

**Specific Objectives:**

To enable the students to understand the basics of Horticulture.

**Theory:**

Introduction, history, importance and future scope, Definition and divisions of horticulture, Classification of horticultural crops, Plant parts, their modifications and functions, Plant environment; climate (temperature, light, humidity etc) and soil (structure, texture, fertility etc), Propagation of horticultural plants.

**Practical:**

Visit of nurseries, commercial gardens and public parks. Identification and nomenclature of important fruits, vegetables and ornamental plants; Garden tools and their uses, Media preparation. Techniques of propagation.

**Books Recommended:**

1. Arteca, R.N. 2006. Introduction to Horticulture. Delmar Learning Science Publishers, USA.
2. Brown, L.V. 1996. Applied Principles of Horticultural Science. Butterworth – Heinemann, Oxford, U.K.
3. Chadha, K.L. 2006. Handbook of Horticulture (6th Ed.). ICAR, New Delhi, India.
4. Hartmann, H.T., D.E. Kester, E.T. Davies and R.L. Geneve. 2009. Plant Propagation–Principles and Practices (7th Ed.). Prentice-Hall India Learning Pvt. Ltd., New Delhi, India.
5. Malik, M.N. 1994. Horticulture. National Book Foundations, Islamabad.
6. Reiley, H.E., C.L. Shry (Jr). 2004. Introductory Horticulture (6th Ed.). Delmar- Thomson Learning, Albany, USA.
7. Sharma, R.R. 2002. Propagation of Horticultural Crops: Principles and Practices. Kalyani Publishers, Ludhiana, New Delhi, India.
8. Singh, B. 2007. Horticulture at a Glance. Kalyani Publishers, Ludhiana, New Delhi, India

## Hort-401

### Introductory Horticulture

The term **Horticulture** is derived from two Latin words **Hortus** (Garden) and **Colore** (Cultivate).

**Definition:** The branch of agriculture concerned with intensively cultivated plants which are used for food, for medicinal purpose and aesthetic gratification.

We deal only garden crops. Horticulture may be considered as a parallel discipline to agriculture since the Latin word Ager (field) and agriculture defined as “the cultivation of field crops where as the horticulture is cultivation of garden crops”. The differences among Horticulture, Agronomy, Forestry, are mainly defined by customs. Horticulture products usually have high water content and highly perishable and are usually utilized as fresh. Whereas agronomic and forestry products are often utilized in non-living state and usually contain high percentage of dry matter.

#### **Divisions of Horticulture:**

There are three basic divisions:-

1. **Pomology:** Study of fruit production.
2. **Olericulture:** Study of vegetable production.
3. **Floriculture:** Study of Flower Production.

Landscape Horticulture and Designing also emerged as distinct branches of Horticulture. Floriculture & Landscaping are treated as one branch of Horticulture also known as ornamental Horticulture. From the commercial point of view, production of nursery plants or nursery culture is also viable branch of Horticulture. There are other concerned branches like seed production and marketing, green house crops, pharmaceutical crops, processing and storage and along with many other sport industries.

#### **Pomology:**

Study of fruit is called Pomology. Botanically a fruit is ripened ovary. Its horticultural definition is edible, fleshy or dry portion of a plant whose development is closely associated with the flowers. Commercial production of fruit is known as orcharding. Grapes plantation are called vine yard and cultivation of grapes is viticulture. Citrus orchards are typically citrus groves. Cultivation of citrus is called citriculture.

#### **Olericulture:**

The study of vegetable production is called Olericulture. It is derived from Oleris (a Herb). A vegetable may be defined as the edible portion of herbaceous plant which is used as fresh or processed. The edible portion may be fruit, foliage, tuber, or any other plant part. Edible portion of tomatoes is fruit. A potato is tuber, sweet potato is root, and Pease are seed and lettuce as leaf.

**Home Gardening:** is the growing of vegetable for home use. It is the oldest of vegetable production and still is the most important source of vegetable in rural household. Besides being very economical this is the only method of assuring fresh produces and the choice of crops can be made according to the liking of family members. If intensive methods are followed, from an area of 10-20 Marla sufficient for vegetables

and some fruits. Fruits can be grown for an average family. Sometimes additional income can be earned by selling the excess.

**Market Gardening:** Near large centers of population, many kinds of perishable for sale. The product of this vegetable culture is sold in local markets which are usually within few miles from cities. This type of market gardening has developed to meet the requirement of people with no land, no time, or interest to grow their own vegetables. Improved roads and transports facilities have made it possible for market gardener to serve distant areas too.

**Truck Gardening:** is the production of vegetables in relatively large quantities and for distant market. Special crops are selected and grown in different Agro Ecological regions. The usually choices are the less perishable or non-perishable crops. Production of potato in Okara District, Mellon and peas in Gujranwala district. Winter musk Mellon in lower Sindh, late summer crops of onion in Baluchistan and Swat are few examples of Truck Gardening.

**Vegetable Forcing:** Production of vegetable out of their normal season of outdoor production is known as vegetable forcing. There is demand for out of season produce and consumer is willing to pay extra. The most common form is early or late production of summer vegetable. A usual limitation of summer vegetable like Potato , cucumber, melon, egg plants, bitter gourds, bell paper. In developed countries such crops are grown in green houses and make it more intensive type of cultivation.

**Vegetable seed production:** is small component of vegetable growing industry but considered important and highly specialized area. Similarly mushroom culture is the branch of Olericulture which has the potential for expansion in some areas.

### **Floriculture & Ornamental Horticulture:**

This branch of Horticulture deals with plants and their layout for the beautification of the environment. Ornamental plants based on their decorative value and personal choice. There are seasonal flowering plants, foliage plants; lawn grasses evergreen and deciduous shrubs and trees. Fruit trees grown in home gardens can also selected for ornamental purpose. Selection of plant according to physical situation of a house public or private building, roads, public facilities, airport, and recreational places like a park is known as landscape designing.

Ornamental Horticulture can play an important role in modification of domestic and urban environment and pollution control.

### **Classification of Horticulture Crops:**

There are several ways to classify plants or Horticulture crops like growth habits, spans, temperature relations, uses, morphology and cultural requirement.

**Growth Habit:** Horticulture crops can be classified as succulent & herbaceous or woody plants. The term Succulent is usually used for foliage plants with extremely tender, water stem and leaves.

**Herbaceous** is a term used for self supporting succulent. Most vegetable and many floral and ornamental plants are herbaceous in their growth habits. Self supporting woody plants are known as shrubs or trees. The distinction between shrubs and trees is made on the basis of number of stem and plant height. Trees are characterized single central stem while shrubs have more than one stem. Plants with climbing or trailing stems can be woody or non-woody. A climbing plant with non-woody stem is known as **vine**. Whereas a woody plant with climbing growth habit is known as **Liana**.

**Deciduous Plants:** Some plants that shed their leaves during winter season are called as deciduous plants.

**Evergreen Plants:** Plants with persistent leaves are called evergreen plants. Most deciduous plants are native to temperate climate while evergreen plants are considered tropical in origin.

**Classification on the base of flowering habit:**

1. Hermaphrodite Flower: Plants with flowers having both male and female sex organs in the same flower are called as hermaphrodite. For example Peas.
2. Dioecious Flowers: Plants with flowers of only one sex organ are called Dioecious flowers. For Example, Date Palm, Papaya, Spinach etc.
3. Monocious Flowers: Plants with separate flowers of a single sex organ are called Monocious flowers. For example Cucurbits.

**Classification according to life span:**

1. Annual Plants: Plants which complete its life cycle in a single growing season are called annual plants. For example many vegetables and seasonal flowering herbs.
2. Biennial Plants: Plants which complete its life cycle in two growing seasons. During the first season growth, they complete their vegetative growth while second seasonal growth they complete their reproductive growth. For example root vegetables, carrot, beats while in leafy vegetables like lattice, cabbage and onion is also biennial in nature. Climate is the critical factor and determining the life span of plants. Annual and biennial plants vary in their life cycle in different climates. Most of the above mentioned biennial vegetables are harvested for consumption after the 1<sup>st</sup> season of growth and the treated as the annual for cultivation purposes.

**Classification on the basis of temperature relations:**

- Cool season crops require maximum temperature not above 80-85 F° and the minimum temperature not fall below 35-40 F°. The optimum temperature for such crops is 65 F°.
- While for warm season crops the optimum temperature is above 80 F°. Warm season crops are usually frost sensitive and cannot grow if the minimum temperature falls below 50 F°.

→ Temperate fruits are mostly deciduous and require certain amount of chilling to flowers. For example apple, pear, peach, apricot, almond and Plum.

→ Sub tropical and tropical fruits are native to warm climate. They are frost sensitive and their foliage can be destroyed by frost. For example, Banana, Papaya, Mango are much more sensitive to low temperature exposure.

While the sub tropical plants such as citrus, guava and grapes are frost tolerant.

**Small Fruits or Soft Fruits:** Fruits born on low growing plants like shrubs or vine are called small of soft fruits. For example Grapes, Falsa, Strawberry.

**Nuts:** Fruit whose edible part is seed. E.g. Almond, Walnuts, Peanuts, Coconuts etc.

**Fleshy Fruits:** Those fruits whose edible part is soft flesh as opposed to the seed. E.g. Mango, Apple.

**True Fruits:** When fruit is formed from the ovary alone is called true fruits. For Example Tomato, Dates and Mango etc.

**False Fruits:** Sometime other part of flower like thalamus carpel also stimulates to grow in take part in the formation of fruit. Such fruits are called false fruits. E.g. Apple, Pear, Loquat etc.

**Multiple Fruit:** When fruit is formed in inflorescence not in a single flower is called Multiple fruit. E.g. Pine apple, Mulberry etc.

**Aggregate Fruit:** Fruit which is formed within a single flower in which many pistils on a common receptacle is called as aggregate fruit. E.g., Strawberries, Black berry, Blue Berry.

**Stone Fruit (Drupe Fruit):** A simple fleshy fruit having stony endocarp. E.g. Mango, Plum, Apricot etc.

**Complete Flower:** When Calyx and Corolla are present in a flower, this flower is called complete flower.

**Incomplete Flower:** When both Calyx and Corolla are absent. (Calyx (Sepals) Corolla (Petals) are collectively called perinath.)

**Pollination:** Transfer of pollen grains of a flower from another to stigma is called pollination.

**Self Pollination:** Transfer of pollen grains of a flower from another to stigma of same flower or flower of same plant. E.g. Rice, Wheat, Cotton etc.

**Cross Pollination:** Transfer of pollen grains of a flower to stigma of a flower of another plant. E.g. Tomatoes, Spinach, Coolly flower.

**Fertilization:** Fusion of male and female gametes is called fertilization.

**Double Fertilization:** The phenomena in which one male gamete fuses with oosphere (female gamete) and the other with secondary nucleus.

**Photosynthesis:** Process which convert light energy into useful chemical energy.

### **Vegetable Crops:-**

Vegetable crops can be divided into ten groups according to their morphology and habits of growth.

1. **Tuber Crop:** Potato and sweet potato.
2. **Root Crops:** Carrot, Reddish, Turnip.
3. **Bulb crops:** Onion, Garlic.
4. **Leafy Vegetables:** Spinach, Lattice, Fenugreek.
5. **Solanaceous Crops:** Tomato, Chili, Bringer.

6. **Cole Crops:** Cabbage, Coolly flower. Kohlrabi.
7. **Cucurbits:** Cucumber, Mellon, Indian squash, bitter gourd, sponge gourd, Bottle gourd, Pumpkin etc.
8. **Peas:** Peas only.
9. **Beans:** Cowpea, Cluster beans, Hyacinth beans.
10. **Okra:** Lady Finger.

#### **Plant parts and their functions:**

1. **Leaf:** Manufacture food, release water and oxygen in to the atmosphere.
2. **Chloroplast:** These are chlorophyll bodies within leaf cells in which photosynthesis takes place in order to manufacture carbohydrates (Sugar & Starch.) for the plant. They give green color to the leaves.
3. **Stomata:** are specialized breathing pores through which CO<sub>2</sub> enter and H<sub>2</sub>O and O<sub>2</sub> release. Stomata closed when H<sub>2</sub>O limited.
4. **Buds:** Buds occurs at the end of shoots (Terminal buds) and along the sides of shoots (Lateral buds). These buds contain embryonic shoots, leaves and flowers for the next growing season.
5. **Lateral Buds:** occur below the terminal buds and leave axils. If terminal bud is removed, lateral bud will grow take its place.
6. **Scaffold branches:** are large branches that give the tree its basic shape and structure.
7. **Lateral Branches:** These are also called secondary branches. These mainly horizontal that create the outline of the tree.
8. **Trunk:** is main stem that support tree to better expose leaves to the sun.
9. **Bark:** is the skin or external protective layer of the tree.
10. **Inner Bark:** is phloem. It is the part of circulatory system carrying organic compounds which needed.
11. **Cambium:** is a layer only a single cell thick between the inner bark and the sapwood (Xylem). It produces the cells that allow both Phloem and Xylem to grow.
12. **Sapwood (Xylem):** It is produced by the cambium and carries water and nutrients from roots to the leaves.
13. **Heart wood:** It is essentially active xylem. It gives the tree strength and rigidity and serve as depository for store food and waste.
14. **Root:** Root system is quite extensive depending primarily on soil texture and depth. Some trees have initial tap roots but as the tree mature other more horizontally growing roots dominant.
15. **Lateral Roots:** develop at the base of trunk and spread these roots forming an extensive network which serve as anchor to tree. They also provide storage for carbohydrates.
16. **Feeder roots:** these roots grow from the lateral roots and serve to transport the water and nutrients absorbed by the root hair. They tend to be concentrated within drip line (Where rain drips at tree) but some may extend to great distances.
17. **Root hair:** These are microscopic appendages to the feeder roots. Root hair absorbs water and nutrients that the tree needs in order to live.

**Maturity:** of the fruit is the final stage of development that must take place when the fruit is still attach to the mother plant. The enlargement of cell and storage of carbohydrates is taking place in this stage.

Aroma and taste producing substances are being accumulated and acidity is reducing generally the fleshy edible portion is not get soften.

**Ripening:** of the fruit involve in certain biochemical changes which takes place in the fruit after full maturation. The softening of edible portion is near completion. Production of fruit characteristics such as aroma and sweet juice increase. Ripening may take place before or after harvesting. E.g. a popular grafted mangoes variety Sindhri grown in Sindh is usually harvested before its ripe on the tree. Generally the fruit is considered to be mature and ready for harvesting when one or two naturally ripe yellowish mangoes drop from tree. The harvested mangoes are mature but are still green. The harvested green fruits kept in wooden crates. These crates are stored in rooms for ripening which usually complete in a week. The yellow fruit attain aroma and become sweet juicy and tasty. At this point it is brought to market and fetch a good price. Generally Sindhri mangoes are transported to big cities like Karachi, Lahore and exported to Middle East countries.

**Senescence:** is physiological aging activity in which plant tissues degenerate and ultimately die. This activity is one of the most mysterious plant growth processes and takes place in almost all organs of the plant.

**Partial Senescence:** involve the degeneration and death of Aerial plant parts. E.g. leaves, branches, flowers, fruits but not underground plant parts. This process occurs with deciduous plants in unfavorable season like in winter the leaves fall down. The commercially important woody perennial Sisham leaves become senescent die and fall off in winter. The rest of the plant services gives out new roots and leaves in spring season where the flowers and fruits in the summer season.

**Complete Senescence:** This is the aging process in which all parts of the plant except seed ultimately die. It is observed in almost all cereals, pulses, vegetables and ornamental seasonal plants.

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## MID COURSE

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### **Propagation of Horticulture Plants**

#### **Sexual Reproduction:**

Propagation through seeds is called sexual reproduction.

Disadvantages of sexual reproduction:

Fruit trees take a long time to come into bearing and have a tendency to grow taller which adds maintainant and harvest cost.

#### **Advantage of sexual reproduction:**

Seedlings are generally hardy where heavy crops bear and are long live

There are several factors, which must be considered before actually sowing of seed.

#### → **Collection of seeds:**

Seeds should be collected from reliable source that minimizes the chance of seedling variation. The fruits selected for seed extraction should possess good fruit and keeping quality characteristics. In most cases, they should be fully mature & taken from healthy vigorous plants with the high degree disease resistance.

#### → **Storage of Seed**

Seeds of most evergreen species sown after extraction out prolong storage. In case it become necessary to store the seeds they should be carefully washed surface dry & mist with an equal part of ground charcoal & packed in suitable size of wooden or metallic container which should be place with temperature 3-13 Celsius.

→ **Sowing:**

Seed is sown either in pots trays or overall plastic bags or in beds in nursery rows with species, which don not tolerate transplanting well seeds, are sown in a specially prepared holes at recommended distance, from plant to plant and row to-row distance. When a small number of seedlings are required, they are raised in earthen wooden, trays or plastic bags. These containers are filled with a potting mixture of equal parts of top soil, sand & well-rotted farmyard manure. A sowing depth is 2 to 3 times is usually considered satisfactory the seeds are covered with sand or leaf mold & water after sowing.

**Asexual Reproduction:**

A sexual or vegetative reproduction overall uses a part of plant for multiple parts stems, leaves, buds, roots, bulbs, corns, suckers & tubers. Sexually propagated plants are identical to the parent plants in all respects.

Vegetatively propagated remained low head & they bear fruit earlier than sexually ones do & with uniformly fruit quality, there are few disadvantage of using vegetative propagation technique

1. Layering.
2. Division.
3. Cutting
4. Grafting
5. Budding.

Budded or grafted are generally less vigorous & short live than seedling & new varieties cannot be evolved through asexual propagation.

**Layering:**

Layering means rooting of shoot stem or branches while they are attach to the parent plant. The advantage of layering is that the young plant continues receiving nourishment from the parent plant. Layering can be carried in spring or late summer season.

→ **Air Layering:** This method is locally known as “Ghotti”. It is common for vegetative propagation of guava, litchi. In areas where rainfall is abundant and humidity is higher. It is done by making a round cut with a knife in a mature and healthy vigorous shoot or branch just below a node. When the cut is made, a very small stone is pushed slightly into the cut to prevent the two sides from reuniting. The cut is then covered with mixture of mud in plastic covering.

→ **Ground Layering:** In ground layering, instead wrapping the rigid or cut portion is buried in the ground or in the soil prepared in the pots. After two



months, a half cut is made in the parent branch just below the layering. If no wilting is noticed, it indicates that the new layer has developed roots. The layering is separated as an independent plant.

→ **Serpentine Layering:** With some species, which gives out long and flexible branches, the shoot to be layered is covered with the soil at several places to encourage rooting at more than one point.

→ **Mound or Stool Layering:** It involves cutting down the parent plant just about the ground level. The stubs or stools are earthed up to encourage the growth of shoots. The earthing up gradually carried out until  $\frac{1}{3}$ rd to  $\frac{1}{2}$  of their length is covered with soil. Growth of shoot is completed in darkness, which results in blanching (etiolation). This etiolation induces development of roots at the basin ends. These are then reattached and transplanted in nursery.

### **Division:**

Division involves separating vegetative part like rhizomes runners and suckers from the parent plant and establishing them as independent plant. This method has wide application in propagation of flowering shrubs, runners, great palm by suckers, propagate other ornamentals among fruit crops starwberries, and bananas are by suckers or rhizome.

### **Cutting:**

It is the piece of plant shoot, stem, leaves, bud, root etc. Cuttings have the capacity to produce root and shoot essential for the development for plant. Identical to the parent plants from which cutting was taken. Cutting should only be taken from strong and healthy plant. Grapes, lemon, sweet lime, roses and other perennial flowering shrubs are commonly propagated through cutting.

→ **Root cutting:** To prepare root cuttings, the roots are cut in to pieces 10-25 cm long, which are, planted horizontally in well-prepared pots or beds. Guava, apple, pear, cherry are propagated by this method. This method is seldom used in Pakistan.

→ **Stem Cutting:** Cuttings are either soft wood or hard wood used to propagate number of fruits and flowering shrubs.

**Soft woodcutting** are taken when the stem is still soft and succulent in spring or early summer and generally consist of terminal portion of these shoots.

**Hard woodcuttings** are taken from previous season mature growth when the stem has shed leaves and hard. Hard cutting are used in the propagation of lemon, grapes, pomegranate and plum. Cuttings of most plant species, which are prepared from mature wood, are of pencil thickness varying from 18-25 cm thickness. The upper cut from 5 cm from node is made to reduce the size of wound. The cuttings are planted 15 cm of each other in rows 30 cm apart. Generally  $\frac{2}{3}$  of hard cuttings and  $\frac{1}{2}$  of soft woodcutting should be

inserted in the soil in a slanting position to prevent rainwater from entering through the cut surface. To expel air the soil around each cutting must be pressed and filled up. The beds or pots are kept moist by daily irrigation. Root growth is favored by temperature 18-21 °C. In evergreen species cuttings are prepared and planted in early spring or rainy season. However, in deciduous species, cuttings are made during dormant season and are stored to be planted during early spring.

### **Grafting:**

Unlike with layering, division and cuttings a grafted plant is composed of two parts. The basal part, which provides the root system for anchoring and absorption of moisture and nutrients, is called rootstock. The upper portion is called scion. It provides the top and fruit bearing surface and synthesizes food, which is transported to the other parts of plant. Scion and rootstock should be compatible and closely related to belonging to the same genus. When a single bud is used as scion and inserted into rootstock this method is called budding. Whereas when a piece of stem or branch carrying one or more than one buds are used is known as Grafting.

**Budding** is relatively easy to do and is extensively used in vegetative propagation in vast number of species of fruits and flowering trees particularly evergreen. There are different methods of budding.

1. **Shield budding/ T budding:** This most common method of vegetative propagation of citrus, apple, roses and many other ornamental trees and shrubs. In this method, a narrow shield of bark 3-4 cm in length bearing a single bud is removed with a budding knife. On rootstock, a vertical cut 3-4 cm in length is made just through the bark on the rootstock. At the top end, a horizontal cut about 1.25-1.5 cm in length is made so that cut resembles the letter T. In areas where heavy rainfall occurs and inverted T cut is used to avoid the entrance of excessive moisture. To hold the bud firmly in position and to exclude air and moisture. The bud union is carefully wrapped using suitable plastic strips keeping the bud exposed. After the buds sprout 10 cm, the tying material is removed and budded plants are trained to the proper size and shape.

2. **Ring Budding:** in this method, a ring of bark 1.5-2 cm in length containing a well-developed bud is loosened on the scion shoot and is gently pulled out from the thinner end of this shoot. No tying is necessary in ring budding. Uniformity in thickness of rootstock and scion shoot is desirable for higher percentage of success. This method is used for mulberry, plum, peach and pear etc.

3. **Chip Budding:** in this method, a single bud with a large piece of

wood is placed on corresponding cut made on the rootstock and tied firmly. This method is used rarely in Pakistan.

### **Types of Grafting:**

**1. Inarching or Approach grafting:** In Pakistan, method has been extensively used in vegetative propagation of mango. This method involves potting healthy one-year-old seedling in earthen pot, which is usually 12 inches deep and 8 inches wide at top. The earth ball along with root system is kept intact and placed in a pot. The unfilled space in the pot is filled with mixture of well-rotted manure and canal silt. The soil is firmly pressed around earth ball, transplanted seedlings, and then watered. Potting the seedlings is usually done one month before actual inarching operation. This allows sufficient time for seedlings to set before grafting. Inarching can be done in spring months and rainy season.

A slanting cut about 5 cm long and 2 cm deep is made on rootstock seedling at a height of 15-20 cm. A similar cut is made on the scion shoot and both cuts then brought together and tied with plastic sheets. To prevent drying up the union point is covered with jute strips and wrapped with polythene sheets. While tying care is taken to bring corresponding cambium surface into contact. Union takes place within 3-4 months. When the graft is still attached to the parent plant, the pot is watered twice a day during summer month.

**2. Wedge or Cleft Grafting:** This method is generally used in propagation of deciduous fruits and plants of inferior variety. Branches of rootstock are 1.25-5 cm thick and cut at the top and vertically split 5-8 cm deep is made in the center of stub with a knife. This split is kept apart until scions containing at least three buds are inserted. The basal end of scion is cut into long sloping wedge about five cm long. One scion is inserted each side of the split. After adjustment of the scion, the tool used to keep the split open is removed. No tying is needed. It is most successful when done in early spring.

**3. Splice Grafting:** A slanting cut about 10 cm long is made at the basal end of the scion, which is placed on a corresponding cut made on the rootstock. Seedling at the high top 30-45 cm from ground level and then tied together. The cambial areas of this scion and the rootstock should be in close contact and to achieve these both should be of scion thickness. The union takes place within 3 weeks to 3 month depending upon plant species, the age and condition of rootstock and scion.

**4. Tongue Grafting:** The scion and rootstock are cut exactly in the same way as in splice grafting to provide strength and exposure of greater cambial area for union tongue shape cut is made in both scion and root stock. The

secondary cut is half of the length of original slanting cut. The scion and rootstock are then brought together and firmly interlocked. The graft wounds are waxed over with or without tying.

**5. Bark Grafting:** Unlike the cleft grafting, the stub of rootstock is not cut horizontally. Instead several scions are trimmed as wedges or inserted between wood and the bark. The operation is done during spring season. When the bark can be loosened more easily.

**6. Bridge Grafting:** It is practiced to save valuable trees with diseased or damaged trunk. To prepare the tree trunk for bridge grafting the damaged part is trimmed back to healthy tissues by removing dead bark from the effected part. Bridge grafting is best during in early spring when the bark can be lifted easily. Scions of sufficient length to bridge over the damaged area. One slanting cut is made each end of that scion. Both cuts are made on same side. The bark on both upper and lower side of wounded area is loosened as in bark grafting. Moreover, scions are inserted between the bark and the rootstock. All the cut surfaces are carefully coated with wax and any sprouting on scion surface should be removed. Complete healing takes place in a few years of time.

**7. Side Grafting:** In side grafting healthy rootstock shoot is selected fresh and mature scion stick about 12-13 cm long are collected from desirable variety and leaves are clipped off. A 2-3 years old rootstock tree planted in orchard rows is selected. At the base of scion of one side a longitudinal cut of 5-8cm is made. Another cut is made on the rootstock at an angle 20-30 degree and about 2.5 cm deep. The scion is inserted in the cut portion and gently pushed down until it fixed in the bark. The union is tied with waxed cotton tape and rapped with polythene. After the graft sprouts, the polythene is removed. This method can be performed both spring and autumn but maximum success rate is 90% in spring season.

**8. T- Grafting:** A T-shape cut is made in the rootstock into which the scion is inserted and firmly wrapped with waxed tape. The graft is covered with polythene.

**Factor influencing success in vegetative propagation:**

- Graft union takes place between varieties and species. It becomes unlikely when plants belonging to species in different genera are involved and impossible in cause of different families.
- Only compatible rootstock and scion combination should be used.
- Used seeds and grafting material from well tested and true types parent trees with high degree of disease resistant, desirable yield and fruit characteristics for batter contact between cambium surface to assure grafting surface rootstock and scion should be same vigor and

thickness and suitable age.

- Grafted seedlings in pots or nursery rows should be carefully handled. They should be also protected from desiccating wind, direct sun light rain and frost injury.
- The material used as bandage and for wrapping graft union should be removed when bud sprout have made some growth.

**Environment:** It is the combination of external physical conditions that effect the growth and development of living organisms.

**Weather:** It is the condition of atmosphere at a particular place over a short period of time.

**Climate:** Climates refers to weather patterns of a place for a long period of time.

**Temperature:** It is the measurement unit of warm and coldness of an object and substance with reference to some standard value.

A narrow range of temperature in which plants can grow makes temperature one of the most limiting factors in crop cultivation. The optimum temperature for growth of most horticultural plant lies between 15-35 C. The tolerance limits for maximum and minimum temperature varies with species to species. E.g., Tomatoes cannot with stand freezing temperature, where as an apple tree will not be harmed at -35 C.

**Temperature Relations to Plant:** The term cardinal temperature explains several critical temperatures for plant. It includes optimum temperature at which plant growth and development occurs rapidly.

- The minimum temperature below which plant cannot grow and the maximum temperature above which plant cannot grow.
- To describe the tolerance for minimum temperature for plant are characterized as hardy, half hard and tender.

1) **Hardy:** The plant can with stand minimum temperature of -4 to -2 C. E.g., peas, spinach, turnip and cabbages are hardy plants.

2) **Half Hardy:** Crops can survive minimum temperature of -1 to 0 C. e.g. carrot, beats, lettuce etc.

3) **Tender:** Crop cannot tolerate 0 C .e.g. beans, squash, melons, cucumber and tomato fall in this category.

A second classification involves the optimum growing season temperature.

There are two classes' which are cool season crops and warm season crops

- The optimum temperature for cool season crops is 18 to 24 C.
- Warm season crops like temperature of 25 to 35 C.

Vegetables crops and annual flowering plants are traditionally classified as summer and winter groups according to their temperature requirement. Trees are classified as temperate, tropical and sub tropical according to their sensitivity and temperature requirement.

## **Plant Growing Structure:**

Varieties of plant growing structures are in use to protect plants against adverse weather or to provide ideal growing environment especially by temperature control.

Systems are available which can provide a complete artificial plant environment. Green house is a general term for any structure used for controlling the environment.

→ Commercial production of many vegetables and ornamentals is carried out in green houses.

- Cold Frame
- Hot beds
- Glasshouses
- Plastic tunnels
- Shade houses

**1. Cold Frames:** A cold frame is an expensive form of temperature control. It is an enclosed soil bed. Covered by a removable and transparent frame. Temperature inside the cold frame increases considerably during the day and heat is stored in the soil. Plants can be protected at night due to excess heat trapping. In warm weather, these frames are removed. Cold frames are commonly used for starting plants from seed or hardening off seedlings to be transplanted.

**2. Glasshouses:** These are permanent structures often on concrete foundations in which temperature and other environmental factors can be regulated. Temperature may be regulated by a combination of heating, cooling and ventilation. In summer, shading the glass or white washing can improve the efficiency of cooling system. Ventilation can be used to regulate humidity. Extra light can be used to extend the duration and intensity of light.

→ Plants are usually grown in containers in artificially prepared soil mixes and given well-controlled fertilizer programs.

→ CO<sub>2</sub> enrichment has been shown to temp. the plant growth and yield in glass houses because of high cost of glass other glazing materials like plastics or fiber glass have also been used.

**3. Plastic tunnels:** Sheets of polyethylene are laid down wooden metal hoops to increase temperature. Within the tunnels, encourage plant growth even with low outside temperature.

Tunnels are especially suitable for early production of summer vegetables. The operation may be carried out in a semi permanent structure or temporary supports over the field bed.

As warm weather approaches, plants may be removed during the day and put back at night.

- Extensive use of tunnels also has some problems.
- High humidity encourages fungal growth.
- Proper ventilation must be carried out to lower the humidity
- Lack of pollination may result in no fruit set in crops like cucurbits and hand pollination must be done to insure fruit set in cross-pollination crops.

#### **4. Shade houses (lath house) :**

Shade or lath houses are structure with semi shade condition provided by screens shading nets or wooden lath. Shade reduces the temperature. This in term reduces water loss by transpiration and evaporation. Shade loving plants and foliage plants can be propagated maintain in lath houses shade houses are also used for hardening plant an for transplanting.

#### **Light:**

Sun lights the ultimate source of energy of earth. Green plants convert solar energy into chemical energy by photosynthesis the stored chemical energy of plant is utilize in different form by non-photosynthesis organism. In addition to photosynthesis light, affect other processes including seed germination vegetative and reproductive growth and plant morphology.

#### **Photoperiodism:**

It is the developmental response of plant to the relative length and dwarf periods. Flowering bulb formation and dormancy period are important development processes controlled by photoperiodism.

#### **Short day plant:**

These plants flower only when the day length is less then critical length, which varies from species to species .The plant remains in vegetative stage if the days are longer than the critical length. E.g. “Chrysanthemum”, poinsettia, soybean.

#### **Long day plant:**

These plant flowers only when day are longer then critical day length. E.g. spinach, radish, beats.

#### **Day Neutral Plant:**

These plants, which produce flower with any day length, provided to plant and are ready to produce.

#### **Phototropism:**

Plants generally bend in the direction of most intensive light. This bending of plants causes if to receive light more evenly on all sides. This response is called phototropism. E.g. sunflower.

Shoots and roots have positive and negative phototropism respectively.

#### **Affect of Light on Seed germination:**

The seeds of some plant will not germinate without exposure to light.

Many weeds plants have this property and germinate only when near the soil

surface or where the soil is disturbed. This gives them an advantage over the other plants since their seeds will germinate under conditions suitable for the survival and growth e.g. lettuce is the best example of this characteristic.

→ If lettuce seeds absorb water in the dark only a few seeds will germinate.

→ If the seeds are exposed to light after absorbing water, germination will be nearly 100%.

### **Humidity**

**Absolute Humidity:** It is the weight of water vapor per unit volume of air and it is expressed g/m<sup>3</sup>.

**Specific Humidity:** It is the weight of water vapor per unit weight of air. It is expressed g/Kg.

**Relative Humidity:** It is the ratio of amount of water vapors present in air and the amount of saturation at the given temperature and pressure and expressed in %.

**Soil Moisture:** Water in soil is found in different forms.

**Free or Gravitational Water:** The portion of water that drains out. This water is available to plants for many short periods of time.

**Capillary water:** The water retained by the soil in soil particles. It is the important component of soil moisture that is available for plants.

**Hygroscopic water:** A small component of water held tightly by the soil particles. This water is called hygroscopic water and is not available for plants.

**Field Capacity:** Amount of water content or soil moisture held in the soil after excess water has drained away.

**Wilting Point:** Minimum point of soil moisture that plants require not to wilt. If moisture content reduces then this wilting point will be reached and plants will not recover forever.

**Available Water:** Difference between field capacity and wilting point is called available water.

### **Phases of Plant Growth.**

**Germination:** When seeds are provided with moisture, proper temperature and air then the dormant embryo (young plant) starts growing.

**1. Epigeal Germination:** The embryo of sown seeds absorbs moisture and swells. Pressure develops inside due to seed coat rupture and the radical first emerges out of the seed coat through the micropyle and goes down into the soil. It becomes the primary root and soon gives out lateral roots and fixes the young seedling in soil. The portion of the axis below the cotyledon is known as **Hypocotyl**. This grows relatively fast and pushes the cotyledon above the surface of soil; hence, it is called epigeal germination.

Germination of the plant, which takes place above the ground surface.

Sometimes the ruptured seed coat is also carried along with the cotyledon.

When the cotyledons are exposed to sunlight or artificial light, they become green and manufacture food by photosynthesis for young seedlings. Plumule



elongate and give out lateral leaf, whole process is called epigeal germination. E.g. Muskmelon, Gourd, Cucumber.

**2. Hypogeal Germination:** A fresh mango seed pre soaked overnight is sown in the soil, it becomes turgid. The pressure exerted by this turgidity splits the hard endocarp. Open at the pointed end. First, the radicle comes out and goes toward force of gravity in the soil. It establishes itself in the soil by sending out small hair and lateral root to absorb water and mineral salts. The epicotyl grows rapidly and carries the plumule above the surface of soil. The large cotyledon which contains the reserve food material don't come above surface of soil, so it remains underground (Hence the hypogeal germination) providing nutrition to the growing tissue and ultimately die. The plumule first gives out brownish leaves, which turn green when they are exposed to sunlight and start manufacturing food like ordinary green leaves. In this way, young seedlings are established. This type of germination is found in litchi, groundnut, peas, and gram.

**Parthenocarpy:** Sometimes fruit is found without fertilization. These fruits do not contain seed like Banana, Mulberry, grapes.

**Soil Fertility:** The ability of a soil to supply nutrients those are essential for plant growth and development.

**Soil Structure:** The arrangement or grouping of soil particles into clumps or aggregates.

**Soil Texture:** The relative proportion of soil particle (Sand, Silt, Clay) in the soil is called soil texture.