5 cm apart (the same length as in the rootstock) in circular motion around the stem. The two cuts are then connected by a vertical cut and the patch of bark is separated intact from the wood. The circumference of the bud patch may be shortened by a vertical cut to fit into the rootstock.

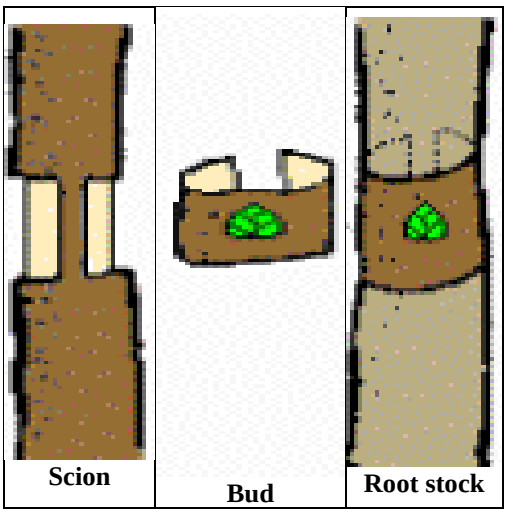

Fig 4.7: Flute Budding

4.8 Ring or Annular Budding
In this method of budding the procedure is closely similar to the Flute budding. It involves the removal of a complete ring of bark from the rootstock without leaving a strip of bark that connects the upper and lower parts of the rootstock. As a result, a portion of the stem is girdled as if in preparation for marcotting. It is then replaced with a complete ring of bark with the same size from the bud stick. Compared to the other methods of budding, it is rarely used because should bud union fail, the upper part of the rootstock above the ring may die.

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