Lecture 6

PROPAGATION OF FRUIT CROPS

Objective of propagation: To produce individuals those are identical to the mother plant or original plant. Thus a successful propagation method is one which transmits all the desirable characteristics of a mother plant to the offspring.

In general field crops as well as almost all the vegetables and flower crops are commercially propagated by seeds but fruit crops are mainly propagated by vegetative means of propagation. Normally, field crops, most of the vegetables and flower crops are highly self pollinated in natures which are considered as homozygous. Hence when they undergo sexual reproduction, the resultant off springs will be homozygous in nature, similar to the mother plant. But in case of fruit crops, they are highly cross pollinated in nature, means highly heterozygous. Hence on sexual process they will produce off spring- not true to the type of mother plant. Therefore, in fruit crops in general vegetative means of propagation is more desirable to get true to the type of mother plant than sexual method of propagation.

Sexual propagation: Raisings of plant by means of seed. It has certain advantages over vegetative means of propagation-

- Seed is relatively a cheaper and simple way of obtaining large number of plants as compared to vegetative propagation.
- Seedlings have usually long life as compared to vegetatively propagated plants.
- Seedling plants have better root system and therefore provide better anchorage than vegetatively propagated plants.
- It is the only practical method of propagation of most of the vegetables, annual flowers and fruit plants like papaya, phalsa, mangosteen which cannot be propagated by vegetative means.
- Hybrids are 1st raised through seeds.
- Rootstocks for budding and grafting purpose are raised through seeds only.
- Sexual propagation may sometimes leads to the production of chance seedlings which may be superior to the mother plant.
- Seedling plants are comparatively more resistant to insect-pest and diseases than the vegetatively propagated plants.
- Seeds can be stored for a longer time and can be easily transported to distance market.
- Seedlings are usually hardy and can tolerate adverse climatic conditions in a better way than the vegetatively propagated plants.
- No special technical skill is required for raising plants through seeds.
- Majority of viruses are not transferred through seeds. Thus, seed propagation is useful in producing virus free plants.
- Nucellar seedlings can be utilized to raise uniform plants.
- In polyembryonic crops like mango, citrus seeds on sowing give rise to more than one seedling. Thus seed is the desirable means of propagation in such crop.
- Mangosteen fruit is developed through parthenogenesis. Seedlings obtained from seeds of such fruits are similar to its mother plant and thus propagated commercially through seed.

Disadvantages:

- Seedling plants are highly heterozygous in nature. Owing to segregation, the seedling trees are not uniform in growth, yield and fruit quality parameters.
- Seedling plants are usually tall and spreading types, thus the management cost involved in operation like harvesting, pruning and plant protection etc. is comparatively higher.
- Seedlings plants have usually long juvenile phase and take more time to come in bearing.
- In case of recalcitrant crop, seed loose viability very soon after extraction and thus very low germination rate.
- The beneficial effect of rootstock on scion variety cannot be taken in sexual propagation.
- Some fruit plants like pineapple, banana does not produce viable seeds and propagation through seeds is not possible in them.
- It is not possible to perpetuate the exact characters of any superior selection through seeds.

Classification of seed on the basis of storability: On the basis of storability of seeds in relation to moisture content, they are classified into two groups *viz*. Orthodox seeds and recalcitrant seeds.

a. **Orthodox seeds:** The seeds which can be dried to low moisture level (5-8% of lower) and lose their viability with the increase of moisture, are called as orthodox seeds. The viability of these seeds can be maintained by drying the seeds and storing them at low temperature for longer period of time. Eg. Ber, custard apple, date palm, fig, grape, guava, mulberry, papaya, passion fruit, peach, pineapple, plum, phalsa, pomegranate *etc*.
b. **Recalcitrant seeds:** The seeds, which remain viable at relatively higher moisture level (8-15% or above) and if dried below certain moisture level, they start to lose their viability, are called as recalcitrant seeds. Eg. Avocado, Barbados cherry, carambola, bread fruit, jack fruit, litchi, mango, mangosteen, rambutan, citrus *etc*.

Vegetative propagation: Any plants are propagated commercially through asexual mean in which vegetative parts of the plant are used. It is possible because all the living cells of a plant have a capacity to regenerate into a full plant under favourable environmental condition. This tendency of plant cell is called as *totipotency*. The term given by Haberlandt in 1902. The plants produced by vegetative means are therefore genetically identical and similar to the mother plant.

Advantages:

- True to the type and uniform in growth, yield and fruit quality
- Ideal method of propagation for the plants which are more prone to seed dormancy (all the temperate fruits).
- Vegetatively propagated plants are less vigorous and thus can easily be maintained as compared to seedling plants.
- Some fruit crops like banana, pineapple, fig and varieties of grape, guava and lemon produce seedless fruit and have no viable seeds. Thus can only be perpetuated through vegetative means.
- Plants come in bearing earlier than seedling plants.

- Possible to regulate the tree size, fruit quality and precocity in bearing by exploiting the desirable effects of different rootstocks.
- It is possible to exploit the desirable abiotic effect of rootstocks on scion cultivar by budding and grafting.
- Helpful to overcome the problem of self incompatibility of different fruit crops by top working the desirable pollenizers on scattered trees throughout the orchards.
- Detection of virus in the plant system by using indicator plant is only possible through budding or grafting. Eg. Kagzi lime can be used as rootstock (indicator plant) for detecting the presence of tristeza virus in citrus.
- Helps in shortening in breeding cycle by grafting scion of new cultivar on to a large established tree or on certain dwarfing rootstock for early assessment.
- A clone can only perpetuated by vegetative means.
- Benefit of certain interstock can only be obtained through vegetative means.
- Damaged part of the tree trunk or root can only be repaired by bridge grafting or inarching.

Disadvantages:

- Have short life cycle and more prone to pest and disease attack.
- New variety cannot be evolved
- Specialized task and need technical skill
- Vegetatively propagated plants are usually prone to suckering
- More expensive than seed propagation
- Not applicable in some fruit crops like papaya.

Techniques for vegetative propagation:

- **Propagation by apomictic seedling**
- **Propagation of plants on its own root system:** Cutting, Layering
- **Propagation of plants on the root system of other plants:** Grafting, Budding
- **Propagation by specialized structures:** Bulbs, Tubers, Rhizomes, Corms, Suckers, Runners, Offsets, Bulbils, Pseudbulbs, Stolon, Slips, Crown *etc*.
- **Micropropagation:** propagation by using different explants (shoot tois, embryos, cell or protoplast culture) under aseptic condition.

Apomoxis

Defination: Development of embryo, not as a result of meiosis and fertilization but from diploid or haploid egg cells or from cells in embryo sac or surrounding nucellus or integument which does not undergo meiosis and emergence of off spring of same genetic makeup as of female parent is called as apomixes.

The seedlings which are produced through apomixis are known as apomictic seedlings.

- Plants that produce only apomictic embryos are called as **obligate apomicts** while other which produce both apomictic and sexual embryos are called as **facultative apomicts**.

Types of apomixes:

a. **Recurrent apomixis:** Embryo develops from the diploid egg mother cell or from some other diploid cells of the embryo sac without fertilization. It is quite common in *Parthenium*, raspberry, apple, onion, *Poa* etc. In some species, this phenomenon occurs without the stimulus of pollination whereas in others, pollination appears to be necessary for the development of a viable embryo.

b. **Non-recurrent apomixis:** Embryo develops directly from the haploid egg cell or some other haploid cells of embryo sac without fertilization and as a result, the embryo developed is also haploid in nature. It is common in *Solanum nigrum* and *Lilium* species.

c. **Adventitious embryony:** It is also called as nucellar embryony. Here the embryo does not develop from the cells of the embryo sac but from a cell or a group of cells either of nucellus or integuments. Such embryos usually develop outside the embryo sac in addition to the regular embryo. This is quite common in citrus, where normal pollination and fertilization takes place in usual manner and apomictic embryos are develop outside the embryo sac.

d. **Vegetative apomixis:** In this type, vegetative buds or bulbils are produced in the inflorescence in place of flowers. These buds or bulbilis may sprouts into new plants while they are still attached to the mother plants. This is quite common in *Allium*, *Agave*, *Poa* and *Dioscorea*.

Apart from these, different scientists also included polyembryony as one type of apomixis. But it is not a separate type of apomixis. It is the phenomenon in which two or more embryos are produced in a single seed. The condition may results from many reasons. One of the most common reasons being the nucleus develops within the embryo sac, which may lead to the development of more than one embryo. Cleavage of pro-embryo during the early stages of development may the other reason for the development of multiple embryos.

Significance of apomixis:

i. Produce homozygous line
ii. Useful for producing uniform rootstock. Eg. Rootstock of apple like *M. tiringoides, M. hupehensis, M. sikkimensis etc*.
iii. Apomictic seedling are quite healthy and highly uniform
iv. Effective for the production of virus free quality planting materials

Cuttings

Types of cuttings

A. Stem cutting: Next to seed, stem cuttings are the most convenient and popular method of plant propagation. Most the cutting techniques fall into this category. A stem cutting is any cutting taken from the main shoot of a plant or any side shoot growing from the same plant or stem. There are few general considerations which helps in selection of suitable cuttings. First of all it is essential for the cutting to have sufficient reserve food to keep tissues alive until root and shoots are produced. The shoots with high carbohydrate content usually root better. To maintain high carbohydrate content in a shoot, ringing or notching stem down to the wood are useful

practices. As a general rule, cutting from young plants root better but if older shoots of the plants are cut back hard, very often they can be induced to produce suitable shoots for rooting. Broadly there are four types of stem cuttings which are as follows-

i. Hardwood cuttings: It is simple method of plant propagation in which cuttings are made from the mature and lignified stems of shrubs and trees. Such cuttings are easy to secure and can be easily handled, stored and transplanted. This type of cutting is prepared during dormant season. Usually from one year old immature shoots of previous season's growth. Only healthy shoots are selected and weak, fast growing shoots with long internodes should be avoided. The length of the cutting varies from 10-45 cm in length and 0.5-2.5 cm in diameter, depending on the species. usually the cutting of 25-30 cm length with pencil thickness are preferred. Each cutting should have at least 2 buds. While preparing the cutting, a straight cut is given at the base of shoot below the node while a slanting cut, 1-2 cm above the bud is given at the top of the cutting. This helps in maintaining the polarity of the shoot and if rain occurs, water does not accumulate on the tip of the cutting, which saves the cutting from fungal infection. It is often advantageous to take hardwood cutting with a heel (in temperate fruit crops), that is with a piece of old wood, attached to the base. Presence of Mallet (present in Quince) at the base of cutting should also be preferred. Similarly, stem cutting will more often root better if bases are etiolated, notched or girdled or ringed before being removed from the parent plant. After preparation of cutting, the basal portion of those cutting should be treated with root initiating hormone, especially Indole-3-butyric acid (IBA). For deciduous crop, the dose of IBA varies from 2500-5000 ppm (with maximum 10,000 ppm in difficult to root crops) while in evergreen plants it is 2000 ppm to slightly higher (5000-10000 ppm in difficult to root crops).

It is generally practised in a number of deciduous fruit plants like grape, hazelnut, chestnut, fig, quince, pomegranate, mulberry, plum, olive are commonly propagated by hardwood cutting.

ii. Semi-hardwood cutting: The semi-hardwood cuttings are prepared from partially matured, slightly woody shoots. These are succulent and tender in nature and are usually prepared from growing wood of current season growth. Usually those shoot, which snap clean when broken, are considered ideal for preparation of semi-hardwood cutting. The length of the cutting varies from 7- 15 cm. The cuttings are prepared by trimming the branches with a straight cut below the node and removing a few lower leaves at the base and retaining 2-4 leaves at the top of the cutting. Treating the cutting with IBA @ 1000- 3000 ppm (maximum 5000 ppm in difficult to root crops) before planting is beneficial for commencement of proper rooting. While planting one quarter of their length should be inserted in the soil. The best time for taking cutting is late spring to summer, when new shoots have emerged and their wood is partially matured.

It is normally practised in evergreen fruit plans like mango, guava, lemon, jackfruit, olive *etc*.

iii. Softwood cutting: Softwood cutting is the name given to any cutting prepared from soft, succulent and non-lignified shoots which have not become hard and woody. Usually, the cutting size is 7.5- 12.5 cm but it varies from species to species. Usually some leaves should be retained with this type of cutting. Before planting treatment with IBA (500-1250 ppm with maximum of

3000 ppm in difficult to root crops) is beneficial. The best time for the preparation of softwood cutting is spring to early summer.

It is normally practiced in different flowering annuals like Juniper, hollyhick, lilac. But some time it is also practised in apple, pear, peach, plum *etc*.

iv. Herbaceous cutting: The terminal leafy portion of the stem of a plant is used for preparing herbaceous stem cutting. These cuttings are soft and succulent with length varying from 7.5-12.5 cm. These cuttings are rooted under the same conditions as the softwood cuttings, requiring high relative humidity but are liable to wilt soon if proper humidity is not maintained. Therefore, much attention is required for working with herbaceous cuttings. Herbaceous cuttings of some plants exude a sticky sap that interferes with rooting process. In such cases basal end of the cutting should be allowed to dry for few hours before planting. For proper root initiation treatment of the basal portion of the cutting with IBA @ 500-1250

It is generally practiced in flowering annuals like Geranium, poinsettia, dieffenbachia, chrysanthemum. In fruit crops it is followed in pineapple (slips and crown), and in persimmon.

B. Root cuttings: Propagation by means of root cuttings is also a simple and cheap methods of vegetative propagation in species which are difficult to propagate with other methods. In general the plants which produce suckers freely are easily propagated by root cuttings. For preparation of root cuttings, roots which are of 1 cm thick and 10-15 cm long are cut into pieces. The best time for taking root cuttings is late winter or early spring when the roots are well supplied with stored food materials but before the new growth starts. However in temperate fruits, root cuttings are prepared in the month of December and are kept in warm place in moss grass or wet sand for callusing and are then transplanted during February- march in open beds. While using root cuttings, it is important to maintain the correct polarity. Thus, to avoid their planting upside down, the proximal end of the cutting should have straight cut and distal end a slanting cut. The proximal end should always be kept up. While planting, insert the cuttings vertically so that the top is above the soil level. However, in some cases, horizontal planting gives satisfactory results as in sweet potato.

Balckberry and raspberry are commercially propagated by this method. However, kiwi fruit, bread fruit, fig, mulberry, apple, pear, peach, cherry and persimmon are also propagated by root cuttings.

Apart from theses different horticultural crops particularly different flowering annuals and vegetable crops also propagated by leaf cutting due to their herbaceous nature but fruit crops are rarely propagated by this particular means of propagation. However, leaf bud cutting technique is sometimes followed for the propagation of black berry, raspberry, lemon.

Propagation by Layering

Layering is a method of plant propagation which is designed to induce plant stems to produce roots while they are attached to the parent plants. After the proper rooting stem is detached from the parent plant and planted in the nursery to become a new plant, growing on its own root system.

Advantage:

1. Easy to perform and does not require much facility

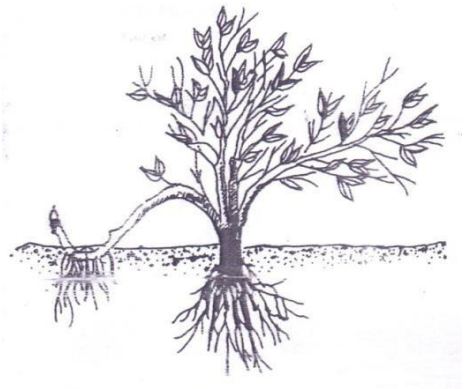
2. Does not require precise control on water, relative humidity or temperature as it requires in other propagation methods.
3. It is possible to produce large sized plants with layering within a short time

Disadvantages:

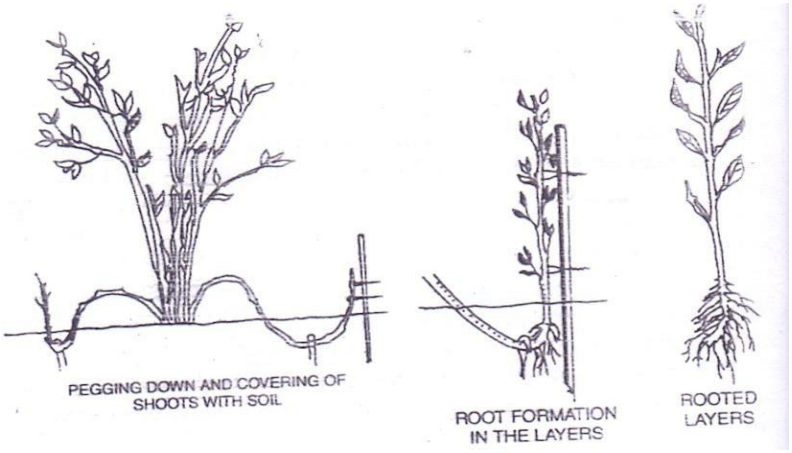
1. Not possible to produce large number of plants at a time
2. The plants produced through layering have brittle root
3. The beneficial effect of root stock on scion cannot be explored
4. The mortality rate of layered plants are usually high

Types of layering

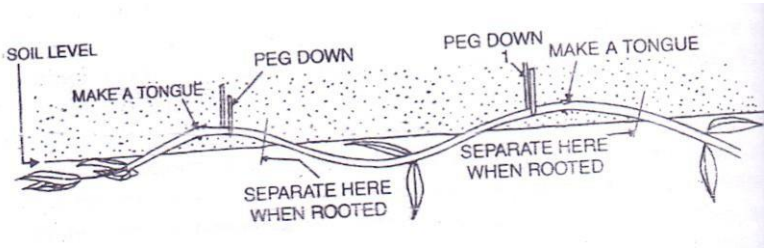
a. Tip layering : Here the tip of the shoots are bend to the ground and the rooting takes place near the tip of the current season's shoot within a month. The new shoot may be detached and transplanted in the nursery during spring. It is the simplest form of layering, which often occur naturally and is a natural method of propagation of blackberry, raspberry etc.



b. Simple layering: It is similar to tip layering except that some manipulations are done to the buried shoot for better rooting. Here, the flexible shoots of a plant are bent downwards over to ground in early spring or in rainy season. A second bend is made in the shoot, a short distance from the tip, which is covered with soil and held in place with wire or wood stakes. The portion is sometimes injured or wounded either by nothing, wiring or girdling to stimulate rooting. The best time for simple layering is early spring. Rooting in shoot takes place within 2-3 months. It is mainly done in citrus, rhododendron etc.



c. Serpentine layering: It is also an easy plant propagation method to perform but only suitable for the plant producing slender, long and flexible shoots. It is the modification of simple layering in which 1 year lod branch is alternatively covered and exposed along its length. The stem is girdled at different points in the underground part. However, the exposed portion of the stem should have at least one bud to develop a new shoot. After rooting, the sections are cut and planted in the field. In this way many plants can be made from a single branch. Mascadine grape is commercially propagated by is method.



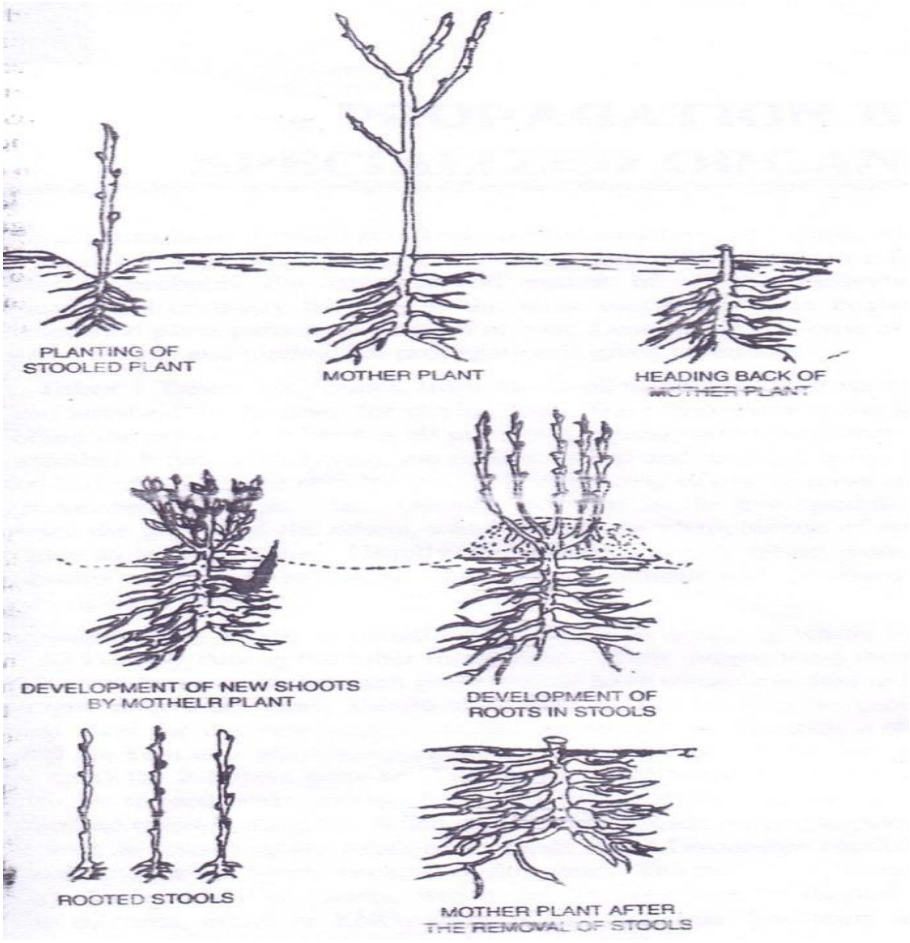
d. Air layering: It is a specialized form of layering, originally introduced from China and now widely used for propagation of many horticultural crops and popularly known as *goottee* and *marcottage* in India. In all other form of layering rooting is induced by bringing the stem in to contact with the soil or other moist medium but air layering is quite differ from the others wherein the moist medium is brought to the stem while the shoot being left to its original position. So the roots are induced on stem well above the ground without using soil at all.

Clean young shoots are best for air layering. They are prepared by making an upward cut about 5 cm long or about the centre of the shoot. The shoot is then girdled by removing a ring of bark about 2 cm wide. The wound is covered with moist sphagnum moss in away to provide complete cover on it followed by covering with thin polyethylene film to prevent the evaporation or moisture losses.

It is mainly done in spring or in rainy season. Rooting often occurs within a month or so under favourable conditions. The rooted layers are then cut from the mother plants and planted in the nursery until established in the field condition. It is mainly done in a wide range of fruit crops including litchi, lime, lemon, jackfruit, guava, fig etc.

e. Mound layering: It is commonly known as stooling. It is somewhat similar to serpentine layering but here the stems/shoots of desired plant are not bending down to the soil. Here, mother plant is headed back to 15-20 cm above the ground level during dormant season. The new sprouts will arise within 2 months. These sprouts are then girdled near the base and rooting hormone (IBA), made in lanolin paste is applied to the upper portion of the ring. The concentration of IBA may vary from 3000-5000 ppm depending upon the maturity of the shoot. These shoots are then left as such for 2 days for proper absorption of hormone before they are covered with moist soil. The root on the shoot may emerge within 30-40 days. After proper root induction, individual shoot should be cut from the mother plant only after 60-70 days and then planted in the nursery.

It is a commercial method of propagation for guava. However, it can also be practiced in apple, pear, peach, plum, cherry etc.



Budding

In grafting, the scion is a detached piece of shoot or stem with several buds. But in budding, scion consists of only one bud and small portion of wood. Thus, budding is a form of grafting and often called as bud grafting.

Advantages: 1. Quick and efficient method of propagation as compared to grafting.
2. Best propagation method if propagating material is scarce.
3. Budding is useful in plants release excessive wound gum (stone fruit) from injury carried to xylem or wood portion of stem at the time of grafting.
4. Budding results into stronger union compared to grafting thus injury to the budded plants due to storms and strong wind is less.
5. It is comparatively simple method of plant propagation than grafting and can be done by common peoples.

Types of budding

i. **Shield or T budding:** as the name indicates shield is the shape of the bud and T is the shape of cut given on the rootstock for the budding operation. It is the most common method of budding practiced by nurserymen throughout the world. For T budding, one year old rootstock seedling of 25-35 cm height and 2-2.5 cm thickness is selected which is in actively growing stage, so that the bark will separate readily from the wood. In this budding, 1st a vertical cut (2.5

cm length) to be made on the stock at 0.-2.5 cm above the soil level. Then the horizontal crosscut to be made at the top of the vertical cut to give T shape. As the horizontal cut is made, the knife is given a twist to open the flaps of bark for the insertion of the bud. Thereafter, scion bud is prepared by removing the bark shield with a bud. For this, an upward slicing cut is started at the point on the stem at 12-13 mm below the bud, continuing under the bud to an about 2.5 cm above. The shield piece should be thin, thick enough to have some rigidity. A 2^{nd} cut is then made at the upper portion of the 1^{st} cut which permitting the removal of the shield piece. After removal of the scion bud, it should be inserted into the T cut on the stock by pushing the shield downward under the two raised flaps of bark until its upper horizontal cut is matches the same cut on the stock. Then wrapping of the bud union must be done using budding tape.

Eg. Apple, pear, peach, plum, apricot, cherry, rose and citrus are propagated by this method.

ii. **Inverted T budding:** In area that experiencing high rainfall during budding season, water running down the stem of the rootstock may enter the T-cut, soak under the bark of the stock and prevent into the shield piece from healing into place. In such condition, inverted T budding gives better results, since excess water is shed. For this, rootstock has the transverse /horizontal cut at the bottom rather than at the top of vertical cut. In removing the shield piece from the bud stick, the cut on bud stick should start above the bud and continuing downward below it. Then insertion of shield into rootstock should be done from lower part to upward direction.

It is usually practiced in citrus.

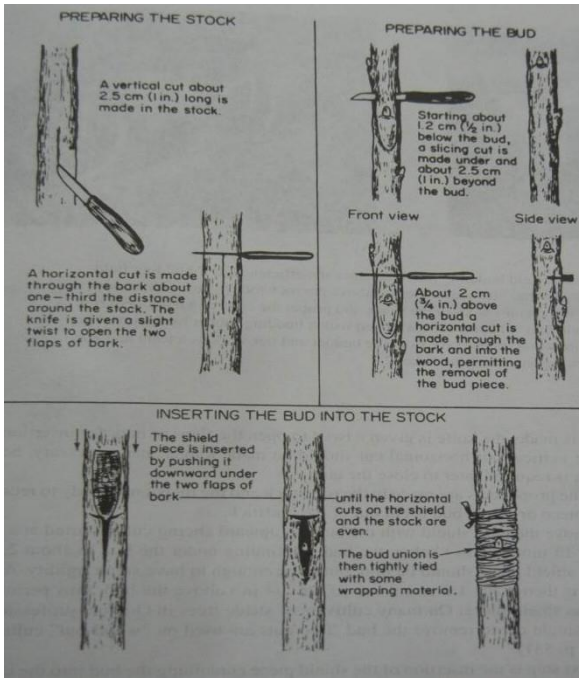
iii. **Patch budding:** Widely successful in thick barked species such as walnut, pecan nut. In patch budding, bark of both stock and scion requires to slip easily. A special knife called double bladed knife is used in this budding technique which makes two transverse parallel cut 2.5-3.5 cm apart through the bark to the wood in a smooth area of the rootstock about 10 cm above the ground. Then two transverse cuts are connected at each side by vertical cuts made with a single bladed knife. The patch of bark containing a bud is cut from the budstick in the same manner as of rootstock. The size of the bark removed from the budstick should be same as of size of the bark removed from the rootstock. After the removal of bud patch from the budstick, it must be inserted immediately on the already prepared rootstock. The inserted patch is now ready to be wrapped.

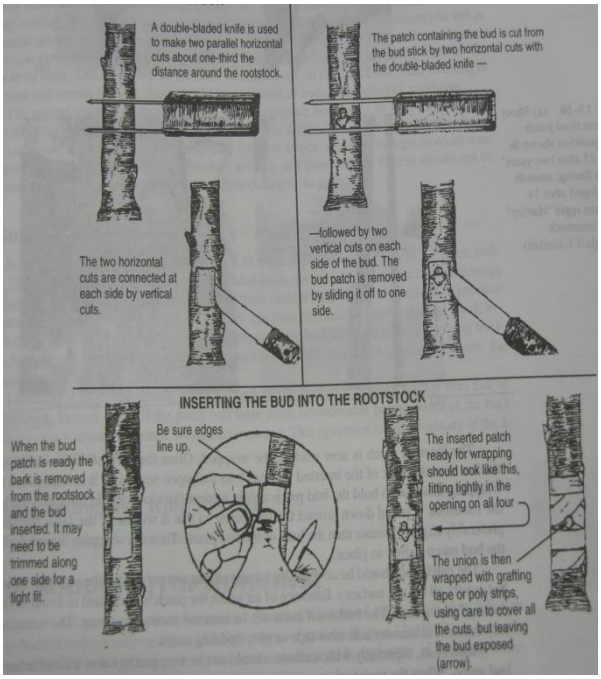
iv. **I- budding:** In this budding, two parallel cuts are made on the rootstock using the same parallel double bladed knife, used in patch budding. These two transverse cuts are then joined at their centres by a single vertical cut to produce the shape of the letter 'I'. The two flaps of bark can then be raised to insert the bud patch beneath them. A better fit may occurs if the side edges of the bud patch are slanted. It is mainly practiced in ber.

v. **Ring budding:** In ring budding, a complete ring of bark is removed from the stick and it is completely girdled. A similar ring of bark containing a bud is removed from the bud stick and it is inserted on to the rootstock. In ring budding, both stock and scion should be of same size. However, it is applicable in stocks having thickness below 2 cm. It has been utilized in ber, peach, mulberry because the newly emerged shoots from the heavily pruned plants are capable of

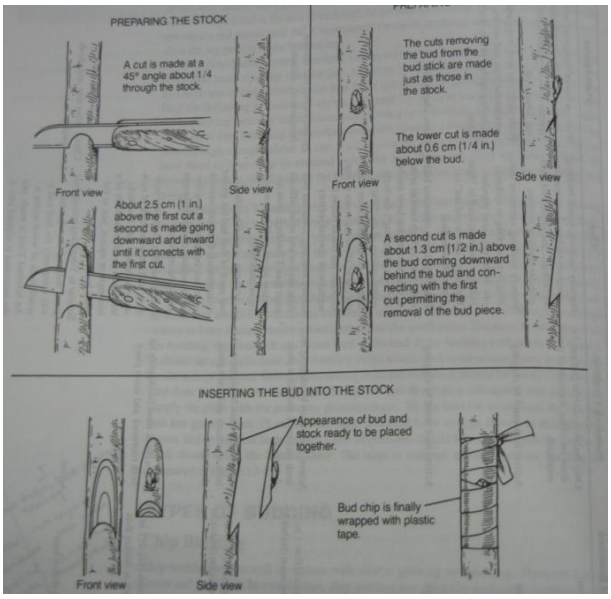
giving such buds for budding, which can easily be separated. In this method, since the stock is completely girdled and if the bud fails to heal in, the stock above the ring may eventually die.

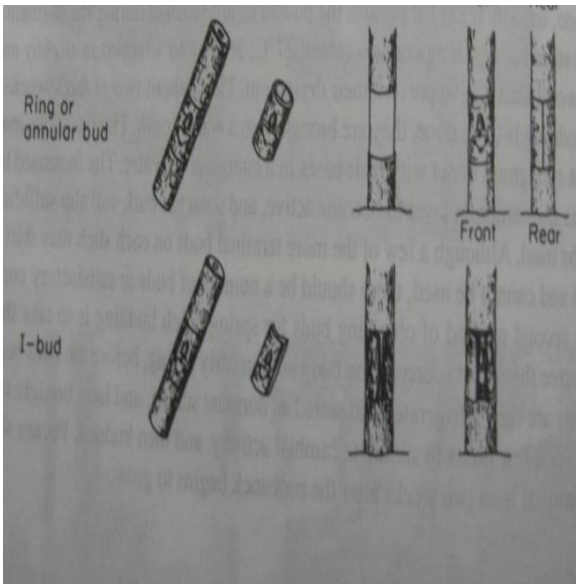
vi. **Chip budding:** it is a successful method of budding when the bark of the rootstock does not slip easily and plants are not in actively growing condition. In this technique, a chip of bark is removed from a smooth place between nodes near the base of the rootstock and replaced by another chip of the same size and shape from the budstick, which contains a bud of the desired cultivars. The chip in both budstick and rootstock are cut out in the same manner. In the budstick, the 1st cut is made just below the bud and down into the wood at an angle of 30-45 degree. The 2nd cut is started about 25 mm above the bud and goes inward and downward behind the bud until it intersects the 1st cut. The chip is removed from the stock in the same manner and replaced by the one from budstick. After proper fitting of bud piece on the stock wrapping should be done properly with suitable wrapping material, leaving the bud uncovered. Mainly followed in grape, apple and pear.





T budding **Patch budding**





Chip budding

Ring and I budding