

# *Principles of Plant Propagation, Methods of Propagation for Horticultural Crops*

## OBJECTIVES

After studying this chapter, students will be able to:

- Gain knowledge of basic plant propagation techniques
- Gain a greater understanding of plant processes and lifecycles
- Develop skills in the art of budding and grafting
- Start agribusiness in nursery production of horticultural plants.

## INTRODUCTION

Propagating new plants is both a science and an art. The study of it can provide a lifetime of challenges and opportunities to learn more about this fascinating craft, or a basic knowledge of it can provide the students with the skills and techniques to start their own business in nursery production of horticultural plants since the demand for planting material of horticultural plants is ever increasing. It can be of great fun to grow your own plants. You may already have some experience growing different plants. Plant propagation is the multiplication of plants by both sexual and asexual means. To start with, start growing a few tomato plants from seeding in kitchen garden, to the conservationist growing endangered species of orchids in test tubes, to the commercial nurseries that grow the millions of annuals, perennials, bulbs, shrubs and trees sold every year, a working knowledge of plant propagation makes all of these endeavors possible. This chapter will give the students greater confidence in producing plants from seed, cuttings, grafting, budding, layering and specialized vegetative structures along with essential skills to work in the horticulture industry.

### **What is Plant Propagation?**

Plant Propagation is defined as the multiplication of plants by both sexual and asexual means. Propagation is an art of multiplication of plants. The horticultural plants are propagated both by sexual and asexual methods.

Most of the horticultural plants are now propagated through grafting and budding, few through cuttings, layering, seeds and micro-propagation. The propagation methods are broadly classified as sexual, asexual and micro-propagation.

The study of plant propagation has three different aspects:

- o A Knowledge of mechanical manipulations and technical skills- *art of propagation*.
- o A knowledge of plant growth and structures- *science of propagation*.
- o A knowledge of different kinds of plants and their methods of propagation

The details of methods are presented below:

### Sexual Propagation

Sexual propagation is the raising of plants by means of seed which is formed due to the fusion of male and female gametes within the ovule of a flower. Plants that are produced from seeds are called seedlings. In ancient times when the asexual methods of plant propagation were not known, this was the only commercial method for plant propagation. Papaya, phalsa and mangosteen, vegetable crops and flowers are still being propagated by seed.



### Advantages

- Seedling trees are generally long-lived, bear more heavily and all comparatively more hardy.
- This is the only means of reproduction, where asexual propagation is not possible or economical e.g. Papaya, phalsa, mangosteen etc.
- To develop new varieties, hybrids are first raised from seed and it is essential to employ this method in such cases.
- It has been responsible for the production of chance seedlings of highly superior merits.
- Polyembryonic character exists in many fruit plants such as in some citrus species and some mango varieties which give rise to more than one seedling from one seed. The nucellar seedlings are true to type. Therefore, polyembryomic varieties can be propagated by seeds.
- Rootstocks upon which the fruit varieties are budded or grafted are mostly raised from seeds.
- Seedlings are cheaper and easy to raise.

- Easily transported to distant places e.g. seeds
- Does not require high technical knowledge and skilled labour.

### Limitations/disadvantages

- Seedling trees are not uniform in their growth, yielding capacity and fruit quality.
- Seedling trees have long juvenile period and take more years to bear the first crop.
- Seedlings become large for economic management.
- It is not possible to maintain the exact character of any superior selection.
- Seed propagation can not be applied in many plants e.g. banana
- It is not possible to avail the modifying influence of rootstock on scion or scion on rootstock.
- Since seed-borne viruses exist in a number of fruit plants and the multiplication of such plants by seed is not recommended.

### Asexual propagation

Propagation of plants through any vegetative parts is called vegetative or asexual propagation. The goal of vegetative propagation is to reproduce progeny plants identical in genotypes to a single source plant.

### Advantages:

- Vegetatively propagated plants are true to type, uniform in growth, yielding capacity and fruit quality.
- Vegetatively propagated plants come into bearing earlier.
- Uniformity in fruit quality makes harvesting and marketing easy.
- Modifying influence of rootstock on scion can be profitably availed off.
- It is possible to regulate the tree size, fruit quality, precocity etc. according to one's requirements by using different rootstocks.
- Cross pollination can be effected by grafting shoots of other suitable varieties (pollinizers) on some of the branches of self-unfruitful variety.
- Grafting can be used to encourage healing of tree wounds caused by rodents, implements.
- Composite tree can be raised.
- One can correct to some extent the initial mistakes of planting inferior or unsuitable varieties.

- Fruit plants producing seedless fruits such as banana can only be multiplied through vegetative means.

### Limitations

- No new variety can be evolved by means of the vegetative method of propagation.
- Sometimes, it is more expensive.
- Vegetatively propagated plants are comparatively short lived.

### Methods of Asexual Propagation:

**Plant Propagation by Cutting:** A portion of a stem, root or leaf is cut from the parent plant and is placed under certain favourable environmental conditions to form roots and shoots. Thus a new independent plant is produced which in most cases identical with the parent plant.

**Stem-cuttings:** Propagation by hardwood cuttings is simple and cheapest method of multiplication. Hardwood cuttings are easily handled and transplanted. One-year-old mature shoots are collected during November-February. Grape, fig, pomegranate, currant, gooseberry, some plums and apple are propagated by hardwood cuttings. Many deciduous ornamental shrubs are started readily by this type of cuttings. Some common ones are privet, forsythia, wisteria, honeysuckle, willow, poplar, dogwood, Potentilla, Sambucus, and Spiraea. Rose rootstocks are propagated by hardwood cuttings. Weak and fast growing shoots with long internodes should not be used for this purpose. Length of

Naphthelene Acetic Acid (NAA) and Indole-3-Butyric Acid (IBA) are the two most commonly used root promoting hormones used.

cuttings should be between 10 and 45cm. It should contain at least 2 buds. Just on the base of shoot below the node a straight cut is given while on the top of the cutting, 1-2cm above the bud a slanting cut is given. This helps maintain the polarity of the shoot and if rain occurs, water does not accumulate on the tip of cutting.

Semi-hardwood cuttings are mostly used in evergreen fruit plants-mango, guava, lemon and jackfruit. Many broad-leaved evergreen shrubs such as *Camellia*, *Pittosporum*, *Rhododendron*, *Euonymus*, evergreen azaleas and holly are commonly propagated by semi-hard wood cuttings. The available shoots during June-July have not attained the full maturity and are 5-9 months old. Such shoots are used for propagation purpose. Length of cuttings should be 7-20cm. It is better to retain 2-4 leaves on the top of cuttings. Treating cuttings with 5,000ppm IBA gives better results.

A novel technique for rooting semi-hardwood cuttings has been perfected. It is known as bottom heat technique. Semi-hardwood cuttings of mango, guava and aonla are prepared during December and treated with IBA 5,000ppm. These cuttings are inserted in rooting medium in a chamber maintained at  $30\pm 2^{\circ}\text{C}$ , and 30-90% cuttings get established in this method.

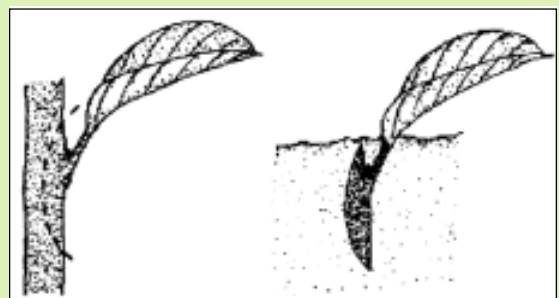
**Soft wood cuttings:** Cuttings are prepared from the soft succulent new spring growth of species which are 4 to 6 months old. Many ornamental woody plants can be propagated by softwood cuttings. Typical examples are the hybrid French lilacs, Forsythia, Magnolia, Spiraea, maples. Nerium, crotons, Eranthemum, Graftophyllum etc can also be multiplied through this type of cuttings.

**Herbaceous stem cuttings:** This type of cuttings is taken from succulent herbaceous green house plants. For example, Chrysanthemum, Coleus, Carnations, Geraniums, Cactus and many foliage plants are multiplied through herbaceous cuttings.

Softwood cuttings and herbaceous cuttings are not used to propagate fruit plants. Only 2-3 months old shoot and very tender shoots are utilized.

**Leaf Cuttings:** Certain plants with thick and fleshy leaves have the capacity to produce plantlets on their leaves. In leaf cuttings, the leaf blade with or without petiole and axillary bud is used for starting new plants. Adventitious roots and shoots form at the base of the leaf and form in to a new plant. However, the original leaf does not become a part of the new plant. Frequent watering and high humidity and bottom heating are desirable for better and rapid rooting of leaf cuttings. Sand or sand and peat moss (1: 1) are satisfactory rooting media for leaf cuttings. For leaf cuttings, depending on the species the whole leaf blade, leaf blade sections or the leaf with petiole is used. Begonia, African violets and peperomia are propagated by leaf cuttings.

**Leaf-bud cutting:** A leaf-bud cutting consists of a leaf blade, petiole and a short piece of stem with attached axillary bud of actively growing leaf Black raspberry, blackberry, boysenberry, lemon, camellia, maple and rhododendron are readily propagated by leaf-bud cuttings as well as many tropical shrubs and most herbaceous greenhouse plants usually started by stem cuttings.



**Root cuttings:** As the name indicates, roots of the plant are utilized as propagating material. Roots 1 cm thick and 10-15cm tall are used. In temperate fruits, such kind of roots are prepared



in December and kept in warm place in moss grass or wet sand for callusing and transplanted during February-March in open beds. Blackberry and raspberry are commercially propagated by this method. This method is also advocated in pecan nut, apple, pear and peach.

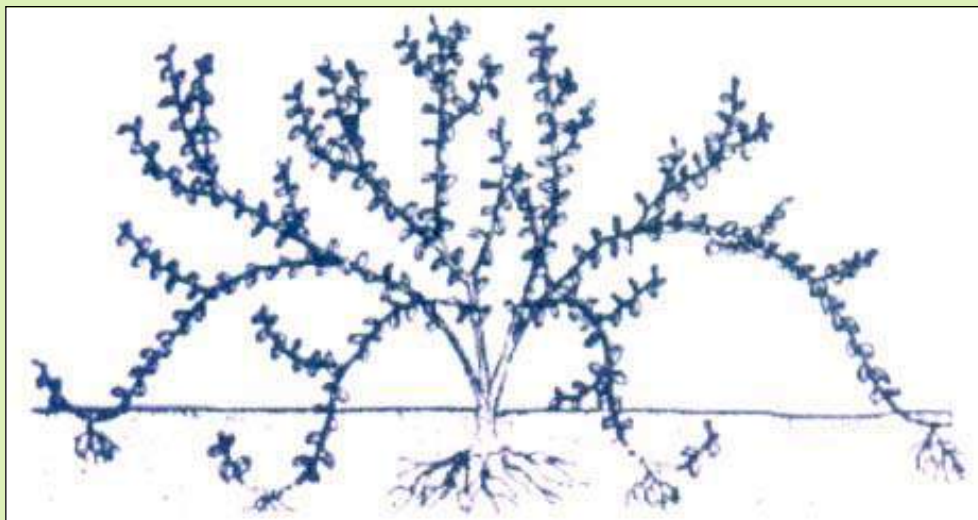
### Propagation by layering



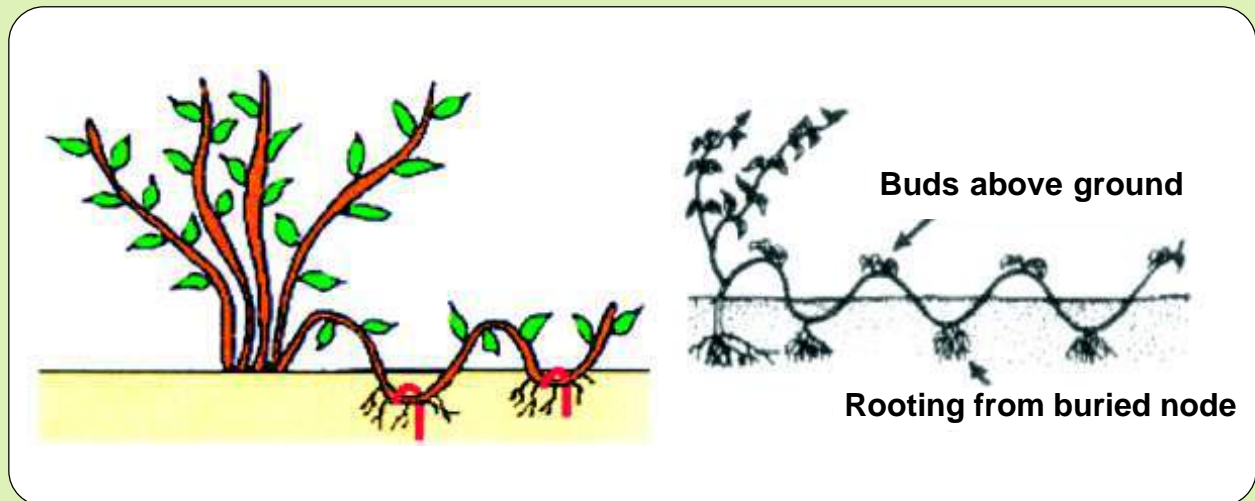
Layering is the method of propagation in which roots are developed on a stem while it is still attached to the parent plant. After proper rooting, the stem is detached and becomes a new plant for growing on its own roots. The high success of layering is obtained by ringing or wounding, etiolation (absence 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 fruit plants are:

**Tip-layering:** In tip-layering, rooting takes place near the tip of current season's shoot which is bent to the ground. It is commonly followed in black berries, raspberries and dewberries. The stem of these plants complete their life in two 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 5-10 cm deep in soil. Rooted layers are detached and planted in soil during spring.



**Serpentine layering:** It is modification of simple layering in which one-year-old branch is alternatively covered and exposed. The stem is girdled at its lower part. The exposed part of stem should have at least one bud to develop a new shoot. After rooting, the sections are cut and planted. Muscadine grape is commercially propagated by this method.

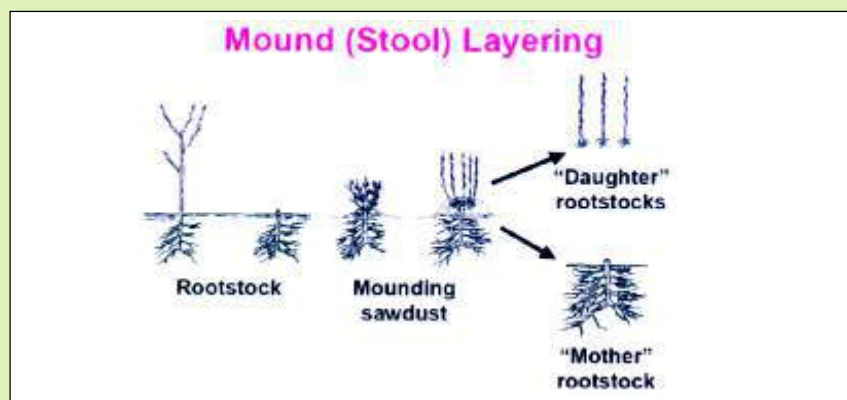
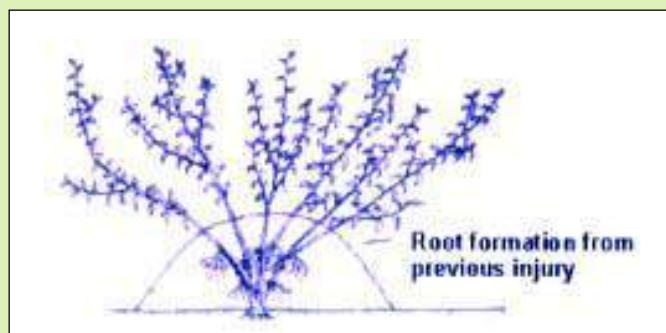


**Air-layering:** In this method, roots are formed in the aerial part of the plant. The stem is girdled and rooting hormone (IBA) is applied to upper part of cut. The moist rooting medium (moss grass) is wrapped with the help of small polythene strip (200-300 gauze, transparent). This method is commonly known as goottee. Many plants like litchi, kagzi lime, jackfruit, guava and cashewnut as well as Ficus species, Croton, Monstera and philodendron are propagated through air-layering. February-March and June-July are the ideal periods for air-layering. Rooting in air layers generally commences within 25-30 days and layers are ready for transplanting within 3 months.





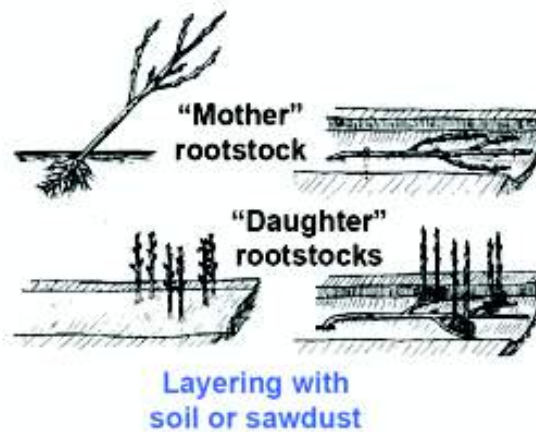
**Mound layering/stooling:** In this method, the plant is headed back to 15cm above the ground level during dormant season. The new sprouts will arise within 2 months. These sprouts are then girdled near base and rooting hormone (IBA), made in lanolin paste is applied to the upper portion of cut with moist soil. These shoots are left as such up to two days for proper absorption of rooting hormone (IBA) before they are covered with moist soil. The concentration of rooting hormone varies from plant-to-plant but in general 3,000-5,000ppm is most commonly used. The rooting of shoots is observed within 20-30 days. After 2 months, the rooted shoots are separated from mother plants and planted in nursery. Apple and pear root stocks 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.



**Trench layering:** Trench layering consists of growing a plant or branch of a plant in a horizontal position in the base of trench and filling in soil around the new shoots. Roots are developed at the base of new shoots, so produced. Rootstocks of apple, pear and walnut are usually propagated by trench layering.



## Trench Layering



### Plant propagation by grafting

Grafting is an art of joining parts of two independent plants in such a manner that they unite and grow together into single independent plant. The part of graft combination which is to become the upper portion or the shoot system or top of the new plant is termed as scion and the part which is to become the lower portion or the root system is the root stock or under stock or some time stock.

**In case of grafting, a bud stick consisting of two or more buds is inserted into the stock whereas in budding only single bud with or without wood is inserted into the stock.**

**Methods of grafting:** There are two main types of grafting- attached scion methods of grafting and detached scion methods of grafting. In attached scion methods of grafting, the scion is still attached to the mother plant till the graft union takes place whereas in detached scion methods of grafting the scion is separated from the mother plant just before grafting. Inarching or approach grafting is most important method under attached scion methods of grafting.

**Inarching/ Approach grafting:** The distinguishing feature of this method of grafting is that two independent plants on their own roots (self sustaining) are grafted together. This method provides a means of establishing a successful union between certain plants which are difficult to graft by any other method as the two plants will be on their own roots till the formation of successful graft. Examples are Guava, mango, sapota.

**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. In this method, 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.



**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. 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.



**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.

**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.



*Steps in cleft grafting*

## Tongue Grafting

This method is highly effective and widely employed for the propagation of peach and pear. In this method, the diameter of the scion and the rootstock should be equal. In this method, 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. Examples are apple, pear, peach, plum, apricot, almond, cherry, kiwi fruit, pecan nut etc. The best time for tongue grafting is December- February in temperate fruits.



*Steps in Tongue grafting*

## Plant Propagation by Budding

Budding is also a method of grafting wherein only one bud with a piece of bark and with or without wood is used as the scion material. It is also called as bud grafting. The plant that grows after union of the stock and bud is known as budding.

**Generally grafting is performed during dormant season whereas budding is done during active growing season**

### Methods of budding:

**T-Budding (Shield budding):** This method is known as T-budding as the cuts given on the stock are of the shape of the letter T, and shield budding as the bud piece like a shield. This method is widely used for propagating fruit trees and many ornamental plants. This method is generally limited to the stock that is about 0.75 to 2.50cm in diameter and actively growing so that the bark separate readily from the wood. Example is Rose and Citrus.





**Inverted T- Budding:** In heavy rainfall areas, water running down the stem of the stock may enter the T cut, soak under the bark and prevent healing of the bud piece. Under such conditions, an inverted T budding may give better results as it is more likely to shed excess water. Inverted T budding procedure is same as that of T-budding except the horizontal cut on the stock is made at the bottom of the vertical cut rather than at the top.

**Patch Budding:** In this method a regular patch of bark is completely removed from the stock plant and is replaced with a patch of bark of the same size containing a bud from the desired mother plant. For this method to be successful the bark of the stock and bud stick should be easily slipping. The diameter of the stock and bud stick should be preferably by about the same (1.5 to 2.75cm). Examples are Pecan nut and walnut.



*Steps in patch budding*



**Ring budding:** The bud is prepared by taking a ring of a bark, 3cm long with the bud in the centre. In the root stock, two transverse cut 1.5cm apart are made and these are connected with a vertical cut and a ring of bark is removed. The prepared scion bud with the ring of bark is fitted in the exposed portion of the rootstock and tied. Example is ber.

**Double working:** It is practiced for several purposes (i) to over come incompatibility between the stock and scion. Incompatible stock and scion may be united by means of a piece of interstock that is compatible to both (ii) to secure resistance to drought or cold by providing a disease or cold resistant trunk by means of double working. (iii) To obtain resistance to pest and dwarfing effect by using a pest resistant stock and a dwarfing stock and (iv) top working of grafted orchard trees is essentially a double working; here the tree trunk as an intermediate stock may exert certain influences on the new top.

**Top working:** Top-working for changing a variety is generally done on long lived species, growing in a healthy condition. Short lived species, old trees or diseased trees are not suitable for top working; in such cases new planting is considered more economical and useful than top working.

## Micro-propagation

Micro propagation (tissue culture or invitro culture) refers to the multiplication of plants, in aseptic condition and in artificial growth medium from plant parts like meristem tip, callus, embryos anthers, axillary buds etc. It is a method by which a true to type and disease free entire plant can be regenerated from a miniature piece of plant in aseptic condition in artificial growing medium rapidly throughout the year. This method is gaining popularity because of advantages over other conventional methods.

## Advantages

- Large-scale multiplication in lesser time and space
- Production of virus-free plants
- Year-round production of plants
- Highly beneficial in those fruits where vegetative propagation is difficult
- In dioecious fruit plants, production of female plants is possible through micro-propagation. Papaya, is a good example.

Under micro-propagation, different plant parts are cultured. Based on explant, different in-vitro methods are used for propagating fruit plants. They are shoot-tip culture, meristem-tip culture, embryo culture and ovule culture.

Tissue culture technique has been perfected in banana. Shoot tips excised from rhizomes of sword suckers are suitable explants and MS medium supplemented with sucrose (3%), and gelrite (0.25%) is the best. Shoot tips and micro-cuttings are highly suitable explants for faster and disease-free production of grape. Salt-tolerant rootstock of grape has increasing demand and in-vitro propagation has been successfully used. Seed-propagated papaya often shows high variability, undesired ratio of male and female plants. Shoot tip culture technique has been successfully used in producing female plants in papaya.

Micro-propagation has been referred to as the most ideal method for propagation of strawberry and blackberry. Scientists in India and abroad are trying hard to perfect micro-propagation in mango, coconut, litchi. However, the success is limited.

Micro-propagation, however, has its limitations. The facilities required are very costly. It requires technical skill, pathogen/disease if appeared in culture may be multiplied to very high levels in a short time and establishment of laboratory produced plants in field is a difficult task until properly hardened.

## APOMIXIS

The embryo is generally produced by sexual reproduction but there are certain cases in which the embryo is produced by an asexual process. This is of great value as the resulting plant can be reproduced by seed propagation in almost the same manner as it would be by any other vegetative method. The seedlings produced through apomixes are known as apomictic seedlings. Apomictic seedlings are identical to their mother plants and similar to the plants raised through other vegetative means, as it has the same genetic make-up as that of the mother plant. Hence, propagation by means of apomictic seedlings is equivalent to vegetative propagation. The phenomenon in which an asexual reproductive process occurs in place of the normal sexual reproductive process of reduction division and fertilization is known as apomixis.

### Kinds of apomixis:

**Obligate apomixis:** Plants that produce only apomictic embryos are known as obligate apomicts.

**Facultative apomixis:** Plants that produce both apomictic and sexual seedlings are called facultative apomicts.

### Types of apomixis:

**Recurrent apomixis:** In this the embryo develops from the diploid egg cell (diploid parthenogenesis) or from some other diploid cells of the embryo sac, without fertilization (diploid

apogamy). As a result, the egg has the normal diploid number of chromosomes, as in the mother plant. e.g, Onion, raspberry, Apple etc. In some plants apomixis occurs without the stimulus of pollination, in others pollination is necessary for embryo development.

**Non-recurrent apomixis:** In this type, the embryo develops directly, either from the haploid egg cell (haploid parthenogenesis) or some other haploid cells of the embryo sac (haploid apogamy). In this case haploid plants are always produced. As the plants produced by this method contain only one set of chromosomes, these are sterile and the process is not continued for more than one generation. Non-recurrent apomixis does not commonly occur and is primarily of genetic interest. e.g. *Solanum nigrum*, *Lilium* spp., etc.

**Adventitious apomixis (Adventitious embryony or nucellar embryony):** In this type of apomixis the embryo does not develop from the cells of the embryo sac, but develops from any diploid sporophytic cell, e.g., cells of the nucellus (usually), integument etc. Hence, the diploid cells of the sporophyte give rise directly to diploid new embryos. This type of apomixis is found in citrus, where fertilization takes place normally and a sexual plus a number of apomictic (nucellar) embryos develop. In opuntia also this type of apomixis occurs.

**Vegetative apomixis (Bulbils):** In this case the flowers in an inflorescence are replaced by bulbils or vegetative buds, which often sprout into new plants while they are still on the mother plant. This type of apomixis is found in some species of *Allium*, *Agave*, *Dioscorea*, *Poa* etc.

**Poly embryony:** This is a type of apomixis. The phenomenon in which two or more embryos present within a single seed is called polyembryony. When such seeds are sown, more than one seedling arises from the seed. Of them one is from the zygote (Sexual seedling). The others are asexual or apomictic seedlings. The reasons for this phenomenon are many. The origin of these extra embryos or seedlings varies.

- a) From nucellus-Nucellar embryony as in citrus and mango
- b) From seed coats (integuments) or antipodals or synergids -rare-mango.
- c) Occasionally more than one nucleus develops within the embryo sac (in addition to the usual and regular nucleus).
- d) Cleavage of the embryo during the early stages of development is common occurrence.

Whatever may be the place of origin, the common thing is, these embryos arise from the maternal tissue of the plant. Examples are Citrus, Mango, Jamun, Rose, apple etc. The polyembryonic seedlings are uniform and true to parent like other vegetatively propagated plants. They are derived by mitosis, and come from maternal tissue (not by meiosis), but they have the characteristics of sexual seedlings like juvenility, vigour, freedom from virus diseases. Examples are Citrus, Mango, Jamun, Rose apple.

**How to differentiate the poly embryonic and sexual seedlings:** It is difficult to differentiate in the nursery. Generally more vigorous seedlings are considered to be polyembryonic. By rejecting about 10% of weaker and weakest seedlings, one can have fairly uniform poly embryonic seedlings.

Standardized and commercial methods of propagation in fruits

Name of fruits	Methods of propagation	
	Standardization	Commercial
Acid lime	Seed, budding, air layering	Seed
Avocado	Grafting (cleft, side, whip), chip budding and cutting	Layering, T-budding
Aonla	Budding (patch, shield)	Patch budding
Bael	Root cutting, budding, (Patch and Shield), air layering	Patch budding
Ber	Cutting, air layering, budding, (T, I, ring and forkert)	Ring and T-budding
Carambola	Seed, approach grafting	Seed
Custard apple	Soft wood grafting	T-budding, Inarching, Offshoots
Date palm	Seed, Offshoots	Offshoots
Fig	Cutting, budding and air layering	Hard wood cuttings
Grape	Hard wood stem cutting, chip budding, layering and micropropagation	Hard wood stem cuttings
Grapefruit	Seed and budding (patch, shield)	T-budding
Guava	Cutting, air layering and budding	Stooling, Inarching
Jamun	Seed and budding	Shield and Patch budding
Karonda	Seeds, soft wood stem cuttings in mist	Seeds, Air layering
Lemon	Seed and layering	Air layering, hard wood stem cuttings
Litchi	Air layering, splice grafting, budding	Air layering

Longan	Seeds, inarching, tongue grafting, air layering	Air layering
Loquat	Budding, grafting, seed and air layering	Inarching
Mandarin	Seeds and budding	T/shield budding
Mango	Inarching, side and Veneer grafting, budding, stool layering and cutting, cleft grafting	Inarching, Veneer grafting
Passion fruit	Stem cutting, cleft grafting	Seeds
Persimmon	Grafting and budding`	Crown grafting
Phalsa	Seeds and cutting	Seeds
Pomegranate	Budding (chip, patch and forkert), air layering, inarching	Hardwood stem cuttings and Air layering
Pummelo	Seed and budding	Seed, T-budding
Sweet orange	Seed and budding	T-budding

### Propagation by specialized vegetative structures

Some fruit plants have natural structures-runner, sucker, offset, rhizome and crown-for propagation.

**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. Pineapple 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.

**Offset:** It is a lateral shoot or branch which is developed from base of the main stem. The date palm and pineapple produce such type of lateral shoots by which they can be propagated.

**Plant propagation by division:** It is a method of propagation of plants using cut section of a particular part like rhizome, tuber and tuberous root etc.

**Rhizome:** A rhizome is a modified stem structure in which the main axis of the plant grows horizontally just below or on the surface of the ground. Banana is a typical example where rhizome is cut into pieces in such a way so that each piece contains at least 3 lateral buds (eyes) for propagation.



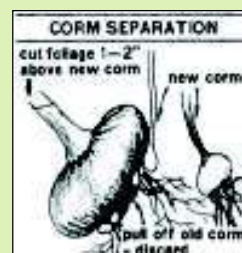
Ginger rhizome



Turmeric rhizomes

**Crown:** It designates that part of a plant at the surface of ground from which new shoots are produced. In strawberry plant, where leaves are seen in groups, is oftenly referred to as 'crown' of plant. Similarly, at the top is the crown of pineapple plant, which can be used for propagation purpose.

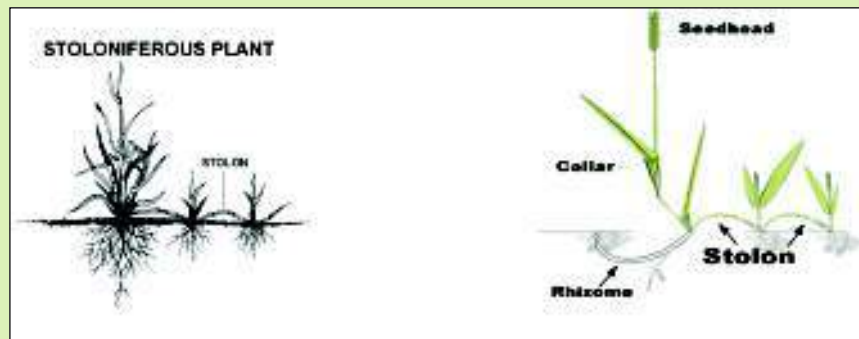
**Corm:** The bulb consists predominantly of modified leaves; the corm is a modified stem. Food is stored in this compact stem, which has nodes and very short internodes and is wrapped up in dry, scaly leaves. When a corm sprouts into a new shoot, the old corm becomes exhausted of its stored food and is destroyed as a new corm forms above it. Several small corms, or cormels, arise at the base of the new corm. The cormels may be separated from the mother corm at maturity (die back) and used to propagate new plants. e.g. Amorphophallus, Colocasia, Gladiolus etc.



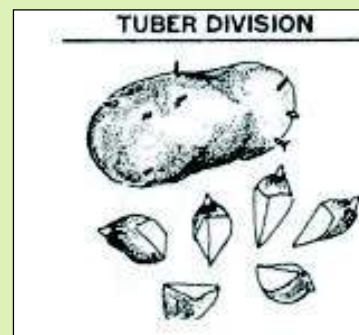
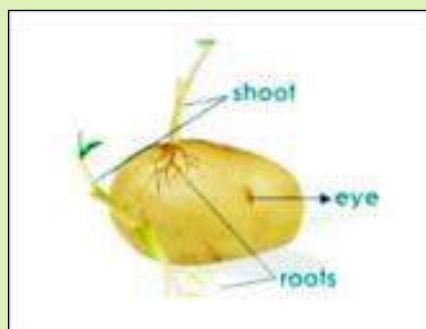
Gladiolus corm

(Source: Plant facts Ohio state university)

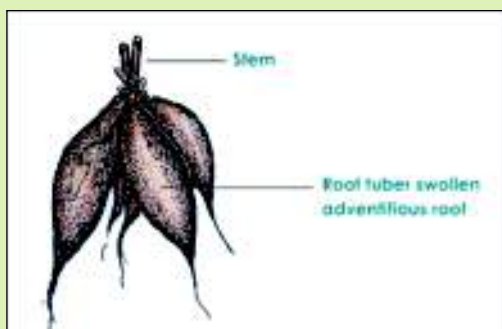
**Stolon:** It is a term used to describe various types of horizontally growing stems that produce adventitious roots when come in contact with the soil. These may be prostrate or sprawling stems growing above ground. In propagating plants by stolon, the stolon can be treated as a naturally occurring rooted layer and can be cut from the parent plant and planted separately. For example, Mint, Bermuda grass etc.



**Stem tuber:** A tuber is specialized swollen underground stem which possesses eyes in regular order over the surface. The eyes represent the nodes of the tuber. The arrangement of the nodes is spiral, beginning with the terminal bud on the stolon to produce a new plant, the tuber is divided into sections so that each section has a good amount of stored food and a bud or eye. Propagation by tubers can be done either by planting the tubers whole or by cutting them into section, each containing a bud or eye. For example, Potato.



Stem tuber of Potato



Root tuber of Sweet potato

**Tuberous roots:** These are thickened tuberous growth that functions as storage organs. These differ from the true stem tuber, in that they lack nodes and internodes. Buds are present only at the crown or stem end. Fibrous roots are commonly produced towards the opposite end. Most plants with fleshy roots must be propagated by dividing the crown so that each section bears a shoot bud. For example, Dahlia, Begonia, Sweet potato.

**Offset:** It is a short thickened horizontal branch growing out of the crown ending at the apex with a tuft of leaves and a cluster of leaves below. These are special type of branches or lateral shoots which are produced from the base of main stem of parent plant. The offset often breaks away from the mother plant and the daughter starts a new independent life. For example, Pistia, Agave, Water hyacinth, Cycas, Dracaena etc.

### Propagation by seed

Papaya, phalsa, kagzi lime and jamun are usually propagated by seeds. Seeds are also used to raise rootstock seedlings in many fruit crops such as citrus and mango. This method being the easiest and cheapest is generally employed on a commercial scale in the fruit crops. In mango and citrus, nucellar seedlings can be used to raise true-to-type plants. Seed propagation is essential for breeding new plant type, conserving gene pools. Propagation by seed requires a thorough knowledge of seed viability, its storage, time of sowing, factors responsible for germination and care of germinated seedling is essential.

The condition in which the seed can germinate immediately upon the absorption of water in the absence of any internal germination barrier, the embryo (or seed) is said to be quiescent. While those seeds which fail to germinate even though the embryo is alive, moisture is absorbed and favourable condition are provided are known as dormant seeds.

In most of the fruit crops, there may be natural or chemical dormancy. The dormancy in seeds of ber, guava and walnut is due to presence of hard seed coat which inhibits penetration of water and oxygen required for germination. Presence of chemical inhibitors (abscisic acid) is responsible for dormancy in seeds of most of temperate fruits (apple, pear, peach and walnut). Besides ABA, higher concentration of pectin, gum, tannin and amino acids (tryptophan) are also responsible for dormancy in seeds of temperate fruits.

### How to overcome dormancy

Seed dormancy due to hard seed coat can be overcome by softening the seed coat and other covering. It can easily be done either by scarification, stratification or by use of chemicals and hormones.

**Scarification:** It is the process of breaking, scratching, altering or softening the seed covering to make it permeable to water and gases. Scarification can be achieved mechanically, or by hot water and acid.

In mechanical scarification, cracking of seed with hammer, rubbing with sand paper or cutting with a file without injury to embryo is generally employed to break the dormancy (ber, peach and walnut).

Impermeable seed coat of guava can be softened by hot water scarification. Seeds are placed in hot water at 77°-100°C. They are immediately removed from hot water and allowed to soak gradually in cool water for 12-24hr.

Acid scarification consists of treating guava seeds with concentrated sulphuric acid for 3 minutes, ber for 5-6 hr and strawberry seeds with 0.25% nitric acid or hydrogen peroxide results in higher germination.

**Stratification:** It is the method of handling of dormant seeds, in which, the imbibed seeds are subjected to a period of chilling to after-ripen the embryo. This term originated as the nurserymen used to place seeds in stratified layers interspaced with a moist medium such as soil or sand out of door or in pits during winter. The term moist chilling has been used as synonym to stratification. Stratification can be achieved by refrigeration of dormant seed.

Dormant seeds of temperate fruits like apple, cherry, pear and apricot are generally placed in layers of sand in a box at a temperature of 1°-5°C. Depending upon the seed type, treatment time varies from 1-5 months for breaking dormancy of seeds.

The seed dormancy due to presence of growth inhibitors can be broken by placing the seeds in running water. It results in leaching of inhibitors. The freshly extracted seeds of strawberry and grape if placed in running water for 7-12 days result in increased germination.

**Chemical treatments:** Many freshly harvested dormant seeds usually respond to soaking in potassium nitrate solution. This technique is largely used in seed testing laboratories where seeds are placed in petri-dishes containing 0.2% solution of potassium nitrate. The seeds of peach and grape, treated with 5,000ppm of thiourea show enhancement in their germination.

**Use of hormones:** The seed dormancy can also be overcome by the treatment of growth regulators. Treatment of seeds of apple, cherry, peach, strawberry and hazelnut with 100-500ppm of GA3 for 24-48hr improves germination and better growth of seedlings. Ethrel (5,000ppm)-treated seeds of guava and strawberry also show better germination and growth of seedlings.

Treatment of apple and peach seeds with 10-20ppm solution of benzyle adenine (BA) is effective for higher seed germination.

### Seed sowing

The fruit seeds are sown in seed bed, polythene bags or in situ. Seeds of tropical and subtropical fruits are sown during monsoon (June-July) or in the beginning of spring (February-March). Generally seeds of mango and jackfruit are sown during June-July while those of guava, ber and aonla during February-March. Seeds of temperate fruits are generally available during June-October and their sowing should be done after the dormancy period is over. In citrus, mango, loquat, litchi and jackfruit, seed viability is very less, so these should be sown immediately after extraction. In north India, seeds of different citrus types are available during winter months. Germination of seeds is low due to prevailing low temperature. Hence use of polythene sheet on seed beds during December-January is useful in increasing germination percentage and faster growth of seedlings.

The seeds are usually sown at a depth 3-4 times of their size. It should be a little deep in light soils while shallow in heavy soils.

Nowadays, sowing of seeds in polythene bags, earthen pots and pans is becoming popular. It is usual practice to sow papaya seeds in polythene bags. For epicotyl grafting, mango stones are also sown in polythene bags.

While raising the plants in polythene bags, care should be taken that root system develops properly. It has been observed a number of times that the roots get twisted and there is difficulty in establishment of the plants in field due to poor anchorage.

In-situ sowing: In walnut, pecan nut, jackfruit and ber, the tap-root system is very vigorous. So during the process of transplanting, root system is disturbed which ultimately affects their establishment in the field. Therefore, for these fruits, sowing of seeds in-situ is recommended. In rocky soils, in-situ sowing of mango seeds and grafting later on is recommended.

**Seed storage:** Based on storage behaviour, seeds are classified as orthodox or recalcitrant. The orthodox seeds can tolerate loss of moisture and their longevity can be increased by preserving them at low temperature. These include the seeds of apple, ber, custard-apple, date palm, fig, grape, guava, lemon, lime, mandarin, mulberry, papaya, passion fruit, peach, pineapple, plum, phalsa, pomegranate and sweet orange. Recalcitrant seeds do not withstand desiccation and need a critical level of moisture to survive. Such seeds can be stored for relatively short period ranging from a few weeks to a few months. Seeds of fruits which show recalcitrant behaviour are avocado, barbados cherry, carambola, breadfruit, durian, jackfruit, litchi, mango, mangosteen



and rambutan. Seeds of most of the tropical and subtropical fruits cannot be stored for a long period. However in controlled temperature and humidity, storage period can be prolonged.

**Cryopreservation:** It is the method of storage of material in liquid nitrogen maintained at a temperature of  $-196^{\circ}\text{C}$ . Successful cryopreservation of material involves the application of chemicals known as cryoprotectants. The most commonly used chemicals are glycerol and DMSO (Dimethyl sulphoxide). This method has recently been used in preservation of embryos of coconut and jackfruits under in-vitro systems.

### ACTIVITY/EXERCISE

1. Describe and explain the conditions needed for successful plant propagation from stem and leaf cuttings
2. Make three different types of stem cuttings.
3. Demonstrate knowledge of propagating plants by layering/grafting/budding in fruit plants growing in your farm/nearby orchard.
4. Visit nearby fruit/flower nursery and find out the methods of propagation being used by nurserymen for the multiplication of various fruits and flowers.

### CHECK YOUR PROGRESS

- 1) Define asexual propagation. How does it differ from sexual propagation?
- 2) Asexual propagation is advantageous in horticulture, why? Also write its limitations.
- 3) Enlist different types of layering and describe air layering giving suitable examples.
- 4) Differentiate between the followings:
  - a. Grafting and budding
  - b. Softwood and herbaceous cuttings
  - c. Leaf cuttings and leaf bud cuttings
  - d. Stratification and scarification
  - e. Mound layering and trench layering
- 5) How seed dormancy can be overcome?

### FILL IN THE BLANKS

1. Two most commonly used rooting hormones are .....and .....
2. Strawberry is commercially propagated through .....

3. Grafting is generally performed during.....season and budding during.....season.
4. Seed germination can be improved by the application of .....growth regulators.
5. Inverted T budding is generally done in areas experiencing.....rains.

### **SUGGESTED FURTHER READINGS**

- Bose, T.K., Mitra, S.K., Sadhu, M.K. and Das, P. 2001. Propagation of Tropical and Subtropical Crops. NayaProkash Publishers, Calcutta.
- Chadha, K.L. 2001. Handbook of Horticulture. Indian Council of Agricultural Research. New Delhi.
- Chattopadhyay, T.K. 1999. A Text Book of Pomology. Vol. I-IV. Kalyani Publishers, Ludhiana.
- Gill, S.S., Bal, J.S. and Sandhu, A.S. 1985. Raising Fruit Nursery. Kalyani Publishers, Ludhiana.
- Hartmann, H.T., Kester, D.E. and Davies, F.T. 1993. Plant Propagation. Prentice Hall of India Pvt. Limited, New Delhi.
- Kunte, Y.N., Kawthalkar, M.P. and Yawalkar, K.S. 2005. Principles of Horticulture and Fruit Growing. Agri-Horticultural Publishing House, Nagpur.
- Sharma, R.R. 2002. Propagation of Horticultural Crops (Principles and practices). Kalyani Publishers, Ludhiana.
- <http://www.iihr.ernet.in>
- <http://www.angrau.ac.in/>