TAMIL NADU AGRICULTURAL UNIVERSITY

HOR 111 FUNDAMENTALS OF HORTICULTURE (1+1)

PRACTICAL MANUAL CUM

RECORD

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HORTICULTURAL COLLEGE AND RESEARCH INSTITUTECOIMBATORE - 641 003
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Exercise. No.1

VISITING COLLEGE ORCHARD TO IDENTIFY DIFFERENT FEATURES OF AN ORCHARD

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

a) **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, weedicides, pesticides, fungicides, fertilizers etc., to the field. In the store room racks should be provided to keep the herbicide or weedicide, pesticide and fungicide. Wooden plank (flat piece of timber) is arranged on the floor to keep fertilizer bags. The garden implements and tools are arranged in the rack. Storage bins are also kept in stores for storing the seeds and produces.

   In the office, racks are used to keep records and registers related to orchard management. Eg. stock register, rainfall register, muster roll, DMS, attendance register, forecast register, tree register etc.

b) **Wells and water tanks**: It should be located at convenient places in different parts of the orchard at the rate of 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. Wells and water tanks are connected with irrigation channels of concrete nature or pipes. From the tank irrigation channels are used to take water to the field.

c) **Separate blocks**: For each fruit crop a separate block should be allotted. Fruits ripening at the same time should be grouped together. In deciduous fruit trees (sheds leaves during winter Eg., **pear, plum, peach**), there are certain varieties which need pollen from another variety to set fruits. The tree which provides pollen are called pollinators. Eg**. Pear – Bartlett, Anjou**, are self-unfruitful. **Beurre Hardy and Flemish beauty** are self fruitful variety. So every third tree

in third row should be planted with a pollinator or every fourth tree in every fourth row should be planted with pollinator.

d) Irrigation channels: Two types of channels viz., concrete and mud channels are laid out in the orchard. Concrete channel reduces water loss through seepage and maintenance are easy when compared to mud channel. Weed growth is very less or nil in concrete channel. Channel should be laid along the gradients for most economical conduct of water. For every 30 m length of channel, 7.5 cm slope should be given.

e) Roads and foot paths: 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 seedlings, layers, grafts, cuttings, etc. In the road in the centre the height should be more than at the sides. There should be a gentle slope from the centre towards the edge of the road, so that there won't be any stagnation of water during rainy season.

f) 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, amla and star goose berry.** Tall growing fruit trees are **avocado, mango, sapota and jack**.

Evergreen trees should be in the front area (Eg. **papaya, sapota, mango and oranges**) and deciduous ones behind the evergreen trees (Eg. **plum, pear, peach and apple**).

Fruits attracting birds and animals should be close to the watchman shed, so that watchman can protect them to the extent possible.

g) Manure pit : Manure pit is essential to dump the waste plant materials after the 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.

h) Fencing: It may be live fence or artificial ones. Live fence is economical and cheaper compared to other. Eg. **Agave, *Prosopis juliflora, Pithecolobium dulce*** etc. These crops are planted closely in 3 rows which serve as good fence. In

artificial fencing, stones or concrete pillars are planted at regular spacing (4 or 5 feet) and they are connected by barbed wire. Trees used for fencing should be drought resistant, easy to propagate from seed, quick growing, have dense foliage, should withstand severe pruning and should be thorny.

i) **Wind breaks**: They 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 minimise the damage to the fruit crops by wind. Wind breaks are planted in area where there is heavy wind. It's effectiveness is maximum for a distance of about 4 times as great as its height but has some effect over twice about that distance. For effective control, wind break should be planted in double rows and the trees are alternately placed. Wind break should be of tall growing nature. The spacing between wind break and first row of fruit tree should be similar to that of the space between fruit trees. It is advantageous to dig a trench of 90 cm deep at a distance of 3 m from the wind break trees and prune and cut the roots of wind break exposed and again fill up the trenches. This has to be repeated for every 3 or 4 years in order to avoid the competition between wind break and fruit trees for moisture and nutrition. Some specific characters of wind break are:

- Erect nature
- Tall growing
- Quick growing
- Hardy and drought resistant
- Mechanically strong framework
- Dense nature to offer maximum resistance to wind.

Eg: ***Casuarina equisetifolia***
Polyalthia longifolia
Eucalyptus globulus
Grevillea robusta
Azadirachta indica

J. Layout of an orchard: Arrangement of plants in a particular system of planting depending upon its vigour, growth habit and spacing requirement is known as layout. While laying out an orchard, the factors to be considered are, system of planting, tree vigour, spacing, water requirement, cultural operations like training/prunin etc. Proper layout of the orchard would facilitate easy supervision, management and planning for future expansion. Cultivation of perennial and annual crops of fruits, vegetables and to some extent flowers should also be taken into account while making layout.

Points to be remembered while establishing an orchard

1. The orchard should be established in such a location where the soil, climate and other physical facilities required for successful growing of crops and marketing of the produce are available.
2. The selected site, if uncultivated, should be cleaned by uprooting the existing trees and bushes and leveled properly after deep tillage. If the land or site is in a hill area, the prepared land should be divided into terraces depending upon the topography of the land and then leveled within the terraces.
3. The leveled land should be divided proportionately for growing crops and for roads, paths, building etc. Minimum / optimum space should be allotted for each feature. Roads & Paths should occupy only 10% of the total area, provided with convenience, economy in transport and supervision. The farm office should be located at the center of an orchard, which should be easily approachable by road.
4. Drainage and irrigation channels should be kept concealed as much as possible which could save water from seepage and evaporation. Irrigation channels should be well spaced so that it could cover all the plots.
5. While planting the fruit trees, evergreen fruits should be planted in the front and deciduous trees at the back.
6. Trees should be grouped according to their height, irrigation requirement and nature of growth.
7. Fruit trees that attract birds should be planted near watch and ward.

8. Self-sterile or self-incompatible fruit trees requiring pollinizer should be planted mixed with pollinizer variety or the same should be side grafted on the fruit trees themselves to ensure optimum fruit set.
9. While planting the trees, proper spacing should be adopted to accommodate inter-crops. Apart from this, vigour of tree and fertility of the soil should also be considered.
10. Under semi-arid conditions, in-situ planting of rootstock can be taken up which facilitates grafting of desired scion at later stage of crop growth.
11. Windbreaks should be planted at the rear end of the orchard. Trees suitable for this purpose should be tall growing, amenable for pruning and evergreen in growth. Eg. Eucalyptus, Casuarina, Silver ok etc.
12. Fencing the orchard with barbed wire or concrete wall or live-fence should be done well in advance to the planting of fruit trees.
13. Nursery area should be located under shade, near water source and office building and should be easily accessible for transport of seedlings and raw materials like potting mixture, sand etc.

Exercise. No.2

HORTICULTURAL TOOLS AND IMPLEMENTS USED FOR VARIOUS OPERATIONS

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 mainly 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. **Secateur** – 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 – 45 cm length at 45^{o} angle. This is used for formation and rectification of irrigation channels, formation of ridges and furrows, earthing up operation and sometimes even in weeding operations.

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. **Iron pan** – It is used for lifting plants in nursery. It is used to measure the soil, FYM and sand in pot mixture preparation.
17. **Rocker sprayer** – It is used for spraying chemicals in tall trees.
18. **Backpack sprayer** – It is used for spraying chemicals in vegetables and seed spice crops.

Exercise. No. 3.
PREPARATION OF NURSERY BEDS FOR RAISING ROOTSTOCKS AND SEEDLINGS

Nursery : Nursery is a place where seedlings, cuttings and grafts are raised with more care before transplanting

Advantages of raising seedlings in nursery

1. It is very convenient to look after the tender seedlings
2. It is easy to protect the seedlings from pests and diseases
3. Economy of land usage (duration in the main field is reduced)
4. Valuable and very small seeds can be raised effectively without any wastage.
5. Uniform crop stand in the main field can be maintained by selecting healthy, uniform and vigorous seedlings in the nursery itself.

Preparation of nursery beds

Selection of site

1. The nursery area should be nearer to the water source.
2. Generally, the location should be partially shaded (ie) under the trees. If not artificial shade is to be provided.
3. It should be well protected from animals.
4. Proper drainage facilities should be provided.

Selection of soil

A medium textured loam (or) sandy loam soil is preferred. Soil should be rich in organic matter. Soil depth should be preferably 15-25 cm.

Types of nursery bed: (a) Flat bed, (b) Raised bed nursery (c) Raising nursery in containers. eg. Polybags, pots etc.

Preparation of raised bed nursery

Selected soil should be worked well to break the clods. Weeds, stones and stubbles should be removed. Height of the raised bed should be 10-15 cm with a width of 1 m and length may be according to the requirement and convenience. Two parts of fine red earth, one part of sand and one part of FYM can be incorporated to each bed to improve aeration and fertility of the soil. Before preparing the bed, the

soil should be drenched with 4% formaldehyde or 0.3% copper oxychloride to kill the pathogenic spores in the soil.

Advantages of raised bed nursery

- Water movement will be uniform and drainage of excess water is possible.
- Germination percentage of seeds is normally high.
- Weeding and plant protection measures are easy.

Seed treatment

Seeds should be treated with Captan or Thiram (2 g) or Carbendazim @ 1 g/kg of seeds for 24 hours before sowing to control seed borne pathogens. The bio-inoculants like *Azospirillum* or *Phosphobacteria* can be mixed with rice Kanji @ 250 ml/200 g of *Azospirillum* or *Phosphobacteria*. Seeds are treated with these bio-inoculants and dried under shade before sowing. Normally 2 packets (400 g) are needed for treating the seeds required for 1 ha. These inoculants help to increase the vigour of the seedling.

Sowing of seeds

The surface of the bed should be levelled using fork or wooden plank. Straight lines are drawn across the bed at a spacing of 10 cm and to a depth of 1-2 cm. Seeds are sown in the lines and covered with sand or fine soil or powdered FYM. Line sowing of seeds facilitates easy weeding, drenching and removal of disease infected seedlings. Depth of sowing determines the rate of emergence. If it is too shallow, the seeds come up and dry out early. If it is too deep the seedling emergence is much delayed. Sow the seeds approximately at a depth of 3-4 times the diameter of the seed.

Season of sowing

Brinjal	-	December - January and May - June
Tomato	-	May-June, November - December and February - March
Chillies	-	June - July and September - October
Bellary onion	-	May - June and January - February
Cabbage & Cauliflower (hills)	-	January - February, July - August and September - October
		August - November (plains)

After sowing the seeds, the bed is covered with paddy straw and watered using rose can so as to avoid washing away of seeds. Watering should be done twice daily till the seeds germinate. After germination mulches should be removed and watered once in a day. A week before transplanting, the seedlings should be exposed to full sunlight and the number of waterings should be reduced so that the seedlings become hardy to bear the shock of transplanting in the main field.

Types of nursery

1. **Temporary nursery** : It consists of raised nursery beds. It can be changed from one place to another, depending on needs.
2. **Permanent nursery** : Side walls with drainage holes are constructed with concrete to a height of 75 cm. Seeds are sown in soil inside the concrete structure. After removal of each batch of seedlings the soil is enriched with manures.

Seed rate per hectare

Tomato	-	400 - 500 g
Chillies	-	1 kg
Brinjal	-	375 - 500 g
Cabbage	-	375 - 500 g
Cauliflower	-	375 - 500 g
Bellary onion	-	8 - 12 kg

Pest and disease management

Pests

There are two types of pests which normally attack the nursery plants

1. Sucking pests - Aphids, whiteflies, thrips etc.
2. Biting (or) chewing pests - Beetles, grasshoppers, leaf eating caterpillars etc.

Apart from causing damage to the seedlings, the sucking pests also act as vectors for transmitting some of the viral diseases even in the nursery stage.

Aphids spread mosaic diseases in chillies.

1. Thrips act as vector for leaf curl virus diseases in chillies and spotted wilt disease in tomato.

Control

i. Application of systemic insecticides like methyl demeton or dimethoate @ one ml per litre of water by using a hand operated sprayer.

ii. Application of carbofuran 10 days before pulling of seedlings will also control the sucking pests in the nursery and in early stages in the main field.

Diseases

Damping off (*Pythium sp., Phytophthora sp., Rhizoctonia sp.*)

Seedlings of tomato, chillies, brinjal, cabbage and cauliflower are highly affected by this disease. Water logging with poor drainage leads to infection. The disease affects the seedlings in two ways.

1. Affected seeds get decayed inside the soil resulting in failure of germination.
2. After germination, the fungi attack the seedlings in the collar region. The tissues will become soft and succulent. In advanced stages, the seedlings become lodged and get decayed.

Control

1. Raising seedlings in raised beds with good drainage facility reduces in infection.
2. Addition of organic matter improve the soil texture and soil aeration.
3. Avoid thick sowing of seeds in beds.
4. Periodical changing of nursery sites.
5. Treating the seeds with Captan, Thiram or Carbedazim @ one g/kg of seeds before sowing can reduce the infection.
6. Drenching the nursery bed once or twice with Bordeaux mixture 1% or copper oxychloride 0.3% can also reduce the infection.

Nematode

Root Knot and lesion nematodes commonly affect the nursery seedlings, before sowing the seeds, carbofuran (or) phorate 100 g/cent should be incroporated in the soil and watered regularly.

Ants: Apply Lindane 10% dust at the rate of 100 g/bed on all sides of bed to protect the seeds from ants.

Exercise. No. 4

PREPARATION OF POT MIXTURE, POTTING AND REPOTTING

For plants to be grown in pots, pot mixture is the medium which supply nutrients to the plants. Pot mixture composition vary from plant to plant.

Quality of pot mixture

1) It should have appropriate physical and chemical properties.
2) It must retain sufficient water and air.
3) It must allow sufficient drainage.
4) It should supply the nutrients required for plant growth.
5) It should be free from weed seeds, soil borne pathogen, nematode.
6) It should be light in weight.

Ingredients for pot mixture preparation

It varies from crop to crop. The common ingredients used in pot mixture preparation are

- Red earth
- Sand
- FYM
- Leaf mould
- Charcoal
- Brick stone
- Dried wooden pieces

Crop		Pot mixture composition
Ornamental plants	-	3 parts of soil 2 parts of organic manure 1 part of sand
Indoor house plants (Begonia, Geraniums etc.)	-	2 parts of soil 1 part of organic matter 1 part of sand
Indoor foliage plants (Dracaena, Dieffenbachia, Philodendron)	-	1 part soil 1 part organic matter 1 part sand
Orchids	-	Half broken bricks compost containing equal parts of fine coconut fibre and fresh sphagnum moss
Anthurium	-	Leaf mould and cocopeat
Roses		Garden loam 4 parts Cow manure 1 part Leaf mould 1 part Wood ash 1 part Ammonium sulphate 1 handful

A. Potting : The process of transferring seedlings or rooted cuttings from bed to pot is called potting. The process of separation of plants from pot to the field is called depotting.

The purpose for which plants are potted are:

i) . Preparing plants for sale such as rooted cuttings of grapes

ii) Growing plants for decoration like crotons

iii) Growing plants for experimental studies like pot-culture studies

i) For using plants as rootstocks in certain grafting methods such as in inarching of mango.

Steps followed in potting of plants.

1. Wet the seed bed before lifting plants. Lift with a ball of earth with as much of the root system intact as possible. Do not pull out seedlings in the hot sun. Do not allow roots or the soil around the roots to dry.
2. Fill up pots by putting some crocks first, then a layer of sand (5-8 cm) and finally pot mixture (8-10 cm).
3. Place the plant with the ball of earth in the centre upon the layer of pot mixture (Place on one side of pots in case of root-stock plants used in inarching).
4. Put pot mixture around the ball of earth, press as you fill up and level off, leaving one inch head space at top. Do not press over the ball of earth. It will break and damage the roots.
5. Set the stem of the plant at the same height as it was in the seed bed.
6. Immerse pot with plant in a tub of water gently and keep inside water till air bubbles cease to come out. Remove and place the pot under shade of trees.

Repotting:

When a plant becomes pot bound that is when its root get matted around the outside of its earth ball, it needs repotting. House plants require repotting depending upon their growth. The slow growing plants like cacti and succulent do not need frequent repotting. The fast growing plants like geranium, begonia etc., require repotting to larger pot at least once in a year. Generally repotting is done in rainy season, when it is easier for them to become established and form new roots. In the

case of root stocks after repotting the plants should be placed under shade and watering should be given frequently (morning and evening) to avoid wilting.

A day prior to repotting, the pot should be watered lightly to facilitate removal of the ball of earth intact from the pot. This can be done by placing fingers over the soil near the base of the plant, turning the pot upside down and tapping its rim on a table edge. The whole ball of earth will emerge intact from the pot. The presence of matted roots indicate the need for repotting. The plant should be set in a larger pot in the centre after removing a little of the soil from its ball of earth. The same soil mixture used for potting may be utilised in repotting and firmed with fingers. Below the pot rim 1cm space may be left to allow for water. The plant should then be thoroughly watered and placed out of direct sun until it is well established.

General

1. The initial reaction after potting and repotting is wilting. The transpiration loss has to be checked to help plants revive. Hence keep freshly potted plants under shade and pot water daily.
2. After about ten days under shade, the plants should be gradually exposed to sun by keeping them for some hours under sun and then putting them under shade. The period of exposure can be increased every week until finally the plants can be kept in the open. This process is called "hardening".
3. The other operations in the maintenance of potted plants are: application of fertilizers, removal old and dried leaves and protecting from pests and diseases. The liquid manure can be prepared in the following ways.

Kinds of liquid manures

Cowdung or horse manure is tied in a gunny bag and immersed in a tub containing water. After a week, the solution can be diluted and applied.

The oil cakes like groundnut cake, pungam cake can be broken and put into water for one or two days until it has undergone fermentation or decomposition which can made out by the foul smell it emits. The dissolved solution is separated and diluted many times with water and used.

Media for propagation

1. **Soil** : The soil texture and structure are important. The texture depends upon relative proportion of sand, silt and clay.
2. **Sand** : Quartz sand is used for propagation and plastering grade is used for rooting of cuttings. Sand should be sterilized before use.
3. **Peat** : Peat consists the remains of aquatic, marsh, bog or swamp vegetation which has been preserved under water in a partially decomposed state.
4. **Sphagmum moss** : It is the dehydrated remains of acid-bog plants of the genus Sphagmum. It is sterile, light in weight and has a very high water holding capacity.
5. **Vermiculite**: It is a micaceous mineral which expands markedly when heated. It is chemically a hydrated magnesium – aluminium – iron - silicate. Light in weight, neutral in reaction and insoluble in water.
6. **Perlite** : It is a gray or white volcanic origin mined from lava flows and has neutral reaction.
7. **Pumice** : It is a gray or white volcanic rock. It provides good aeration and drainage to the media.
8. **Leaf mould** : It is easily available in India. Any type of leaf which is available locally can be decomposed and used.
9. **Sawdust** : It is a by-product formed during the processing of wood material.
10. **Coco peat or Coco dust** : A by-product of cutting and silting coconuts for fibre production.

Containers:

1. **Seed pan and seed boxes**

Seed pans are shallow earthern pots of about 10cm depth and 35cm diameter at the top. They have for drainage one large hole in the center or 3 holes equidistant from each other. Seed boxes are made of wood, 40 cm wide and 60cm long and 10cm deep, with 6-8 properly spaced holes drilled in the bottom. Against each of the holes is placed a crock with its concave side down. Some large pieces of crock are put over it and by the side of this crock. Two or three handfuls of coarse sand is

sprinkled on the crock pieces forming a thin layer to prevent fine soil from clogging the drainage.

2. Earthern pots

They are made of burnt porous clay in various sizes to provide requisite amount of soil and root space to different kinds and sizes of plant. They have straight sides and are made wider at the top than at the bottom to hold the greatest bulk of compost where the feeding roots are and to facilitate easy removal of soil, intact with roots (ball of earth) at the time of planting or repotting.

	Name	**Height (cm)**	**Diameter (c)**	**Cost per pot (Rs.)**
(i)	Tube pot	17	12	1.50
(ii)	¼ size pot	18	22	5.50
(iii)	½ size pot	24	28	8.00
(iv)	Full size pot	28	30	12.00
(v)	Full size pot	43	42	15.00
(vi)	Seedling pans Seeding pans	10	35	8.00

Tube pots are used to raise rootstocks of mango and sapota for grafting purposes. ¼ size pots are used for potting singly very small seedlings during first transplanting and also for layering in plants like West Indian Cherry and Guava. ½ size pots are extensively employed for growing well rooted cuttings of several kinds of plants and small plants of all kinds. ¾ size pots are preferred for growing almost all kinds of annuals. Thali are preferred for growing **Dhalia, Cannas, Palms, Shrubs, Roses** etc.

3. Polythene bags

Small polythene bags with holes punched in the bottom for drainage and filled with a porous rooting medium are used for propagation of cutting in crops like Jasmines, Duranta, crotons, etc., in mist chamber. Sometimes, young seedlings which are raised in the nursery are subsequently transplanted in these polythene bags and kept there till they attain required growth for transplanting them to the main field (eg. **papaya, curry leaf** etc.).

4. Plastic pots

Plastic pots of round and square shapes are used to grow indoor plants. They are reusable, light in weight, non-porous and they require only little storage space.

Exercise. No. 5

SPECIALIZED PLANT PARTS USED IN PROPAGATION

Propagation refers to the multiplication or perpetuation of individual or group of plants which have specific value to human kind.

In certain horticultural crops, the plants possess some special vegetative structures which store food and used for propagation purpose. These structures are naturally detachable from mother plant and this procedure is called **'separation'**. Sometimes such structures are to be cut into sections for the purpose of propagation then this process is called **'division'**.

1) Bulb:

It is an underground part. It has short, fleshy vertical stem axis bearing at its apex a growing point or flower primordium enclosed by scales. The outer scales are fleshy and contain food materials whereas the scale towards the inner portion contain less food. Bulbs having dry and membranous outer scale are called as **'tunicate bulb'** (eg. **onion**) and bulb which lack this cover is known as **'non-tunicate bulb'** (eg. **lily**).

Corm:

It is the swollen base of a stem axis enclosed by the dry, scale like leaves. It is a solid stem structure with distinct nodes and internodes, eg. gladiolus corm. The miniature corms develop between the old and the new corms is termed as **'cormels'**. These corms can be cut into sections, retaining a bud in each section and used for planting. Eg. **Elephant foot yam**.

Tuber:

It is a modified stem structure which develops below the ground as a result of the swelling of the sub apical portion of a stolen and subsequent accumulation of reserve materials. A tuber has all the parts of a typical stem eg. **Potato, Jerusalem Artichoke**. These tubers are used for propagation either by planting whole tubers or by cutting them into sections each containing one or more buds. Some plants produce tubers in the axils of leaves which are known as tubercles (eg. ***Dioscorea bulbifera***) and used for propagation.

Tuberous roots and stem

In some plants like **sweet potato** and **dahlia**, the adventitious roots become thickened and they have external and internal structures of roots but lack nodes and internodes. These are known as tuberous roots.

In plants like begonia, cyclamen have thickened structure which have arisen from enlarged hypocotyl tissue. They have a vertical arrangement and may show features of stems. Propagation of plant with such roots or stems consists of division of such materials into sections, but each section should have a section of the crown bearing a short bud.

Rhizome

It is a stem structure in which the main axis of the plant grows horizontally at or just below the ground surface. It consists of nodes and internodes having leaf scars on the node. Eg. **Ginger, Turmeric**, Ferns etc. In determinate type of rhizomes each clump ends in a flowering stalk and growth continues only from lateral branches. Eg. **Cardamom**.

Indeterminate type of rhizomes do not produce a clump but spread extensively over an area and grow continuously from the terminal apex and from lateral branches. Propagation through rhizome is by cutting the rhizome into sections and each piece has at least one lateral bud or eye.

Runner :

It is a stem which develops from the axis of a leaf at the crown of a plant, grows horizontally along the ground and forms a new plant at one of the nodes eg. **strawberry and mint**.

Offset :

It is a special type of lateral shoot or branch which develops from the main stem in certain plants and it is characterized by shortened thickened stem of rosette like appearance. Offsets which produce sufficient roots can be separated by cutting them close to the main stem with sharp knife and used for propagation Eg. **pine apple, date palm**.

Sucker :

A sucker is a shoot which arises on a plant from below ground usually from an adventitious buds on a root, eg**. Chrysanthemum**.

Division:

It is the simplest method of propagation for increasing the number of stock plants. Division must be carried out during the dormant season. Each division should contain about 3 or 4 buds or stem and the outside portions of the clump should be selected because they are more vigorous Eg. **Daisy and Delphinium**.

Stolon :

A stolen is an aerial shoot which comes in contact with the ground and strikes roots. It may be a prostate or sprawling stem which grows horizontally from the crown. Eg. **Cyanodon dactylon**. A shoot rooted in this manner is merely cut from the parent plants and transplanted or potted.

Bulbils :

Aerial stem bulblets commonly known as bulbils are formed in the axils of leaves of some lily species such as ***Lilium bulbiferum, L.tiginum***. Bulbils develop in the early part of the season and fall to the ground several weeks after the plant flowers.

Crown :

This is the extension of central axis above the fruit consisting of a short stem bearing closely set, short leaves. These can be cut and planted for producing an individual plant. Crowns will produce fruit in about 22 months after planting while slips produce in 12-18 months. Eg. **Pineapple**. he term crown used in horticultural terminology is that part of a plant stem on the surface of the ground from which new shoots are produced. **In trees or shrubs** with a single trunk, the crown is principally a point of location near the ground surface marking the general transition zone between stem and root. **In herbaceous** perennials, the crown is the part of the plant from which new shoots arise annually. The adventitious roots develop along the base of the new shoots.

Exercise.No. 6.

PROPAGATION STRUCTURES

Some vegetable crops like cabbage, cauliflower, brinjal, chillies, tomato and few others are usually started in well prepared nursery beds and the young plants are transplanted later in the main field. This is the normal practice followed inmost of the tropical countries where severe winter season is absent. But in countries having long cold winters and short growing seasons, these kinds of vegetables and some flower crops are grown in some plant growing structures. These plant growing structures are also used for starting solely for an early crop in certain areas where winters are not so severe. These plant growing structures include hot beds, cold frames, green houses or glass houses.

1. Increasing the length of the growing season and making it possible to grow long season crops in regions where summer is short.
2. Making it possible to grow more than one crop on the same land in one growing season.
3. Protecting the plants from unfavourable weather.
4. Obtaining more yields of long season tender crops in places where summers are short.
5. Making it possible to produce an earlier crop by planting seed before it would be safe to plant in the open.

Mist Chamber

Mist chamber is an enclosed space covered by polyethylene sheet or fibre glass in which a sterile medium is provided for planting cuttings. Water is sprayed in the form of a mist through fine nozzles periodically so as to maintain the humidity at very high level (95 – 98%). It is used for propagation of plants through cuttings, hardening of layers, grafts etc.

It is well known that increase in relative humidity prevents desiccation of cuttings and provides more favorable environmental condition for root formation. As the humid condition facilities root formation in cuttings and layers, plants are usually propagated in the monsoon. Plants, which fail to root from cuttings or develop low percentage of rooting under ordinary condition or even in a alkathane chamber have shown satisfactory rooting under mist. Mist propagation of fruit and

ornamental plants has been taken up systematically probably for the first time in India at the Birla Laboratory, Agricultural and Horticulture Society of India.

Mist chamber is a propagation structure provided with mist system and covered with high density polyethylene sheets. Intermittent mist systems are widely used for rooting of softwood, semi-hardwood, hardwood and herbaceous cuttings. Mist sprays provide a film of water over the cuttings and media. Intermittent mist controls water loss from cuttings by reducing both leaf and surrounding air temperature via evaporative cooling, and raising relative humidity.

In some species where a sheath of lignified tissue in stems or a continuous ring of sclerenchyma acts as a mechanical barrier to root emergence, intermittent mist causes considerable cell expansion and proliferation in the cortex, phloem and cambium resulting in breaks in continuous sclerenchyma rings. This facilitates emergence of root primordia.

Mist arrangement.

Flow of water from the overhead tank is forced by a automatic pressure pump in the pipe-line and then through the solenoid valve into distribution system, when the coil of the valve is energized by the current coming from the mains through the Time Switch. The on and off periods of the Time Switch are regulated by changing the Selector Knob. During the 'on' period of Time Switch water is forced through the jets in the form of fine mist. The installation, operation and management of mist unit do not require any specialised technical knowledge. It has also been possible to develop very efficient automatic Time Switch to regulate the spray of water and other components of mist arrangement locally. Students, research workers and nurserymen can easily manage or maintain it. The nozzles should be fitted on the propagation frame in a glass-house or alkathene chamber.

Preparation of cuttings for mist propagation

For mist propagation, cuttings are made usually from top shoot 20-30 cm in length depending on the type of the plant and 4-6 leaves are retained in each cutting. Basal cut is given by a sharp Knife about 0.5 cm below the node. In order to examine root formation in cuttings and also to facilitate removal of the rooted

cuttings they are planted in 12-16 cm earthenware pot containing coarse washed sand placed on raised platforms or propagation frame in the mist chamber.

The cuttings can also be planted directly in sand bed. Planting of cuttings 5-10 cm basal portion should be inserted in the sand and very close planting should also be avoided for exposing maximum leaf surface to receive the line spray of water.

Season of propagation

As the humidity in the mist chamber is under control, cuttings can be planted throughout the year, if the temperature is not very high or too low. Because of the radiation, temperature inside the glasshouse or alkathene chamber is higher than in the open, in the summer months, temperature can be minimized considerably by covering the top with a sunblind made of gunny cloth painted green. The range of temperature in the mist chamber which show satisfactory root formation is arises between 22-25°C.

Cuttings can be taken from evergreen plants at any time of the year, while in case of deciduous plants, dormant and leafless shoots show less rooting even when the temperature of the mist chamber is favorable. Under local conditions, satisfactory root formation in cuttings has been recorded during 9 months in a year except in January, April and May. As most of plants develop roots in 4-6 week in mist chamber, 4-5 sets of cuttings can be taken during a year.

Green houses:

There are number of types of green houses namely low cost green house and commercial green houses. In green house construction, a wood or metal frame work is built to which wood or metal bars are fixed to support panes of glass embedded in putty. In all polyhouses / green houses means of providing air movement and air exchange is necessary to aid in controlling temperature and humidity. It is best, if possible to have in the green house heating and self opening ventilators and evaporative cooling systems.

Plastic green houses:

Green houses covered with various types of plastic film have become very popular for small home garden as well as for large commercial installations. Several kinds of plastic materials are available and are cheaper than glass. Plastic houses are usually of temporary construction except when permanent high cost coverings are used. Plastic covered green houses tend to be much lighter than glass covered ones with a build up of excessive high humidity.

Polythene film: This is the most inexpensive covering material but it is the short lasting one. However, UV ray resisting polyethylene film of various thickness is usually recommended which lasts longer.

a) **PVC film**: This material is pliable and comes in various thickness and widths upto 6 ft. It is longer lasting than polythene and is more expensive PVC surface of film tends to collect dust and lower the light intensity in due course of time.
b) **Polyester film**: This is a strong material with excellent weathering properties lasting for 3 – 5 years and is unaffected by extremes of heat or cold. But is usually costlier than polythene film / PVC film.
c) **Fiberglass**: Rigid panels, corrugated or flat fiber glass sheets embedded in plastic are widely used for green house construction. Fibre glass is strong, long lasting, light weight and easily applied which is coming in a variety of widths, lengths and thickness. It is costlier than polythene film / PVC film.

Hot beds:

The hot bed is often used for the same purpose as a green house but in a smaller scale. Amateur operations and seedlings can be started and leafy cuttings root early in the season in such structures. Heat is provided artificially below the propagating medium by electric heating cables, pot water, steam pipes or hot air blows. As in the green house, in the hot beds attention must be paid for shading and ventilation as well as temperature and humidity control. Hot beds have different heating systems : (i) Manure heated, (ii) Flue heated (iii) Hot water heated depending upon the sources through which heat is developed in the hot bed.

Lath houses:

These structures are very useful in providing protection from the sun for container grown nursery stock in areas of high summer temperatures and high light intensity. Well established plants also can require lath house protection including shade loving plants. Lathhouses construction varies widely depending on the material used. Aluminium pre-fabricated lathhouses are available but may be more costly than wood structures. Shade is provided by appropriate structures and use of shade nets of different densities allow various intensities of light in the lathhouses.

Cold Frames

Cold frames are satisfactory for starting plants provided little protection is necessary. The cold frames are constructed in very much the same way as hot beds except that no pit is required and therefore, no heat is required in the cold frame except that provided by the sun. This is the main difference between cold frames and hot beds. Permanent cold frames are made of concrete and temporary ones are made of boards. They are covered with glass sash canvas or cloth. These cold frames are used (i) to start the plants in the spring, (ii) to harden the plants that have been started in the hot bed or green house, (iii) to grow certain vegetable crops like lettuce, celery, radish, beetroot to maturity.

Mist beds

These are valuable propagating units both in the green house and out doors and are useful mainly in rooting of leafy cuttings.

Nursery bed

These are raised beds or boxes made of brick and mortar, provided with drainage holes at the bottom. The dimensions of the boxes are 60 cm high, 120 cm broad and length as required preferably not exceeding 10 m. Roof structures for planting on both sides and forming ridges at the centre are constructed on the top of the nursery beds. These structures may be made permanent with angle iron or may be made of wood. Moveable bamboo mats, palm leaf mats are placed over these structures to protect the seedling from hot sun and heavy rains. Even shade roofing can be used for this purpose for raising seedlings.

Fluorescent light boxes

Young plants of many species grow satisfactorily under artificial light from fluorescent lamp units. Although adequate growth of many plant species may be obtained under fluorescent lamps but not upto the mark compared to good green house conditions.

Propagating cases

Even in green house, humidity conditions are often not sufficiently high for rooting. The use of enclosed frames or cases covered with glass or plastic materials may be necessary for successful rooting. In using such structures, care is necessary to avoid the build up of disease organisms due to high humidity.

Exercise. No. 7

PREPARATION OF GROWTH REGULATORS AND METHOD OF APPLICATION AND PROPAGATION THROUGH CUTTINGS

Plant growth regulators or plant regulators are the organic chemical compounds which modify or regulate physiological processes in an appreciable measure in the plants when used in small concentrations. They are readily absorbed and they move rapidly through the tissues when applied to different parts of the plant.

Plant hormones or phyto hormones are also regulators but are produced by the plants in very low concentration and these hormones move from the site of production to the site of action. The difference between the plant regulator and plant hormone is that the plant regulator is synthetic and plant hormone is natural from the plant source.

1. Growth promoters

(i) Auxins: Auxin like substances are produced in buds, tips of stem, root etc. Some of the synthetic substances having auxin like activity are IAA, NAA etc.

Main action of these auxin like substances are (i) cell division, (ii) cell enlargement, (iii) cell differentiation.

(ii) Gibberellins: This kind of substances stimulate growth in tissues of young internodes (Eg.) **GA_3**. It acts by (i) Modifying RNA produced in nucleus ie. It has control over cell elongation. Cell elongation or by hydrolysis of starch leads to increased concentration of sugar in cell sap and make entry of water and finally it stretches the cell size.

(iii) Cytokinins: This type of chemicals interact with auxins. It acts on cell initiation/cell division. When cytokinin: auxin ratio is low, root development will be more. If the ratio is more, shoot development will be more. The prevalence of equal ratio leads to undifferentiated callus production.

These plant growth regulators are used to induce rooting of cuttings. Certain kind of plants like **Hibiscus, Nerium, Poinsettia, rose, apple and lemon** may not

successfully root under normal conditions and with the help of these plant regulators they can be easily made to induce rooting. The commonly used compounds are :

- Indole butyric acid (IBA)
- Naphthalene acetic acid (NAA)
- Indole acetic acid (IAA)
- 2,4-Dichloro phenoxy acetic acid (2, 4-D)

Another usage of plant growth regulator in propagation of plant is in rooting of airlayers. When the ring of bark is removed from the stem, the growth regulator like IBA and IAA in powder or in powder or in a lanolin paste is applied at the distal end of the bark removed portion.

Another use of plant growth regulators in the field for propagation is the stimulation of growth in the nursery plants so that it is possible to obtain graftable rigid rootstocks in mango and citrus within a short time, say three months. Otherwise, normally these rootstocks take one year to reach graftable size. Gibberellic acid is one such plant growth regulator which is used to induce vigorous growth of nursery plants. When this chemical is applied to the growing tips induces rapid cell division and cell elongation resulting in very rapid growth.

Method of application of plant growth regulators

Growth regulators are generally applied at very low concentrations ie. in ppm (parts per million). One milligram in one litre of water gives 1 ppm solution. The growth regulators may be applied in powder form or paste (lanolin paste) or spray solution. Good water should be used for dissolving chemicals. If the growth regulator is insoluble in cold water, hot water or alcohol can be used to dissolve the chemicals.

It is essential to prepare the solution of correct concentration for particular crop to get the expected results. Higher or lower concentration of chemical may some times give negative effect.

It is a general rule that spraying of growth regulators should be taken up in early morning or late evening hours for better utilization of the chemical. High volume hand operated sprayers are recommended for spraying.

a. Talc method
b. Quick dip method

a. Talc method : Some of the plant regulators are in powder form. The cuttings may be moistened with water at their lower ends and then dipped in the powder and planted afterwards, lower end going beneath the soil. eg. Seradix A and B can be used in the form of powder.

b. Quick dip & Prolonged soaking method : Some of the chemicals are used in the form of solutions. They are dissolved in alcohol and then in water. The lower end of the cuttings may be soaked in this solution. The concentration of the solution vary from 10 to 2000 ppm. If the concentration of the solution is 10 - 50 ppm the cuttings may be soaked for 18 to 24 hours. (Prolonged soaking method) If it is 500 to 2000 ppm, the cuttings are soaked for a minute or less. This is called quick dip method. The concentration differ according to the type of cuttings.

Effectiveness of plant regulators depends on so many factors:

a. Type of plant regulator used
b. Method of treatment
c. Age of the parent tree
d. Position of the shoot from which cuttings are taken
e. Seasons
f. Nutritional status of the parent plant
g. Temperature
h. Duration of light
i. Presence or absence of leaves on the cuttings.

PROPAGATION THROUGH CUTTINGS

Cuttage may be described as a method of propagation of plants by the use of detached vegetative plant parts which when placed under conditions favourable for rejuvenation will develop into a complete plant similar in all characteristics to the parent from which it was taken.

A cutting may be defined as any vegetative plant part when detached from the parent is capable of regenerating the missing organ or organs. According to the plant part from which a cutting is prepared they can be classified as root cuttings, stem cuttings, leaf cuttings and leaf bud cuttings.

Root cuttings

Root cuttings may be made from the true roots of any plant species. Their use is limited to plants with roots capable of producing shoots or shoot primordia. Root cuttings of 10 to 25 cm long are planted horizontally in soil or moist sand and watered regularly. The adventitious buds will sprout to produce shoots (eg**. Seedless bread fruit**).

Stem cuttings

According to the nature of the wood used in making the cuttings, the stem cuttings are of four classes viz., hard wood, semihard wood, soft wood and herbaceous cuttings.

a. **Hard wood cuttings** : Most of the fruit plants are propagated by hard wood cuttings. Cuttings are prepared during dormant season from the wood of the previous season growth. In certain fruit crops like **Fig and Olive**, hard wood cuttings are prepared from two years or still older woods. These cuttings have ample supply of stored food to nourish the developing shoots and roots.

   Hard wood cuttings should be about 15 to 25 cm long, with atleast 2 to 3 nodes. Basal end of the cuttings should be slanting, just below the basal node while the top cut end should be straight and 2 to 3 cm above the last node. The cuttings may be planted slantingly in rooting media with or without leaves keeping about one - third of their length buried in the soil. **Grapes, root stocks of roses, pear** are propagated by hard wood cuttings.

b. **Semi-hard wood cuttings** : This type of cuttings is generally taken from ever green species during summer from new shoots just after a flush of growth has taken place and the wood is partially matured leaves are retained on this type of cuttings usually on the top side (eg. **Duranta, Hibiscus, Crotons**, etc.)

c. **Soft wood cuttings**: This type of cuttings is also known as green wood cuttings. These cuttings are taken from woody plants prior to lignification when the tissues are still relatively soft.

d. The best cuttings material of this kind has some degree of flexibility but it is matured enough to break when bent sharply. Soft wood cuttings root easier and quicker than the other types, but require more attention (eg. **Jasmine, Hibiscus**, etc.).

e. **Herbaceous cuttings** : This type of cutting is made from succulent herbaceous plants such as geranium, chrysanthemum, coleus or carnations. This differs from soft wood cutting in that these plants will not develop wood tissues. These will root relatively in a shorter period under proper conditions.

f. **Leaf and lead-bud cuttings** : Leaf and closely related parts are used to propagate many common greenhouse plants. The red begonia may be propagated by severing some of the radial veins or vascular bundles of the leaf and placing it in top of a moist propagation medium. The severed tissues are capable of regenerating both roots and shoots, with the subsequent production of new plants.

A whole leaf of the common Bryophyllum produces a plant from each of its lobes. In other plants like **Sansivieria**, long tapering leaf is cut into sections of 5 to 8 cm long. These leaf pieces when inserted three-fourth of their length in sand, new plants form after a period of time.

Leaf bud cutting consists of leaf blade, petiole and a short piece of stem with the attached auxillary buds. Auxillary buds gives rise to the shoot and the roots are initiated from the basal end of the stem piece (eg. **Tea, Camellia, Rhododendron**).

Exercise No. 8

PROPAGATION THROUGH LAYERING

Layering or Layerage

It is a vegetative propagation method in which the development of roots on a stem while it is still attached to the mother plant or parent plant.

Advantages of layering

1) It is easy to perform layering
2) Any plant which cannot be easily rooted by stem cuttings may be made to root through layers.
3) Desired size of plants that is big or small can be obtained by layers.

Disadvantage

1) Number of layers which can be produced from a mother plant is low as compared to cuttings.
2) Even though layering operation is simple, after care of the layers is essential which requires daily watering to maintain good growth.

Types of layering

It is divided into 2 groups viz., air layering (gootee) and ground layering.

(a) Air layering

In air layering roots are formed on aerial part of the plant where the stem has been girdled or slit at on upward angle and covered with rooting medium. The rooting medium may be sphagmum mass or vermiculite. Air layering should be done in humid months because, root initiation will be high under high humid conditions.

Steps involved in air layering

1) Pencil thickness branch should be selected
2) The stem should be girdled for about a length of 2.5 to 3.0 cm to induce adventitious root formation. It should be done at 30 to 40 cm from the tip of the branch.

3) The injured portion is covered with moist sphagmum moss or vermiculite or peat and tied with polythene sheets. Now-a-days black polythene tube of 10cm diameter is tied 2.5cm below the girdled portion (proximal end) and then filled with media and then tied 2.5cm above the girdled portion (distal end). The polythene sheets permit gaseous exchange but are impervious to water. The roots are formed above the girdle portion. The root formation can be observed through transparent films. The rooting occurs in 1 ½ to 3 months depending upon the species. For better rooting IBA 1000-2000 ppm in lanolin paste is smeared to distal end of the girdled portion.

4) When the roots are formed in the stem, first half cut is given just below the point of rooting and within 15 days next half cut is given in the same place to cut off the rooted portion.

5) Then layers are potted in pots filled with pot mixture and kept in partial shade and watered regularly till the layer is established.

Eg. ***Ficus elastica*, crotons, fig, carambola, litchi, loquat, mangosteen, phalsa and pomegranate.**

Season : Layering done in spring or early summer are best and the percentage of success is also high.

B. Ground Layering

In this method, the rooting of layers takes place in the ground media or in pots containing rooting media. There are different types in ground layering like simple layering, compound or serpentine layering, trench layering or etiolation method, tip layering and mound layering or stooling.

(1) Simple layering

Branches that have formed roots in one area are called simple layers. This is done by bending the shoot and burying a part of it in the soil by leaving the tip in the air. The branch selected should be healthy and of pencil thickness from a lower branch near the ground, for easy bending. The common practice is to injure the portion to be covered by notching, girdling, cutting or twisting.

This practice destroys the phloem tissue partially or completely and retards the downward movement of food material and hormones produced by the leaves. The injury is given at 15-30cm back from the tip. The bent injured part of the shoot is inserted into the soil. The layered branches are held firmly in position by pegs or large stones.

Some times a single tongue like cut is made in the shoots on the underside towards the growing point. At the cut portion, a pebble is placed to avoid fusion of tissues. Then it is covered with soil. After 2 months in the cut portion roots will develop. Then they are detached from the mother plant, potted and kept under cool humid conditions for curing.

It should be done in early spring for temperate species before growth has started. For tropical crops, an actively growing period is selected. Eg. **Jasmine, rose, guava, bougainvillea and duranta.**

(2) Compound or serpentine layering

Similar to simple layering, the branches is alternatively covered with soil and then exposed along its length so that the roots are formed at the nodes that are covered with soil, new shoots develop at exposed area. After the root formation the layers are detached from mother plant and potted.

(3) Tip layering

In this method tip of current season's shoots are buried in the soil. The tip of the shoots grows downward into the ground. After rooting, the plants are detached and potted. Eg. **blackberry and raspberry**.

Other types of ground layering are trench layering, mound layering or stooling which are practiced in temperate fruit crops. Eg. **Apple & Pear**.

Exercise No.9

PROPAGATION BY BUDDING

Budding

It is an art of inserting a bud on the root stock in such a way that both will unite and continue to grow as a single individual plant.

Advantages of budding

(1) The economy in the use of scion material. From single shoot more number of buds can be taken and more number of buddings can be done.

Characters of rootstock for budding

1) It should be vigorous in its growth habit
2) Disease resistance
3) Easily propagated through seeds
4) Usually one year old root stock
5) Pencil thickness root stock should be selected but seedlings of slow growing nature may require two seasons.
6) Root stock should be free from diseases.

Bud wood

The shoots of mother plant from which buds are taken for use as scion material for budding are called bud wood.

Characters of bud wood

1. It should be collected from selected mother plant.
2. It should be well matured past season's growth.
3. Plumpy and well developed buds which should be dormant but ready to grow.
4. Ten to fifteen days before the removal of bud the shoots should be defoliated so as to activate the buds.
5. Buds can be removed with or without wood from the scion shoot.

6. Budding should be done when the root stock is still in active growing condition with free flow of sap which will help in easy lifting of bark in budding operation for proper union.
7. Bud wood should be free from pest and diseases.

Types of budding

1. Shield or 'T' budding or '⊥' budding

In this method, the appearance of the bud resemble shield and 'T' or '⊥' shaped incision is made in root stock and so it is called shield or 'T' or '⊥' budding.

Steps involved in 'T' budding

1. In the root stock, a transverse or horizontal cut of 1 to 1.5cm length is made first.
2. Below or above this cut, a vertical cut of 2.5 to 3cm length is made and connected to the horizontal cut.
3. Two flaps of the bark should be opened with help of knife (ivory edge).
4. The cuts are given in the stock at a height of 5 to 25cm above the soil in a smooth bark surface.
5. In the scion, 1.25cm above the bud, a slanting cut is made and 2.5cm long bud is taken in the shape of a shield.
6. Insert the bud by pushing it downward under the two flaps of bark (Horizontal cut of stock and scion should be even).
7. Then budded portion is covered with plastic tape or adhesive tape.

Season : Temperate crops – July-September or in March in some species. If budding is done in late May or early June it is called June budding. Eg. **sweet orange, roses, plum and peach.**

2. Patch budding

It is called so because a patch of scion and root stock are used in this method.

Steps involved in patch budding

1. A rectangular patch of bark of about 3cm length and 1.5cm width is removed from the root stock.
2. Similar patch with prominent bud is removed from the bud stick
3. After removal from bud stick, it must be placed in position immediately on stock.
4. Then covered the budded portion by exposing the bud with tape or wax cloth.

Season : Late summer or early monsoon season.

Eg**. citrus, mango, rubber, annona, walnut, pecan nut and cashew.**

3. Chip budding

It is being practised at time when bark is not slipping from mother plant. In this method bark with some wood is removed from but stick as scion and used for budding.

4. Flap or forket budding

A transverse incision is made in the bark of the root stock and then bark is peeled off carefully to a length of 5cm. The bud shield is removed from scion and inserted under the flap till the exposed edges of root stocks meet. Then flap is cut to half and is brought to cover the bud shield partially and then wrapped. If the flap is not cut and used to wrap the bud then this method is called modified flap or forket.

Eg**. grapes**.

5. Ring budding

The bud is prepared by taking a ring bark of 3 cm length with a bud in the centre. In the stock two circular cuts of 1.5cm apart are made and these are connected by vertical cut and ring of bark is removed. The prepared scion bud with the ring of bark is fitted in the exposed portion of stock and tied with plastic tape.

Eg. **Cinchona.**

6. Flute budding

The root stock plant is topped off at 25cm height and at the top about 2.5 – 3cm of bark is removed leaving the wood exposed. The bud in the form of flute is inserted in the stock. The diameter of stock and scion should be same. Otherwise the contact between them will not be proper. It is similar to ring budding, the difference being that the ringed bark can be removed easily in the form of a flute.

Exercise No.10

PROPAGATION THROUGH GRAFTING

Grafting or graftage

It is an art of inserting a part of one plant into another plant by exposing the actively growing tissue so that they will unite and continue their growth as one plant.

Scion: It is the upper part of the graft and from which stem and branches will grow into a plant.

Root stock

It is the lower part of the graft and this forms the root system of the grafted plant. Root stock is also called as stock or under stock.

Types of rootstock

There are two types (1) Seedling root stock (2) Clonal root stock

The seedling root stock exhibit variations in growth and used in crops like mango, plum and peaches. The clonal root stock are used to avoid variation and these are propagated by cutting or layers, root stock propagated asexually are termed as clonal rootstock. Eg. **apple and pear.**

Types of grafting

1. **Inarching or approach grafting** :- In this method root stock are raised in pots. Then they are brought near the mother plant. Here scion remains in mother plant.

One year old seedling of pencil thickness are selected. Above ground level at 15 to 20cm height in root stock, 5 to 8cm long slice of bark with wood is removed. This cut should be smooth and it tapers gently towards the tip and bottom. Same type of cut is made on scion and the two cuts are placed face to face and tied firmly with banana fibre and then with twine over it. After that union is covered with a mixture of cow dung and mud in equal parts. After 6-8 weeks top of root stock is removed above graft union and base of scion below the graft union. First half cut is given and another half cut is given after an interval of 10 days.

Pot stands, bamboo clefts and platforms are employed to accommodate the root stocks or the mother trees are trained to produce low spreading branches. Eg. **mango and sapota.**

Tongued approach grafting, is a modified method of approach grafting after the first cut is made in each stem to be joined, a second downward cut on the stock and upward cut on the scion is made, thus providing a thin tongue on each piece. By interlocking these tongues, a very tight, closely fitting graft union can be obtained.

2. Epicotyl or stone grafting

Seeds are raised in bed and the germinated seedlings of 8 to 15 days old are taken out and grafted indoor by beheading the seedling about 5cm above the seed and then inserting the wedge shape scion in the vertical split at the beheaded stock. Polythene tape at 200 gauge thickness are utilised for tying the graft. The grafts are planted in polybags filled with 1:1 (Soil & FYM) pot mixture.Eg.**Mango**

3. Softwood grafting

The top of rootstock are beheaded where the wood is soft and green with the help of a sharp knife and a slit of 5cm deep is made to accommodate the precured scion. The lower portion of the scion is made to a wedge shape with equal faces on both sides to a length of 5cm. After inserting the scion into the root stock, the union is tied with polythene strip. The scions are covered with a polythene bag of 100 gauge thickness and tied with a thread to keep the scions fresh till the union is completed. When the scions are sprouting (20-30 days after grafting) the polythene cover is removed. When the leaves on the graft are fully matured, the bandage is removed to prevent girdling of the graft.

Other types of grafting are side grafting, whip and tongue grafting, cleft grafting, veneer grafting etc. which are not of commercial importance.

4. Side grafting : In this methods, the scion is inserted into the side of the stock, which is generally larger in diameter than the scion. The scion is prepared from the terminal shoots of the past season's growth and used when it is still on the tree. Procuring is done by removing all the leaves except those at the top 20cm are

retaining their petiole intact. Buds in the axils of these will swell and these precured scion will be cut and used as scion after a week.

The scion is inserted into the side of the rootstock. In the stock, a slanting cut of 2.5 cm is made at the base, at an angle of 20 to 25^0. After insertion of the scion, it is tied well. After a month, the buds in the scion begin to grow. When they grow to 7.5-9cm long, the rootstock stem above the joint is removed. Eg**. Mango, Sapota, Fig and Mangosteen.**

5. Whip or splice grafting : In the scion shoot, a slanting cut of 7.5-9 cm long is given at the basal end. A corresponding cut of same length is made on the rootstock. The two cut surfaces are placed together and secured tightly in position by proper tying or some times
sealed with grafting wax.

6. In the whip and tongue grafting, a tongue like cut upward on the scion and downward on the stock is made after the first cut, which helps holding the stock and scion more tightly. It heals quickly and makes a strong union because of more close contact between the cambia regions. Eg. **Apple and Pear.**

7. Cleft grafting : The base of the scion is prepared in the form of a wedge. The rootstock is split in which the scion is inserted. This method is usually done on thick stocks of 2-8 cm in diameter. This is the common method followed in top working of trees. The stock is given a smooth cut and then it is split at the centre and two scions are inserted at the ends in such a way that the cambial layers of stock and scion are in contact. After the successful graft union, one of the scions, which is well developed is allowed to grow. Eg. **Pear.**

8. Veneer grafting : This is modification of side grafting. In this method, a shallow downward and inward cut of 2.5-4 cm long is made in a smooth area just above the crown of the stock plant. At the base of this cut, a second short inward and downward cut is made intersecting the first cut, so as to remove a piece of wood and bark. The scion is prepared with a long cut along one side and a very short one at the

base of the scion on the opposite side. The scion cuts should be the same length and width as those made in the stock so that the cambium layers can be matched as closely as possible.

9. Bark grafting : In this method, vertical cuts of 2.5-5 cm long are made at the top end of the shoot through the bark to the wood. The bark is then lifted slightly along both sides. In the scion, one cut of about 5 cm long is made along one side at the base. On the opposite side, a second shorter cut is made, thereby bringing the basal end of the scion to a wedge shape. The scion is then inserted between the bark and wood of the stock directly under the vertical cut through the bark.

10. Bridge grafting : It is a form of repair grafting and is used when the root system of the tree has not been damaged but there is injury to the trunk. Sometimes cultivation implements, rodents, disease or insect injury damage a considerable trunk area often girdling the tree completely. If the damage to the bark is extensive, the tree is almost certain to die, because the roots will be deprived of their food supply from the top of the tree.

In bridge grafting, the wounded area is trimmed by removing dead or torn bark. Then every 5 to 7.5 cm around the injured section, a scion is inserted, attached at both the upper and lower ends into live undamaged bark. The scions should be inserted right side up. After all the scions have been inserted, the cut surfaces must be thoroughly covered with grafting wax.

Exercise No.11

REJUVENATION OF ORCHARD BY VARIOUS TOP WORKING METHODS

Rejuvenation is restoring the vigour of the plant or trees by adopting propagation techniques like grafting and budding.

In old orchards and plantations, the roots, trunks or large branches are damaged by winter, implements like tractors or power tillers, some diseases like rotting or rodents or stem borers etc. such damaged trees can be repaired and saved by use of top working, bridge grafting and buttress grafting.

1. Top working

Top working is aimed at changing the established plant, tree, shrub or vine with a desirable cultivar. For this three to five well spaced scaffold branches which are not larger than about 10cm in diameter are selected. They are conveniently cut close to ground. The selected branches are given smooth cut without tearing the bark from the trunk. Thus, these branches are used as root stocks and grafting is done. For rejuvenation, the following grafting techniques are used.

1. Inarching
2. Bark grafting
3. Side grafting
4. Veneer grafting
5. Cleft grafting
6. Bridge grafting
7. Buttress grafting

In bark grafting, the bark is split in the root stock and scion is inserted between the bark and wood. The graft joint may be sealed with grafting wax.

In veneer grafting, a cut of 2.5 to 3 cm is made downward. A small notch is made by removing a piece of wood by a diagonal cut at the base to accommodate the wedge shaped scion. Trees just grafted should be supplied with water so that the tissues are in a high state of turgidity. This is necessary to have adequate callus production which is essential for the healing of the graft union.

The bridge grafting, is used when the root system of the tree has not been damaged but, there is injury to the bark of the trunk. It is done during the active growth of the tree so that the bark is slipping easily. The scion is selected from one year old growth, 0.5 to 1.5cm in diameter of the same or compatible species. First trim the wounded area back to healthy undamaged tissue by removing dead bark. Then every 8 to 10cm around the injured section or scion is inserted into live bark. The scion is inserted right side up in the live bark. After inserting all scions, graft unions have to be covered with wax. The buds on the scions will often push into growth if the grafts are successful. These shoots are removed because no branches would be desired in this position. The scion will rapidly enlarge in size and completely heal over the wound in a few years.

Buttress grafting is useful in supporting branches that may be in danger of breaking off or where there is a weak crotch. A small branch about a pencil size or little larger coming at about 30cm or above the weak crotch is grafted into the adjacent branch to be supported.

Exercise No. 12

VISIT TO TISSUE CULTURE LABORATORY

Tissue culture laboratory is a place where plants are mass multiplied through micro-propagation techniques under controlled environment.

MICRO PROPAGATION

Micro propagation or *in vitro* propagation refers to the development of new plants in an artificial medium under aseptic conditions from very small pieces of plants, such as embryos, seeds, stems, shoot tips, root tips, callus, single cells and pollen grains. This technique has been put into various applications in the discipline of agriculture, horticulture and forestry ever since the concept of `totipotency' of plant cell was scientifically proved by scientists in late fifties. The various applications of micro propagation of plants are

1. Rapid rate of multiplication of a plant clonally.
2. Production of disease-free and disease resistant plants.
3. Induction of mutant and selection of mutants.
4. Production of haploids through anther culture
5. Wide hybridization through excised embryo and ovule culture.
6. Somatic hybrids and cybrids through protoplast fusion.
7. Transformation through uptake of foreign genome.
8. Nitrogen fixation
9. Cryopreservation of germplasm types.

Requirements for micro propagation

1. **Laminar air flow chamber** : This chamber is useful to perform all operations in aseptic culture. Sterilization is achieved by the ultra - violet (UV) germicidal lamp fitted in it and by the flow of filtered air toward the person doing the operations, which prevents dust particles which carry micro organisms from settling on the explant.
2. **Auto-clave or pressure cooker** : It is used to sterilize the media, containers, petridishes and the various accessories required in the transfer operations. Normally sterilization is done for 15-20 minutes at 15 PSI pressure at 121 - 144°C.
3. **Alcohol lamps**, disinfectants and sterile water are also required

4. **Culture medium** : A medium consists of mineral salts, carbon and energy source, vitamins, plant growth regulators and other organic components. The most commonly used medium is Murashige and Skoog medium (MS medium).

Tissue culture laboratory divided into three compartments

a. Preparation area
b. Transfer area(Inoculation room)
c. Growing area (Culture room)

a. Preparation area (Kitchen, Cleaning glassware, Preparation and sterilization of media and storage of glassware and supplies)

Equipments needed

a. Refrigerator
b. Autoclave(120^{o}c or 250^{0}F with 15PSI pressure)
c. pH meter indicator paper
d. Gas or heating plate
e. Stirrers and mixing device
f. Filter
g. Water purifier or Distillation unit
h. Vaccum pump (or) ultrasonic cleaner used to decontaminate explants
i. Storage for flasks bottles and petri dishes

b. Transfer area (or) Inoculation room

To do the transferring the explants into the culture medium under aseptic condition (Laminar Airflow Chamber)

a. U.V Germicidal lamp
b. Filtered air provided towards the working person
c. Alcohollamp
d. Forceps
e. Dissecting needle, Scalpel and Blade
f. Bottles petri dishes and sterile water

c. Growing area

Environment is kept under controlled conditions

Temperature =21-30 ^{0}c

Light: 3 to 30W/m^2 PAR cool light or Gro-lux fluorescent lamps are provided

Photo period 16/8 (day and night hrs)

Humidity 30-60%

Media preparation

Ingredients varied with kind of plant and propagation stage, it contains

a. Inorganic salts
b. Organic compounds
c. Vitamins
d. Growth regulators
e. Antioxidants (citric acid and ascorbic acid prevents the contamination)
f. Complex natural ingredients
g. Agar (support agent)

Important medium

a. Murashige –Skoog (MS) medium
b. Lins maier medium
c. Woody plant medium (woody plants)
d. Anderson medium
e. Gamborg G5 medium

Table-1. Composition of some widely used media for plant tissue and cell culture

	White's medium	**Murashige and Skoog's medium**	**Gamborg's medium**
Macronutrients (mg/l)			
NH_4NO_3	-	1650	-
KNO_3	80	1900	2500
$CaCl_2$, $2H_2O$	-	440	150
$MgSO_4$, $7H_2O$	720	370	250
KH_2PO_4	-	170	-
$(NH_4)_2$ SO_4	-	-	134

NaH_2PO_4, H_2O	16.5	-	150
$Ca(NO_3)_2$, $4H_2O$	300	-	-
Na_2SO_4	200	-	-
KCI	65	-	-
Micronutrients (mg/l)			
H_3BO_3	1.5	6.2	3.0
$MnSO_4$, $4H_2O$	7.0	22.3	-
$MnSO_4$, H_2O	-	-	10.0
$ZnSO_4$, $7H_2O$	3.0	8.6	2.0
$Na_2Mo\ O_4$, $2H_2O$	-	0.25	0.25
$CuSO_4$, $5H_2O$	-	0.025	0.025
$CoCl_2$, $6H_2O$	-	0.025	0.025
$FeSO_4$, $7H_2O$	2.5	27.8	-

Procedure for micro propagation (There are four stages)

Stage-I **:** Establishment and stabilization.
Stage-II : Shoots multiplication.
Stage-III : Root formation.
Stage-IV : Acclimatization

Collection of explants
↓
Surface sterilization of explants (Sodium hypochloride, Calcium hypochloride and mercuric chloride 0.5-2%,5-10% and0.1%)
↓
Inoculation (under laminar air flow chamber)
↓
Incubated at $28+2^0$c with 16hr light (1000 lux) in culture room
↓
Sub-culturing (shoot multiplication)
↓
Rooting
↓
Hardening (under mist chamber)
↓
Ready for sale

Disadvantages

1. Expensive and sophisticated facilities trained personnel and specialized techniques needed.
2. High cost of production results from expensive facilities and high labour input.
3. Contamination (or) insect infestation can cause high losses in short time.
4. Variability and production of off-type individual.
5. Economics and marketing are key to the success of commercial operation.

Exercise No.13

PLANNING, LAYOUT AND PLANTING OF HORTICULTURAL CROPS

ESTABLISHMENT of an orchard is a long-term investment and hence needs thorough planning. Any mistake committed during selection of site, planting distances, choice of crops/varieties, quality of nursery stocks etc., reflects greatly on the orchard performance or efficiency. Hence it is advisable for the orchardist to seek the guidance of an experienced horticulturist.

PLANNING

While planning an orchard, the following critical components need adequate attention.

Roads

A well-laid out internal network of main, cross roads and paths is essential for efficient movement of men and machinery.

Orchard structures

This includes establishment of adequate number of buildings like office, implement shed, godown-cum-store, pump houses etc. at convenient locations as far as possible in a centralized manner to ensure efficient supervision and watch-and-ward. In any case, the area under roads and buildings should not exceed 10% of the total orchard area.

Fence and windbreak

A strong, impenetrable fence is one of the main prerequisites to successful orcharding. It is intended to protect orchards from damage by trespass of wild and domestic animals and pilferage. It is an expensive item and needs judicious planning. It is done in many ways. Temporary fences erected with thorny bushes would lead to recurring annual expenditure of repair and maintenance costs while construction of wall and barbed wire fence are quite expensive.

The other viable alternative would be growing of thorny live hedges impregnated with barbed wire which is a cheaper and effective alternative. The only disadvantage is that the hedges grow beyond limits and are required to be trimmed and also may compete with orchard trees for water and nutrients. The suitable hedge plants are *Duranta* plumieri, Clerodendron inerme, Lantana camera, Tecoma stans, Prosopis juliflora, Inga dulcis, Opuntia sp. etc.

The orchard trees should be protected from high velocity winds which could cause harm by uprooting trees, breaking branches, causing premature fruit drop, erosion of top soil and evaporation of soil moisture. Use of windbreaks by growing tall, mechanically strong, compact and quick-growing trees planted at close spacings all along the fence is essential. The windbreaks are needed to be established at least 2—3 years before planting trees. Care should be taken by opening 1m deep trench all around the orchard to avoid competition between windbreak and orchard trees for water and nutrients. Some trees used as windbreak are: *Casuarirna equisetifolia, Grevillea robusta, Artocarpus hirsuta. Eucalyptus, Acacia auriculiformis, Carissa carandas, Syzygium* sp. etc.

Irrigation

Efficient orcharding, to a great extent depends on optimum use of water especially during critical stages of plant growth and development. Main sources of irrigation are either open wells or borewells with distributary pipelines laid out along the gradient connecting various blocks preferably availing the expertise of a water management specialist. Necessary care is required to avoid waterlogging.

Spacing

Spacing depends on crop, varieties within the same crop, rootstocks employed, cropping system and management practices. Adoption of optimum spacing is intended towards harnessing solar energy, avoiding root competition and efficient exploitation of water and nutrients. The concept of high-density orcharding is increasingly gaining acceptance to optimize productivity. Further, spacings may also vary depending on the cropping system adopted to harmonise various

compatible crops. Spacings generally followed for different fruit crops are given in

Table. Commonly followed spacing in fruit crops

Crop	Spacing
Pineapple	30cm x 60cm x 90cm
Banana, papaya and grape	1.8-2m to 3m x 1.8m-2 to 3m
Passion fruit, phalsa and pomegranate	2m x 3m, 3m x 3m
Custard-apple	4.5m x 4.5m
Date palm, fig, mandarin, lime, lemon and sweet orange	6m x 6m
Pumelo and grapefruit	6-7m x 6-7m
Guava and cashewnut	6-8m x 6-8m
Sapota, loquat, avocado and star-apple	8-9m x 8-9m
Aonla, mangosteen and nutmeg	9-11m x 9-11m
Mango, jamun, litchi and ber	10-12m x 10-12m
Jackfruit and bread fruit	12m x 12m

In close planting, plants grow tall and slender without proper canopy spread. Thus they become prone to damage by strong winds compared to trees with low headed crown. Further, cost on pruning, plant protection and harvesting comes higher.

Such plants produce low yields of poor size and inferior quality. The trees in closely planted gardens appear sick and are prone to rapid attack by pests and disease, and interculture becomes difficult.

Selection of planting material

The planting material should be vigorous, true-to-type derived from healthy mother plants. It should be propagated on standard rootstocks with guaranteed performance. Low or high budded or grafted plants should be avoided. The roots should be free from knots and possess sufficient lateral and fibrous roots. The planting material should be certified by the concerned authorities.

A careful plan is necessary for the most efficient and economic management. The layout should aim at providing maximum number of trees per hectare, adequate space for development of trees and cultural operation. The system of layout is broadly divided into two categories viz., vertical row (eg. square and rectangular

system) and alternate row planting (eg. Hexagonal, Quincunx and Triangular system).

1 **Square system**: The trees are planted on each corner of square whatever may be the planting distance. The central place between 4 trees may be used to grow short-lived trees or intercrops may be cultivated.

2. **Rectangular system**: The trees are planted on each corner of a rectangle. The distance between 2 rows is more than the distance between 2 trees in a row. The interspace is used for cultivation of intercrops and short-lived trees.

3. **Hexagonal system**: The trees are planted in each corner of an equilateral triangle. In this way six trees form a hexagon with seventh tree in the centre. So it is also called as **'septule'**. It provides equal spacing but layout is difficult. The perpendicular distance between any two adjacent rows is equal to the product of 0.866 X the distance between any two trees. This system accommodate 15% more trees than square system.

4. **Quincunx or diagonal system**: This is the square method but with one more plant in the centre of the square. This will not provide equal spacing but accommodate double the number of plants. The central tree is called 'filler' tree and may be short lived. This system can be followed when the distance between the permanent tree is more than 10 m.

5. **Triangular system**: The trees are planted as in square system but here the trees in even numbered row are midway between those in the odd rows. The distance between 2 trees in a row is equal to the perpendicular distance between any two adjacent rows. The vertical distance between 2 trees in a row is equal to the product of (1.118 x distance between 2 trees in a row). It occupies few trees per hectare than square system.

6. **Contour system**: It is followed in hills. The plants are planted along the contour across the slope. This system minimizes land erosion and conserve soil moisture.

7. **Terrace system**: Planting of trees in flat strip of land formed across a sloping side of a hill, in terraced fields rise in steps one above the other and help to bring more area into productive use and prevent erosion.

Planting of horticultural crops:

The minimum vertical distance between any two trees is called as planting distance. There are 2 principles in deciding the planting distance.

1. Trees when fully grown, the fringes of trees should touch each other but the branches should not interlock.
2. The root of trees spread over larger area than top of the tree, so there should be enough space for roots to feed without competition.

There are certain factors which decide the planting distance.

(1) ***Kind of fruit tree*** – mango (10 x 10 m), guava (5 x 5 m) whereas papaya are planted at 2 x 2 m spacing.

(2) ***Rainfall*** – In low rainfall areas wider spacing should be provided than high rainfall area.

(3) ***Soil type and soil fertility*** – In heavy soil less spacing should be given because the top and root growth are limited.

(4) ***Root stocks*** – Trees of some variety grafted on different root stocks will grow to different size and such trees require different planting distance (eg.) Apple.

(5) ***Pruning and training*** – Trees trained on head system require closer spacing than the other type of training.

(6) ***Irrigation system*** – If the spacing between the trees is too wide, the yield per unit area would be greatly reduced. So it is more profitable to plant the trees closer together and supply the needed water and food materials. If the trees are planted, closely they grow tall rendering pruning, spraying and harvesting difficult. There is root competition and inadequate nutrition and the trees as such give less yield and produce smaller fruits of poor colour. Close planting results in a greater yield per unit area in the early life but less in the later years.

PLANTING AND AFTERCARE

After completion of layout, the pits of required dimension are opened at appropriate spacings depending on weather conditions at least a fortnight or a month before planting which also facilitates curing. Then they are covered using jungle soil, farmyard manure, treated with termitecides and kept ready for planting. For identifying planting spot, one could use planting board to ensure accuracy.

The planting board is a rectangular plank 152cm long, 10cm wide and 3cm thick. The grafts are placed erect in the centre of the pits using planting board and pressed tightly all around. The bud/graft union should remain well above the soil level. The plants are then given copious irrigation and provided with stakes to avoid filling. In hills and semi-arid tracts, it is better to go for in-situ method of planting which involves planting of mature, healthy seeds of suitable rootstocks and grafting of trained single stem either by side or veneer method using selected scion material. This method ensures better survival of grafted/budded plants.

Aftercare

The transplants should be irrigated frequently to facilitate better establishment. The quantum and frequency of irrigation depends on type of soil and weather conditions but it is essential to keep the soil always moist to the level, of field capacity. Mulching of basins also helps conserve soil moisture and reduce weed growth. Precaution is however, needed to avoid waterlogging by ensuring adequate drainage as excess water is harmful to young plants.

Other post-planting orchard operations include, covering/protecting plants against sun, soil operations, application of manures and fertilizers, weed and water management, raising of cover, inter, companion mixed and multistoried crops are essential components of orchard productivity and efficiency. For improving productivity of majority of orchard crops, it is important to maintain higher organic matter content in the soil which helps in improving soil structure, water-holding capacity, buffering capacity besides enriching microbial activity. In pre-bearing orchard, it is possible to grow intercrops. Growing intercrops also helps in regular cultivation, efficient weed, pest and disease management.

Leguminous cover crops enrich soil fertility and assist in soil conservation. It is required to ensure that the intercrop chosen should not deplete the orchard soil and become competitive to the main crop. It is normal that quick growing fruits like pineapple, papaya, banana, phalsa and guava, and short-duration vegetables-cole crops, cucurbits, tomato, chilli, ginger, turmeric and root crops like tapioca, yam, etc.,—are included as intercrops. The choice of crops mainly depends upon the suitability, facilities of disposal, environmental conditions, flow of finance and the market demand.

Exercise. No.14

TECHNIQUES OF MANURING AND IRRIGATION

Manures are substances of organic or inorganic nature which are capable of supplying the nutrients to the plants when applied to the soil. In general, manures are divided into organic and inorganic manures. Organic manures includes cattle manure or farm yard manure, night soil, guana, bones, oil cakes, leaf mould, wood ash, coir compost and vermicompost.

Role of organic manures

1. To serve as a good source of major and minor nutrients
2. To build up soil organic matter and maintain fertility
3. To improve physical, chemical and biological properties of the soil
4. To have residual effect
5. To control pest and diseases
6. To improve the quality of the crop
7. To act as a chelating agent

The soil organic matter can be increased by the addition of farm yard manure which is popularly called as compost. Compost is defined as the material resulting from the decomposition of plant residues under the action of bacteria and fungi.

The soil organic matter can be increased by cultivating green manure crop or green leaf manures. The green manure crops are generally leguminous plants, raised in the field for the purpose of serving as manure. Eg. **Sunhemp (*Crotolaria juncea*), Daincha (*Sesbania aculeata*), Pillipesara (*Sesbania speciosa*)**.

Green leaf manuring refers to the incorporation of the green leaves and other tender parts of the plants collected from the shrubs and trees grown outside the field and also collected from the waste lands and nearby forests into the soil. Eg. **Gliricidia (*Gliricidia maculata*), Sesbania (*Sesbania speciosa*) and Pungam (*Pungamia pinnata*)**.

Inorganic fertilizers

1. Nitrogenous fertilizer

These fertilizers supply nitrogen to the crops when applied to the soil. Eg. **Urea, ammonium sulphate, ammonium nitrate, sodium nitrate** etc.

	Name of the fertilizer	Nitrogen content	(%) Form of N
a)	Sod Nitrate ($NaNO_3$)	16	Nitrate
b)	Pot. Nitrate (KNO_3)	12.5-13.5	Nitrate
c)	Amm. Sulphate [(HN_4) $2SO_4$)]	20.6	Ammonical
d)	Ammophos-A	11	Ammonical
e)	Ammophos-B	16	Ammonial
f)	Amm. Nitrate (NH_4NO_3)	33	Ammonical and nitrate in equal proportion
g)	Amm. Sulphate Nitrate	25.6	Ammonical (19)
			Nitrate (6.6)
h)	Urea (co $(NH_2)_2$)	46	Amide
i)	Calcium cyanamide	20.6	Amide
j)	Diammonium phosphate (DAP)	20	Amide

2. Phosphate fertilizers

These fertilizers supply phosphorus to the crops when applied to the soils.

Eg. Super phosphate : 16-18% water soluble phosphate,

Basic slag : 8-18% Phosphoric acid

Rock phosphate: 30-40% of P_2O_5, 3-4% flourine and varying amounts of lime.

3. Potassic fertilizers

These fertilizers supply potassium to the crops when applied to the soils.

Eg. Muriate of potash (potassium chloride) : 48-62% K_2O and 35-47% chlorine.

Potassium sulphate. : 48% K_2O.

4. Mixed fertilizers

It is a mixture of more than one straight fertilizers which can supply more than one plant nutrient elements. Eg.17:17:17 complex.

Advantage of mixed fertilizers

1. Saving in time and labour in application.
2. Saving from transport of too many straight fertilizers from too many places.

Disadvantages

1. Specific needs of crops and individual nutrient element cannot be satisfied.
2. Unit cost of mixed fertilizer is higher than unit cost of straight fertilizers.

Biofertilizers or bio-inoculants

Bio-fertilizers are carrier based preparations containing beneficial micro organisms in a viable state intended for seed or soil application and designed to improve soil fertility and help plant growth by increasing the number and biological activity of desired microorganisms in the root environment. Three types of bio-inoculants are used to increase the growth and production of horticultural crops.

1. **Inoculants of biological nitrogen fixing micro-organisms. Eg. *Azotobacter, Rhizobium* and *Azospirillum***
2. **Phosphobacterial inoculants. Eg. *Bacillus sp. Pseudomonas sp.* (Bacteria), *Pencillium sp.* and *Aspergillus sp.* (fungi) and phosphobacteria**
3. **Mycorrhizal inoculants eg. (VAM) vasicular arbuscular mycorrhizal fungi.**

Time of application

The manures are applied to supply the nutrients which are not present in sufficient quantities in the soil. Yield is increased when they are applied at proper time and at proper place. There are certain factors which decide the time of application of fertilizers and manures after choosing the fertilizers to be used.

1. Nitrogen is required throughout the crop growth and all nitrogenous fertilizers are readily soluble in water and loss is found to occur. So it is better to supply nitrogenous fertilizers in split doses. i.e. basal and top dressing.

2. Phosphorus is required in large amounts in the early stages of growth. All phosphatic fertilizers are found to be slow acting and fixed in the soil and hence the entire quantity of these fertilizers are applied as basal.
3. Potassium is required throughout the crop growth but the release of this nutrient is slow and hence entire quantity is applied as basal dressing.

Method of application

Solid manures and fertilizers are commonly applied to crop plants by the following methods.

1. Broadcasting as a basal dressing

The fertilizer is applied uniformly over the entire cultivated surface of the land. It may or may not be incorporated into the soil. The broadcasting can be done just before the last ploughing or planting or sowing depending upon the nature of materials and crops grown. Concentrated organic manures, bulky organic manures like cattle manure, various ammonical fertilizers and potassic fertilizers are applied as basal broadcast.

2. Broadcasting as top dressing

This refers to the application of fertilizers by broadcasting when the crop is in the field. This is done to meet the immediate demands of the growing crops. Only nitrogenous fertilizers are usually used for top dressing.

Liquid fertilizers : It may be applied by the following methods

1. Starter solution

It is a solution containing water soluble nitrogenous, phosphatic and potassic fertilizers in small quantities (0.05%) which are used for the establishment of young plants, this solution is called starter solution. Eg. **Tomato**

2. Foliar application

Many nutrients are absorbed through the leaves of the plants. When compared to soil application plants require less quantity of nutrients if supplied through foliar application. 2 or 3 trace elements can be combined and applied. Eg. Urea spray in **brinjal and bhendi**. Concentration used for foliar spraying should be correct otherwise it creates many problems to the crop plants.

IRRIGATION

It is necessary for rapid growth and satisfactory crops and to maintain turgor in cells for maximum photosynthetic activity. The need for irrigation and amount of water are influenced by the following factors.

1. **Annual precipitation**

If rainfall is high or low but irrigation facilities are available intensive cropping can be followed. If rainfall is poor and irrigation facilities are not available means extensive cropping can be followed.

2. **Period of moisture shortage**

In South India December to May is drought period and irrigation is needed in this period.

3. Stage of crop

The bearing mango trees, are to be irrigated at 10-15 days interval at fruit development stage whereas irrigation must be stopped 2-3 months before expected flowering period.

4. Type of crops and cropping

Deep rooted fruit trees do not suffer during drought if sub soil moisture is high. The succulent vegetables suffer during cell enlargement because of moisture shortage.

Frequency of irrigation

It depends upon

1. **Nature of soil** :- Fine texture hold more water than coarse texture soil. Deep soil hold water than shallow soil.
2. **Rate of absorption by plant** :- If transpiration rate is more then it affects rate of absorption. The plants with large leaf surface require more water than plants with reduced leaf surface.
3. **The root system of the crop**:- The shallow rooted crop need more frequent irrigation than deep rooted crop. The symptoms of lack of water are wilting, dropping of leaves, curling of leaves, shrinkage of fruits etc.

Systems of irrigation

A. Surface Irrigation

Applying water to the soil without aerial application is known as surface irrigation. Different systems of surface irrigation are as follows.

1. **Flooding** : This is followed in wet lands mostly for banana. This is a wasteful method which will lead to stagnation of water and help weed growth.
2. **Check** : Check bunds for large areas enclosing a number of trees are provided with channels between two rows. This is more economical than flood system.
3. **Basins** : This is widely practiced. The basins should be square or circular and should be sloping from the trunk to the periphery. This method is useful in young orchards, light sandy and alkaline soil. The size of the basin should be widened as the roots spread.
4. **Ring** : In this system, small ring bund will be provided around the trees or one single irrigation channel connecting all trees will be formed and around each tree the channel is widened to form basin.
5. **Bed** : This is adopted in heavy soils for fruit crops like banana, wherein 3-4 plants are enclosed in a bed and is irrigated by opening in on one side of the bed.
6. **Furrow** : This is most widely followed for vegetable crops like tomato, onion, brinjal etc.

All the above different systems of surface irrigation do not ensure uniform distribution of water. It may be more near channels and less away from channels.

Sub surface irrigation

This method supplies water from below soil through underground pipes or by ditches on one side. This is useful for green houses. Pipes are laid 45-60cm deep and 6m apart. Pipes will have holes at regular intervals. This method is costly and deep cultivation is not possible. But evaporation of moisture is prevented to a great extent.

c. Special Irrigation methods

1. Overhead irrigation

Overhead irrigation is by the use of sprinklers, most widely used over head system. In this system, the initial cost of installation is rather high but there are

several advantages. There is saving in labour cost and water. More uniform wetting of soil is possible and erosion will be eliminated. This method is best for steep and terraced lands. This is more widely adopted in plantations. There are also some disadvantages. Due to the influence of wind, there will be non-uniformity in coverage. In hot sun, droplets on leaves and fruits may cause sunburn. Certain diseases may spread easily.

2. Drip irrigation

Drip irrigation is known by various names like ‘trickle irrigation’ or ‘high frequency irrigation’ or ‘daily flow irrigation’. This is a method of watering plants at a rate of equivalent to its consumptive use so that plants would not experience any stress during the growing phase. In this the water is conveyed from a source under low pressure to the root zone of the crop only. The twin objectives of this method of irrigation are:

(1) provision of optimum quantity of water to the crop for optimum production and (2) saving the valuable water from wastage thereby increasing the water use efficiency and the command area.

Exercise**. No.15**

BEARING HABITS OF HORTICULTURAL CROPS, SPECIAL TRAINING AND PRUNING PRACTICES FOLLOWED IN ORCHARD

Bearing habit

Fruit trees may bear the fruits either terminally on a long or short growth, laterally on current or past season growth or adventitiously from any point on the trunk.

The relative position of a fruit with reference to its potential bud giving rise to flower or inflorescence in the shoot is often known as bearing habit.

Different kinds of flower bearing shoots

Based on the position of fruit bud and the kind of flower bearing shoots it produces, fruit trees can be classified into following groups.

Group 1 : Fruit buds borne terminally and unfold to produce inflorescence without leaves e.g. **Mango**

Group 2 : Fruit buds borne terminally unfolding to produce leafy shoots that terminate in flower clusters, e.g., **apples, pears.**

Group 3 : Fruit buds borne terminally unfolding to produce leafy shoots with flowers or flower clusters in the leaf axils e.g. **guava**.

Group 4 : Fruit buds borne laterally unfolding to produce flower parts only without any leaves, e.g**. citrus, coconut, papya, coffee**.

Group 5 : Fruit buds borne laterally unfolding to produce leafy shoots terminating in flower clusters e.g., **grapes**.

Group 6 : Fruit buds borne laterally unfolding to produce leafy shoots with flower clusters in the leaf axils, e.g**., fig, avocado**.

Group 7 : Fruit buds borne both terminally and laterally but unfolding to produce inflorescence terminally, e.g., **walnut**.

Group 8 : Fruit buds always borne adventitiously in old trunk or shoots, e.g., **jack, cocoa, Indian star gooseberry.**

Training

When a plant is tied, fastened, staked or supported over a trellis or pergola in a certain fashion or some of its parts are pruned with a view to giving the plants a frame work the operation is called 'training'.

Objective of training

(i) To admit more light and air to the centre of the tree and to expose maximum leaf surface to the sun.

(ii) To direct the growth of the tree so that various cultural operations, such as spraying and harvesting can be done at the lowest cost.

ii) To protect the tree from sun burn and damage.

iii) To secure a balanced distribution of fruit bearing parts on the main limbs of the tree.

Details of training

1. Height of head

The distance from the ground level at which the main or scaffold limits branch from the trunk is known as the height of the head and this has to be decided before training is done. Trees in which scaffold branches come out within 0.7 to 0.9m is referred as 'low headed' and those in which they come out from the trunk above 1.2m or more is called 'high headed'. High headed trees help in easy orchard cultivation but in tropical climate, high headed trees are unsuitable as their exposed trunks are subjected to sunscald injuries. Low headed trees come into bearing comparatively much earlier and are able to resist stormy winds more effectively and permit easy cultural operations like pruning, spraying, thinning and picking.

2. Number of scaffold limbs

The number of main branches or scaffold limbs to be allowed while training varies from 2 to 15 or even more. Neither extreme is desirable. If there are only two or three main scaffold limbs, they are almost certain to form 'crotches', that they are likely to split and allow one or two branches to break down. These weak crotches may be avoided by training more and better spaced scaffold limbs. A fruit tree with 5

to 8 numbers of scaffold branches make a tree mechanically strong and at the same time open enough to facilitate necessary orchard operations.

3. Distribution of scaffold limbs

The distribution is more important than the number. If the scaffold branches arise at closer interval i.e. 20 to 25cm distance, they form bad crotches much sooner than when distributed at 45 to 60cm distance of the trunk.

Methods of leader training

The method of leader training should be suited to the normal growth habit of the fruit tree. The common system of training followed are.

1. Open Centre

In this system the main stem is allowed to grow only upto a certain height and the leader stem is pruned to encourage scaffold branches production. This system is also known as **Vase-shaped system**.

2. Central Leader

In this system a tree is trained to form a trunk which extends from the surface of the soil to the top of the tree. This system of training is also known as **closed centered one.**

3. Modified leader

It is intermediate between the open centre and central leader. This is developed by first training the trees to the leader type by allowing the central axis to grow unhampered for the first four or five years. The central stem is then headed back and lateral branches are allowed to grow as in the open centre system.

Trees are trained to different forms with or without the support of certain structures. The following are some of the systems requiring the support of the structures.

1. Bower system

It is also called as **'Pandal'** or **'Arbour'** or **'Pergola'** system. It is generally practiced in **grapes** and other **cucurbitaceous** vegetables like **snake gourd, ribbed gourd, bitter gourd** etc.

In this system, the vines are spread over a criss cross net work of wires, usually at 2.1 to 2.4m above ground, supported by concrete or stone pillars or live support like **Commiphera sp**. The vine is allowed to grow single shoot till it reaches the wire net and is usually supported by bamboo sticks tied with jute thread. When the vine reaches the wires, its growing point is pinched off to facilitate the production of side shoots.

Espalier system

Plants are trained to grow flat on trellis or on horizontal wires by training the branches perpendicularly to the main stem on both the sides, and trained horizontally on the wires. Plants trained in this systems are called **'espaliers'**. An espalier with one shoot or two shoots growing in opposite or parallel directions are called a **'cordon'**.

Kniffin system

In this system, two trellis of wire are strongly supported by vertical posts. The vines such as grape when trained in this system has four canes one along each wire and the bearing shoot hangs freely with no tying being necessary.

Telephone system

This system is also known as overhead trellis system. This system consists of 3 or 4 wires usually kept at 45-60 cm apart fixed to the cross-angle arms supported by vertical pillars or posts.

Tatura trellis

In this system, trees are trained to a multi-layered wire trellis. The trellis is V-shaped, supported by two long, stout poles embedded into the soil angles of 60° from the horizontal. Five wires at 60cm intervals are fastened to these poles. This system, is being now followed for pome fruits, nut fruits and grapes. The trees are

grown as double leader. Trees with each leader inclined at an angle of 60° from the horizontal.

The followings are some of the training systems which do not require the support of any structure but will be trained to a particular shape.

a) Head system
b) Palmette
c) Spindle bush
d) Dwarf pyrmaid
e) Head and spread systems

Pruning

Commonly, trees are pruned annually in two ways. A few shoots or branches that are considered undesirable are removed entirely without leaving any stub. This operation is known as 'thinning out'. The other method which involves removal of terminal portion of the shoots, branches or limb, leaving its basal portion intact, is called 'heading back'. Thinning out involving large limbs as in old and diseased trees is called 'bulk pruning'. Pruning is done with the following specific objectives.

i) To remove surplus branches,
ii) To open the trees so that the fruits will colour more satisfactorily
iii) To train it to some desired form
iv) To remove the dead and diseased limbs
v) To remove the water sprouts and
vi) To improve fruiting wood and to regulate production of floral buds.

Season of Pruning

Under South Indian conditions, old non bearing mango trees are pruned during August – September. The pome fruits such as apple, plum, pears and peaches are pruned every year in December - January. Jasmines are pruned to 45cm height from the ground level during the last week of November.

SPECIAL PRUNING TECHNIQUES

1. Root Pruning

A circular trench of 45cm away from the stem is dug out annually and the roots are cut-off every year with a sharp knife. After pruning, the trench is filled with manures liberally.

The tree is thus fed and watered artificially in a restricted area. Each year prune 4 to 5 cm of the stumps of the previous year growth. This helps to increase the production of mass fibrous roots, dwarf the trees and bears abundantly. This practices is not advocated every year to the fruit trees.

2. Ringing

It is one of the known practices to increase fruit bud formation in certain fruit crops. The operation consists of removal of a complete ring of bark from a branch or the trunk. Ringing interrupts the downward passage of carbohydrates through the phloem and thus causes them to accumulate in the part of the tree above the ring. Ringing is practiced on **Mango** to force flowering in over vegetative trees which do not normally bear a satisfactory crop. This practice cannot be recommended for all fruit crops and it is found beneficial in promoting fruit set in certain **vigorously growing grape varieties** and they often result in large size fruits.

3. Notching

Notching is a partial ringing of a branch above a dormant lateral bud. Eg. **Fig, apple** etc.

4. Smudging

It refers to the practice of smoking the trees like mango, commonly employed in Philippines to produce off-season crop. Smudging of **Mango** trees in India has not been found to induce early blossom.

5. Bending

Bending of branches is widely practiced in the Deccan for increasing fruit production in **guava**, especially in the erect growing varieties.

6. Coppicing

This refers to the practice of complete removal of the trunk in trees like **Eucalyptus and Cinchona** leaving 30-35cm stump alone.

The coppiced stump starts producing many vigorous shoots in about 6 months time. Only 2-3 shoots are retained per stump and the rest ones are completely thinned out. These left out shoots attain coppicing stage in about 10 years depending upon the locations and other factors.

7. Pollarding

This refers to the practice of removing the growing point in shade trees especially in **silver oak** in order to encourage side branches.

8. Lopping

This refers to the practice of reducing the canopy cover in shade trees in order to permit more light.

9. Pinching

Carnation, chrysanthemum to reduce the plant height and to promote auxillary branching.

10. Disbudding

The practice of removing unwanted flower buds in a cluster so as to encourage the remaining buds to develop into a large, showy, quality bloom is called disbudding. This practices is commonly done in cut flowers like **carnation, chrysanthemum, dahlia, marigold and zinnia** etc.

Thinning

Fruiting is an exhaustive process to the tree especially if the crop is heavy. The other objectives of fruit thinning are the following :

1. To increase the annual yield of marketable fruit.
2. To improve the fruit size.
3. To improve the colour of the fruit.
4. To improve the quality of fruit (T.S.S.)
5. It reduces the limb breakage.

6. It promotes tree vigor and ensures more regular cropping.
7. It permits more thorough spraying and dusting of fruits during the late season application.
8. It ensures uniform ripening.

Time of thinning at blossom timing, thinning is done at marble stage. Soon after the natural fruit drop of young fruits has started.

Methods of thinning

1. Hand thinning
2. Chemical thinning

NAA at 100 ppm reduces the fruit setting from 67% to 50% in Anab-e-Shahi variety of grapes.

In mandarin, NAA 600 ppm on marble sized stage is recommended to thin the overbearing fruits so as to increase the size and quality of fruit.

Ex.No.l6

MATURITY INDICES FOR VARIOUS HORTICULTURAL CROPS, HANDLING AND PACKING TECHNIQUES

The post harvest quality and storage life of horticultural crops appear to be controlled by the maturity. If the horticultural crops are harvested at a proper stage maturity the quality is excellent. The quality and shelf life are poor if harvesting is done too early or too late. Maturity can be described as the attainment of a particular size, stage after which ripening takes place.

Different maturity indices are number of days from fruit set, size, shape, colour, appearance, texture, lentical number, specific gravity, starch content, soluble solids, sugar: acid ratio and oil content.

Methods to determine the proper time to pick the fruits

1. Maturity tests

a) Colour change: Eg. In mango, change of peel colour from green to yellow and in papaya change of colour at apical end of fruit. In pumpkin, change of colour from green to brown colour and in ash gourd disappearance of ashy bloom on the surface.
b) Increase in size
c) Softening of the tissue of the fruit eg. Figs and sapota
d) Ease of detachment from the stalk eg. Sapota, annona
e) Shrivelling of fruit stalk eg. Water melon
f) Time elapsed from the date of flowering to picking maturity
g) Sound by tapping jack and water melon when ripe produce hollow and dull sound on tapping but produce metallic sound if unripe

2. Accurate tests:

a) Colour charts:

Charts are prepared for indicating colour on different stages of maturity. By referring to this ready chart, one can easily judge the correct stage of maturity.

b) Penetrometer:

It is an instrument which indicates or measures the softening of tissues as an index of maturity. It chiefly helps in determining when fruits are too soft and ripe to storage rather than when picking should begin.

c) Sugar: acid or Brix : acid ratio:

This is based on the principle that acid content reduces and sugar increases which induce ripening.

The fruit growers should bestow more attention and considerable care during the picking season to reduce to a minimum level of careless handling of fruits by pickers.

1) Picking must be commenced from the lower branches of a tree advancing towards the tip in order to reduce dropping of fruits to the minimum.
2) As far as possible, dropping of the fruits from the tree should be avoided to avoid any possible physical damage.
3) During picking, care must be taken to avoid any possible damages to the branches especially to the spurs as the subsequent cropping depends upon them.
4) Picking early in the morning is always best. Picked fruits should be kept in shade and excluded from sun. After picking, the fruits must be kept in the coolest place available which is well ventilated to arrest respiration and break down as much as possible.
5) There should not be any bruises in the fruits while picking as it will lower the marketable quality.
6) If picking is done in mid-day or hot weather, fruits should be kept in a shed overnight to cool.

Crop	Symptoms of maturity
Apple	Texture, TSS, colour, size, internal ethylene evolution, starch and heat units.
Grapes	TSS-18-20^0 Brix, Easy separation of berries from the bunch and peel colour.
Orange	Colour of rind, TSS.12-14^0 Brix, acidity 0.35 to 0.4% and juice content 35-50%

Papaya	Change of colour at the apical end, TSS 11-13^0 Brix, if twisted it will be easily pulled out and days after fruit set to fruit harvest 110 days.
Banana	Fullness of fingers, disappearance of angularity, days after fruit set 90-100 days peel to pulpratio 1.2:120.
Mango	Fullness of cheeks, colour development in beak end, growth of seed hair, days after fruit set 100-120 days.
Pineapple	Flattening of eyes with slight hollowness at centre, colour changes TSS-12^0 Brix, acidity 0.5-0.6% and specific gravity 0.98-1.02%.
Sapota	Colour develop in to potato colour or dull orange colour, disappearance of scaliness, milky latex exudation is less and drying of stigma at the fruit end.
Strawberry	Three fourth of the surface of the fruit develops colour
Vegetable	
Tomato	(i) **Immature :** Before seeds have fully developed and jelly like substance surrounding the seed have formed. Fruits are not suitable for consumption. (ii) **Mature green:** Fully mature, light green at bloom end and yellowish green in all other areas. Seeds are surrounded by jelly like substances, filling the seed cavity. This kind of fruits are artificially ripened and suitable for long distance market. (iii) **Turning (Breaker stage):** 1/4th of the surface at blossom end shows pink colour. (iv) **Pink :** 3/4th surface shows pink colour (v) **Hard ripe :** Nearly all the areas are red or pink but flesh is firm. (vi) **Over ripe:** Fully red coloured and soft This is suitable for processing as it possess good quality and colour development.
Onion	Bulbs are considered mature when the neck tissues begin to soften and tops are about to abscise and decolourise.
Chillies	Development of uniform red colour is treated as maturity index.
Bhendi (Okra)	Development of crude fibre is used to determine the optimum stage of maturity.
Beans	Seed size, percent seed, dry matter content, distribution of seeds are some of the reliable maturity indices. Tender and fleshy pods can be harvested for vegetable purpose.
Peas	In peas, pod colour changes from dark green to light green with well filled grains/seeds at full maturity.
Brinjal and Cucumber	Tenderness is the main structure is the indication of maturity

	for harvesting.
Musk melon	Development of net like structure is the indication of maturity for harvesting.
Sweet potato	When the leaves turn yellow and begin to shed, tubers can be harvested. The tubers can also be cut and judged. In immature tuber, cut surface show dark greenish colour white the colour will be milky white in fully mature tubers.
Tapioca	In tapioca, maturity is indicated by the cracks formed in the soil, yellowing and falling of leaves.
Dioscorea and amorphophallus	In these crops, maturity is indicated by yellowing, drying and then dropping of leaves.

HANDLING:

Handling includes all processes from picking to delivery or disposal at the consumer point. This includes the treatments given for getting the fruits ready for the market viz., packaging and wrapping, ripening and storage. One of the important treatments is the dipping the fruits in antiseptic solutions like 1-2% caustic soda to remove the dust and infestation of scale insects and washing with 1 - 1.5% of Hydrochloric acid to remove any spray residue and to improve the appearance.

Pre-cooling: It refers to the rapid removal of the field heat from the freshly harvested fruits and vegetables in order to slow ripening and reduce deterioration prior to storage and shipments. Different methods are adopted to precool the fruits, the important ones are

(i) air cooling - in which the fruits are kept in a cold room, (ii) hydro cooling-dipping of the fruits in cold water or by spraying cold water on the fruits and (iii) vacuum cooling - a costlier technique in which the atmospheric pressure is reduced so as to reduce the pressure of water vapour in chamber which results in evaporation of water from fruits which bring down the temperature. Vacuum cooling causes about 1% weight loss in the produce.

GRADING:

Grades or grading refers to the assortment of the fruits into different groups based

on certain characters. This includes colour, condition to firmness and soundness and free from blemishes and also size of the fruit. Grading is a good market practice which improves the mutual confidence of salesman and consumer.

In India, grading is mostly done on the basis of size. But in the developed countries, grading is a rule.

WRAPPING:

Covering the fruits after harvest with any material in order to improve its post harvest life is known as wrapping. The materials commonly employed as wrappers are tissue papers, waxed paper, polyfilm, cellophane paper, aluminum foils and alkathene paper etc. Wrapping has the following advantages:

i) it minimizes the loss of moisture in shrivelling,

ii) it protects against the spread of diseases from one to the other,

iii) it reduces, the bruises,

iv) it reduces damage during transport or in storage, and

v) it makes the fruit more attractive.

Waxing: This is the treatment given to the fruits during handling. Waxing of fruits helps

in reducing the moisture loss, improving the appearance of fruits and reduces the incidence of storage diseases. Wax emulsion is prepared by melting microcrystalline paraffin or cranaube wax along with emulsifiers.

Packaging (or) packing: The term packaging encompasses both the direct or primary packaging around the product and the secondary and tertiary packaging, the over packaging such as over warts, cartons and crates etc. Proper packaging is essential otherwise the spoilage of fruits and vegetable are more in our country.

A packing material should be sturdy and it should protect the fruits in transport, more specifically it must be economical. The materials that are generally used in India for construction of a package of fruits and vegetables are bamboo, wood, gunny bags, plastic films, fibre and plastic corrugated boards etc.. Bamboo baskets and wooden crates of different shapes and sizes are used for a number of perishable commodities. Mud pots, gunny bags and palmyrah mats are also used for

a variety of purposes. Bamboo baskets are though relatively cheaper, they have many disadvantages like (1) the low dimensional inability to withstand stacking load, (2) they are not strong enough to withstand rough handling. Packaging of grapes in mud pots is quite common in South India.

It is often observed that during transport, the mud pots break and the contents get damaged. Though the mud pot has its own advantages as a container for grapes and such other fruits, it has to be handled very carefully thus affecting the speed of handling. In some cases like mango, pineapple, banana etc., a straight load is practiced in certain regions. For example, banana in bunches are loaded without any packaging into the railway wagons or trucks and transported from Maharashtra to Delhi. Similarly, mangoes are transported from South to North and pineapples are shipped from North East India and Kerala to different regions. In these cases, it has been observed that the losses due to spoilage are considerable.

Cushioning materials:

The cushioning materials used for packaging fruits and vegetables are dry grasses, paddy straw, leaves, saw dust, paper shavings etc. The properties of a good cushion materials are

(1) it should have a resilient property,

(2) it should have the ability to dissipate the heat of respiration of the produce,

(3) it should not carry any infective pathogens or it should not injure the soft fruit in any way,

(4) it should be physiologically inactive.