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# PLANT PROPAGATION AND NURSERY MANAGEMENT

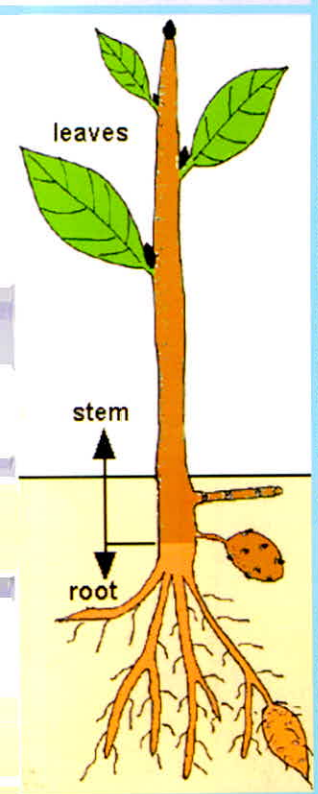
## (A PRACTICAL MANUAL)

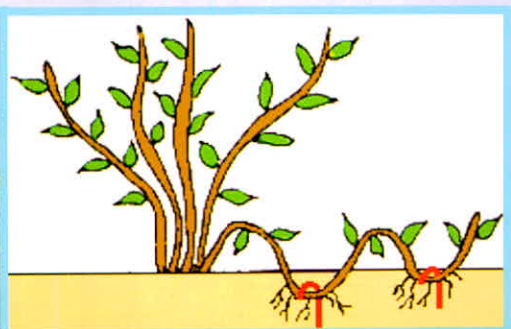
for

B.Sc. (Horticulture)

(2013)

*Annu Verma*
*Hemant Kumar Panigrahi*
*Abhay Bisen*



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**B.Sc. (Horticulture)**
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**(Annu Verma)**

# MANUAL ON PLANT PROPAGATION AND NURSERY MANAGEMENT

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# PRACTICAL 1: MEDIA FOR PROPAGATION OF PLANTS IN NURSERY BEDS AND MIST CHAMBERS

**Exercise:** Media for propagation of plants in nursery beds and mist chambers.

**Materials required:** Sand, soil, FYM or other formulation of compost, digging and media preparing tools, pots.

**Procedure:**

- Media used for propagation of Horticultural plants mainly consists of organic and inorganic components.
- The components of organic media include peat, sphagnum moss or bark. Sometimes leaf mulch, wheat straw, paddy straw, paddy hulls and saw dust are also used. While using these components some coarse mineral components should be used for increasing aeration such as sand, grit, pumice, vermiculite, perlite etc. The characteristics of different medium used for propagation are as under:-

Soil:

- The soil texture and structure is the first deciding factor for preparations of soil media.
- A soil having 40 percent sand, 40 percent silt and 20 percent clay is considered best for seed germination, where as sandy loam soils are excellent for preparation of soil mixtures for container growing plants.
- The soil pH of 5.5. to 6.5 is generally preferred. On the other hand structure of soil plays vital role in the germination of seed and rooting of cuttings
- Heavy soils are avoided, as working with such type of soil is quite difficult.

**Mixing of soil media**

**Sand:**

- Sand contains silica and has almost no mineral in it. Quartz sand, which chiefly contains silica components, is used by nurserymen for propagation. Because sand is the heaviest of all rooting media, it should be used in combinations with some other organic material.
- Sand should be washed, fumigated or heat treated before use to kill harmful pathogens present in sand.

**Vermiculite:**

- It is a micaceous mineral obtained from mica ore after processing the ore at 1090°C.
- Sterilization of material is done by heating. Heating turn water to steam, popping the layers apart forming small, sponge like kernels.
- Chemically, it is hydrated magnesium-aluminum-iron silicate. It is neutral in reaction with good buffering property and insoluble in water.
- It can absorb large quantities of water. It has good cation exchange capacity and can hold nutrients in reserve and release them slowly. It contains enough magnesium and potassium, which is needed for plant growth.
- Horticultural vermiculite has four grades according to the size of particles:

**Media Preparation for Nursery:**

In a Nursery potting mixtures for rooted cuttings and young seedlings generally contains 1 part of sand, 1 part of Loam soil and 1 part of peat moss or shredded bark or leaf mould is generally recommended as potting mixture.

**Compost:**

- It is decomposed and rotten material of farm waste. For growing seeds and cuttings it is very common and useful material. Compost is rich in organic matter, nutrients or has higher water holding capacity. It can be used as a medium for propagation but should be mixed with soil. The whole process of compost making occur in three steps.

1. Decomposition of easily degradable material, which is for few days.
2. Cellulose compounds are degraded at a high temperature which takes several months.
3. The micro-organisms recolonize the material.

- Mostly, compost is prepared using dung which contains faecal pass out, living seed of weeds and may be infested with soil dwelling pests like beetles, grubs and root-rotting pathogens. Therefore, it should preferably be used after sterilization

**Perlite:**

It is grey-white silicaceous material obtained after processing of crude ore which appears, after volcanic eruption.

- Perlite is obtained after heating the crushed ore to about 760oC. As a result of heating, the moisture in the particle changes to steam and expand the particles to small, sponge like kernels that are very light. It holds 3-4 times more water to its weight.
- It is neutral in reaction with a pH of 6.0 to 8.0. It does not contain mineral nutrient. Perlite in combination with peat moss is a very popular rooting medium for cuttings.
- Perlite is available in different grades with particle size of 1.6 to 3.0 mm in diameter is mostly used for propagation. In combination with peat moss it is an ideal rooting medium for rooting of cuttings.

**Peat:**

- Peat consists of the decomposed remains of aquatic, marsh, bog, or swamp vegetation and sediment of water bodies. Peat is of three types:
- Moss Peat: It is least decomposed and derived from sphagnum or other mosses. It has high moisture holding capacity about 15 times to its dry weight. It varies in colour ranging from light tan to dark brown.

It has highly acidic pH (3.2 to 4.5) and contains little amount of nitrogen. This type of peat is mostly used in horticultural nurseries, the course grade being the best. When peat moss is to be used in mixes as a propagation medium, it must be broken down into pieces and moistened before use. However, its continuous use may be improved by using agents like Agro Grow.

- Reed sedge peat: It consists of remains of grasses, reeds sedges and other swamp plants. It holds about 10 times more water to its dry weight and its pH ranges from 4.0 to 7.5.
- Peat humus: Peat humus is highly decomposed material. It can originate from hypnum moss or reed sedge peat. It has very low moisture holding capacity and pH ranges from 2.0 to 3.5. It may contain latent seed inoculations of soil dwelling pathogens, so it should be pasteurized while using.

**Sphagnum moss:**

- It is a bog grass plant of the genus Sphagnum such as Sphagnum papillosum, S.capillaceum and S.palustre.
- It grows as lithophytes in swampy spheres and is commonly found in hilly tracts of India. Sphagnum is obtained after dehydrating living portion of the grass. Sphagnum moss is relatively sterile, light in weight, having high moisture holding capacity.
- It has pH of about 3.5 to 4.0. It is widely used for keeping the live material moist for distant transport of seedlings and in air layering (goottee) of plants.
- It can be used as rooting medium for cuttings. Moss should be shredded either by hand or mechanically before use.
- It should be moistened with water before use. Sometimes, moss contains a strain of Streptomyces bacteria, which inhibit damping off the seedlings in the nursery.

**Saw dust; wood-shaving and shredded bark:**

- Saw dust, wood shavings and shredded bark of different plants like cedar, fir, pines, maple and redwood etc. can be used in mixtures with various propagating medium.
- Because of low cost, light weight and easy availability, these are mainly used in soil mixes for container grown plants.
- These mixes usually contain a lower amount of nutrients and hence additional amount of nutrients may be added to the mixes before their use as a growing medium.
- Being organic in nature, saw dust is ideal for the growth of fungus and hence its use is limited in propagation.

**Coco peat:**

- It is also called as coco dust. It is a byproduct of cutting and shifting of coconuts for fibre production.
- It is becoming very popular propagating and growing medium these days, because it has an excellent pore space (25-30 per cent) and fine structure required for proper growth and development of seedlings.
- It is a rich source of nutrients and can easily be mixed with other growing media.

**Grain Husk:** Several type of husks are available, paddy husk is one of the important wastage from rice mills. It is light in weight and cheaply available. It is suitable for mixing with other types of media.

**Pumice:** It is gray or white coloured volcanic rock, which was originally formed from the gases to give it a sponge like porous character. It is made up of aluminium silicate and also contains small quantities of potassium and sodium. It provides good aeration and drainage to medium.

**Polymers:** Since container-grown plants rely on regular watering to survive, some mixes contain polymers to hold moisture. Polymers, which may look like tiny plastic marbles, act like sponges. They absorb and hold water when the medium is moist, but release it back into the soil when dry. This helps maintain a consistent level of moisture for plant roots.

### Characteristics of Medium for propagation:

1. It should be sufficiently firm so as to facilitate the holding of seeds or cuttings in place.
2. It should not shrink excessively when dry, i.e., its volume should be constant when dry or wet.
3. In order to avoid watering at frequent intervals, the medium should be fairly retentive of moisture.
4. For proper drainage of excess water, it should be sufficiently porous. This would provide adequate aeration.
5. The medium should be free from weed seeds and disease organisms.
6. The medium should have a pH level suitable for the plant to be propagated.

### Soil mixes:

- Different soil mixes are used as medium for propagation. Usually, soil mixtures are prepared by mixing sand, loam soil leaf moulds in different proportions.
- Ideal soil mixtures should be porous and should have good water holding capacity.
- Soil mixtures are not only used as propagation medium for seed germination or rooting of cuttings but also for filling of containers.
- The success of these mixes lies in the proportion and thorough mixing of the ingredients.

### Precautions

1. The media used for propagation should be free from infections
2. We must use economic source of media preferably locally available

For propagation of plants as well as for growing plants, several types of containers are used. The principal types of containers used in India are:

1. **Earthen Pots:** These are of different types and sizes. The common types are locally known as (a) Parli, (b) Madki,(c) Khobda,(d) Nand, (e) Pela,(f) Kundi,and (g) Gamla.
2. **Wooden Trays or Boxes:** These are used for propagation of plants by cuttings or for raising seedlings.
3. **Baskets:** These may be made of either bamboo or wire. These are most commonly used for ornamental plants.

# PRACTICAL 2 :HARDENING OF NURSERY PLANTS

## Hardening of Nursery Plants

Small shade net houses are required for hardening of nursery plants. Young, pampered seedlings that were grown either indoors or in a greenhouse will need a period to adjust and acclimatize to outdoor conditions, prior to planting. This transition period is called "hardening off". Hardening off gradually exposes the tender plants to wind, sun and rain and toughens them up by thickening the cuticle on the leaves so that the leaves lose less water. This helps prevent transplant shock in which the seedlings have a stunted growth or they die from sudden changes in temperature. Hardenings off time depend on the type of plants grown and the temperature fluctuations.

## Hardening of Grafted Plants:

Hardening off plants is the act of acclimating plants that have been started indoors, to the harsher conditions of the outdoors. To harden off plants, start by placing seedlings outdoors for 2-3 hours at a time during the day. The plants should be placed in an area that is shaded and protected from wind and any animals or pests. This is continued for 3-4 days. After 3-4 days, start leaving your plants out for longer periods of time, always making sure to bring them in each night. You should continue to do this for another 7-10 days, gradually increasing the time they are left out every few days. For plants that will require full sun when planted in the ground, start slowly moving the plants out into the sunlight after the first 7 days or so. Plants should not be left in the sunlight for the whole day; rather they should have limited exposure for only a few hours. It is essential to make certain that the soil remains moist during this time. After about two weeks of this process, the plants should be ready to be safely transplanted into the ground.

## Hardening of the Tissue Cultured Transplants:

Hardening reduces the growth rate, thickens the cuticle and waxy layers, reduces the percentage of freezable water in the plant and often results in a pink color in stems, leaf veins and petioles. Such plants often have smaller and darker green leaves than non hardened plants. Hardening results in an increased level of carbohydrates in the plant permitting a more rapid root development than occurs in non hardened plants. Cool-season flower and vegetable plants can develop hardiness allowing them to withstand cold temperatures.

## Cautions for Hardening Transplants

Hardening is not necessary for all transplants. The exception of tomatoes, plants that are susceptible to frost should not be hardened. Overly hardened plants while withstanding unfavorable outside conditions are slow to get started and may never overcome the stress placed on the plant during the hardening process. Plants are hardened for no longer than seven to ten days before planting to the garden site.

# PRACTICAL 3: USE OF MIST CHAMBER FOR PROPAGATION AND HARDENING OF PLANTS

**Procedure:**

- Mist propagation units are used for propagation of difficult to root cuttings.
- The main aim of misting is to maintain continuously a film of water on the leaves by reducing transpiration and keeping the cuttings turgid until rooting takes place.
- The misting is controlled by time clock, operating a magnetic solenoid value and is set in a way to turn on the mist for 3-5 seconds to wet the leaves and turn off for some time and by the time leaves are dry, the mist is given turned on.

Cuttings in mist chamber

Hardening of plants in mist chamber

**Generally, mist has five control mechanisms.**

**I). Timer:** Two types of timers are used in a mist unit one turn on in the morning and off at night and second operates during day hours to produce an intermittent mist, usually 60 seconds 'On' and 90 seconds 'Off'.

**ii) Electronic leaf:** A plastic with two terminals is placed under the mist along with cuttings, the alternate drying and wetting of the terminal breaks off the current, which in turn controls the solenoid value.

**iii) Thermostat:** Controls the temperature of mist.

**Iv) Screen balance:** It consists of a stainless steel screen attached to a lever with mercury switch. When mist is on water is controlled on the screen and when weight is more, it trips the mercury switch.

**v) Photoelectric cell:** It is based on the relationship between light intensity and transpiration rate.

**Hardening of plants in mist chamber**

- After rooting in the mist, hardening of the rooted cuttings is important for better field survival. When cuttings are rooted, misting should not cease abruptly because this may lead to drying of young plants as a result of scorching.
- The weaving off process should be adopted in which misting is continued but the number of sprays are gradually reduced. Lessening the 'On' period and increasing the 'Off' period can do it.
- Another way is to shift the rooted cuttings to a greenhouse, fog chamber or frames, maintained at higher temperature and low relative humidity.
- Hardening should be done in phased manner so that rooted cuttings are planted at permanent locations.

**Precautions**

i) There should be regular supply of water

ii) The pH of water should be in the range of 5.5 to 6.5, avoid hard and alkaline water, as it blocks the nozzles.

iii) Rooting media should have good aeration

iv) Keep mist chamber free from the growth of blue green algae.

# PRACTICAL 4: TYPES OF PLANT PROPAGATION

## Plant Propagation

**Definition:** Propagation of plants may be defined as the controlled reproduction of plants by man to perpetuate selected individual or groups of individual plants which are of specific value to him.

The reproduction can be done by two methods:

1. By using seeds, known as sexual reproduction or propagation
2. By using a plant part itself, known as asexual or vegetative propagation

## Advantages of asexual or vegetative propagation

- Plants that are propagated are true to type.
- Some fruits such as bananas, pineapple (normally), grapes and oranges that produce no viable seeds, are propagated only by this method.
- Vegetative propagated fruit plants start bearing earlier than the seedlings.
- In some cases, plants are propagated vegetative to increase their resistance to certain disease or pest.
- Top working of inferior varieties or old unproductive plants is possible.
- Composite trees can be raised: This type of tree bears several varieties or types of fruits (e.g. apple and pear).

In vegetative propagation, the tree size, precocity, fruit quality, etc. can be regulated by the use of suitable rootstocks.

## Disadvantages

- Trees are less vigorous and short lived.
- The chance of producing new varieties is not given.

## SEXUAL OR SEED PROPAGATION

The life cycle of plants can be divided into two phases, 1) the vegetative cycle and 2) the sexual reproductive cycle. Sexual propagation is propagation through seeds, which are the result of the sexual reproductive cycle.

The vegetative cycle is called more correctly the sporophyte generation, and the vegetative plant body, which is produced by mitosis, is the sporophyte (2N). The sexual reproductive cycle is called more correctly the gametophyte generation that, by meiosis, produces the gametes, which are the sex cells (1N). The male gametes (microspores) develop into the pollen grains (lN) and the female gamete (megaspore) develops into the egg (1N). Pollination is the deposition of pollen grains on the stigma of the pistil of the flower. Fertilization is the union of the nuclei of the pollen grains (male gametes or sperm, 1N) with the nucleus of the egg (female gamete, 1N); the fertilized egg is then called a zygote (2N). Flowering plants (Angiosperms) have double fertilization, in which 1 pollen grain nucleus (1N) unites with the egg nucleus (1N) to form a zygote (2N), and one pollen grain nucleus (1N) unites with two polar nuclei (each 1N) to form the endosperm (3N).

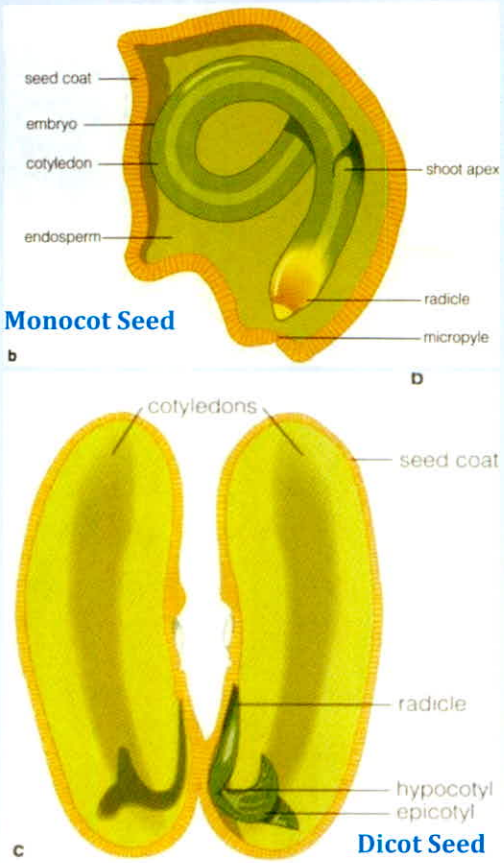
## Seed Germination:

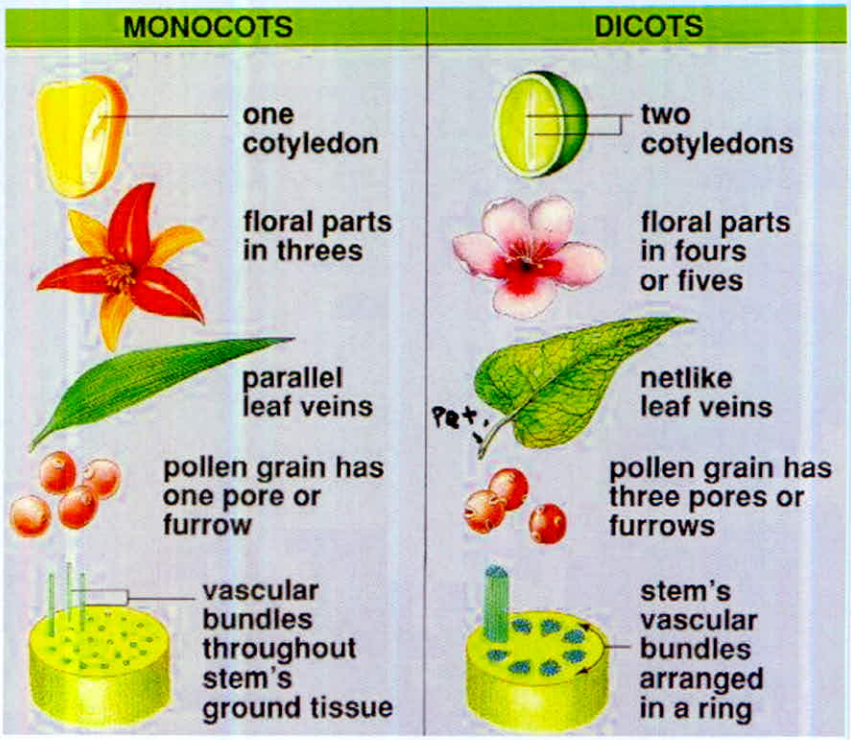
**Monocot Seed**

The seed imbibes (absorbs) water from the soil Emergence of radicle (primary root) and the plumule (primary shoot) These form the primary parts of the plant.

**Dicot Seed**

Seed imbibes water from soil and swells. Radicle emerges and grows downward. Hook of the bean (hypocotyl) emerges from soil, carrying the two cotyledons (leaves) with it.




**Difference between Monocot and Dicot Plants**

## Asexual or Vegetative Propagation

**Asexual (or vegetative) propagation is** the non-sexual reproduction or propagation (by cuttings, layering, division, grafting or budding) of a new plant from vegetative organs (stem, root, leaf). This is opposed to **sexual propagation** (union of gametes) from the reproductive organ, the flower, and resultant fruits and seeds.

**Tissue culture** (often called **micro propagation**) is a special type of asexual propagation where a very small piece of tissue (shoot apex, leaf section, etc.) is excised (cut-out) and placed in sterile, aseptic culture in a test tube or Petri dish containing a special culture medium. The culture medium contains the proper mixture of nutrients, sugars, vitamins and hormones, which causes the plant part to grow at very rapid rates to produce new plantlets. It has been estimated that one chrysanthemum apex placed in tissue culture could produce up to 1,000,000 new plantlets in one year. Thus, tissue culture is used for rapid multiplication of plants. A very specialized laboratory is required for tissue culture.

# PRACTICAL 5: SEED TREATMENTS FOR BREAKING SEED DORMANCY AND INDUCING VIGOROUS SEEDLING GROWTH

**Scarification:** Scarification is any process of breaking, scratching, mechanically altering or softening the seed covering to make them permeable to water and gases. Three types of treatments are commonly used as scarification treatments.

**Natural scarification** to soften hard seed coats may occur in several ways: 1) mechanical (physical) abrasion, 2) alternate freezing and thawing, 3) fire, 4) attack by microorganisms (fungi and bacteria), or 5) passing through the digestive tract of birds and mammals. Seeds with very hard seed coats may remain dormant for several years before these natural mechanisms sufficiently soften the seed coats.

Artificial scarification is frequently used by horticulturists to hasten germination.

**Mechanical scarification:**

- It is simple and effective if suitable equipment is available.
- Chipping hard seed coat by rubbing with sand paper, cutting with a file or cracking with a hammer are simple methods useful for small amount of relatively large seeds.
- For large scale, mechanical scarifiers are used. Seeds can be tumbled in drums lined with sand paper or in concrete mixers containing coarse sand or gravel.
- The sand gravel should be of different size than the seed to facilitate subsequent separation.

**Acid scarification:**

- Dry seeds are placed in containers and covered with concentrated sulfuric acid (H2SO4) or HCl in the ratio of one part seed to two parts acid.
- The amount of seed treated at any time should be restricted to not more than 10kg to avoid uncontrollable heating.
- The containers should be of glass, earthenware or wood non metal or plastic. The mixture should be stirred cautiously at intervals during the treatment to produce uniform results.
- The time may vary from 10 minutes to 6 hours depending upon the species. With thick-coated seeds that require long periods, the process of scarification may be judged by drawing out samples at intervals and checking the thickness of the seed coat.
- When it becomes paper thin, the treatment should be terminated immediately.
- At the end of the treatment, the acid is poured off and the seeds are washed to remove the acid.
- The acid treated seeds can either be planted immediately when wet or dried and stored for later planting.
- Large seeds of most legume species respond to simple sulfuric acid treatment.

**Hot water scarification:**

- Drop the seeds into 4-5 times their volume of hot water with temperature ranging from 77 to 100oC.
- The heat source is immediately removed, and the seeds soaked in the gradually cooking water for 12 to 24 hours.
- The unswollen seeds may be separated from the swollen seeds by suitable screens. The seed should be sown immediately after hot water treatment.

**Stratification:**

- Stratification is a method of handling dormant seed in which the imbibed seeds are subjected to a period of chilling to after ripen the embryo in alternate layers of sand or soil for a specific period. It is also known as moist chilling.

- The seeds can be planted immediately after stratification in the field.
- Seeds with a hard endocarp, such as Prunus spp. (the stone fruit including cherry, plum and peaches) show increased germination if planted early enough in the summer or fall to provide one to two months of warm temperature prior to the onset of chilling.

**Refrigerated stratification:**

- An alternative to outdoor field stratification is refrigerated stratification. It is useful for small seed lots or valuable seeds that require special handling.
- Dry seeds should be fully imbibed with water prior to refrigerated stratification. Twelve to twenty four hours of soaking at warm temperature may be sufficient for seeds without hard seed coats.
- After soaking seeds are usually mixed with well washed sand, peat moss or vermiculite. A good medium is a mixture of one part coarse sand to one part peat, moistened and allowed to stand 24 hours before use.
- Seeds are placed in alternate layers of sand or medium. The usual stratification temperature is 0-10oC.
- At higher temperature seeds sprout prematurely and low temperature delay sprouting.
- During stratification seeds should be examined periodically, if they are dry, the medium should be remoistened.
- The stratified seed is separated from the medium prior to sowing in nursery beds.

**Stratified seed of apple(Plump and swollen)**

**Stratified seed of apple( inside view)**

| Kinds of Fruit | Stratification period (days) | % germination |
|---|---|---|
| Apple | 70-75 | 70-75 |
| Kainth (*Pyrus patia*) | 30-35 | 90-95 |
| Peach | 60-70 | 55-60 |
| Apricot | 45-50 | 75-80 |
| Almond | 45-50 | 85-90 |
| Walnut | 95-100 | 80-85 |
| Pecan | 70-75 | 75-80 |

**Precautions:**

- Scarification should not proceed to the point at which the seeds are injured and inner parts of seed are exposed.
- The sand should be passed through coarse sieve mesh to separate bigger size gravels so as to avoid confusion between seed and gravels at the time of sowing.
- Irrigation during stratification should be given at regular intervals to maintain adequate moisture level.
- Seed should not sprout during stratification.

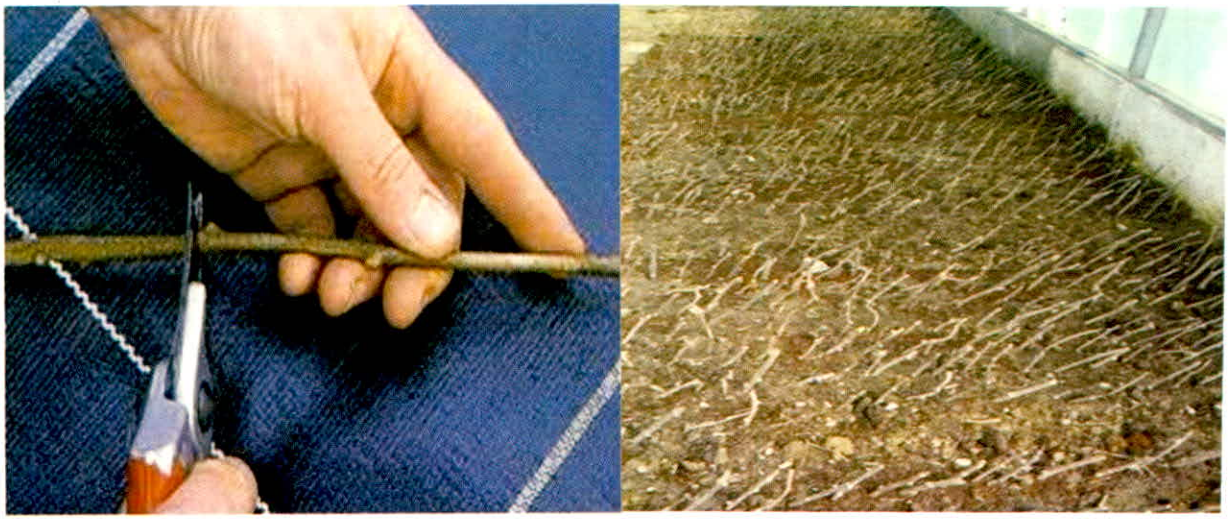
# PRACTICAL 6: CUTTINGS

A **Cutting,** sometimes called a **propagule**, is a portion of a stem, root or leaf taken from a parent plant that, when placed under favorable environmental conditions, regenerates **adventitious roots** and/or **adventitious shoots.** This produces a new independent plant identical to (or a clone of) the parent.

**On the basis of plant part used and relative position on a plant, cuttings is classified into various groups as:**

**a.) Stem cuttings:** 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. The shoots with high carbohydrate content usually root better. Broadly, there are four types of stem cuttings, namely hardwood, softwood, semi hardwood and herbaceous cuttings.

**Hardwood cuttings (HWC):** Cutting from mature and lignified stem of shrubs and trees are called as hardwood cuttings. Hardwood cuttings are prepared during dormant season, usually from one year old immature shoots of previous season's growth. The length of cuttings varies from 10 to 45 cm in length and 0.5 to 2.5 cm in diameter, depending upon the species. Usually, the cuttings of 25-30cm length, with pencil thickness are preferred. Each cutting should have at least two buds or more. While preparing the cutting, a straight cut is given at the base of shoot- below the node while a slanting cut, 1 to 2 cm above the bud is given at the top of cutting.



**Hard wood cuttings preparation and planting**

However, in case of hollow pith species such as Kiwifruit top cut should also be close to bud to avoid drying up of top portion. 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. A number of deciduous fruit plants like grape, hazelnut, chestnut, fig, quince, pomegranate, mulberry, plum, olive, gooseberry and apple etc. are commercially propagated by hard wood cuttings.

**Semi-hardwood (greenwood) cuttings**: Semi-hardwood cuttings are those made from woody, broad-leaved evergreen species and leafy summer and early fall cuttings of deciduous plants with partially matured wood. These types of cuttings are mostly used in evergreen fruit plants like mango, guava, lemon, jackfruit, some shrubs and shrubby plants and ornamental shrubs. The length of the cuttings varies from 7 to 20cm.

The cuttings are prepared by trimming the cutting with a straight cut below a node and removing a few lower leaves. However, it is better to retain two to four leaves on the top of the cuttings. While planting 1/4th of their length should be inserted in the soil. The best time for taking cuttings in summer, when new shoots have emerged and their wood is partially matured. It is necessary that leafy cuttings be rooted under conditions that will keep water loss from the leaves at a minimum. Commercially they are rooted under intermittent mist, fog or under polyethylene sheets laid over the cuttings. The concentration of rooting hormone depends upon the species to be propagated

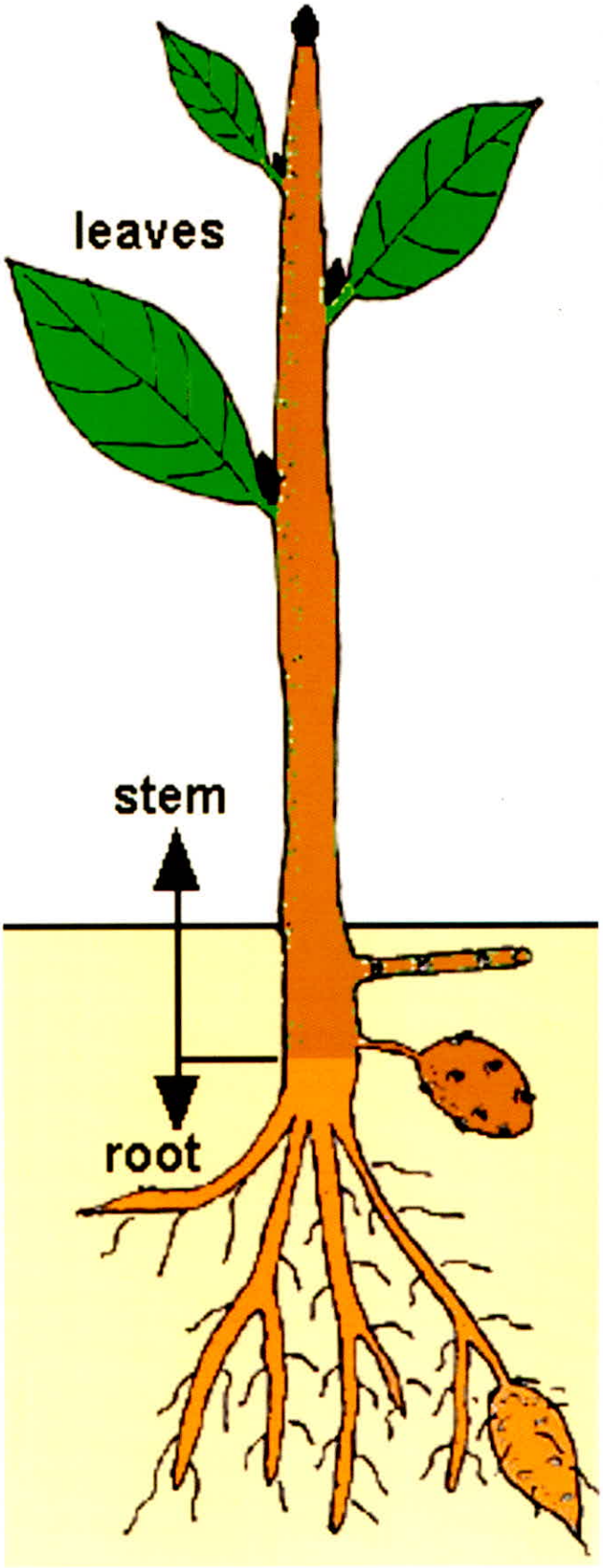
**Softwood cuttings:** Cuttings prepared from the soft-succulent and non-lignified shoots, which have not become hard or woody, are called as soft wood cutting. Such types of cuttings are very prone to desiccation. Therefore, proper arrangement for controlling humidity is required. Usually the cutting size is 5-5.7 cm but it varies from species to species. Usually, some leaves should be retained with this type of cuttings. The best time for preparing soft-wood cuttings is late summer. Softwood cuttings generally root easier and quicker than other types, but require more attention and sophisticated equipment. Temperature should be maintained during rooting at 23 to 27oC at the base of cuttings. The concentration of rooting hormone depends upon the species to be propagated.

**Herbaceous cuttings:** Herbaceous cuttings are made from succulent non-woody plants like geranium, chrysanthemums, coleus, carnation and many foliage crops. They are 7-15 cm long with leaves retained at the upper end. They are rooted under the same conditions as softwood cuttings, requiring high relative humidity. Bottom heat is also useful for initiation of rooting process. Herbaceous cuttings of some plants exclude a sticky sap (as in geranium, pineapple, cactus etc.) that interferes with root initiation process. In such cases basal ends of cutting should be allowed to dry for few hours before planting. Generally, fruit plants are not propagated by herbaceous cuttings.

**Root cuttings:** Propagation by means of root cuttings is also a simple and cheap method of vegetative propagation in species which are difficult to propagate by 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 1cm thickness and 10-15cm long are cut into pieces. Best time for taking root cutting is late winter or early spring, when roots are well supplied with stored food material 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 the open beds. Blackberry and raspberry are commercially propagated by this method. However, kiwi fruit, breadfruit, fig, rose, mulberry, apple, pear, peach, cherry and persimmon are also propagated by root cuttings.

**Leaf cuttings:** Propagation through leaf bud cuttings is partially useful in species where leaves develop root system but die because of non-development of shoot system. Leaf bud cuttings are particularly useful when planting material is scarce because the each node in leaf can be used as cutting. Leaf bud cutting should preferably be prepared during growing season because buds if enters into dormancy may be difficult to force to active stage. A leaf bud cutting consists of a leaf blade, petiole and shoot piece of stem with attached axillary bud of actively growing leaves. In leaf bud cutting, 1-15cm stem portion is used when propagating material is small. It is useful method of propagation in blackberry, raspberry, lemon, camellia etc.

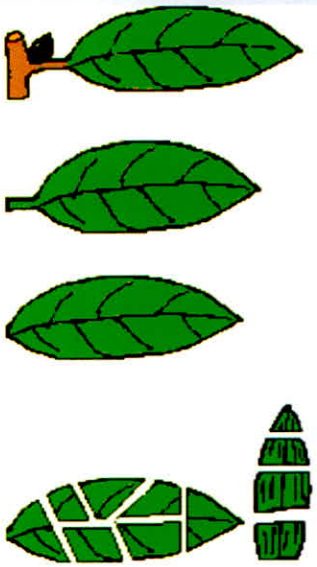
**LEAF CUTTINGS** - must form both adventitious shoots and roots (except leaf bud).




**a) leaf bud**

**b) leaf petiole**

**c) leaf blade**



**STEM CUTTINGS** - must form adventitious roots

**a) hardwood**

**b) semi-hardwood**

**d) leaf section**

semi-hardwood

**d) leaf section**

softwood
of herbaceous

**e) cane**

leafless stem

cane

rhizome

**f) rhizome**

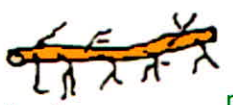
**g) tuber**

undergruond
stem

tuber

**ROOT CUTTINGS**

must form adventitious shoots



root section

root

tuberous

# PRACTICAL 7: LAYERING

**Layering or layerage** is a propagation technique where roots are induced to be formed on a stem prior to detachment from the parent plant.

**Advantages:**

1. It is an easy method and does not require much care and arrangement like cutting.
2. The mother plant supplies nutrient and other metabolites as it remains attached while rooting.
3. By using a large branch a much larger plant can be obtained in the first instance.
4. Some plants that cannot be satisfactorily started from cuttings can be propagated by layering.

**Disadvantages:**

1. It is a costlier method.
2. It is a slow process
3. Limited number of plants can be propagated
4. Layered plants are generally shallow rooted
5. Interference with cultivation
6. Require more individual attention
7. The beneficial effect of root stock cannot be exploited.

**Simple Layering:**

- Simple layer consists of bending an intact shoot to the ground to cause adventitious root to form (Fig.7.1). The method can be used to propagate a wide range of plants, indoor or outdoor on wood shrubs that produce numerous suckers.
- Layering is usually done in the early spring using flexible, dormant, one year-old shoot-branches of the plant that can be bent easily to the ground.
- These shoots are bent and "pegged down" at a location 15 to 20 cm (6-9 inches) from the tip forming a "U". Bending, twisting, cutting, or girding at the bottom of the "U" stimulates rooting at that location.
- The base of the layer is covered, leaving the tip exposed.

**Compound or serpentine layering:**

- It is modification of simple layering in which one year-old 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 lined out in the field. In this way many new plants can be made from one branch.
- It is also an easy plant propagation method to perform but is only suitable for plants producing slender, long and flexible shoots. Muscadine grape is commercially propagated by this method.

**Continuous or trench layering:**

- It is the most common method of propagation in woody plants, which produce long vines and are difficult to propagate by other methods of propagation.
- Vigorous roots of apple like M-16, and M-25 and walnut can usually be propagated by trench layering. In this method, it is important to establish a permanent row of plants to be propagated.

- The mother plants are planted at the base of a trench at an angle of 450C in rows spaced 90 cm apart.
- The long and flexible stems of these plants are pegged down on the ground to form a continuous line of layered plants.
- The young shoots that arise from these plants are gradually mounded up to a depth of 15-20 cm in autumn, winter or at the end of the growing season, depending on the species to be propagated.

**Air layering ( Marcottage, Gootee, Pot Layerage):**

- Air layering is an ancient method of layering, originally introduced from China and now commercially used for propagation of a number of tropical and subtropical trees and shrubs including litchi, longan, Persian lime (Citrus aurantifolia), ficus, croton etc.

**Mound /Stool layering or stooling:**

- The term stooling was first coined by Lynch in 1942. Mound layering is a method where the shoots are cut back to the ground and soil or rooting medium is mounded around them to stimulate roots to develop at their bases.
- This method is commercially used to propagate apple, pear, quince, currants, gooseberry and other fruit crops. In stooling, the mother plant is headed back to 15 to 20 cm above ground level during dormant season . The new sprouts will arise within 2 months.
- The sprouts are then girdled near the base and rooting hormones (IBA), made in lanolin paste is applied to the upper portion of the ring, the concentration of IBA depends on species but generally 3000 to 5000 ppm is commonly used.
- These shoots are left as such for two days for proper absorption of rooting hormone, before they are covered with moist soil. Care should be taken to keep the soil heaps moist all the times. It facilitates rooting in the stools.
- The roots in shoots may emerge within 30 to 40 days. However, the rooted shoots should be severed from the mother plants only after 60 to 70 days and then planted in the nursery.

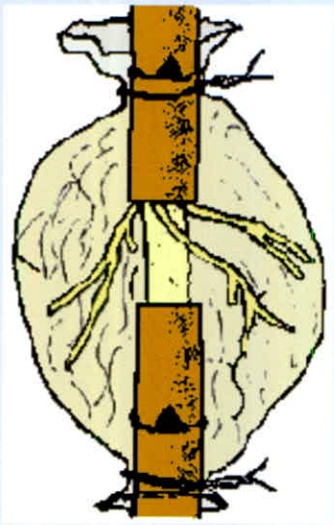
**Tip layering:**

- It is the simplest form of layering, which often occurs naturally. It is a natural method of propagation for black berries, raspberries etc.
- The tip of the shoots is bent to the ground and the rooting takes place near the tip of current season shoot. The stem of these plants completes its life in two years.
- The tips of shoots are buried 5 to 10cm deep in the soil. Rooting in buried shoots takes place within a month.
- The new plants (layers) may be detached and transplanted in the soil during spring. Currants, gooseberries and rambling roses can also be propagated by tip layering easily.

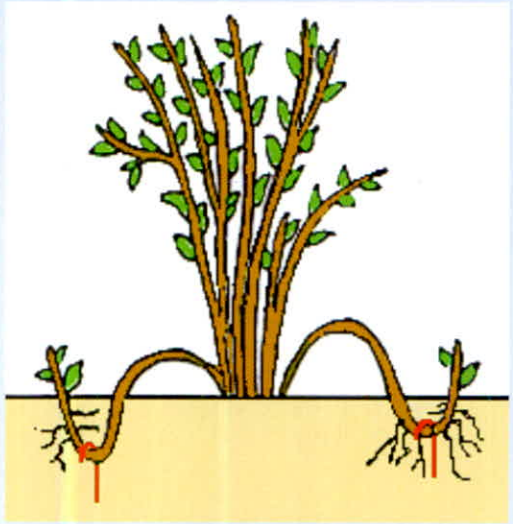
**Precautions:**

- The incisions should be given carefully
- The earthing-up should be done carefully
- The detached stools/ layers should be lined out properly for hardening.

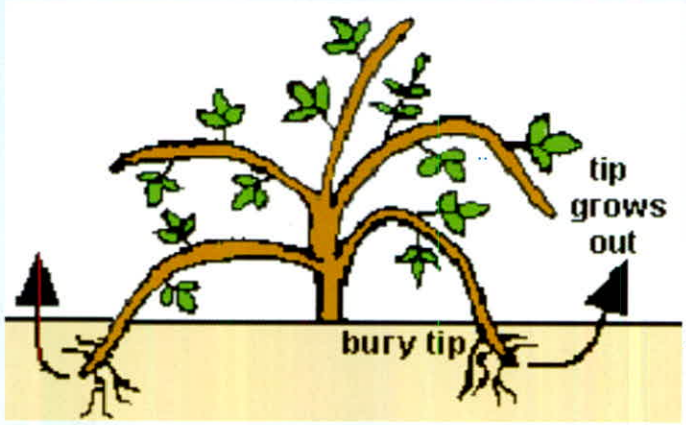
## TYPES OF LAYERING



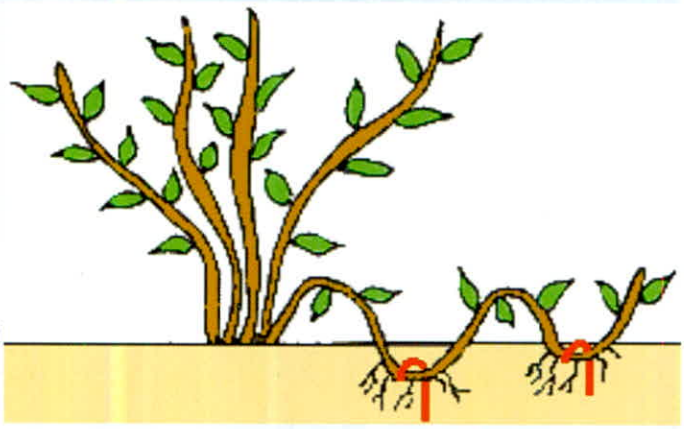
air layer



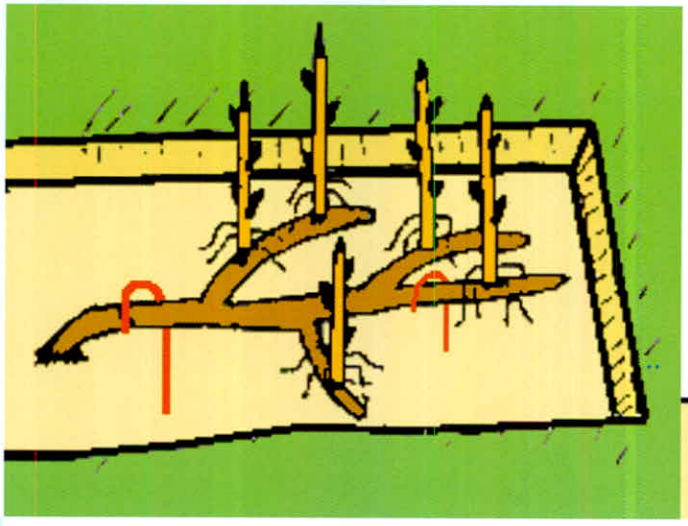
simple layer



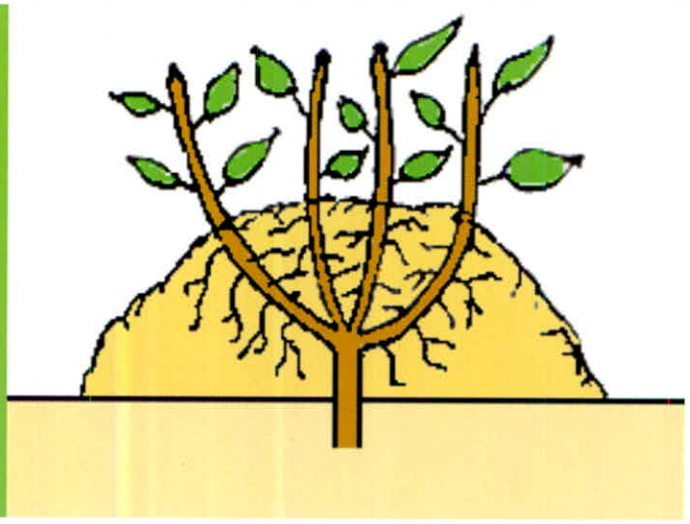

tip layer



serpentine layer



trench layer



mound or stool layer

# PRACTICAL 8: AIR LAYERING

**Monocot Air Layering**

1) Six to twelve inches (15-30 cm) from the stem tip, depending on the plant, make a diagonal (30-45o) cut or slit through a node and 1/3 the way through the stem. Place a toothpick, match stick or bamboo strip across the slit to hold it open.
2) Wrap the area with moist, but not soggy, coarse unshreaded sphagnum peat moss to form a ball approximately 7-10 cm (3-4") in diameter.
3) Wrap and completely enclose the sphagnum peat moss ball with a polyethylene (plastic) sheet. Tie-off the ends of the plastic with twist-ties (or rubber bands, or tape). Make sure no shreds of sphagnum extend from the polyethylene wrapping or it will wick-out all of the water.
4) The layered area may be covered with aluminum foil to decrease light and temperature build-up (i.e. greenhouse effect).
5) Bamboo stakes may be attached as splints along the stems across the layer for added support.
6) When a fair number of roots are visible in the sphagnum and against the polyethylene, cut the layer off from the parent plant just below the peat moss ball, and remove the foil and plastic. Pot the layer in a suitable medium and pot, then water well and place in a shaded area for a few days.

**Dicot/Gymnosperm Air Layering**

1) Six to twelve inches (15-30 cm) from the tip of the stem (depending on the plant species) make 2 ringing (girdling) cuts 1/2-1" (1-3 cm) apart. Connect the 2 cuts with a longitudinal slit and remove the cylinder of bark. Scrape the exposed surface of the stem to remove all adhering phloem and cambium.
2) Same as Steps 2-6 for monocot.

Removing epidermis for layering.

Packing moss around area to provide moisture.

Wrap in saran wrap to keep moisture in.

Removing sartan warp to see new roots and bud.

New bud with roots.

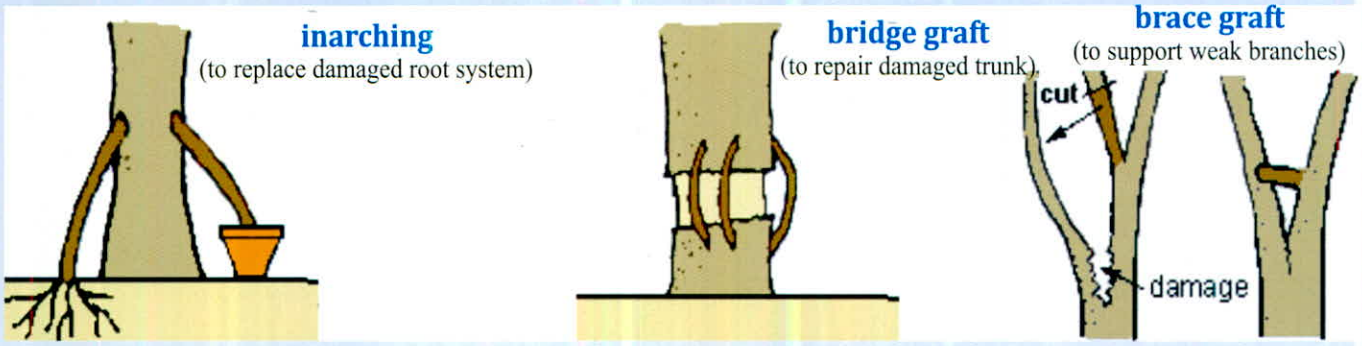
**Air Layering**

**Eg. Crotons, ficus, fig, Guava, Phalsa, Pomegranate.**

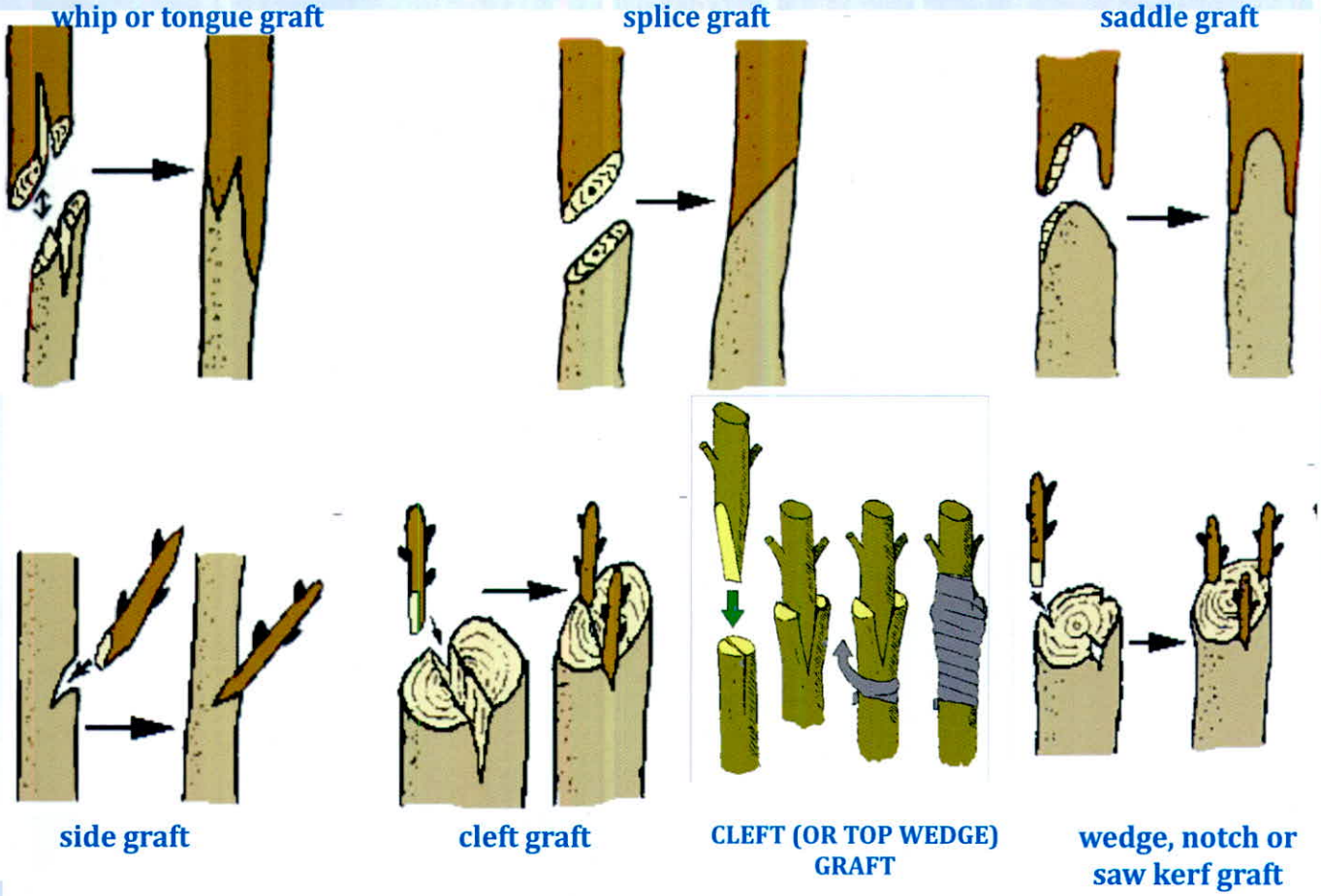
# PRACTICAL 9: GRAFTING

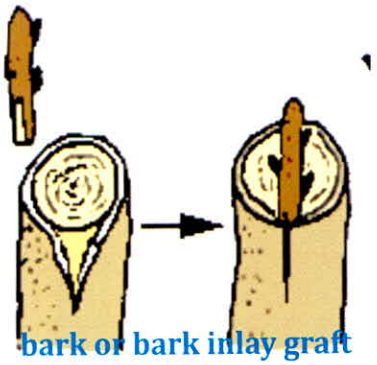
**Grafting** is the technique or process of joining two separate plant parts such that a union (intermingling of newly produced cells) is formed between the two parts, after which they continue growth as one plant. The upper part of the graft or top of the new plant is called a **scion** or **cion**, and the lower part of the graft or bottom of the new plant is called the **stock, rootstock or understock**. In some types of grafts a third stem piece is inserted between the scion and stock, which is called an **interstock**. The single plant obtained as a result of union between the stock and scion is termed as **Stion**.

**TYPES USED TO REPAIR DAMAGE**

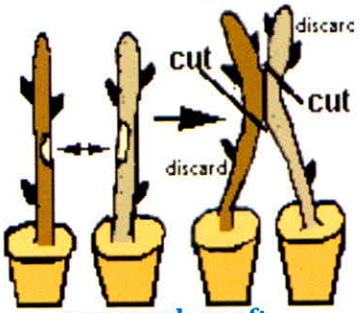



**TYPES USED WHEN SCION AND STOCK ARE APPROXIMATELY EQUAL IN SIZE**

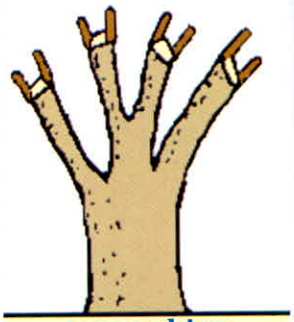




bark or bark inlay graft




approach graft



topworking

**Methods of grafting:** Mainly in grafting there are two types. ***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 (Scion Plant) till the graft union takes place where as in detached scion methods of grafting the scion is separated from the scion plant or mother plant just before grafting. Under attached scion methods of grafting simple inarching or approach grafting is most important.

**Simple 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. Eg.Guava, mango, Sapota.

***Procedure:*** Select a healthy shoot of having a 3.5cm girth on the selected mother plant which is to be used as a scion source. Select a root stock (raised in pot) having approximately the same size as that of the selected shoot on the mother plant. On the internodal region, where the union is to occur, a slice of bark and wood 2.5 to5 cm long is cut from both the selected stock and scion shoots. The cut should be given on the stock and scion should be of the same size. The cuts should be perfectly smooth so that a close contact of the cambial layers of stock and scion is brought about when they are pressed together.Tie the two cut surfaces together tightly with string or cloth.

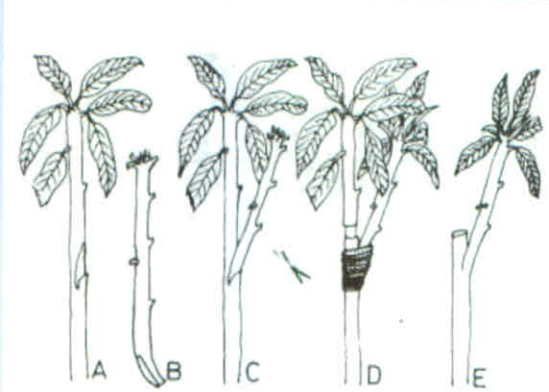
**Pre-curing of scion:** In detached scion methods of grafting, the scion is to be procured before grafting. For precuring, a partially matured scion shoot about the thickness of a little finger is selected.The maturity is indicated by the presence of dark green leaves and grey dark colour on the shoots. The selected shoot is defoliated retaining only the petioles up to a length of about 4? from the apical bud. The defoliated shoot is left on the tree for a period of 7-10 days. During this time, the bud on the shoot begins to swell. This shoot is then called as **-Pre-cured scion**, which is separated from the tree.

In detached scion methods of grafting there are two types-they are ***side grafting*** and ***apical grafting*** methods.

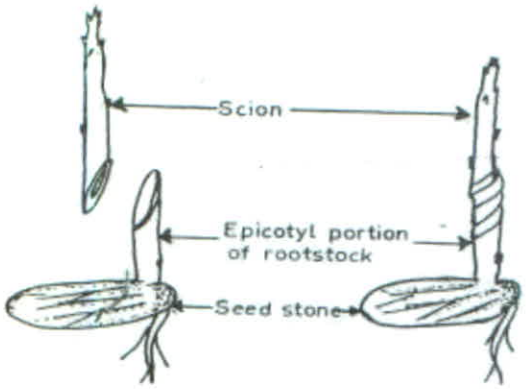
**Veneer grafting:** This is also a kind of side grafting with slight modification .It is used widely for grafting small potted plants and insitu grafting .Eg. .Avocado, Mango etc.

***Procedure:*** On the stock plant, at the desired height, in the internodal region, give a shallow inward cut running to a length of about 2.5 to 5cm. At the base of the first cut make another short and inward cut intersecting the first cut and remove a piece of wood and bark. On the scion , towards the base, give a long (2.5-5.0cm), slanting cut towards one side and another short, inward and downward cut on the opposite side.

The cuts given on stock and scion should be of same dimensions, so that, the cambium layers can be matched as closely as possible. Insert the scion on to the rootstock such that a contact of cambium is established at least on one side, and tie them firmly. After the union has healed, cut back the stock above the graft union either on gradual steps or all at once.



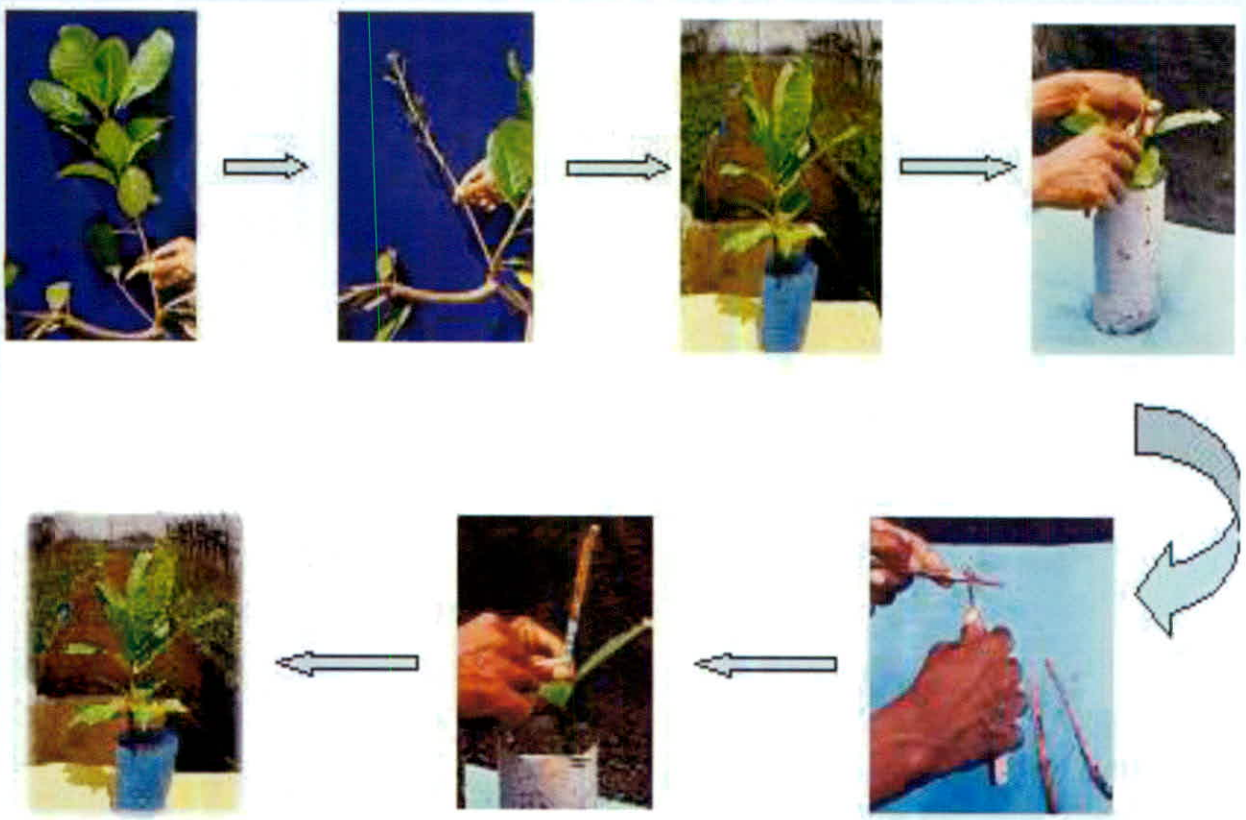

**A-Prepared root stock, B-prepared Scion, C-Scion inserted, D-Girdled stock and tied graft joint, E-Successful graft, the stock being removed**



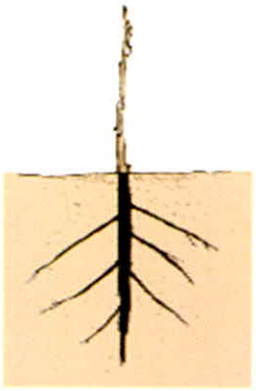

**Epicotyl grafting**

**Epicotyl (Stone) Grafting:** This method of grafting is done on the epicotyl region of the young seedlings; hence the name epicotyl grafting. Eg. Cashew, mango etc.

**Soft wood grafting:** It has been developed to graft small and young rootstocks which are grown in situ or in pots. Eg. Cashew, Mango.



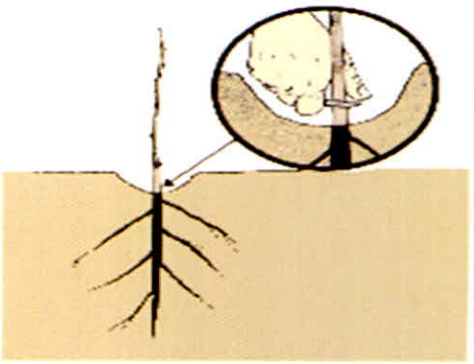
**Sotfwood grafting**



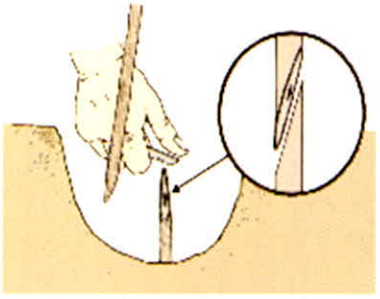
Step 1 - Selection

Step 2 - Tools

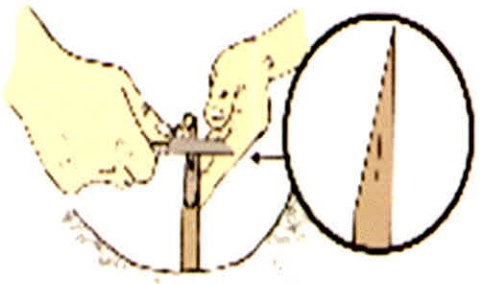
Whip Grafting



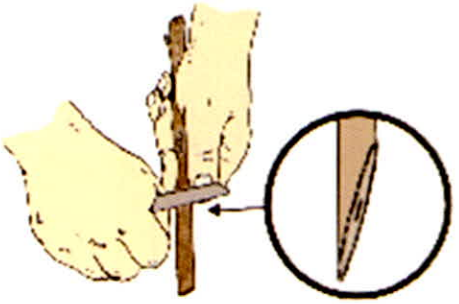
Step 3 - Cutting Stem to make area for grafting



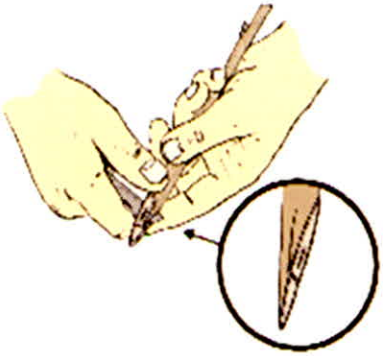
Step 4 - Showing how to make the cut



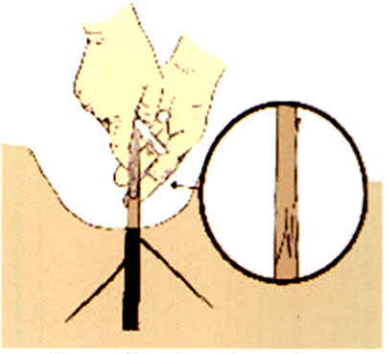
Step 5 - Adding the cut down through the middle



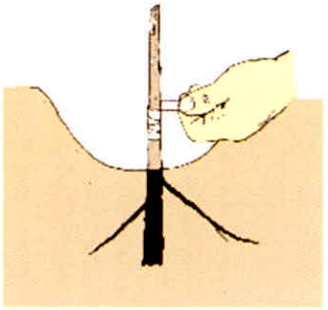
Step 6 - Making the cut on the grafting material



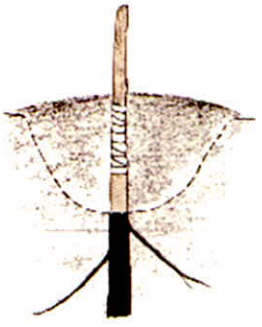
Step 7 - Making incision into the gratf



Step 8 - Putting the two grafts together



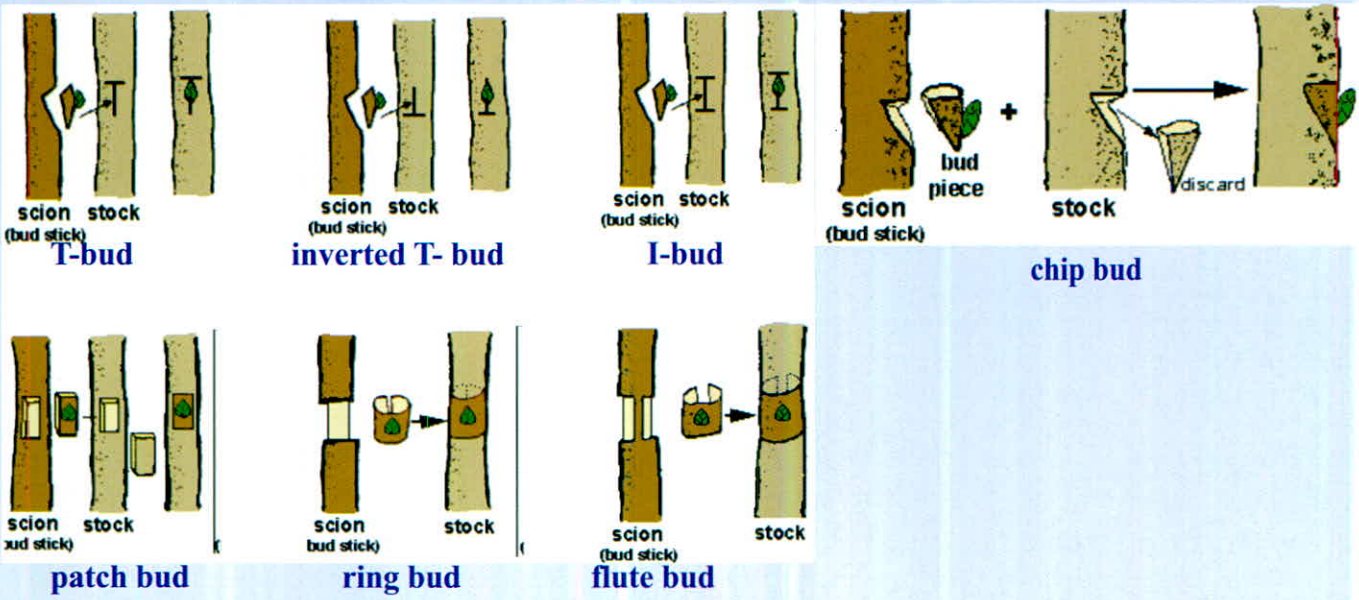
Step 9 - Wrapping the graft



Step 10 - Finished product

# PRACTICAL 10: BUDDING

**TYPES USED WHEN BARK IS SLIPPING** **TYPE USED WHEN BARK IS NOT SLIPPING**




**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. Eg.Citrus, Rose etc.

***Procedure:*** After selecting the stock plant, select an internodal region with smooth bark preferably at a height of 15-25 cm from ground level. Give a vertical cut through the bark to a length of about 2.5-3.75cm. At the top of this vertical cut, give another horizontal cut (1cm or 1/3rd of the circumference of the stem) in such a way that the two cuts given resemble the letter **T**. Lift the bark piece on either side of the vertical cut for the insertion of the bud. Select a required bud stick and start a slicing cut about 1.5cm below the bud and continue it upward and under the bud to about 2.5cm above the bud. Give another horizontal cut about 1cm above the bud. Remove the shield of bark containing bud. The traces of wood, if attached may be removed. Insert the bud between the flaps of bark on the stock with the help of budding knife in such a way that the horizontal cut of the shield matches the horizontal cut on the stock. Wrap the bud stick tightly with polythene strip exposing only the 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"*. This means that the vascular cambium is actively growing, and the bark can be peeled easily from the stock piece with little damage.

**Securing the Bud:** Pull the cut together by winding a 10 to 12 cm long polythene strip around the stem to hold the flaps tightly over the bud shield and prevent drying. Secure the polythene strip by overlapping all windings and tucking the end under the last turn. Do not cover the bud.

Removal of Bud

T Shaped cut on the Rootstock

Inserting the Bud

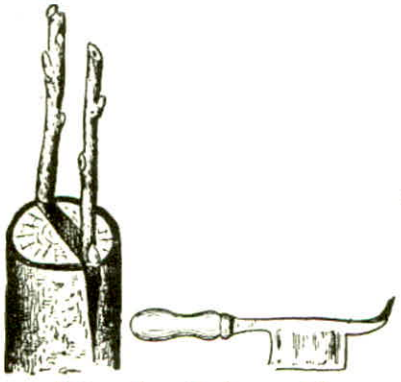
Securing the Bud with Polythene

Bud and stock Joint

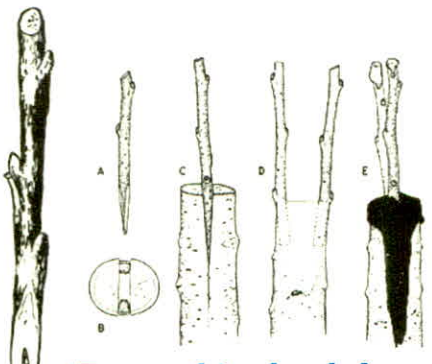
**Inverted T- Budding:** In heavy rainfall areas, water running down the stem of the stock may enter the T cut, soak under the bark and prevent healing of the bud piece. Under such conditions an inverted T budding may give better results as it is more likely to shed excess water. Inverted T budding procedure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

**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.

This practice is resorted to (1) when the existing tree is of inferior type, (2) when the tree is unproductive and (3) to provide pollenizers (4) to change the variety. For top working different methods of grafting like cleft grafting, bark grafting, splice grafting or side grafting can be used. However, cleft is the most popular and commonly used method for top working especially when thick branches are selected. When younger and thin branches are used, whip and tongue grafting are best. Top working of older trees is generally done over a period of two years. In the first year, half of the scaffold branches are top worked retaining the other branches as nurse branches which in turn are grafted in the second year. In the smaller and comparatively younger trees the entire tree is top worked in the first year. Here also one or more nurse branches are retained till the union is successful. Nurse branches protect the top worked scions from winter injury, sun burn and also from desiccating winds and water sprouts develop less frequently when nurse branches are retained.Top working is most successful when relatively young trees are used. If older trees are selected for top working, it is better to select vigorous lateral branches that arise from the main limbs.The branches to be top worked should be cut in such a way that the cut surface is smooth and is at a point of the branch where there are no knots or smaller branches.



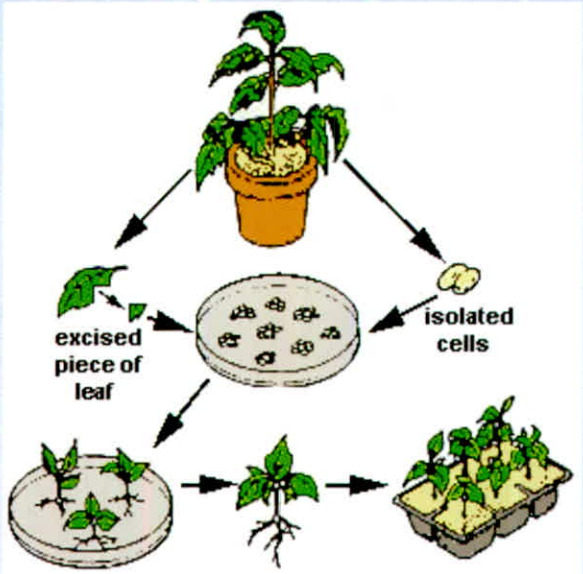
Top working by cleft grafting



Top working by cleft grafting on main branches

# PRACTICAL 11: PROPAGATION BY TISSUE CULTURE (MICROPROPAGATION)

Tissue culture (often called micro propagation) is a special type of asexual propagation where a very small piece of tissue (shoot apex, leaf section, or even an individual cell) is excised (cut-out) and placed in sterile (aseptic) culture in a test tube, Petri dish or tissue culture container containing a special culture medium.




**Overview of the Tissue Culture Process**

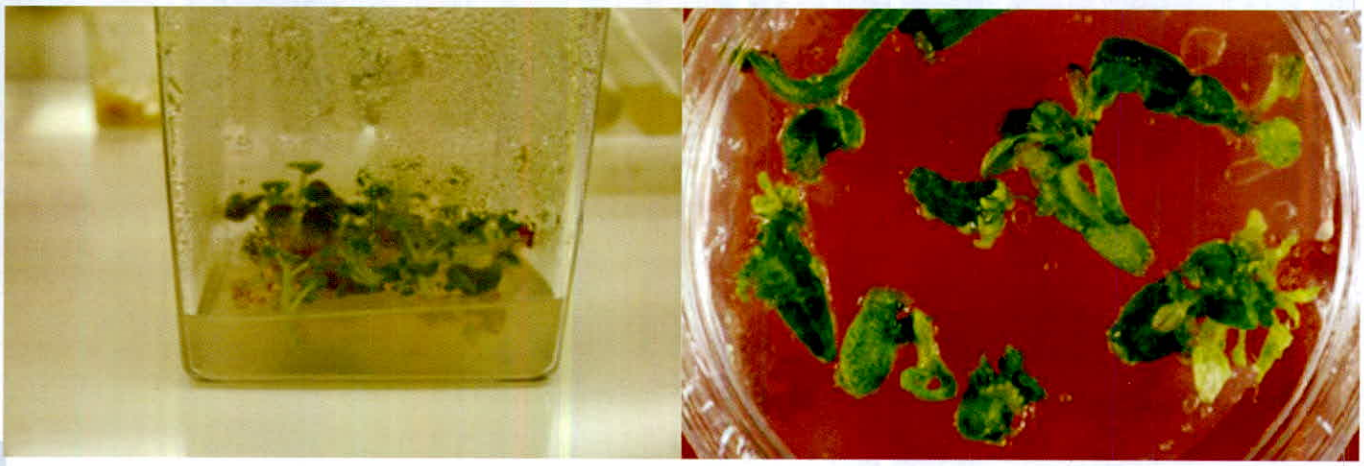
## Steps in Tissue Culture

**Explant: Cut-out Plant Tissue and Place in Tissue Culture Container**

The first step is to obtain what is called and explant. An explant is a very small piece of leaf, stem, flower or root tissue, the growing point , or even isolate individual cells that are cut and removed from the plant and placed in a tissue culture container. The tissue has to be sterilized so it will not have any contaminating bacteria or fungus. It is then placed inside the tissue culture contain on a gel called agar. In the agar is dissolved all the sugar, nutrients and hormones the plant needs.

Explants can be pieces of any part of the plant (leaves, stems, flowers, etc.), or even individual isolated cells.

**Multiplication: Tissue Grows and Produces Small Plants**



**New plantlets (shoots with leaves) are forming.**

The tissue will begin to grow. It may make a big blob of tissue called callus, or it may make new shoots directly from the explant tissue that was inserted in the container. A mass of callus tissue is formed that is just starting to make new plantlets.

If the conditions are right a small "forest" of plants will develop in the tissue culture container.

### Rapid Multiplication by Transfer of Cultures

Once the plantlets start developing, some can be removed and placed in new tissue culture containers. Thus, another "forest"' of plants is produced. This results in a rapid multiplication of the cultures and many thousands of plants can be produced in a few months.

Some of the small plantlets can be removed and transferred to new tissue culture containers. These will produce more shoots and fill the container.

### Transplanting

When the plantlets are large enough, they can be removed from the tissue culture container and transferred into pots with potting soil. The young plants are growth in a greenhouse just like you would any young seedling or cutting.

When the small plant clones are removed from the culture containers, they must be transplanted into some type of acclimation container or kept under a mist system until the acclimate to the ambientenvironment.

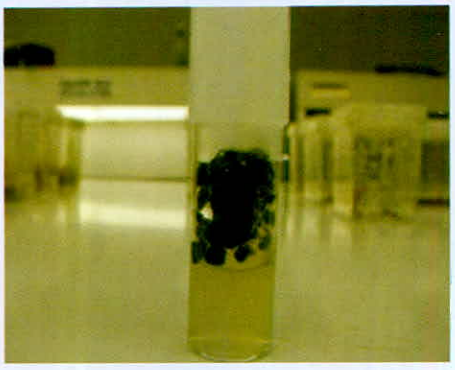
After acclimation, the young plants can be transplanted and grown in pots in a greenhouse to produce new plants.

### Tissue Culture Transfer Protocol

Demonstrating the protocol to transfer African violets from tissue culture containers where they were grown into a small "forest" of cloned plants (called multiplication culture tubes) to tissue containers where the young clones will form new roots. After the roots are formed, they can be removed and potted into containers. This procedure must be done in the sterile environment of a transfer hood.

Sterilize the surfaces of the transfer hood.

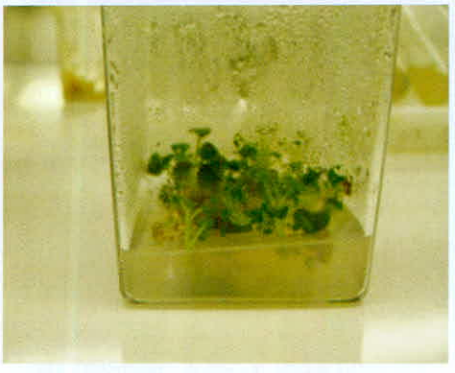
Sterilize all tools that touch the plants by first dipping in alcohol them flaming.



African violet clones in a shoot multiplication tube.

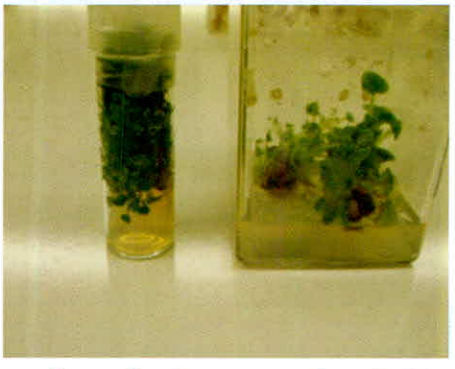
Remove the cluster of plants in the culture.

Insert the cluster of plants into the new culture container.



Break up the cluster of plants and spread them out.

Seal the container with paraffin film.



The culture before transfer (left) and after transfer (right).

## PRACTICAL 12: DIGGING, LABELLING AND PACKING OF FRUIT PLANTS

1. Grafted or budded evergreen plants. Which are generally 1 to 11/2 year old and may be 60 to 75 cm height, are lifted from the nursery. Root system of such plants is also developed upto 20-30 cms deep. Lifting of plants is generally done with the onset of monsoon when the prospective growers purchase plant material for transplanting in their fields.
   Eg: In case of grapes, rooted cuttings are lifted in January which is the planting season.
2. In case of evergreen plants, the plant is lifted along with ball of earth and maximum care has to be taken to cause minimum damage to roots. As such, nursery beds should be irrigated lightly before actual lifting of plants. The first step in lifting of the evergreen plants is to firm the loose soil around the plant with the help of a beater. Then, by using a digging fork, remove the soil from one side of the plant upto 20 to 30 cm and then from the other side. This will facilitate lifting of the plant slowly along with ball of earth. Scrape off the earth ball to a suitable size. Trim the exposed roots, some small shoots and a few leaves to keep a proper balance between the top and the root. In this manner, required number of grafts are lifted for packing. The earth ball is then wrapped firmly with paddy straw or with banana leaves in South India. The root portion of the plants is then packed with gunny cloth and wetted and tied. The top portion of plants in the package may also be tied about 4 to 5 cm downwards so that tops also remain together. This method is called 'ball and burlapped' method.
3. Rooted cuttings or seedlings may be transferred after lifting in polybags which may be placed in a container Empty spaces like corners in the container may be filled up by grass to serve as cushion to avoid jerks during transport.
4. When plants are packed with bare roots. It is advisable to pack them with moist moss covering root portion further wrapping them with polythene or water-proof cover. This is further covered with hessian clath which is wetted by sprinkling water. These are then kept in cardboard or plywood or bamboo baskets for transportation.
5. There is also a practice of packing plants in wooden or bamboo baskets with a flat base, having 25 to 30 cm height and a circular rim. Plants are kept in such baskets and cushioning of grass is provided in gaps. These are useful for sending plants to long distance without damage. It is, however, essential to maintain moisture content by sprinkling water during transit on the wrapping of root portion.
6. In every package of plant material, keep only one variety and plants of same size.
7. After packing, label the package indicating the name of fruit plant, variety, name and address of the sender and receiver. Use of semi-permanent label would be useful so that it remains intact during transport. Mark of identification of nursery may also be made.
8. Small-sized, undersized, insect-damaged or disease-affected plants as well as those having poor root system should not be lifted and packed for sale because they will not establish satisfactorily in the orchard of purchaser and may thus bring discredit to the nurseryman.
9. There would also be a demand for supply of bud sticks for in situ grafting or budding. Select proper bud sticks of pencil size in perfect sap flowing condition with unsprouted buds. Each bud stick may have 4-5 buds. Wrap the bud sticks completely with moist sphagnum moss and put them in polybags having few pin holes for aeration. Generally, the package is dispatched by post parcel or courier service. It is, however, necessary that bud sticks must be used within 3-4 days after detachment from the mother plant. Label the package indicating the fruit crop, variety, etc. To avoid delay in transit and spoilage of bud sticks, it would be desirable that the grower or his representative should personally visit the nursery and carry the package with him to avoid any delay in grafting/budding

# PRACTICAL 13: PREPARATION AND APPLICATION METHODS OF PLANT GROWTH REGULATOR SOLUTIONS FOR SEED GERMINATION AND VEGETATIVE PROPAGATION.

**Preparation of growth regulator solution:**

- The strength of growth regulators is calculated in ppm (parts per million). One ppm means 1.0mg of chemical dissolved in one litre of water.
- After weighing the required quantity of growth regulator transfer it to a beaker and dissolve it with the small quantity of solvent.
- Auxins are soluble in alcohol or 0.1% NaOH. Gibberellins are soluble in absolute alcohol, while, cytokinins can be dissolved in 1-2 ml N/10 HCl.
- Abscisic acid is highly soluble in NaOH. Shake the beaker till the growth regulator/chemical is fully dissolved. Now transfer it into volumetric flask and make final volume with distilled water to one litre.

**Preparation of hormonal powder:**

- For preparation of hormonal powder, the required quantity of hormone is weighed precisely with the help of sensitive balance.
- It is dissolved in ½ litre ethanol, methanol or acetone in a beaker. This material is poured into one kilogram of talc taken in mortar and mixed thoroughly with a glass rod.
- After mixing, the mixture is kept open in air for few hours. The alcohol will evaporate soon, after which, the dried talc is ground to a fine powder.
- This fine powder should be kept in air tight containers to avoid moistening and can be used as and when required.

**Preparation of hormonal paste:**

- For preparing hormonal pastes, the required quantity of the hormone is weighed accurately and dissolved completely in a few drops of alcohol.
- The required quantity of lanolin (wool fat, a product similar to grease and is greenish-yellow in colour) is weighed and heated slightly in a beaker under gentle flame.
- When the lanolin is slightly liquefied the dissolved hormone is poured in it.
- The mixture is dissolved thoroughly with constant stirring with a glass rod. The mixture is allowed to cool down.

The paste is ready for use. Until use, the paste may be kept for few months in a cool dry place but one should prefer to use fresh paste.

**Precaution:**

- First of all check the expiry date of the hormone powder.
- The weight should be taken precisely, preferably on electronic balance.
- Proper solvent should be used to avoid precipitation.
- Hormones deteriorate under high temperature, so store in cool and dry place.
- Hormones are photosensitive; therefore they must be stored in dark or amber colored bottles.
- Use hormonal solutions for treatment of cuttings and lanolin paste for layers.
- Solutions should be prepared fresh. If required to store for some time use, refrigerators.
- The treated cuttings should be planted with the help of some stick to make hole, so as to avoid removal of solution from basal end of cutting.

## Method of application of growth regulators:

The effectiveness of growth regulators not only depend the concentration, but also on the method of application. Auxins are most effectively and widely used rooting hormone. Among synthetic auxins IBA and NAA are found to be most effective for inducing rooting. The different methods used for treatment of cuttings and layers are as under:

### Prolonged soaking method:

- In this method, the basal end of cuttings is dipped in the dilute solution of the hormone for 24 hours in a cool dry place.
- The concentration of hormone or growth regulator usually varies from 20ppm to 200 ppm, depending upon plant species and type of cutting.
- After treatment cuttings are planted in growing medium. The concentration is usually low in growing medium.
- The concentration is usually low for easy to root species and vice versa.
- This method is very useful for difficult to root species, where some materials like vitamins, sugars and nitrogenous compounds are also used along with the growth regulators for facilitating rooting.

### Quick dip method:

- In this method, the basal end of cuttings is dipped in the concentrated solution of a hormone for a short time, usually for 5 seconds to 2 minutes depending upon the species to be propagated.
- Treated cuttings are planted in the rooting medium or field. The concentration of hormone for quick dip method may vary from 500 to 10,000 ppm depending upon the type of cutting and species, but generally a concentration of 3000 to 5000 ppm is used.

### Powders dip method:

- In this method also basal ends of cuttings are dipped in the hormonal powder which carries (talc) for some time.
- After treatment of cuttings, extra amount of powder adhering to the cuttings should be removed by shaking and cuttings are immediately inserted into the rooting medium.
- For effective rooting, the cut ends of the cuttings should be moistened before the treatment and care should be taken that extra powder adhered to cuttings should be shaken off, otherwise, it may cause adverse effect on the rooting process.
- Seradix, Rootex or many other formulations are available in the market as powders.

### Lanolin paste method:

- As described under preparation of hormonal paste, the paste of growth regulators made in lanolin is applied to the girdled portion of a layer or stool for inducing rooting in them.

### Spray method:

- Spraying of growth regulators is sometimes done to mother plants before taking cuttings from them. Spraying of stock plants with 2,4,5-T in concentrations ranging from 25 to 100 ppm is done about 30 to 40 days before taking cuttings from them, Cuttings taken from such plants root better as compared to untreated plants.

## PRACTICAL 14: EXERCISES ON PREPARATION OF PLANT GROWTH REGULATORS SOLUTION.

**Preparation in powder medium**

Now indigenous prototypes of Seradix are available in the name of Rootone, Surutex, Arodix and sereral other brands. These products can be manufactured in small laboratories by anybody having some knowledge of handling laboratory chemicals and apparatus.

**Calculation of chemicals -** Let us presume that we have to prepare 500 g of 5000 ppm IBA in powder form. Calculate first the quantity of IBA needed for this purpose. The calculation is simple:

1 ppm means 1 mg of the hormone in 1 kg or 1000 g of talc.
Therefore, 5000 ppm means 5000 mg of the hormone in 1000 g of talc
Or, For 1000 g talc 5000 mg IBA will be required,
Hence, For 500 g talc (5000 g ÷2) =2500 mg (2.5 g) IBA will be needed.

**Procedure:** After the calculation is over, weigh 500 g talc, previously strained, in the physical balance and put it in a 1 litre beaker. Weigh 2.5 g IBA in chemical balance and put it in another 200 ml beaker and mix some ethyl alcohol with it and stir with a glass rod till the hormone goes into solution. The quantity of alcohol should be such that when mixed with the powder it makes a clayey substance. About 250-300 ml of alcohol is needed per kg of talc for this purpose.

Pour the alcoholic solution of the hormone into the talc, stir vigorously with the glass rod for five minutes and leave it covered with a handkerchief overnight. The alcohol evaporates completely and next day the material forms a soft cake. Break it finely and pass trough the strainer. Store the powder in an airtight container for future use or pack into smaller containers for sale.

**Preparation in water medium:** Hormone concentrations are prepared in aqueous form for immediate use. Here the equivalent of 1 kg is taken a 1 litre.

The procedure is, however, slightly different. Take the required quantity of hormone in a 1-litre beaker and go on adding small quantities of alcohol with it while continuously stirring with a glass rod till it goes into solution completely. Now, add slowly distilled water while continuously stirring till the level of water reaches 500 cc mark. The solution is ready for use.

Sometimes the hormone may return as precipitate after the addition of distilled water starts, In that case some more alcohol has to be added till the precipitate dissolves. Continue filling with the distilled water till the mark is reached.

**Example:** Prepare 1 % solution of auxin (NAA or IBA)

**Method of preparation:** 1 g of substance (NAA or IBA) is taken on butter paper and weighed by using digital chemical balance. The substance4 is transferred into a beaker very carefully and dissolved by adding few ml. of pure alcohol. Then the volume is made upto 100ml by adding distilled water.

**Preparation in lanolin medium:** Lanolin is an organic product from wool. It looks like the common vaselin, a brand name of petroleum jelly, used as lubricant or as base for preparing ointment, cosmetics etc. A common use of Vaseline is to keep the leather of football, volleyball etc. soft and resistant to damage by water. Semi-solid in ordinary temperature, lanolin becomes liquid when put under low fire for some time.

Calculate the quantity of hormone as before and weigh it in a chemical balance. Weigh the required quantity of lanolin with the physical balance in a heat resistant Pyrex glass beaker. Put the beaker on a low

flame of the burner. Take away the beaker from the flame when the lanolin melts to the liquid form; mix the hormone gradually while stirring the lanolin vigorously with a glass rod. Continue stirring for 5 minutes more after the addition of hormone is over to ensure a thorough mixing. Hormone in lanolin medioum is sticly. It is convenient for use in layering. This preparation is not available in the market and,therefore, has to be prepared for personal use.

**Example:** Calculate the quantity of IBA in gram to prepare 5000 ppm of 3 kg lanolin paste of IBA?

**Solution:** 1 mg IBA in 1 kg of lanolin paste =1 ppm

**For 1 kg**

1 ppm=1 mg IBA in 1kg

Therefore,5000 ppm =5000 mg in 1 kg

=5 g

**For 3 kg**

=5g x3=15g

Hence 15 g IBA is required to prepare 5000 ppm of 3 kg lanolin paste.

**Conversion of solution in % to ppm or vice-versa:**

- 1 % =10,000 ppm
- 1 ppm = 1/10000 %
- Or 1 ppm = 0.0001 %
- ppm x 0.0001 = %

- ppm = % / 0.0001
- or ppm = % x 10000

**Storage of hormone preparations:** Whatever may be the medium of preparation of hormone, the products must be stored in a dark and cool place. If it is intended to be stored in a glass container, its colour must be dark. If the storage container is transparent, it should be wrapped with a black paper outside. Strong light damages the effectiveness of hormone.

**Technique of use:** In plant propagation hormone in powder form is widely used. Powder does not stick to a dry surface. Therefore, the surface should be moistened before application.

For this purpose the basal 5 cm part of the cuttings should be dipped in water and the excess water should be absorbed with a piece of moist cotton cloth.

In layering the part, where the powder is to be applied, should be lightly rubbed with a moist cloth so that the place becomes receptive to the hormone powder. If the concentration in the instant method is 5000 ppm it is only 150 ppm in the prolonged dip method.

# PRACTICAL 15: NUTRIENT MANAGEMENT IN NURSERY

## Manures and Fertilizers Application in Nursery

### Types of Manures

The excreta of animals including dung and urine, along with straw and other organic materials are used as manures in crop production. The decomposed manure is called Farm Yard Manure. The average composition of well decomposed Farm Yard Manure is 0.5 per cent nitrogen (N), 0.3 per cent Phosphorous (P2O5) and 0.5 per cent Potassium (K2O). For the best performance of fruits and vegetables balanced nutrition of the nursery plants are necessary. alance nutrition can be achieved by supplying nutrients in both organic and inorganic form.

- Organic manures
- Inorganic fertilizers or chemical fertilizers
- Biofertilizers

### Manures

Manures are prepared by using plants and animals debris.It can be categorized as follows:

1. Manures from plant origin e.g. green manures
2. Manures from animal origin e.g. Poultry manure
3. Manures from plants and animal origin e.g. Compost, Farm Yard Manure.
4. Organic fertilizers e.g. Bone Meal, Fish Meal, Blood Meal.

### Biofertilizers

1. Nitrogen supplying biofertilizers- Azotobacter, Rhyzobium, Acetobacter, Azospyrillum.
2. Phosphate supplying biofertilizers - Phosphate solubalizing bacterias (PSB)
3. Microbial decomposers- Tricoderma viridae

### Important Points regarding the Nutrition Management in Nursery Plants

- Selective and balanced nutrition should be given to the mother plants through soil or irrigation. Excess nitrogen will reduce the root growth.
- In nursery different types of rooting media are used. It does not contain nutrients so we have to provide nutrition according to plants need.
- In nursery extra attention should be given to nutrition in sprouting, root initiation stage, hardening of plants. Nutrient deficiency can be reclaimed through application of foliar sprays.
- For balanced nutrition organic manures, inorganic fertilizers and bio-fertilizers should be used together.

### Fertilizer Requirement of Different Nursery Plants.

Manures and Fertilizers are applied in a Nursery to provide adequate nutrients for growth and development of nursery plants, to provide essential nutrients during critical growth period of plants to achieve well developed, healthy and pest and disease free plant growth.

**(A) Fertilizer Requirement of Vegetable Nursery Plants**

1. Fully decomposed organic manure and chemical fertilizer grade is used to fortify sterilized coco peat.
2. Drenching: Soluble fertilizers as 19:19:19, 12:61:00, 00:52:34, 00:00:50, 13:00:45 are used at 2gm/lit of water along with fungicides. In vegetable nursery tomato, chilly, brinjal, cabbage, cauliflower, melons at the interval of 6-7 days for the period of 25-30 days 3-4 times till the date of transplanting.

3. Foliar application: The same grades of soluble fertilizers are used in the foliar application @ 2 gm/ liter of water. The foliar application is done 4-5 times according to the growth stage of nursery plants until the seedlings are ready for transplanting.

**(B) Fertilizer Requirement of Fruit Nursery Plants.**

1. Media for filling polythene bags - Red soil and decomposed FYM or compost are mixed thoroughly.
2. Drenching of soluble fertilizers is done 5-6 times according to growth stages @ 2gm/liter of water.
3. Foliar application of fertilizers 5-6 times through spraying is done according to plant growth stage @ 2gm/liter of water.

**Methods of Application of Manures and Fertilizers**

**1. Broadcasting:**

Bulky organic manure like FYM and compost are broadcasted over the beds and mixed thoroughly with the help of a spade or rake. The seeds are sown once the beds are well prepared.

**2. Ring around Stem:**

Grown up trees and plants are given manures and fertilizers by making ring around the trunk or stem of the plant.

**3. Fertilizer Placing Near Plants in Polybags/Urea Brickets**

Fertilizers are placed directly in the polybags near the stem with the help of weeding hoe in adequate doses.

**4. Fertigation:**

Adequate dose of fertilizers can be mixed in the irrigation water and given to nursery plants through drip or sprinkler irrigation or drenching near the stem.

**5. Foliar Fertilization:**

Fertilization of plants or feeding nutrients to the plants by spraying chemical fertilizers on the foliage. This is also known as foliar feeding or spray fertilization.

# PRACTICAL 16: PEST MANAGEMENT IN NURSERY

## Pest Control

In the present day context, pest control includes the use of all those methods which are employed for preventing pests and diseases without disturbing environment.

## Methods of Pest Control

Important methods of pest control are briefly described below:

1. **Cultural Method:** It refers to manipulation of farm practices to check the pests. Some of the important cultural methods are: Crop rotations, Tillage methods (deep summer ploughing), High seed rate, Water management, Manipulation of date of sowing, and Trap cropping.

2. **Physical Method:** Various physical methods are: Temperature manipulation, Moisture manipulation, Light manipulation, and Use of sound.

3. **Mechanical Method:** This refers to the use of mechanical implements and devices like Screens, traps, nets and suction devices, Hooking devices with iron rod in the hole bore by the insect, Banding with grease or polythene sheets on stem, Covering of seedling with net; and trenching and water barrier-ant pans.

4. **Legal or Regulatory Method:** This refers, to the legal restrictions proposed by the Central and State Governments such as Inspection and quarantine and Destructive Insect Pests Act can be enlisted under this heading.

5. **Resistant Varieties:** Use of resistant varieties help in avoiding or tolerating or recovering from pest attack.

6. **Biological Method:** This method refers to the use of natural enemies of pests viz. parasites, predators and microbes or pathogens (bacteria, virus, nematodes, fungi, protozoa etc.) for conservation and encouragement of indigenous natural enemies, importation of exotic natural enemies and mass rearing and releases of parasites/predators and microbes.

7. **Chemical Control:** Pesticides are without any doubt an effective means of killing pests quickly and on demand. No other control method provides users with an immediate and visibly effective means of pest control.

8. **Use of Botanical Pesticides:** Many plant products (leaf extracts, oils and cakes) and oils are sprayed on the crops. Neem oil, neem cake and other neem based formulations have been found effective against pests. The various methods of pesticides application are Seed treatment, foliar application, Soil application, Granular application, Seedling root dip, Fumigation, Baiting etc.

## Use of Pesticides in Pest Control

| Pest | Damage | Management |
|---|---|---|
| Aphids | Aphids damage the plants by sucking the leaf sap in young stage, cotyledonary leaves crinkle and in severe cases the plants withers off. | Spraying Malathion (0.1 %) or Metasystox (0.1-0.2%) |
| Jassids | Both nymphs and adults suck the sap from the lower surface of the leaves. The infested leaf curl upward along the margins, which may turn yellowish and show, burnt up patches. | Spraying Malathion (0.1%) or Dichlorvos (0.05%) |
| Root-Knot Nematodes | The affected plants show the development of galls on the roots. The plants become stunted and the leaves show chlorotic symptoms. | Treating the nursery beds with Phoret @ 5 g a.i./m2 or Neem Cake 1 kg/m2 Select resistant varieties. |
| Thrips | Nymphs and black adults feed on tender leaves causing silvering, mottling and distortion of leaves. | Soil application of thimate twice at 15 days interval at 5 gm/bed and also take spray. |
| Leaf Miner | Larvae attack tender leaves and feed in the epidermal layers of the leaf by making serpentine mines in which air gets trapped and gives them silvery appearance. | Spraying the plants with Quinalphos @0.05% |
| Cutworms | The tender plants are found damped at ground level during the night Young larvae feed gregariously on foliage but later segregate and enter into soil. | Soil application of Phorate (1kg a.i./ha) |
| Whitefly | The damage by whitefly also leads to yellowing of leaves and stunted growth, in severe cases leading to shedding of leaves | Spraying Triazophos 40 EC (1.5 ml/ L of water) + 1.0 ml of Dichlorvos 76 EC per litre of water. |

# PRACTICAL 17: DISEASE MANAGEMENT IN NURSERY

## (A) Preventive Measures

**Cultural Practices:**

Cultural practices exert significant influence on the microclimate of the crop plants in a field.

## (B) Control Measures

**Chemical Control:** The chemical control of plant diseases is classified in three categories: seed treatments, soil treatments and protective sprays or dusts.

**1. Seed Treatments :** Seed treatment is of two types; viz., physical and chemical. Physical treatments include hot-water treatment, solar-heat treatment, etc. Chemical treatments include the use of fungicides and bactericides.

**2. Soil Treatments:** Formaldehyde or captan applied against sclerotia-producing fungi that cause seedling blights, stem rots, and root rots of many nursery seedlings.

**Protective Sprays and Dust:**

Protective fungicides prevent germination, growth and penetration. In order to use protective fungicides effectively, the farmer must not only select the right fungicide for the job but also apply it in the right amount, at the right times and in the right way. Too little fungicide fails to control disease; too much can prove toxic to the plants to be protected. The nurseryman and applicator, therefore, must always follow use instructions to the latter. Timing of applications is also critical.

**Important Diseases and their control measures**

| Diseases | Symptoms and Damage | Management |
|---|---|---|
| Damping off | The infections take place at the base of the young stems or at the soil level. Tissue becomes water soaked and rapidly collapse thus topping the seedlings. These pathogens cause pre- and post emergence damping off and wire stem of seedlings. It causes mortality of seedlings. | Treat seed/soil/media with Captaf/ thirum/ Tricoderma etc. |
| Stem rot/ foot rot/ collar rot | Rooting of seedling stem near collar region | Spray Kavach/Rovral/Metalaxy/ Mancozeb (2 g/l) |
| Wilt | The foliar are yellowing and production of crookneck shoots. The leaves and shoots wither and become brownish. Stems when cut open show brown discoloration at the vascular region. | Soil fumigation and treating the nursery beds with benlate or with Thiophanate methyl and using *Tricoderma* etc. |

**Biological Control Measure**

Biological control is defined as the use of a living organism to control or manage another living organism. Natural enemies include parasites, predators, fungi, nematodes and viruses.

Softwood grafting