THE NEOTIA UNIVERSITY

ज्ञानम् आत्म प्रदीपाय

# Fundamentals of Horticulture
# Practical Manual
# Course code,CC-AGP101 Credits,2(1+1)


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# Content

# Experiment No. 1: Identification of Horticultural Tools

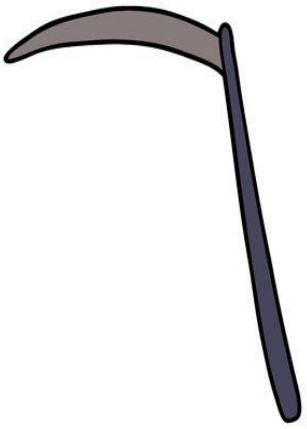
Certain special operations are required while cultivating horticultural crops viz. a) Pruning, b) Training, c) Preparation of cuttings, d) Layering, e) Grafting, f) Budding g) Lawn making h) Harvesting of fruits, i) Nursery management etc. Special types of tools implements are required to carry over this operation.

1. **Rose can/ Water can**- This is used for watering the nursery beds. Fine rose should be used for nursery of small sized seeds.
2. **Crow bar-** A long iron bar used for digging pits.
3. **Garden shears-** This is used to prune hedges and edges.
4. **Scythe-** It is a long flat metal of 5 cm wide with 45- 50 cm length fitted with a wooden handle. At the end of the metal, it is slightly curved with sharp edges. This is used for cutting grasses manually.
5. **Digging fork-** This has prongs of 20 cm long fitted to a wooden handle. This is used for uprooting of plants, rooted cuttings, harvesting of tubers etc. without damaging the root system or tubers.
6. **Shovel-** This is a curved steel plate attached to a wooden handle and used for transferring soil and manure etc.
7. **Secature-** This is used for cutting small shoots to regulate shoot growth in fruit trees, shrubs and vines. It is mainly used for preparation of cuttings for propagation purpose.
8. **Budding and Grafting knife-** This is used for budding and grafting. It has two soft blades in which one is with ivory edge used for lifting the bark in budding operation.
9. **Hand hoe-** It is used for manual weeding.
10. **Spade-** An iron square plate fitted to a wooden handle of 30-45cm length at 45º angle. This is used for formation and retification of irrigation channels, formation of ridges and furrows, earthing up operation and sometimes even in weeding operation.
11. **Fruit Harvester-** This is provided with a long handle and a net like structure for holding the harvested fruits. The handle is very light in weight usually with hollow bamboo and the net is made up of ordinary cotton thread or nylon rope.
12. **Garden rake-** This is used for levelling lands and collecting weeds in nursery. The rake consists of a number of nail like projections from a crow bar provided with long handle.

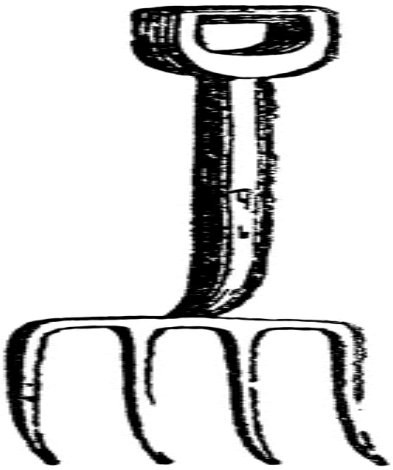
13. **Pruning saw-** This is used for pruning dead branches of the trees. Small saw with slightly curved edges are useful for removing thick branches and water shoots which could not be sheared off with secateur.
14. **Tree pruner-** It is provided with a long handle and is used for pruning stray branches which cannot be reached easily.
15. **Garden fork-** It is used to loosen the soil while harvesting bulb crops like onion and garlic and also in weeding.
16. **Rocker sprayer-** It is used for spraying chemicals in tall trees.
17. **Backpack sprayer-** It is used for spraying chemicals in vegetables and seed spice crops.


Rose can/ Water can

Crow bar



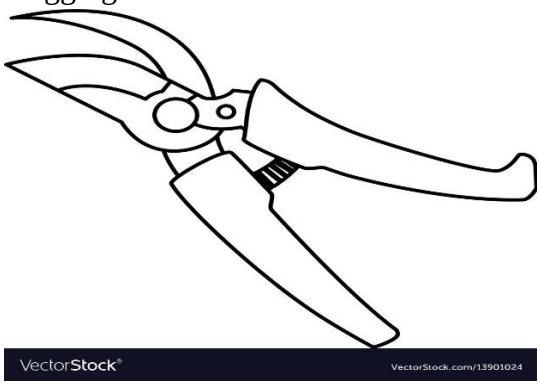
Garden Shear



Scythe

Digging Fork

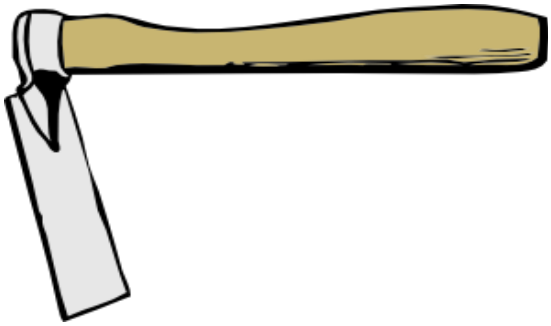
Shovel

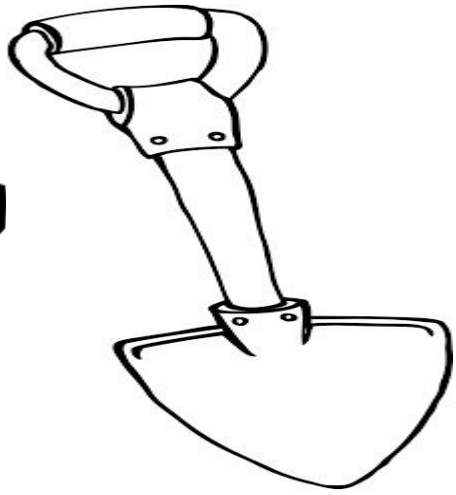




Secateur

Budding grafting knife





Hand Hoe

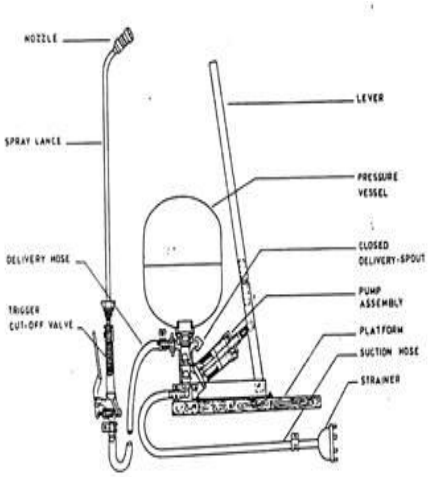
Spade

Fruit Harvester


Garden Rake

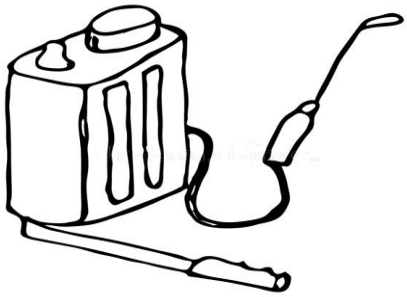
Pruning Saw

Tree Pruner


Garden Fork

Rocker Sprayer



Backpack sprayer

# Experiment No. 2: Identification of Horticultural crops

Horticultural crops are classified in different times for various purposes where each of the classifications have definite objective and grouped under botanical, horticultural and commercial heads.

**Branches of Horticulture**

a. **Pomology**- Production and marketing of fruit crops.
b. **Olericulture**- Production and marketing of vegetable crops.
c. **Floriculture and landscaping**- Production and marketing of flower/ornamental crops, beautification through design and alteration of land using planting material etc.
d. **Plantation Crops**- Cultivation and marketing of commercial crops on extensive scale like coconut, tea, coffee, Cashew nut etc.
e. **Spices & Aromatic Crops** - Cultivation and marketing of crops having aroma, taste and flavor value.
f. **Medicinal and aromatic Plants**- Cultivation and marketing of crops having potential source of drugs.

**Identification of Fruit plants**

| Family | Common name | Botanical name | Chromosome number |
|---|---|---|---|
| **a) Monocotyledoneae** | | | |
| Arecaceae | Coconut | *Cocos nucifera* | 32 |
| | Arecanut | *Areca catechu* | 32 |
| | Oil palm | *Ealiasguinensis* | 32 |
| | Date palm | *Phoenix dactylifera* | 32 |
| Bromeliaceae | Pineapple | Ananascomosus | 50 |
| Musaceae | Banana | *Musa paradisica* | 22, 33, 44 |
| | | | |
| **b) Dicotyledoneae** | | | |
| Anacardiaceae | Mango | *Mangiferaindica* | 40 |
| | Cashew | *Anacardiumoccidentale* | 42 |
| | Pistachio nut | *Pistachiavera* | 30 |

| | | | |
|---|---|---|---|
| Annonaceae | Custard Apple | *Annona squamosa* | 14 |
| Caricaceae | Papaya | *Carica papaya* | 18 |
| Euphorbiaceae | Aonla | *Emblica officinalis* | 28 |
| Moraceae | Jackfruit | *Artocarpusheterophyllus* | 56 |
| | Fig | *Ficuscarica* | 56 |
| Myrtaceae | Guava | *Psidiumguajava* | 22 |
| | Jamun | *Syzgiumcumunii* | 40 |
| Punicaceae | Pomegranate | *Punicagranatum* | 18 |
| Rhamnaceae | Ber | *Zizyphusmauritiana* | 48 |
| Rutaceae | Mandarin | *Citrus reticulata* | 18 |
| | Sweet orange | *Citrus sinensis* | 18 |
| | Lemon | *Citrus limon* | 18 |
| | Grapefruit | *Citrus paradisi* | 18 |
| Rosaceae | Apple | *Malus domestica* | 34 |
| | Plum | *Prunusdomestica* | 16 |
| | Cherry | *Prunusavium* | 16 |
| Sapindaceae | Litchi | *Litchi chinensis* | 30 |
| Spotaceae | Sapota | *Achruszapota* | 26 |
| Vitaceae | Grape | *Vitisvinifera* | 38 |
| Rubiaceae | Coffee | *Coffearobusta* | 22 |
| Theaceae | Tea | *Camelia sinensis* | 30 |
| Actinidaceae | Kiwifruit | *Actinidiadeliciosa* | 58 |

| **Identification of Vegetable crops** | | | |
|---|---|---|---|
| **Family** | **Comon Name** | **Botanical name** | **Chromosome number** |
| Alliaceae | Onion | *Allium cepa* | 16 |
| | Garlic | *Allium sativum* | 16 |
| | Leek | *Allium porum* | 32 |
| Graminae | Sweet corn | *Zea mays* | 20 |
| Liliaceae | Asparagus | *Asparagus officinalis* | 20 |
| Amaranthaceae | Amaranthus | *Amaranthus officinalis* | 32 |
| Chenopodiaceae | Beet root | *Beta vulgaris* | 18 |
| | Palak | *Beta vulgaris var. bengalensis* | 18 |
| | Spinach | *Spinaceaoleracea* | 12 |
| Compositae | Lettuce | *Lactuca sativa* | 18 |
| Cruciferare | Cabbage | *Brassica oleracea var. capitate* | 18 |
| | Cauliflower | *Brassica oleracea var. botrytis* | 18 |
| | Broccoli | *Brassica oleracea var. italica* | 18 |

| | | | |
|---|---|---|---|
| | Turnip | *Brassica rapa subsp. Rapa* | 20 |
| | Raddish | *Raphanussativus* | 18 |
| Cucurbitaceae | Cucumber | *Cucumissativus* | 14 |
| | Muskmelon | *Cucumismelo* | 24 |
| | Watermelon | *Citrulluslanatus* | 22 |
| | Pumpkin | *Cucurbita pepo* | 40 |
| | Bottle gourd | *Lagenariasiceraria* | 22 |
| | Bitter gourd | *Momordicacharantia* | 22 |
| | Ridge gourd | *Luffa acutangula* | 26 |
| Leguminoceae | Peas | *Pisumsativum* | 14 |
| | French Bean | *Phaseolus vulgaris* | 22 |
| | Cow pea | *Vignaunguiculata* | 22 |
| Malvaceae | Okra | *Abelmoschusesculentus* | 130 |
| Solanaceae | Potato | *Solanum tubrosum* | 48 |
| | Tomato | *Lycopersiconesculentum* | 24 |
| | Chilli | *Capsicum annum* | 24 |
| | Brinjal | *Solanum melongena* | 24 |
| | Sweet pepper | *Capsicum annum* | 24 |
| Umbelliferae | Carrot | *Dacuscarota* | 18 |
| | Coriander | *Coriandrumsativum* | 22 |

| **Identification of Medicinal and Aromatic crops** | | | |
|---|---|---|---|
| **Family** | **Comon Name** | **Botanical name** | **Chromosome number** |
| Apiaceae | Dill | *Anethumgraveolens* | 20 |
| Solanaceae | Aswagandha | *Withaniasomnifera* | 48 |
| Apocynaceae | Sarpagandha | *Rauvolfiaserpentina* | 20 |
| Liliaceae | Safed Musli | *Chlorophytum spp.* | 16 |
| Leguminoceae | Liquorice or Mulathi | *Glycyrhizaglabra* | 14 |
| Papavaraceae | Opium (Poppy) | *Papaver sominiferum* | 22 |
| Liliaceae | Aloe | *Aloe barbadensis* | 14 |
| Meliaceae | Neem | *Azadirachtaindica* | 28 |
| Solanaceae | Datura | *Datura innoxia* | 24 |
| Piperaceae | Long pepper | *Piper longum* | 24 |
| Lamiaceae | Rosemary | *Rosemarius officinalis* | 20 |
| | Basil | *Occimumbasilium* | 72 |
| Umbellifereae | Celery | *Apiumgraveolens* | 74 |
| Labiatae | Japanese mint | *Menthaarvensis* | 96 |

# Experiment No. 3: Preparation of Seed bed/Nursery bed

**Materials required:** Digging and hoeing implements, seed, measuring tape, rope and wooden pegs, organic manures (FYM), mulching material.

1. **Preparation of seedbed-**
   - A seedbed/seedling bed is the local soil environment in which seeds are planted.
   - Seedbed is used to increase the chance of germination.
   - Soil of seedbed need to be loose, smooth and without large clumps. Large clumps, uneven depth would make plant depth random.
   - Loose soil provides aeration and space for root growth.
   - Seedbed preparation is done by secondary tillage through use of harrow and cultivators.
2. **Steps in Nursery beds/Seedbed preparation**
   - Removal of debris- E.g. insect eggs, disease spores, stones etc. are removed.
   - Leveling- It is done for achieving even drainage.
   - Breaking up the soil- compacted soil broken up by digging followed by disking.
   - Soil improvement- Compost, decomposed organic matter are added.
   - Fertilizing- If soil is deficient in any nutrients, it can be added manually.
3. **Seedbed Treatment**

For raising healthy seedlings, soil must be treated for making it pathogen and pest free.

**Methods of treatment:**

- Application of fungicide- E.g. Captan, thiram
- Use of insecticides- E.g. Cholropyriphos@2ml/litre of water
- Fumigation- Use of methyl bromide

4. **Preparation of Nursery beds/Seed beds**

There are 3 types of nursery beds-

- Flat beds
- Raised beds
- Sunken beds

**A) Flat nursery bed:**

- It is prepared during spring-summer when there is no risk of rain and in the areas where the soil is light sandy to sandy loam and has no problem of water stagnation.
- The area selected for nursery is well prepared till the pulverization of land and well rotten FYM at the rate of 10 kg per square meter area and is thoroughly mixed in the soil. The field is divided into small plots comprising of beds of uniform size depending upon the requirement, with the help of layout rope and measuring tape.
- Ridges are prepared around each bed, which facilitate the cultural practices. In between two rows of beds, control irrigation channel is prepared through which each bed is connected.
- Flat beds are used where water availability is adequate and there are no drainage problems.
- In some areas, crops like maize, sorghum, beans, and potatoes are started out on a flat bed; as the season progresses, soil is thrown into the crop row to mound up the plants; this is called "hilling-up" and is done to control in-row weeds, provide support, and improve drainage. (Potatoes are also hilled up to keep the developing tubers covered with soil.) Hilling-up only works with plants that have enough stem height.

**B) Raised nursery bed:**

- It is especially useful for raising seedlings during rainy season when stagnation of water becomes problematic and causes damping off disease. Raised bed of 10 to 15 cm height from ground level is prepared.
- All the stumps, stones, pebbles, weeds etc. are removed from the bed and FYM at the rate of 10kg per square meter is mixed in the soil.
- In between two rows, a space of 45 to 60cm is left so as to carry out cultural practices easily. The seeds are sown in lines in the bed.

**C) Raised beds may have several advantages:**

- Much better drainage compared with flat or sunken beds.
- They provide a double layer of topsoil, because they're made by dragging in topsoil from the surrounding alleyways. (Because of this, they're also likely to be looser than flat or sunken beds.)
- In temperate regions, raised beds warm up more quickly in the spring, which may benefit cold-sensitive crops and even permit earlier planting.

- Plants on raised beds are easier to reach when doing hand operations such as weeding and thinning.

**Disadvantage-**

- Raised beds usually aren't a good choice during the dry season, because they dry out more quickly than flat or sunken beds; also, water tends to run off them and be lost into the alley-ways.
- These disadvantages can be partly overcome by mulching the bed with straw or rice hulls, making a lip around the bed's edge to reduce run-off, and by reducing bed height to 10 cm or less

**Sunken nursery bed:**

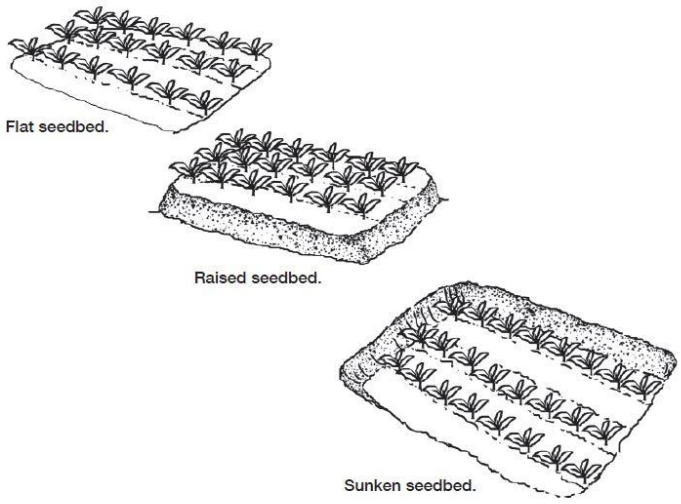
- This type of bed is useful and prepared during winter season. This type of nursery is prepared 10 to 15cm downwards from the soil surface.
- The air blows across the surface of soil and the seedlings in sunken bed is not hit by the cool breeze of the air.
- Further, covering of sunken bed with polyethylene sheets becomes easy which is required for protecting the seedlings from cool air.

**Sunken Beds**

In dry regions, especially on sandy soils with low water-holding capacity, vegetables can be planted in sunken beds (i.e. shallow basins) about 100-130 cm wide and 2-5 cm below the surrounding soil level. Sunken beds conserve water much more effectively than raised beds for 2 reasons:

- Sunken beds don't have the exposed sides of raised beds from where considerable moisture can be lost by evaporation.
- None of the applied water is lost by runoff.

One disadvantage of sunken beds is that some topsoil is lost in the usual method of construction. This probably won't affect crop growth, as long as the topsoil is of normal depth let least 15 cm and enough compost or manure is added.




**Sowing of seeds:** Till the soil to a fine tilth by removing stones, pebbles, crop residues etc.Break the clods and level the land/bed. Mix FYM@ 3 to 4kg, 250 g ammonium sulphate and 250 g super phosphate per square meter area.

- The seeds are sown about 2 to 4 cm deep and 8 to 10 cm apart. The depth of the furrow depends upon the size of seeds.
- Bigger are the seeds, deeper the furrow. After sowing, the seeds should be covered with a mixture of FYM and coarse sand in the ratio of 3:1.
- Level the bed and sprinkle water after mulching the seed beds, as per requirement.
- Over watering should be avoided, as excess moisture encourages root rot disease.

**In situ sowing:** In situ sowing refers to sowing of seeds directly in the field and grafting and budding are performed there itself.

- It is particularly important in some fruits like walnut, pecan nut, jackfruit and ber, which has long tap root system, In situ sowing enables to avoid the damage to tap root at the time of transplanting or uprooting of plants from the nursery.
- Similarly, for high density planting in Amrapali mango, in situ orchard establishment is recommended.

**Precautions:**

- The seed source should be genuine and good quality.
- The depth of sowing should be decided carefully depending upon the size of seed.
- Avoid over watering of nursery beds and stress conditions.

## Experiment No. 4: To study about the Sexual Propagationof Horticultural crops

Multiplication of plants by using seed is called as Sexual propagation.

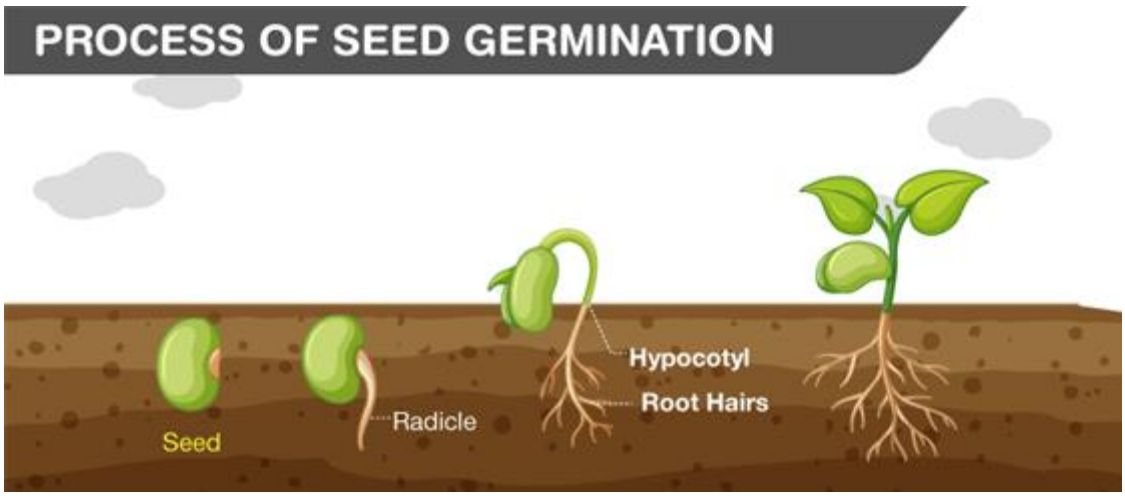
A seed is formed when a pollen grain lands on the stigma of the flower, and sends down a pollen tube which releases a sperm cell into the ovule. The fertilization of the sperm cell and ovule forms a cell called a zygote. The zygote then develops into an embryo. The embryo along with the food storage organs, cotyledons and/or endosperm and the seed coat make up what is called the seed.

The process of seed germination is much more complicated than it would appear. Germination is a biochemical process that involves the activation of many chemical reactions. This happens in three stages.

The first stage of seed germination involves the uptake of water. This is called imbibition. During imbibition the protein synthesizing systems are activated and various enzymes are synthesized. These enzymes catalyse reactions used in the second stage of germination.

The second stage of germination involves the breakdown of the stored energy rich compounds of the cotyledons and endosperm.

During the third stage of germination, cell division begins and the embryo grows into a seedling. The first growth occurs in the radicle and root system is established. This is followed by the emergence of plumule. Once the seedling has formed leaves it becomes a self -sufficient plant.



**Advantages:**

Sexual method of propagation has several advantages, like

- Propagation by seeds is simple and easy.
- Seed propagation is only mean of diversity particularly in the selection of chance seedlings.
- Seedling plants are long lived, productive and have greater tolerance to adverse soil and climatic conditions and diseases.
- Seed propagation makes feasible to propagate plants like papaya and coconut in which asexual means of propagation is not common.
- Hybrids can only be developed by sexual means.
- Sexual propagation offers opportunities of polyembryony (citrus, mango or jamun) and apomixis (Malus sikkimensis, Malus hupehensis, Malus sargentii), which produces true- to - type plants.
- Seed is the source for production of rootstocks for asexual propagation.
- Seeds, if stored properly can be kept for longer duration /period for future use.

**Disadvantages:**

Sexual method of propagation has some disadvantages, like

- Seedling plants are not true to type to the mother plants due to heterozygous nature of fruit plants.
- Seedling plants have long juvenile phase (6-10 years) and hence flowering and fruiting commences very late.
- Sexually raised plants are generally tall and spreading type and thus are cumbersome for carrying out various management practices like pruning, spraying, harvesting etc.
- Seeds of many fruits are to be sown immediately after extraction from the fruits as they lose their viability very soon e.g. cashew nut, jamun, jackfruit, citrus, mango and papaya.
- The beneficial influences of rootstocks on scion variety cannot be exploited in sexual propagation.
- Seedling plants usually produce fruits of inferior quality.

## Experiment No. 5: To study about the propagation by cuttings.

**Materials Required:** Cuttings, Secateurs, prepared nursery beds, growth hormone, sensitive balance, alcohol, measuring cylinders, small tub

**Procedure:**

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.

**I) 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.

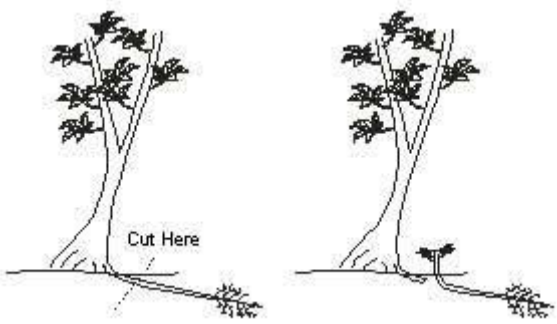
However, in case of Kiwifruit top cut should also be close to bud to avoid drying up of top portion. This helps in maintaining the polarity of the shoot and if rain occurs, water does not accumulate on the tip of the cutting, which saves the cutting from fungal infection. A number of deciduous fruit plants like grape, hazelnut, chestnut, fig, quince, pomegranate, mulberry, plum, olive, gooseberry and apple etc. are commercially propagated by hard wood cuttings. The concentration of rooting hormone depends upon the species to be propagated.

**II) 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

**III) 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.

**IV) 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.

**b) 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.




**c) 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.

**Precautions:**

- Cuttings of appropriate type should be selected and prepared.
- Concentration of rooting hormone should be prepared accurately.
- Rooting media should be prepared in accurate proportion.
- Optimum level of relative humidity should be maintained.

## Eexperiment No. 6: To study about the propagation by Layering

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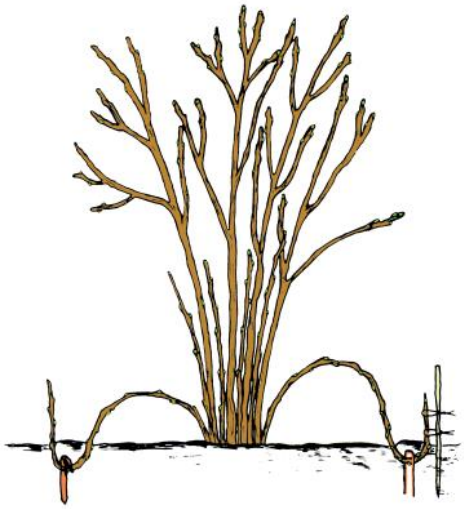
**Materials Required**: Secateurs, prepared nursery beds, growth hormone, sensitive balance, alcohol, measuring cylinders, small tub, planted mother stool

**Procedure(s):**

The most commercially used methods are mound layering for multiplication of rootstocks and air layering for some tropical fruits.

### 1. Simple Layering:

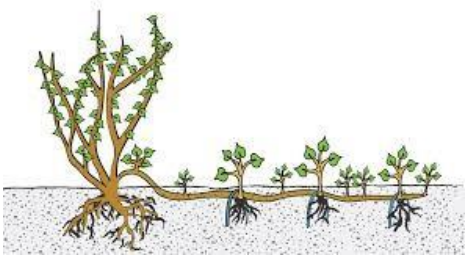
Simple layer consists of bending an intact shoot to the ground to cause adventitious root to form. The method can be used to propagate a wide range of plants, indoor or outdoor on wood shrubs that produce numerous suckers. Layering is usually done in the early spring using flexible, dormant, one year-old 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.



**Simple Layering**

## 2. 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.



**Compound or serpentine layering**

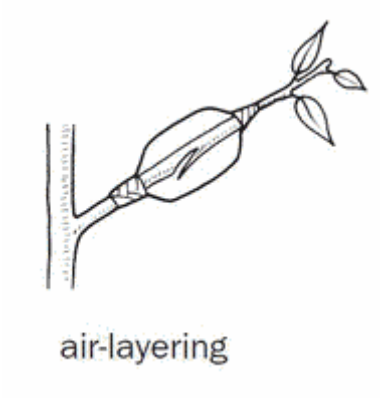
## 3. Continuous or trench layering:

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.


**Continuous or trench layering**

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

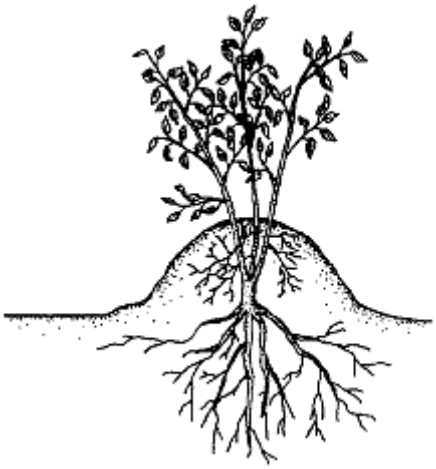
Air layering is an ancient method of layering, originally introduced from China and now commercially used for propagation of a number of tropical and subtropical trees and shrubs including litchi, longan, Persian lime (Citrus aurantifolia),ficus, croton etc. Air layers are made in the spring or summer on stems of the previous season's growth. The presence of active leaves on the layered shoot speeds root formation. Layers are prepared by making an upward cut about 5 cm long at or about the centre of the shoot. The shoot is then girdled by removing a ring of bark about 2 cm wide. The upper part of wound is applied with IBA paste made in lanolin. The wound is covered with moist sphagnum moss in a way to provide complete cover to it. Polyethylene film is wrapped around the moss grass in such a way as to leave no opening, which could allow evaporation of moisture from the moss. Pruning to reduce the top in proportion to the roots is usually advisable. The rooted layers may be severed from mother plant and may be planted in the nursery under shade.




**5. 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.

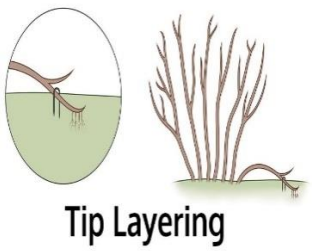
The sprouts are then girdled near the base and rooting hormones (IBA), made in lanolin paste is applied to the upper portion of the ring, the concentration of IBA depends on species but generally 3000 to 5000 ppm is commonly used.These shoots are left as such for two days for proper absorption of rooting 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.



**Mound /Stool layering or stooling**

**6. 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.



# Experiment no. 7: To study about the propagation by Grafting.

**Materials Required:** Secateurs, grafting knife, scion wood, rootstock, wrapping material
**Procedure:** Before practicing any grafting method, the selection of optimum size, thickness of root stock and scion is of prime importance. The sequential steps involved in different methods are described as under:

## Grafting

Many horticultural plants are propagated by grafting. In grafting, the desired cultivar can be raised on other plants (rootstocks) for achieving the desired benefits.

Grafting is an art of joining the stock and scion in close contact with each other in such a way that they will unite and continue to grow as single individual/composite plant. The upper part of the composite plant is termed as 'scion' and the part which forms the root is termed as 'rootstock'. Sometimes, when scion and rootstocks are not compatible with each other, another piece of wood is used in between the stock and scion, which is compatible with both; this is called as 'interstock'.

**Principles of Grafting-** The principal steps involved in healing process and formation of the graft union are

i. Establishment of direct contact between the cambial region of both stock and scion.

ii. Production and interlocking of parenchymatous cells.

iii. Production of new cambial cell.

iv. Formation of new vascular tissues.

**Different methods of grafting-**

### 1. Inarching

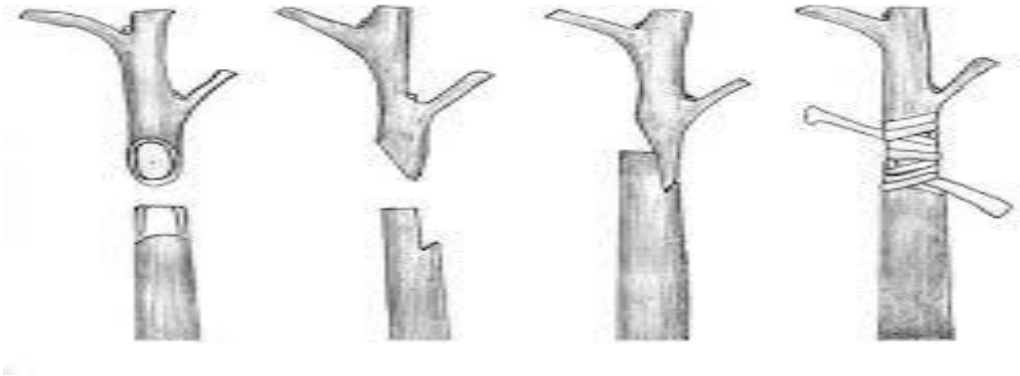
It is generally used for repairing or replacing damaged root system and hence also called as repair grafting. Selection of parent tree for taking the scion is an important factor for its success. The scion plant should be healthy, vigorous and high yielding. The stock is brought close to the scion. A thin slice of bark (6-8 cm long and about 1/3 inch in thickness at height) at about 20 cm above the ground level is removed from the stock with a sharp knife. A similar cut is made in the scion. Thus the cambium layers of both stock and scion are exposed. These cuts are brought together and tied firmly with the help of polythene strip. After successful union, stock above and scion below the graft union are looped of gradually.

It is done soon after rainy season provided that temperature of the localities does not fall below the 15ºC. e.g Mango, sapota, guava, litchi.

**Inarching**

## 2. Veneer grafting

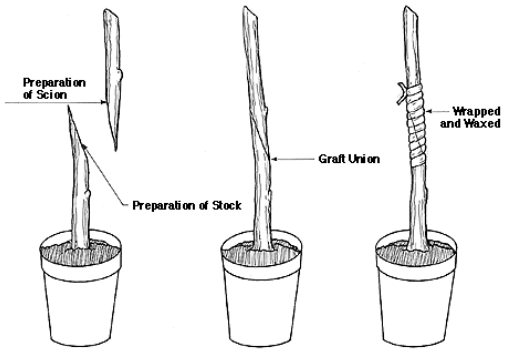
This method is used for propagating Mango. In this method, a terminal shoot of 10-15 cm length having pencil thickness is used as a scion. About 10 days before grafting, the scion-shoot is defoliated to facilitate swelling of bud. Shallow, downward and inward cut ensuring V-shape incision in lower portion of incision on rootstock is prepared. Similar matching cut in slanting manner is prepared on lower portion of scion. Both rootstock and scion are fastened together using 300 gauge polythene tape of 0.5 cm width. During May and September this system is quite successful and good result is obtained. In about 3-4 weeks, union is completed. When scion sprouts completely, the upper portion of rootstock, above graft union is removed in two instalments.



**Veneer Grafting**

### 3. Whip grafting

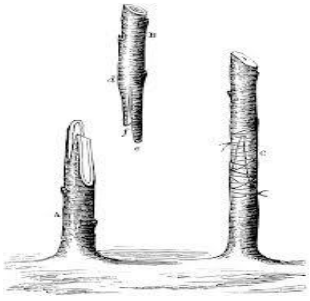
It is simple and popular method of grafting. In this method of grafting, it is essential that both stock and scion should be of equal diameter1-1.5 cm. About one year old rootstock is headed back at a height of 20-25 cm from the soil and a diagonal cut is made at the distal end of the rootstock. A similar slanting cut of 2-4 cm is made on the proximal end of the scion. The cut surface of both rootstock and scion are bound together and tied firmly with polythene tape. Many fruit plant are propagated by whip grafting e.g. Apple and Pear etc.




**Whip Grafting**

### 4. Tongue grafting

This is modification of whip grafting. In this method, a slanting cut similar to whip grafting is prepared on rootstock and scion. A second cut is also given in reverse direction on previous cut in rootstock and scion. The second cut is started downward at about one third distance from tip ad should continue to about ½ the length of first cut. The scion and stock are inserted which interlock each other. While matching, it is seen that cambium layer of rootstock and scion, it must match along one side. After uniting rootstock and scion, both are fastened using polythene tape. This method secures contact with six layers of wood, hence the chances of union increase and there is quick healing in grafting. This method is used for propagating apple, pear and walnut.



**Tongue Grafting**

## 5. Cleft grafting

It is particularly suitable in rootstock having diameter greater than the scion. Rootstock with 5-7 cm or more girth is selected for this purpose. The rootstock is cleft grafted after decapitating the stock 20-40 cm above the ground level. The beheaded rootstock is split to about 5cm deep through the center of stem. After that a hard wooden wedge is inserted to keep open for the subsequent insertion of scion. The scion of 15-20 cm size is taken from a terminal shoot, which is more than three month old and then it is wedge securely (6-7 cm). The cleft of the scion then slipped into the split of the stock. In thicker rootstock more than one scion should be inserted. The graft should be thoroughly waxed to prevent wilting. eg Avocado, apple, pear, plum, mango.

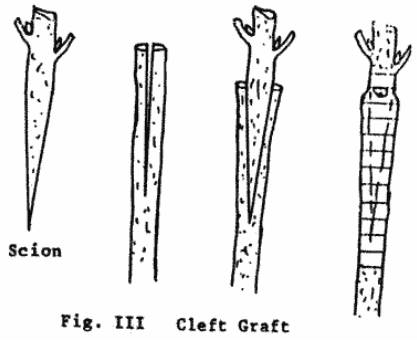
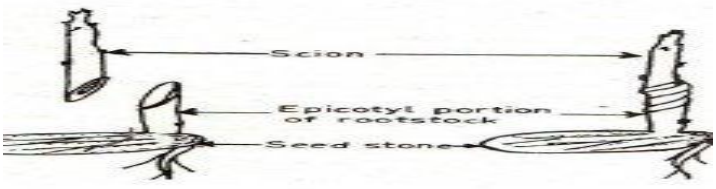


Fig. III Cleft Graft

**Cleft Grafting**

## 6. Epicotyl /Stone grafting-

In this method, in case of mango, the seeds are sown in nursery bed and covered with 5 cm to 7 cm thick layer of farmyard manure. While sowing seed,preference is given to seed bed which provides ease in rooting of seedlings required at the time of grafting. In about 15 to 20 days, seed start germination. The germinated seedlings of 7 to 10 day age, when its leaves remain coppery in colour, is used for grafting. The seedling is beheaded at a height of 10 cm from ground level. A vertical slit of 2.5 to 4 cm length is given on beheaded portion of rootstock. Scion shoot of 2 to 3 months age having pencil thickness is used. The leaves of scion is defoliated 10 days before grafting to facilitate sprouting. After uniting rootstock and scion, it is wrapped using polythene tape of 300 gauge. The grafted plants are then maintained in other beds or pots in nursery. This method of grafting is practised during June-July during which the environment remains sufficiently moist.



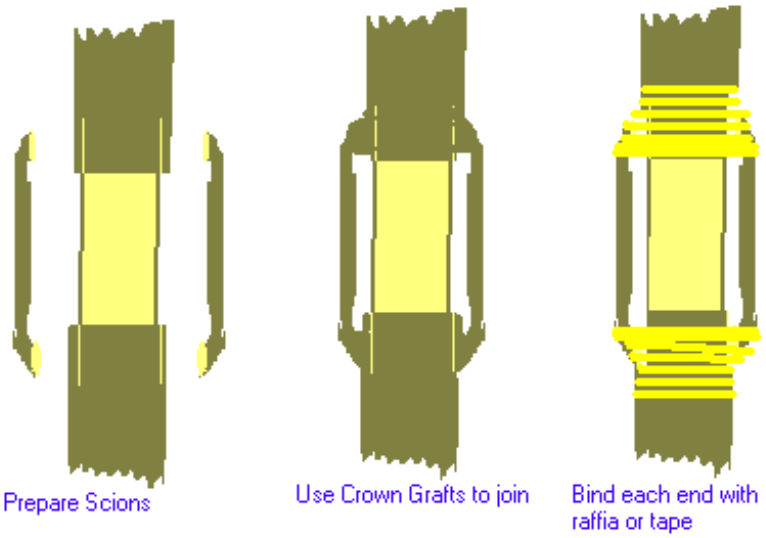
Epicotyl grafting

7. **Soft wood grafting**- This technique is commercially used for raising Cashew nut, Mango, Jamun, Tamarind, Custard apple. In this method, the seeds of mango are sown at desired distance in the field during rainy season. To ensure germination, 2 to 3 seeds are sown in each pit. When the plant become one year old and attains pencil thickness, it is used for grafting. The process of grafting is done during rainy season when new growth appears on rootstock. When new growth leaves start turning yellow from coppery colour grafting is performed. Scion shoot of 10 to 15 cm length, 3 to 5 months age and pencil thickness girth is selected. At 15 to 20 cm height from ground level, the rootstock is beheaded. A vertical slit of 2.5 to 4 cm length is given in rootstock. On scion shoot, similar matching cut is prepared in slanting manner on both the surfaces in lower portion. It is inserted in incision on rootstock and wrapped using polythene tape. In about 3 to 4 weeks, sprouting starts and graft starts growing. The grafted plant develops at its intact tap root system and shows better survival in the field.

**Softwood Grafting**

**8. Top working-**This is commonly practiced to convert an old/ unproductive orchard of inferior variety in to productive one by grafting with desirable variety. To begin with the process, the plants are headed back within one meter height from ground level during spring. The new shoot appears in response to heading back are selected and vegetative propagation (budding/grafting) method is resorted during June-July.

**9. Bridge grafting**- Bridge grafting is done with objective of repairing of damaged fruit plant. The scions are prepared by giving slanting cuts on one side of the top and base. These scions are inserted above and below the injury of the plant and tied properly.




**Bridge Grafting**

## Experiment no. 8 : To study about the propagation by Budding

**Materials Required:** Secateurs, budding/grafting knife, scion wood, rootstock, wrapping material

**Procedure:** Methodology followed in different budding techniques is described as under:

### 1. Chip Budding:

Chip budding is done in early spring, summer or autumn. In chip budding a chip of bark and wood is removed from the smooth surface between the nodes of the stock. A chip of similar size and shape is also removed from the bud wood of the desired cultivar. For which a 2-3cm long downward cut is made through the bark and slightly into the wood of the stock. Then a second cut of about 2.5cm is made so that it bisects the first cut at an angle of 30-45O and the chip is removed from the stock. Similarly a chip of bud is removed from the bud-wood, ensuring that the bud is in the middle of chip.The bud chip inserted in the stock in such a way that cambium of the bud chip should have direct contact with the cambium of the stock. It is then tightly wrapped with some wrapping material like polythene strip, leaving the bud uncovered. The bud may sprout after 3-4 weeks and afterwards the wrapping material should be removed. When the bud starts growing, the stock may be cut propagated by this method.

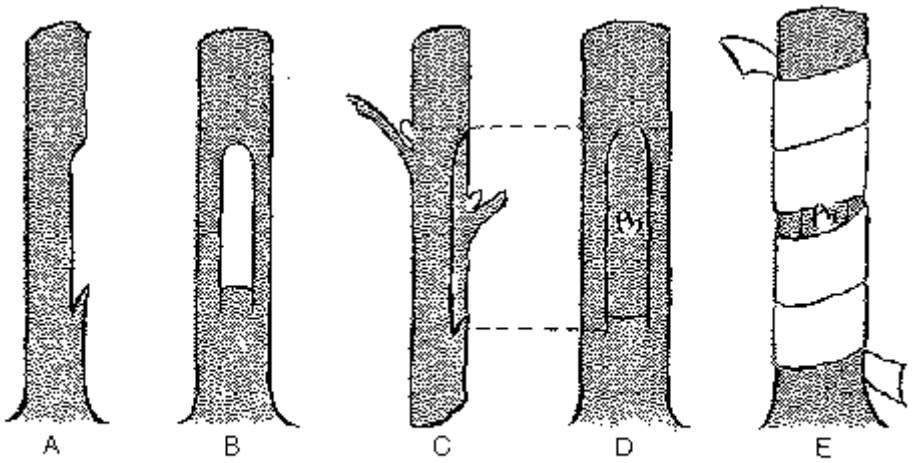
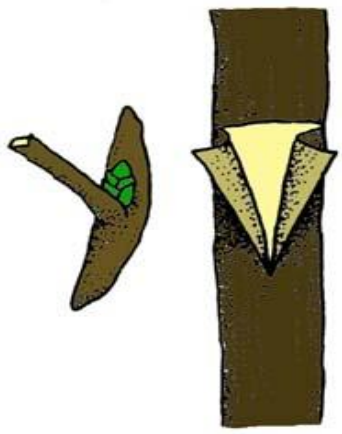



Figure 8.—(A) Side view of stock cut for chip budding. (B) Front view of stock cut. (C) Chip bud shield. (D) Chip bud set in stock. Note that if the chip bud is smaller than the cut that has been made for it, the bud should be lined up with the edge of the cut to obtain cambium contact. (E) Polyethylene tape to seal chip bud; only bud is left uncovered.

**Chip Budding**

**2. Shield or T-budding:**

As the name indicates shield is the shape of the bud and 'T' is the shape of cut given on the rootstock. It is the most common method of budding used by nurserymen worldwide. For shield budding one year old rootstock seedlings of 25-35 cm height and 2-2.5 cm thickness is selected. The bark of seedlings should slip easily. The selected bud of desired cultivar is inserted 15-20cm above the ground level and is tied with a polythene strip. For performing budding operation, a "T" shaped cut is made on the selected portion of the stock with the help of a sharp budding knife. The incision should be given through the bark not the wood. The two flaps of bark are loosened with the help of budding knife. The healthy bud is removed from the bud wood by cutting shallowly about 5-6 mm below and 2-3cm above the bud.This shield piece containing a bud is inserted in the "T" cut made on the rootstock. The shield should be covered by two flaps of the bark, but bud should be exposed. The buds are pressed firmly, fitted into the "T" cut and finally tied with polythene strip. When bud healing process is over, the bud may attain height of 15-20cm, the remaining portion of the stock is cut to about 10-15cm above the bud. Plants with thin bark, with sufficient flow of the sap like apple, pear, peach, plum and apricot, cherry, rose and citrus are propagated by this method.

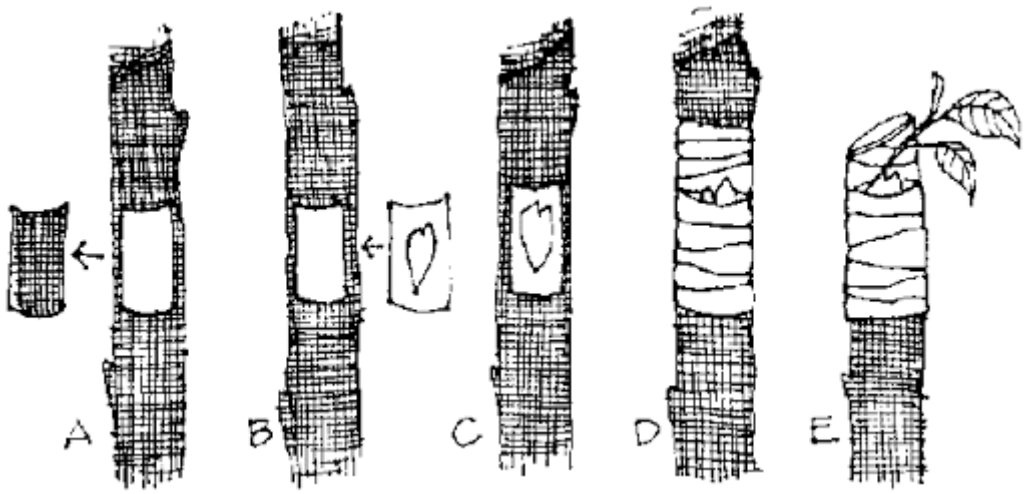


**T-Budding**

**3. Patch budding:**

In case of patch budding a rectangular patch of bark is removed completely from the rootstock and replaced with a patch of bark of the same size containing a bud of the cultivar

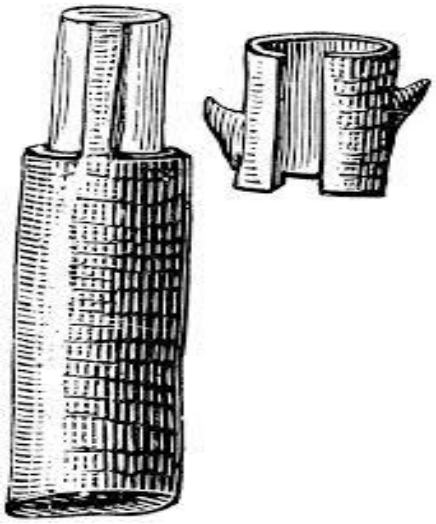
to be propagated. It is slower and difficult to perform than T-budding. It is widely used in thick-barked species, such as walnuts and pecans and rubber tree, where T-budding gives poor results due to poor fit around the margins of the bud-particularly the top and bottom . It is usually done in late summer or early fall, but can be done in spring also. In patch budding, the stock and scion should preferably of same thickness (20-25mm). First a rectangular piece of bark (25mm long and 10-15cm wide) is removed from the stock and a similar patch, containing a bud is removed from the scion by making two horizontal cuts above and below the bud and then two vertical cuts connecting the horizontal cut. After removing the patch, the bud should fit tightly at the top and bottom. It is then wrapped with polythene strip, keeping the bud uncovered. The wrapping material should hold the bark tightly and cover all the cut surfaces to prevent free entry of air or water. After the bud starts sprouting, the stock above the bud union may be cut off step by step. In addition to pecan nut and walnut, mango, rubber plant, aonla, jackfruit and jamun are also propagated by this method.




**Patch Budding**

**4. Ring or annular budding:**

In this type of budding, a complete ring of bark is removed from the stock and it is completely girdled. A similar ring of bark containing a bud is removed from the bud stick and is inserted on to the rootstock. The thickness of stock and scion should be same size. It has been utilized in ber, peach and mulberry because the newly emerged shoots from the heavily pruned plants are capable of giving such buds for budding, which can be easily separated. In this method since the stock is completely girdled and if the bud fails to heal in, the stock above the ring may eventually die.



**Ring Budding**

**5. Forkert budding:**

In forkert budding, the stock is prepared by giving two vertical cuts and a transverse cut above the vertical cuts to join them. The bark is removed carefully along the cuts, so the flap of bark hangs down. The scion is prepared in a fashion similar to patch budding, having the size similar to cuts made on the stock. The scion is then slipped into the exposed portion of the stock and the flap is drawn over the inserted bud patch. It is then tied with a suitable wrapping material. After successful growth of bud, the portion of stock above union is removed carefully.

**Precautions:**

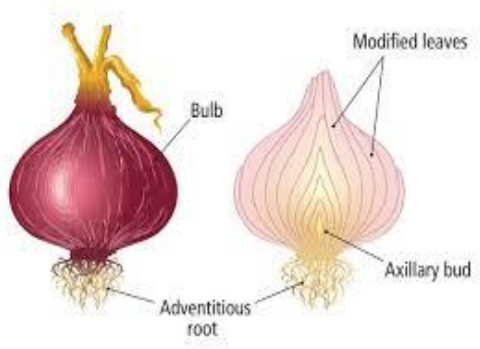
- The bud to be used as scion should be mature.
- Wrapping of bud union should be performed carefully to avoid air entry at the point of union.
- Budded stock should be irrigated at regular intervals
- De-shooting of sprouts below bud union should be done as the sprouts appear
- The wrapping material should be removed when it gets tightened.
- In case of chip budding in fall season the bud grafts should be protected from chilly winter in cold arid conditions

## Experiment No. 9: To study about the propagation by specialised organs

Specialised organs are modified stems or roots, developing above the ground surface or underground, which may be used for multiplication of plants. In horticulture, bulbous ornamentals include bulbs, corms, tubers, tuberous roots and rhizomes.

### 1. Bulb

Bulb is a specialised underground structure having a flat basal stem and surrounded by fleshy scales, e g., onion, tuberose, amaryllis. Structurally, bulbs are tunicated and non-tunicated. In tunicated bulbs, the outer layer of scales is converted into dry membranous covering, which gives protection, e g., onion, tuberose, amaryllis, tulip, etc. Non-tunicated bulbs do not possess the enveloping dry covering and are represented by lily.



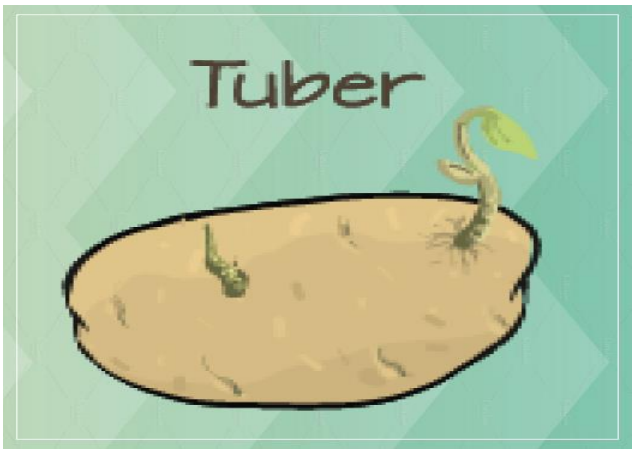

**Bulb**

### 2. Corm

It is a swollen solid specialized underground structure which possesses distinct nodes and internodes. It remains enclosed by the dry, scale like leaves. Gladiolus and crocus are propagated by corm.

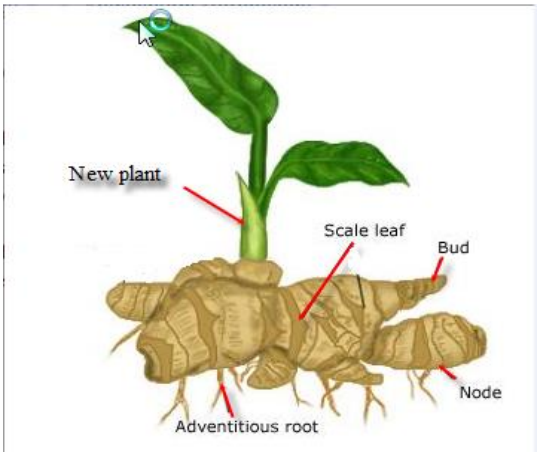
### 3. Tuber

A tuber is a specialized swollen underground stem which possesses eyes in regular order over the surface. The eye represent the nodes of the tuber. The nodes are arranged spirally in tuber. It is common in caladium, Jerusalem artichoke, dioscorea, irish potato, potato etc.




### 4. Rhizome

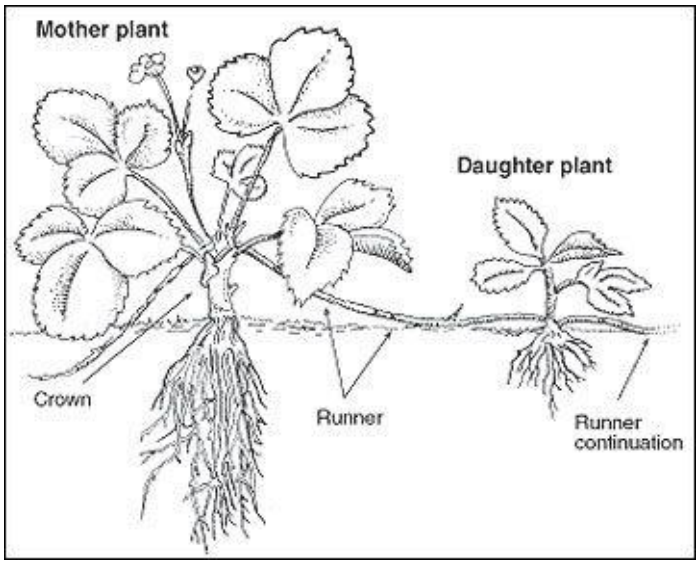
A modified stem of some plant growing horizontally just below the ground surface, e g., canna, ferns, ginger, iris, etc.




**Rhizome**

## 5. Runner

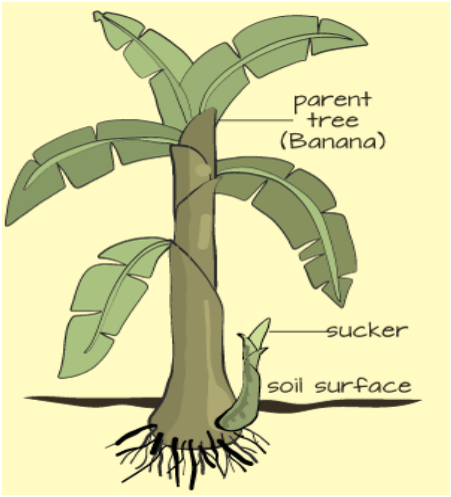
Runner is a thin and long stem which develops from the axils of leaves, grows horizontally along the ground and forms a new plant at the nodes where it comes in contact of soil. Runner is a mode of propagation in strawberry, doob grass, chlorophytum, etc. When runners develop sufficient root, it is dug and planted in the field.




**Runners**

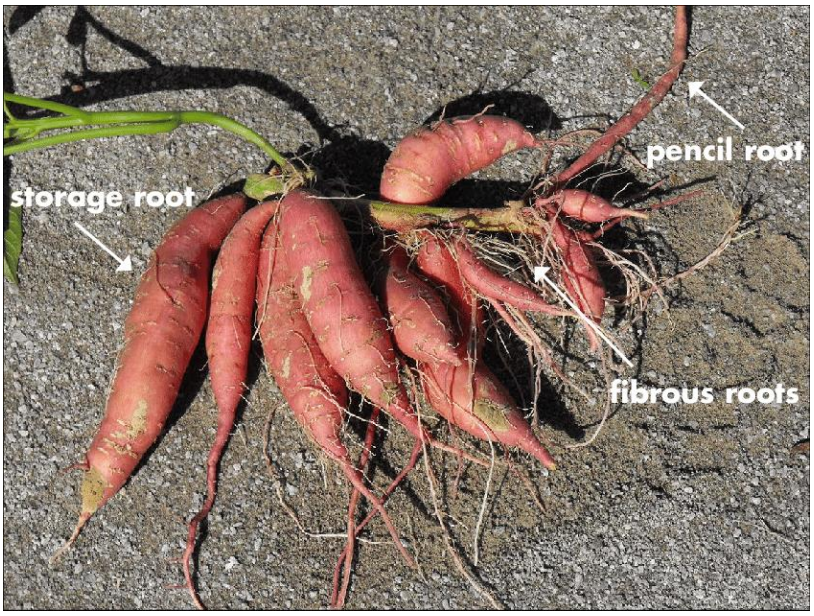
## 6. Suckers

Sucker is a shoot that develops from an adventitious bud on a root and grows vertically. The shoot appears from the rootstock below the union of bud or graft is termed as sucker. Shoot arising from latent bud of stem and vigorous in growth is also a sucker. The sucker originating from root is dug out and used as propagating material. Banana, Raspberry, blackberry, date palm, pineapple etc. are propagated by suckers.




### 7. Tuberous roots

These are thickened tuberous growth that function as a storage organs. Tuberous roots are found in sweet potato, cassava, dahlia etc.




**Tuberous Root (Sweet Potato)**

## Experiment No. 10: To study about Micro-propagation

Micropropagation refers to the production of plants from very small plant parts, tissues or cells, grown aseptically in a test tube or containers under controlled nutritional, environmental and aseptic conditions. All the biological principles of micropropagation techniques are based on the phenomenon or totipotency of cell, which implies that a plant cell has the capacity to generate into a full-fledged plant having different organs.

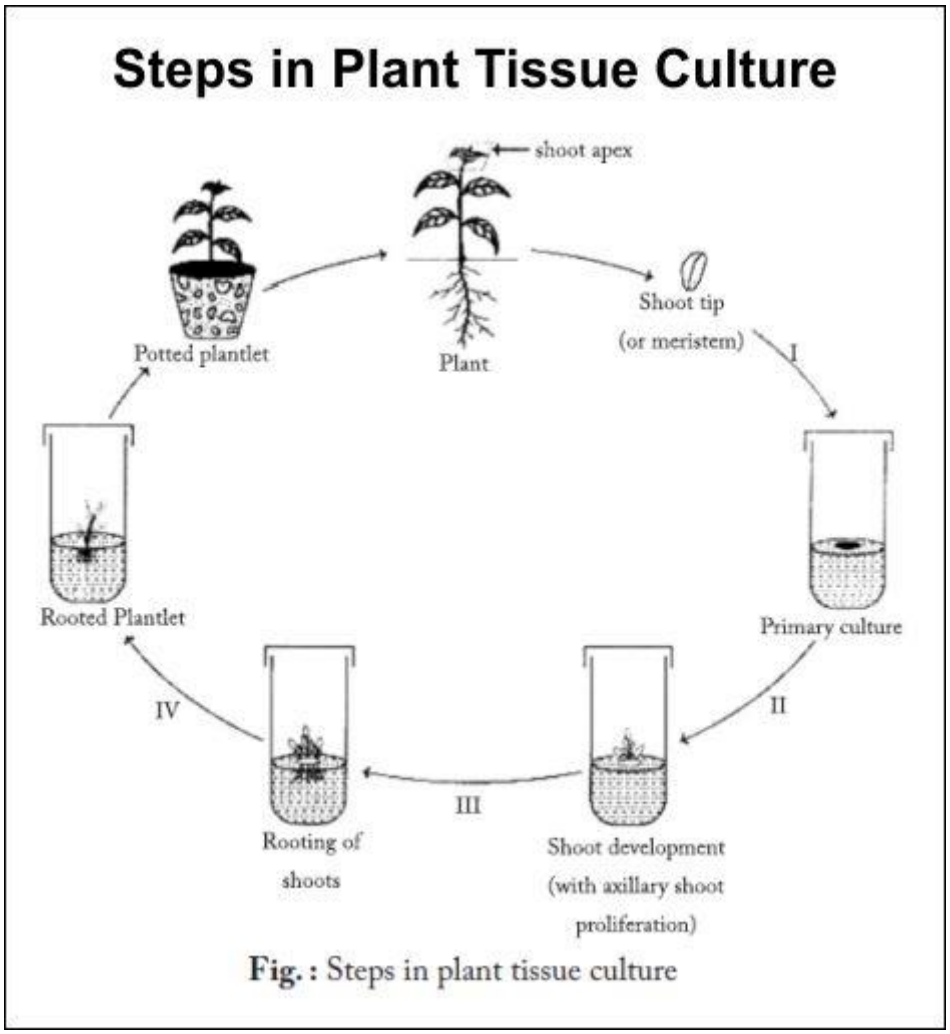



**Fig.:** Steps in plant tissue culture

**Micropropagation versus other propagation methods:**

Micropropagation propagation differs from other vegetative propagation methods as:

- A very small plant part (explants) is used as a starting material.
- The explants are maintained in small containers having well defined culture medium.
- Highly aseptic conditions are required.
- A large propagating material is produced in a very short-time.

**Advantages**

- Production of large propagating material in shorter time
- Production of disease-free plants
- Clonal propagation of parental stock for hybrid seed production
- Year-around nursery production
- Useful in propagation of dioecious plants
- Breeding cycle is reduced
- Useful in hard-to-propagate plant species
- Germplasm preservation

**Disadvantages**

- Expensive and sophisticated facilities, trained personnel and specialized techniques are required
- High cost of production results from expensive facilities and high labour inputs
- Contamination or insect infestation can cause high losses in a short time
- Higher level of somatic variation
- Poor establishment of the plantlets in the field

**Stages of Micropropagation**

Micro propagation is an integrated process in which cells, tissues or organs of the selected plants are isolated, surface sterilized and incubated in growth promoting, sterile medium and environment to produce a large number of plants. The different stages are:

Stage 0: Selection of mother plant for explants isolation:

The mother plant from which explants has to be excised should be

a.) A certified and true to type representative of the desired species and or cultivar.
b.) Healthy and free from insect pest and disease
c.) Should be quite vigorous.

**Stage1: Explant establishment in culture medium:**

During this stage the explant is cultured in a suitable culture medium, preferably agar based media for tissue activation and multiplication.

**Stage2: Proliferation and multiplication:**

In this stage, repeated sub-culturing is done to encourage more proliferation, which largely depends upon the combination of growth regulators. The duration of this stage is unlimited and largely depends on the choice of propagator.

**Stage 3: Plant establishment and rooting:**

In this stage the selected plants are forced for root formation, which can be achieved by media modification and modifying the concentration of growth regulators. The concentration of cytokinins and sugars are reduced and concentration of auxins and light intensity in the laboratory is increased to start with photosynthesis and other physiological activities.

**Stage 4. Acclimatization or hardening:**

The plantlets developed in the culture tubes are acclimatized to specific environment having a high humidity, a low light level and a constant temperature. Besides, the roots developed in vitro are hairless and hence delicate, requiring care during transfer from culture medium. To have better survival rate, the plantlets may be transferred to container kept in mist chambers where relative humidity is maintained at higher order. Once new growth is seen, the plants may be slowly transferred to outside by exposing to increased light intensity in stages.

Once plantlets are well rooted, they must be acclimatized to the green house environment. In vitro rooted plants are removed from the culture vessel and the agar is washed away completely to remove a potential source of contamination. Plantlets are transplanted into a standard pasteurized rooting or soil mixture in small pots or cells in a more or less conventional manner. Initially, micro-plants should be protected from desiccation in a

shaded, high humidity tent or under mist or fog. Several days may be required for new functional roots to form.

Plantlets should be gradually exposed to a lower relative humidity and a higher light intensity.

## Experiment No. 11: Layout and planting of orchard

Orchard is a place where long-term investment and needs lot of planning and expertise. While planning and planting a new orchard, one should give utmost attention and care to various aspects to achieve maximum benefits-

1. Selection of location and site,
2. Nature of soil and subsoil,
3. Layout plan

**1. Selection of location and site-**

- Proper selection of site is basic need for growing of crops. Location of orchard should be in well established fruit growing regions as one could get the benefits from the experienced growers, easy market facility.
- Proper transportation facility must be there as horticultural produces are perishable.
- Market area should be close to the orchard.
- Site must have proper drainage during the rainy season.

**2. Nature of Soil and Subsoil**

Soil fertility soil depth and nature of subsoil must be observed. Soil with pH at neutral range, alongwith with loose subsoil is the best for the root environment. There should not be fluctuating water table which may hinder the physiological activity of the root.

**3. Preparation of land**

- The land should be cleaned properly for free movement of men and machinery.
- All the trees, bushes and creepers should be removed.
- The soil of the area designed for growing fruit plants needs thorough preparation.
- A virgin land requires a deep ploughing and harrowing.
- The land should be repeatedly ploughed and bring the soil to a fine tilth.

**3. Layout plan**

- The marking of position of the plant in the field is referred as layout.
- The layout plan of the orchard should be prepared carefully, preferably in consultation with horticultural experts.
- The orchard layout plan includes the system of planning provision for orchard paths, roads, water channels and farm building.

- A sketch of the proposed orchard should be prepared before the actual planting is taken up.

**4. Method of layout**

- For laying out an orchard, according to square system, a base line is first established and position of the trees is marked along this line by laying wooden stakes in the ground.
- Another base line at right angle to the first base line, is then marked along with the other edge of the field with the help of a carpenter square or a cross staff.
- The right angle can also be drawn with the help of measuring tape.
- One end of this tape is fixed at three metre distance from the corner along the first line and the tape is then stretched along the second base line for a distance of four metre.
- The diagonal distance between these two points should be five metre.
- The wooden stakes are put in the ground at the desired distance along the second line.
- All the four rows are thus established and staked.
- Three men, one putting the peg in the field and others correcting alignment while moving along the base line, can easily stake the whole field.
- The marking of position of the plant in the field is called “layout”.

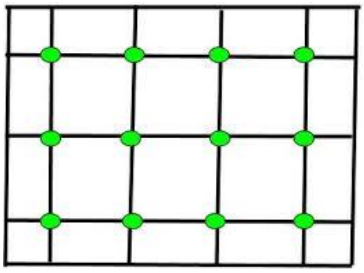
**Types of planting systems**

**1. Square system**

It is the most commonly used method and easy to layout in the field. In this system, plant to plant and row to row distance is the same. The plants are at the right angle to each other, every unit of four plants forming a square. This system facilitates the interculture in two directions after the orchard is planted.

**Advantages**

1. Most easy and popular one.
2. In this row to row and plant to plant distance is kept similar.
3. Plants are exactly at right angle to each other.
4. Interculture operations can be done in both the directions.
5. Adequate space for inter-cultivation of remunerative crops like vegetables.

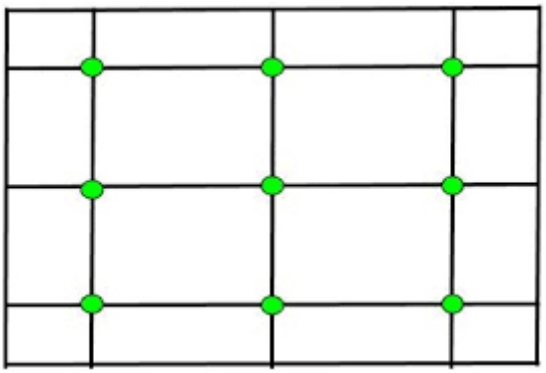


## 2. Rectangular system

In this system, the plot is divided into rectangles instead of squares and trees are planted at the four corners of the rectangle in straight rows running at right angles. Like square system, this system also facilitates the interculture in two directions. The only difference is that in this system more plants can be accommodated in the row keeping more space between the rows.

**Advantages**

1. Layout in rectangular shape.
2. More space between row to row.
3. Inter-cultural operations can be done in both the ways.
4. Plants get proper space and sunlight.



## 3. Hexagonal system

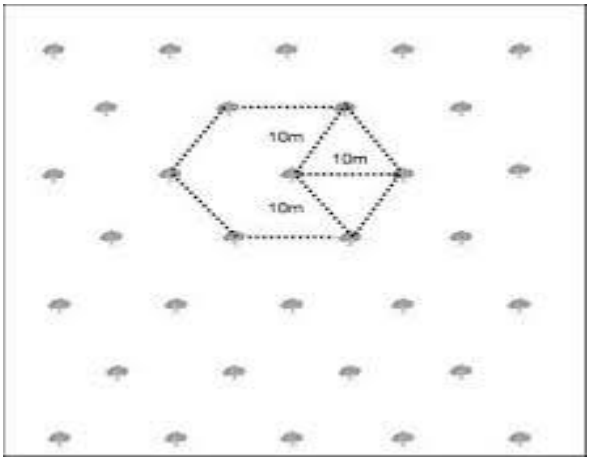
In hexagonal system, the trees are planted in the corners of equilateral triangles. Six trees thus form a hexagon with another tree at its centre. This system, though a little difficult for execution but accommodates 15 percent more plants. Cultivation of land between the tree rows is possible in three directions with this system. This system is generally followed where the land is costly and very fertile with ample provision of irrigation water.

**Advantages**

1. Accommodates 15 % more plants than the square system.
2. Plants are planted at the corner of equilateral triangle.
3. Six trees are planted making a hexagon.
4. The seventh tree is planted in the centre and called septule.
5. This requires fertile land.

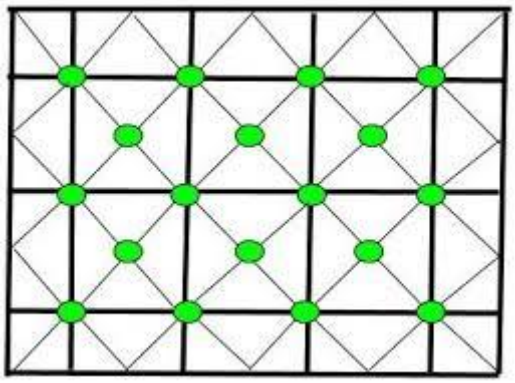
**Disadvantage**

**1.** Lay out is difficult and cumbersome.



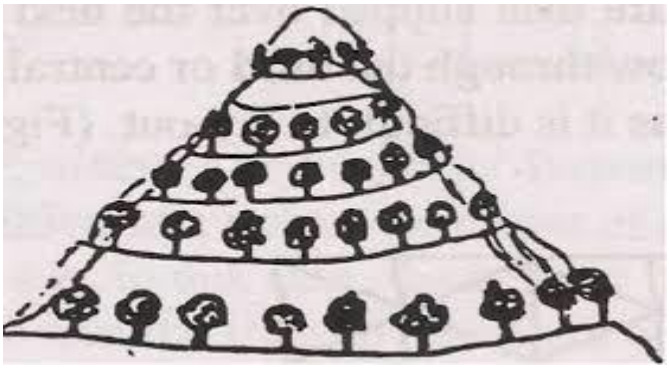

**4. Quincunx system**

- This system is exactly like the square system but one additional tree is planted in the centre of each square.
- The number of plants per acre by this system is almost doubled than the square system.
- Fruit trees like papaya, kinnow, phalsa, guava, peach, plum etc. can be planted as fillers in the permanent trees provides an additional income to the grower in the early life of the orchard.
- The filler trees are uprooted when the main orchard trees start commercial fruiting.



**5. Contour system**

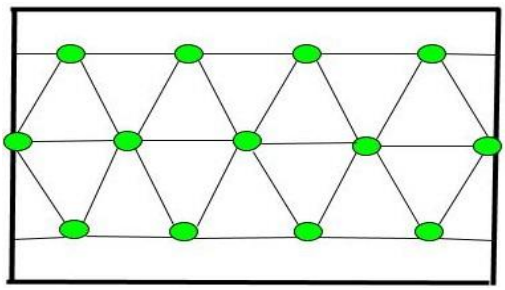
- This system is usually followed in the hilly areas with high slopes but it is very much similar to the square/rectangular system.
- Under such circumstances, the trees may be well planted in lines following the contour of the soil with only a slight slope.
- Irrigation and cultivation are then practiced only across the slope of the land as this practice reduces the chances of soil erosion.
- In this system layout is done as in square/rectangular system, first by establishing the base line at the lowest level and then marking for the trees should be done from the base to the top.
- Bench terraces are used where the slope is greater than 10 per cent.



**6. Triangular system**

- In this system, trees are planted as in the square system but the plants in the 2nd, 4th, 6th and such other alternate rows are planted midway between the 1st, 3rd, 5th and such other alternative rows.

- This system provides more open space for the trees and for intercrop.



## Experiment No. 12: Principles and Methods of Training and Pruning

Some of cultivated fruit trees grow wild and do not give sufficient yield unless pruned or trained to a specific form. All types of fruit tree do not require pruning e.g. mango, sapota, etc. and some fruit trees can grow well naturally e.g. pineapple, papaya they do not require pruning. While most deciduous tree like apple, pear, almond etc and grapes, ber, fig citrus, pomegranate, guava etc. require pruning to train them for desired shape.

### 1. PRUNING

Pruning may be defined as the art and science of cutting away of portion of plant to improve its shape, to influence its growth, flowering and fruitfulness and to improve the quality of the product. It is done to divert a part of plant energy from one part to another part of plant.

**Objective of Pruning:**

- Maintenance of grown up trees i.e. to maintain the health of bearing plant
- To bring vigour in old trees
- To improve size, color and quality of fruits.
- To increase vegetative growth of plants.

**Principles of Pruning:**

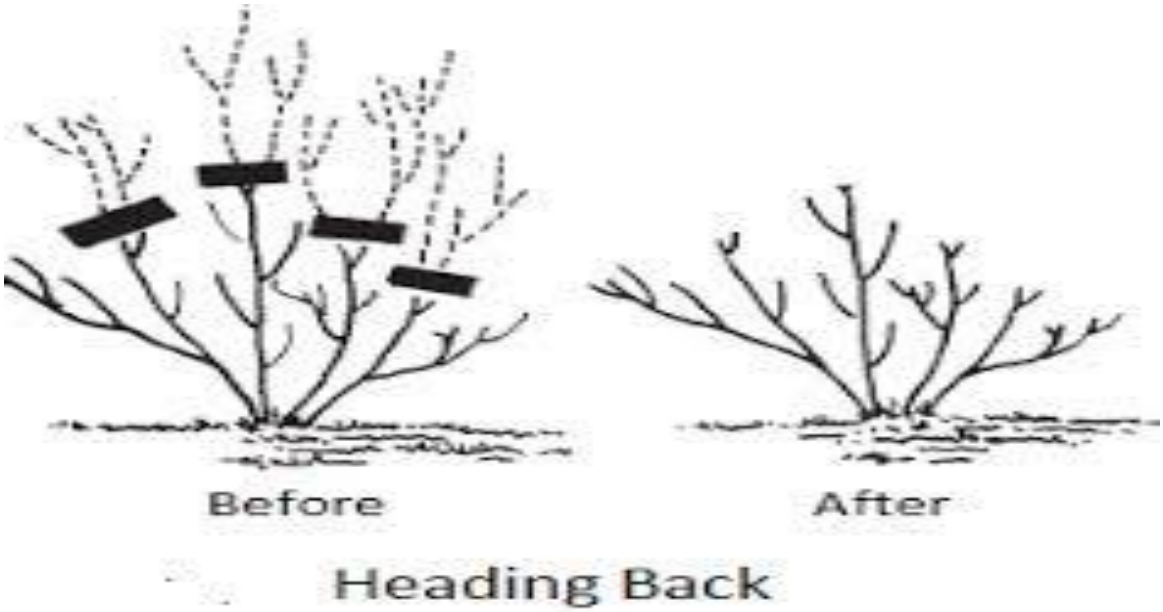
- Young trees are pruned to train it to acquire a desired shape.
- In0 old trees light heading back is done to stimulate the flowering
- In bearing trees light pruning is done to stimulate fresh growth. it bearing flower buds on fresh growth

- In old trees heavy pruning is done to restore vigorous
- All the diseased, weak, dead or shading branches must be removed.

**Types of Pruning System:**

## 1. Heading Back:

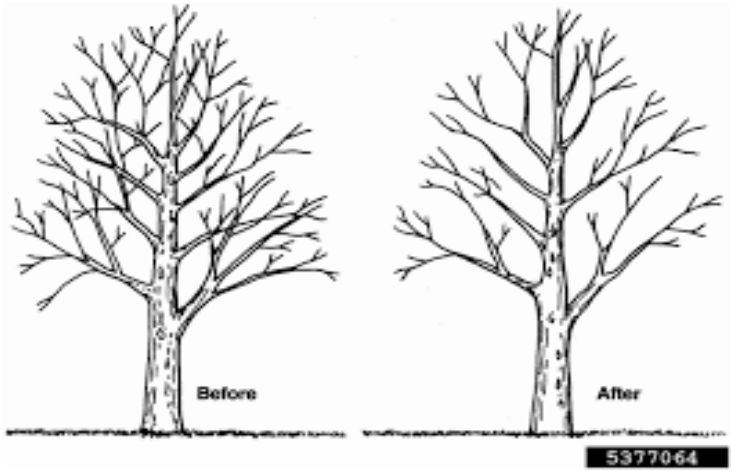
In heading back, the terminal portion of twigs, canes or shoots is removed, but the basal portion is not. It stimulates the development of more growing points.




Heading Back

## 2. Thinning out:

When the shoots or branches, which are considered undesirable, are removed entirely from the base or point of attachment, is called thinning out.




### 3. Ringing or girdling:

In this process, a circular ring of bark measuring about 3cm in length is removed.

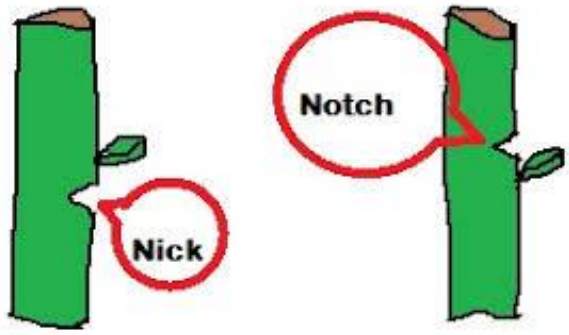
**Girdling**

### 4. Notching:

Making a notch above the bud by removing a wedge shaped piece of bark is termed as notching. It checks the influence of hormone and encourage growth.

### 5. Nicking:

Making a notch below the bud by removing a wedge shaped piece of bark is termed as nicking.




## 2. TRAINING:

It means developing a desired shape of the tree with particular objectives by controlling habit of growth. Training is start from nursery stage of plant. Physical techniques that control the shape, size and direction of plant growth are known as training or in other words training in effect is orientation of plant in space through techniques like tying, fastening, staking, supporting over a trellis or pergola in a certain fashion or pruning of some parts. Some fruit crops like grape vines, ber, fig, guava etc. require training.

**Objective of Training:**

- To admit more light and air to the centre of the tree to expose maximum leaf surface to the sun
- To direct the growth of the tree so that various cultural operations such as spraying, ploughing, harvesting can be performed easily and at lower cost.
- To protect the tree from sun burn and wind damage.
- To secure a balanced distribution of fruit bearing parts of the tree.

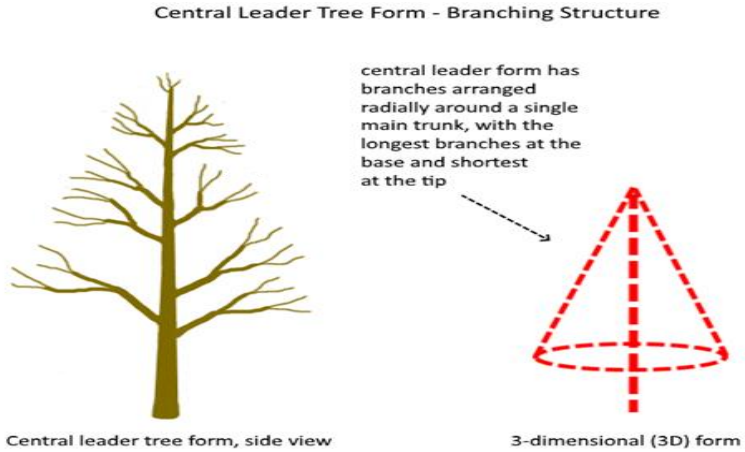
**Principles of Training:**

- Formation of the mainframe work must be strong. The branches must be suitable spaced apart and the tree must be balanced on all the sides.
- Never allow several branches to grow at one place or very near each other.
- Careful training of main branches is very essential.
- Another important point about training is that if two branches are growing at the same point try to train them to grow at a wider angle. Narrow angle is always weak.

## Types of training systems:

## 1. Central leader/ Pyramid system:

The main trunk is allowed to develop without interruption. The first branch is allowed to grow at 45 to 50 cm height from ground level and other branches are allowed to grow on main stem at a distance of 15 to 20 cm. In this system, intercultural operations like spraying, pruning, thinning and harvesting are difficult to operate. The sunlight exposure of tree is not uniform, hence fruit bearing is on the upper portion of the tree only. This system is most suitable for Pear.




## 2. Open Centre/ Open Head System:

The main trunk is beheaded, when the plant attains a height of 40-50 cm. 3-5 nearly equally developed primary lateral branches which are well scattered, arranged and distributed are allowed to develop from trunk. This system leads to a spreading structure, through with somewhat weaker crotches facilitating thinning, spraying, picking, removal of diseased portions. It exposes the tree to maximum extent and this has uniform distribution of fruits on the branches. This system is not suitable for high altitude where frost observance is common. It is mostly practiced in peaches, apple, cherries and plum.

Fig. 7.1 Open centre system

### 3. Modified Leader System-

This is intermediate form of central leader and open center system and draws the benefits of both system. It is first trained like centre leader by allowing stem to grow for first 4-5 years and then headed back to 75-120 cm height from ground level. On the main stem, the first shoot is selected at the height of 40 cm from ground and 4 to 5 branches located at a distance of 15 to 20 cm and placed all around the main stem are selected. When properly formed, it provides stronger crotches, better spacing between laterals and more height than open head tree. In this system. Intercultural operations like spraying, pruning and harvesting can be done easily. This system is mostly adopted in Apple.

Fig. 7.3 Modified leader system

# Experiment No. 13: Preparation of Potting mixture

The material in which plants grow in pots is known as ‘potting material’, while the substrate or medium used to grow plants is called ‘growing medium’. The choice of the type of potting material is important as the growth of plants largely depends on it.

**Functions of growing medium**

- It supplies nutrients, air and water to the roots of plants.
- It retains necessary water in the soil, while excess is drained out.
- It provides physical support to plants.
- It facilitates maximum root growth.

**Characteristics of growing medium**

- The medium must have adequate aeration, drainage and water-holding capacity.
- It must not be too heavy to lift.
- The medium must be slightly acidic to neutral, i.e., pH of 6 – 6.5 being satisfactory in most cases.
- It must be free of weeds, pests and pathogens.
- It must be easily available.
- It must not be too expensive.

**Types of growing medium**

The main function of growing medium is to supply nutrients, air and water to the roots of a plant. It supports the plant physically and holds it in upright position, allowing growth against the gravitational force. For the above two functions, it is necessary that the medium facilitates the growth of roots within it. The chemical composition, as well as, physical structure of the medium favours the growth of the plant. Different types of growing medium are used as per the requirement of plants.

**Garden soil**

Light and sandy loam soil must be used as growing medium, while silty or clayey soils are not preferred due to poor aeration and stickiness. The soil contains both organic and inorganic matter. When the soil is used as a medium, it may contain disease-causing

pathogens, along with weed seeds, which is a serious problem in growing crops. The soil is easily available and comparatively a cheaper medium used in a nursery.

**Sand**

Large particle size makes this medium more porous, aerated and well-drained. The water-holding capacity of this medium decreases with an increase in the size of the particles. The usual size of sand is 0.05–2 mm. Quartz sand is a useful growing medium but it lacks in nutrient content. It is relatively inexpensive and heavy. Generally, it is mixed with soil and used as a well-drained porous medium.

**Compost**

Compost is formed due to the decomposition of organic matter. Leaves, grass clippings, bagasse, litter, wood waste, rice husk, sawdust and farmyard manure are some of the common ingredients used for preparing compost. Compost contains nutrients that plants need for growth. Vermicompost is a supplement that is added to a growing medium.

**Sphagnum moss**

Commercial sphagnum moss is a dehydrated by-product of bog plants of genus Sphagnum. Commonly used moss grass is comparatively light in weight, acidic in reaction, sterile in nature and has sufficient water-holding capacity. Hence, it is commercially used as a rooting medium in air layering.

**Peat**

Peat consists of residues from marsh swamp and organic nitrogen. It helps in fast vegetative growth and is commonly used for growing newly rooted cuttings or newly germinated seeds.

**Coir peat or coco peat**

Coir peat is obtained from coir's fibre dust. It is acidic in nature and has a pH of about 5. It has a high water retention capacity.

**Vermiculite**

Vermiculite is chemically hydrated magnesium aluminum iron silicate. It is produced by heat treatment of mica. It is porous in nature and light in weight. It has adequate water-holding capacity.

**Perlite**

Perlite is a natural mineral of volcanic origin, which is light in weight. Its pH is, usually, neutral to slightly alkaline.

**Sawdust**

It is the by-product of sawmills. It is easily available and cheap. It is poor in nutrient

## Experiment No. 14 :Fertilizer application in Horticultural crops

A fertilizer is any material of natural or synthetic origin that is applied to soil or to plant tissues to supply one or more plant nutrients essential to the growth of plants. Many sources of fertilizer exist, both natural and industrially produced.

**Inorganic fertilizers**

- Industrially manufactured chemicals.
- Contains higher nutrient than organic manures.
- Nutrient input is lost through leaching, runoff, volatilization, fixation by soil or consumption by weeds etc.

**Organic fertilizers**

- These are plant and animal wastes that are used as nutrients after decomposition.
- Improves the soil tilth, aeration, water holding capacity and activity of micro-organism.

**Where to apply manures?**

- In fully grown trees, the manures and fertilizers should be given over the area, where their active roots are spread.
- Fertilizer should be given in restricted area i.e., in the surrounding area of about 1 to 1.5 m away from the trunk of the trees.

**Time of Fertilizer Application**

- It must be applied when the plants need it.
- Timing depends on the type of fertilizer and climate.
- Fruit trees require more nutrients at the emergence of new flushes and differentiations of floral buds.
- Utilized more during the course of fruit development.
- Nutrients should be available to them in February –March.
- So, it would be better to apply them in October-November to be available to the trees in February to March.

**Methods of Fertilizer Application**

1. **Broadcasting**
    - Fertilizer in solid state or granular or dust are spread uniformly over the entire field.
    - Leaching loss may be more.

**Disadvantages**

- Some of the elements like phosphorous and potash do not readily move in the soil. Therefore, surface application may not be available to the trees especially in drier tracks.
- Leads to accumulation of potassium in surface soil beyond detrimental levels causing injury to plants.
- Surface application always stimulates weed growth.

2. **Band placement**
    - Application of fertilizer on the sides of rows.
    - Fertilizer in solid and liquid forms can be applied.
    - Quantity of fertilizer may be economised.
3. **Ring Placement**
    - Commonly followed in fruit trees.
    - Fertilizers are applied in a ring encircling the trunk of the trees extending the entire canopy.
    - It is more labour intensive and costly.
4. **Foliar Application**
    - Fertilizers are applied in liquid form as foliar sprays.
    - They are easily absorbed by leaves.
    - Fertilizers are applied in a very low concentration tolerable to the leaves.
    - Recommended when the nutrients are required in small quantity.
5. **Starter Solution**
    - Liquid form of fertilizer application.
    - Seedlings and propagules are kept emerged up to their root system for varying duration in starter solution.
    - The starter solution is prepared either by dissolving concentrated fertilizer mixture at a concentration not exceeding 1%.

**6. Fertigation**

- Application of fertilizers in irrigation water in either open or closed systems.
- Nitrogen and sulphur are the principal nutrients applied.
- Phosphorous fertigation is less common because of formation of precipitates takes place with high Ca and Mg containing water.

**Advantages**

- Nutrients especially nitrogen can be applied in several split doses at the time of greatest need of the plant.
- Nutrient is mixed with water and applied directly near the root zone, as such higher use efficiency.
- Cost on labour is saved.

Best results of fertigation are noticed when the fertilizer is applied towards the middle of the irrigation period and applied towards the middle of the irrigation period and their application terminated shortly before completion of irrigation. Use of soluble fertilizer improves use efficiency.

Note: The grower must consider the economics and advantages before deciding for using fertigation.

**7. Tree Injection**

- Direct injection of essential nutrients into the tree trunk.
- Iron salts are injected into chlorotic trees that are known to suffer from iron deficiency.

**Factors favouring nutrients absorption and transport**

- High humidity, proper temperature and incident radiation.
- Good CHO supply and vigorous growth.
- Chemical and physical properties of nutrient spray solution.
- Leaf characters like leaf thickness, hairyness and wax coating on the leaf.
- Generally more vigorous plant and young growing leaves have good capacity to absorb nutrients.
- Nitrogen- applied in the form of urea (1%) is readily absorbed.
- Sodium and potassium (KCl) - readily absorbed by leaves and they are among the highly mobile Elements.

**Precautions**

- While applying foliar sprays, care should be taken to ensure correct concentration of spray solution.
- Apply in the morning or evening hours on a clear sky day.

**Calculation of quantity of fertilizers based on nutrient requirement**

Quantity of fertilizer = (quantity nutrient required x 100) ÷ nutrient present in fertilizer

Q = (N1 x100) ÷N2

Where, Q = Quantity of fertilizer

N1 = quantity nutrient required

N2 = nutrient present in fertilizer

Or

Q = quantity of nutrient required x factor

**Calculation of quantity of complex fertilizers**

First find out the quantity of fertilizer required for supplying of whole quantity of major nutrient present in the particular fertilizer. Thereafter, calculate the amount of second nutrient supplied through the calculated quantity of fertilizer. Then subtract calculated amount of nutrient from the whole amount of second nutrient. Calculate the quantity of another source of fertilizers for balance nutrient quantity of second nutrient.

**Calculation of quantity of chemicals for spray solution**

V1= (C2 x V2) x C1

Where,

V1 = quantity of chemical or commercial product

V2 = volume of spray solution to be prepared

C1 = nutrient content in chemical or commercial product

C2 = concentration of spray solution

$$\text{Desired quantity of Chemical} = \frac{\text{Qty. of spray solution required}}{\text{\% of actual ingredient of nutrient in chemical}}$$

# Experiment No. 15 : Visit to commercial orchard/nursery

## Introduction

Indian topography and agro climates are well suited for horticultural crops, which are considered ideal for achieving sustainability of smallholdings, increasing employment, improving environment, providing an enormous export potential and above all achieving nutritional security. Furthermore, horticulture has the potential for improvement of wasteland as well as arid and semi-arid areas. Most of the horticultural crops need comparatively less water compared to field crops and provide higher employment opportunities, better nutritional security as well as healthy environment. Fruit production is profitable. Farmers involved in fruit production usually earn much higher income as compared to cereal producers. It also provides ample opportunities for sustaining large number of agro-industries, which generate substantial employment opportunities. It is indeed important for students to know about different horticultural crops, their nomenclature, at what time we plant them, how do we plant them, what are their important insect-pests and diseases and their management and how do we harvest them and market them.

## Features of an ideal Orchard

Orchard is a piece of land cultivated with fruit crops and related horticulture crops.

1. **Store and Office building**-It should be in the centre of the orchard for easy and proper supervision of work by the manager. For easy approach of labours to take any implements and tools needed for their work, to take the inputs like herbicides, weedicide, pesticides, fungicides, fertilizers etc. to the field. In store room, racks should be provided to keep the herbicide or weedicide, pesticide and fungicide. Storage bins are also kept in stores for storing the seeds and produces.

In the office, racks are used to keep record and registers related to orchard management such as stock register, produce register, attendance register, tree register etc.

2. **Wells and water tanks**-It should be located at convenient places in different parts of the orchard at least one well for 2 to 4 hectares. Water tanks are used to store water. From the well the water is lifted and stored in the tank and used for irrigation. From the tank, irrigation channel are used to take water to the field.

3. **Irrigation Channels**- Two types of channels which are concrete and mud channel are laid out in the orchard. Concrete channel reduces water loss through seepage and maintenance is easy. Weed growth is less or negligible in concrete channel. Channel should be laid along the gradients for most economical conduct of water for every 30 meters length of channel, 7.5 cm slope should be given.
4. **Roads and Footpaths**:These two components should occupy minimum space for the economy of transport. The metal road in the main areas are advantageous because it is easier for the movement of vehicles like tractor or lorry to carry fertilizers, pesticides and harvested produces, planting materials like seedling, layers, grafts, cuttings etc.
5. **Fruit Trees**:Short growing fruit trees should be planted at the front and tall at the back for easy watch and to improve the appearance of the orchard. Short growing fruit trees are guava, pomegranate, annona and aonla. Tall growing fruit trees are mangoes, leeches and sapota.
6. **Manure Pit:** Manure pit is essential to dump the waste plant material after harvest of the produce. This will enable to supply considerable quantity of organic manure to the farm. This should be located in a corner of the orchard.
7. **Wind Breaks:** These are rows of tall trees planted close together around the orchard. These are essential to resist wind velocity which cause severe loss particularly moisture loss from the soil through evaporation and fruit drop. Wind breaks are efficient in reducing the velocity of wind thereby minimize the damage to the fruit crops by wind. Wind break should be of tall growing nature. Some of the common wind breaks are *eucalyptus globules, polyalthialongifolia, azadirachtaindica,* etc.

## Observation

Observe about the features existing in the orchard visited by you and compare with the features of an idle orchard.

Record your observation in the data sheet.

| DATASHEET | | | | | |
|---|---|---|---|---|---|
| **Sr. No.** | **Particulars** | Fruit crops in orchard | | | |
| | | 1 | 2 | 3 | 4 |
| **A** | **Name of the variety** | | | | |
| **B** | **Name(s) of fertilizer applied** | | | | |
| **C** | **Dose of fertilizer applied** | | | | |
| **D** | **Time and method of application of fertilizer applied** | | | | |
| **E** | **Layout system adopted** | | | | |
| **F** | **Time of harvest** | | | | |
| **G** | **Weed Control: weedicide and dose used** | | | | |
| **H** | **Disease and insect pest management** | | | | |

**********END**********