HOR 111 Fundamentals of Horticulture 1 + 1

PRACTICALS

CONTENTS

TAMIL NADU AGRICULTURAL UNIVERSITY

HOR 111 FUNDAMENTALS OF HORTICULTURE (1+1)

PRACTICAL MANUAL CUM RECORD

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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	-	January - February, July - August and September - October (hills)
		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 incorporated 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 and toxic chemicals and 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 and 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.

7.

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. Then the soil should be put in the pot to set the plant to a right height and the new soil mixture filled around the roots. 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. Over this, required soil mixture is added. Very delicate kinds of seed like **Cineraria, Begonia Gloxinia and Petunia** etc are. best sown in these containers.

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.

In our country, pots of varying sizes viz., tube pots, ¼ size, ½ size, ¾ size and ‘thali’ are used commonly.

	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**). Tunicate bulbs are protected by outer scale and non-tunicate bulbs are easily damaged.

2) 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. They are harvested shortly before they fall naturally and are then planted. Increased bulbil production can be induced by disbudding as soon as flower buds have formed. Some lily species which do not form bulbils naturally can be induced to do so by pinching out the flower buds. Eg. ***Lilium candidum, L.maculatum***.

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 used in propagation of pineapple are

taken either from the fruit or at the time of harvest. Crowns will produce fruit in about 22 months after planting while slips produce in 12-18 months. Eg. **Pineapple**.

The 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 sphagnum 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. 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.
6. 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-. 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
$FeSO_4$, $7H_2O$	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.

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

Planting

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.

HOR.111 Fundamentals of Horticulture (1 + 1)

Theory

HOR.111 Fundamentals of Horticulture (1 + 1)

Theory

The term Horticulture first appeared in the writings of 17th century. The word is derived from the latin word '**Hortus**' meaning garden an **cultura** meaning 'cultivation'. According to the modern world, horticulture is defined as the crop science which deals with the production, utilization and improvement of fruits, vegetables, ornamental plants, spices and plantation crops, medicinal and aromatic plants. Horticultural science can be distinguished from agricultural or forestry science in one or more of the following factors

- Horticulture produces are utilized in the fresh state and are highly perishable. In contrast, agricultural field crops are often utilized in the dried state of are usually high in dry matter content.
- Horticultural crops generally require intensive cultivation warranting a large input, capital, labour and technology per unit area of land.
- Cultural operations such as propagation, fertilization, training pruning, harvesting and marketing are skilled operations and are specific to each and every horticulture crops.
- Horticulture crops are rich in sources of vitamins and minerals where as agricultural crops are generally rich in carbohydrates or protein.
- Aesthetic sense is an exclusive phenomenon for horticulture science.

Divisions of Horticulture

1.Pomology

Pomology is the study of fruit crops and science.

Woody Plants Evergreen – Acid lime, Litchi, Mango

Decid – Apple, pear

Herbaceous perennial – Strawberry, Banana, Pineapple

2. Olericulture

Olericulture is the branch of horticulture which deals on Vegetables like leafy vegetables, root, tuber, cole crops etc.

3. Floriculture

Floriculture is another branch of horticulture which deals on commercial Floriculture, landscaping and cut flowers.

Arboriculture: Growing of trees for aesthetic/scientific/educational purpose

Landscape gardening

Ornamental floriculture

Indoor garden and Outdoor garden

4. **Spices, Plantation, Medicinal and Aromatic crops**

Spices – used for food flavoring to aroma and flavour pepper, cardamom, clove, nutmeg

Condiments – plants used to add taste only (coriander, cumin)

Plantation crops – Arecanut, Tea, Coffee, Rubber, grown extensive area

Medicinal plants – Senna, periwinkle, Aswagandha

Aroma crops – Eucalyptus, Palmarosa, Citronella

Other branches of Horticulture

1. **Fruit nurseries**
2. **Vegetable/Flower seed production**
3. **Fruit/Vegetable processing**
4. **Medicinal plants extraction**
5. **Essential oil (oleoresin)**

Horticulture crops occupy only 7.0% of the total cropped area. But its contribution to natural income is 18-20% of total value of agricultural produce. The export of agricultural crops contributes 25% of our export out of this, horticulture crops alone contributes 56% of total earnings from agricultural sector. Horticulture crops fetch 20-30 times more foreign exchange/unit are than creates due to higher yields of price.

Fruits and Vegetables

i Fruits and Vegetables are regarded as 'protected foods' since they supply minerals such as calcium, iron and phosphorus. Vitamins like A,B,C. Fruits and Vegetables are good laxatives.

ii The nutrition expert group presents a daily a minimum of 2400-3900 calories of energy, 55g protein, 0.4-0.5 g calcium, 20g of Iron, 3000 mg of B carotene (Vit A) 1.2-2.0 mg thiamine, 1-2.2 mg riboflavin, 16-26 mg nicotinic acid, 50mg ascorbic acid.

iii To obtain this, dieticians recommended 300g of vegetables i-e. 125 g of leafy vegetables, 100g of roots and tubers, 75 g of other vegetables, 90 g of fruits.

iv But the per capital availability works to 30g fruits 92 g vegetables only.

AREA AND PRODUCTION, IMPORTS AND EXPORTS OF HORTICULTURAL CROPS TAMIL NADU (1996-97)

FRUIT CROPS

MAJOR DISTRICTS	CROPS	AREA (HA)	PRODUCTION (Ton)	PRODUCTIVITY
DPI, Vellore, MDU, Theni, DGL.	Mango	85,009	4,13,900	4.87
CBE, Erode, Tuti, NV, TVM, Vellore	Banana	79,314	31,17,780	39.31
MDU, DGL	Guava	8,269	95,040	11.49
DGL, TNV	Lime	6,693	10,450	1.56
Salem, Namakal, DGL	Orange	3,376	18,240	5.40
K.K.D.DGL, CUD	Jack	2,547	75,440	29.62
CBE, DPI, Theni, TNV, DGL	Grapes	2,209	47,420	21.47
DGL	Pear	1,411	29,631	21.00
DGL, Namakkal	Pine apple	471	10,570	22.44
TOTAL		1,94,987	38,55,827	19.77

VEGETABLES – TAMIL NADU (1997-98)

	AREA (HA)	PRODUCTION (Te)	PRODUCTIVITY (M.To./ha)
Tapioca	85,240	29,83,400	35.00
Tomato	25,120	3,76,800	15.00
Onion	25,230	4,54,140	18.00
Brinjal	8,120	1,62,400	20.00
Ladies finger	4,750	47,500	10.00
Potato	4,675	1,02,850	22.00
Carrot	4,475	89,500	20.00
Greens	2,300	34,500	15.00
Beans	1,700	13,600	8.00
Sweet potato	1,250	31,250	25.00
Yam	1,370	34,250	25.00
Cabbage	1,750	1,83,750	105.00
Beet root	1,100	25,300	23.00
Pumpkin	610	13,420	22.00
Other veg.	8,850	2,38,950	27.00
TOTAL	**1,76,540**	**47,91,610**	**27.14**

SPICES AND CONDIMENTS

Sl. No.	Particulars	AREA (HA)	PRODUCTION (Te)	PRODUCTIVITY (M.Te./ha)
1.	Chillies	80,240	56,168	0.70
2.	Coriander	38,850	15,540	0.40
3.	Tamarind	18,900	66,150	3.50
4.	Turmeric	16,850	1,01,100	6.00
5.	Cardamom	5,520	519	0.09
6.	Pepper	3,550	1,065	0.30
7.	Garlic	1,260	7,560	6.00
8.	Clove	700	700	1.00
9.	Ginger	600	15,000	25.00
10.	Other spices	1,350	2,700	2.00
	Total	**1,67,820**	**2,66,502**	**1.59**

PLANTATION CROPS

Sl. No.	Particulars	AREA (HA)	PRODUCTION (Te)	PRODUCTIVITY (M.Te./ha)
1.	Cashew	84,200	37,890	0.45
2.	Tea	63,400	5,07,200	8.00
3.	Coffee	32,400	19,440	0.60
4.	Betelvine	3,380	76,050	22.50
5.	Arecanut	2,650	4,505	1.70
	Total	**1,86,030**	**6,45,085**	**3.67**
	Flower crops	**16,745**	**1,42,333**	**8.50**

ABSTRACT

Particulars	AREA (HA)	PRODUCTION (Te)	PRODUCTIVITY (M.Te./ha)
Fruits	2,06,850	50,05,940	24.201
Vegetables	1,76,540	47,91,610	27.142
Spices & condiments	1,67,820	2,66,502	1.588
Plantation crops	1,86,030	6,45,085	3.468
Flowers	16,745	1,42,333	8.500
Total	**7,53,985**	**1,08,51,470**	**14.392**

SPECIAL FEATURES OF HORTICULTURAL CROPS GROWN IN INDIA

Horticultural crops

1. Utilised in fresh state - Highly perishable
2. Require intensive cultivation - Input, capital, labour, technology per unit area
3. Practices like propagation, fertilization, training, pruning, harvesting & marketing - Skilled & specific to hort crops
4. Rich sources of vit.B & minerals proteins - Field crops are rich in CHO &
5. Aesthetic sense - Exclusive to horticulture
6. Horticulture therapy: a recent science fast developing western countries.

EXPORT

Fresh banana

1994-95

Quantity - 966.08 MTs.
Value - 89.56 lakhs rupees
Chief importing countries - Nepal, Netherland, Qatar, Russia

Guava Export (Fresh (or) dried)
1994-95

Quantity	-	16,813.40 MTs.
Value	-	4048.98 lakh Rs.
Importers	-	Bangaladesh, Hong Kong, Kuwait, Netherlands, UAE, UK, Saudi

Dried Grapes
1994-95

Quantity	-	63.55 MTs.
Value	-	35.81 lakh Rs.

Fresh Mangoes
1994-95

Quantity	-	25,414.36 MTs
Value	-	4,502.73 lakh Rs.
Importers	-	UAE, Bangladesh, Saudi, UK, Kuwait

Mango Pulp
1994-95

Quantity	-	34,460 MTs.
Value	-	80.71 Crore Rs.

Mango slices
1994-95

Quantity	-	1,095.95 MTs.
Value	-	227.52 lakh Rs.

Mango Juice
1994-95

Quantity	-	793.96 MTs.
Value	-	198.75 lakh Rs.

Mango Pickles & Chutneys
1994-95

Quantity	-	7,935.28 MTs.
Value	-	2323.66 lakh Rs.

Papaya-Fresh
1994-95

Quantity	-	320.87 MTs.
Value	-	44.90 lakh Rs.

CLIMATIC ZONES OF INDIA FOR HORT.CROP PRODUCTION

Advantages of classification

1. To expose the agricultural potentiality of an area
2. Location of homo climatic zones-enables identification of soil + climatic problems
3. Helps in introduction of new crops eg. Oil palms in Kerala
4. Development of crop production technologies specific for the regions.
5. To take up research work to solve regional problems.
6. To transfer the technology developed.

1. **Temperate Northern region**
   J & K, H.P., hills of U.P., W.B.,
   Crops: Temperate fruits & veg.
2. **North Western arid region**
   Rajasthan, Gujarat, parts of Punjab & Haryana
   Crops: Ber, Pomegranate, Aonla, Seed spices
3. **North Easter sub-tropical-humid region**
   Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland & Tripura
   Crops: Banana, P.Apple, Citrus, Jack fruit, Tea & Cardmom
4. **North Central sub-tropical region**
   Parts of U.P., Bihar, entire M.P., and part of Maharastra
   Crops: Mango, sapota, sweet oranges & guava.
5. **South Central tropical region**
   Western & easter ghats of T.N., A.P., Karnatak & part of Maharashtra
   Crops: Mango, guava, sapota, P.Apple, turmeric
6. **Coastal tropical humid region**
   The entire coastal belt of Bay of Bengal & Arabian sea.
   Crops: Banana, Mango, Cashew, Coconut
7. **Southern hilly zone**
   Western & Eastern ghat above 800 M MSL.
   Crops: Coffee, Tea, cardamom, pepper, oranges, P.apple

AGROCLIMATIC ZONES OF TAMIL NADU

1. **Geographic location**
   Southern most, 8, º5' and 13º 10 North Lat. & 76º 15' and 80º 20º' East.
A coastal line of about 1000km in east & south.

2. **Physical characters**
   a Coastal plaints, b.Eastern ghats, c.Central plains and d.Western ghats.
3. **Climate**
   Semi-arid (Thorthwaite and Mather)
4. **Rainfall**
   Mean – 937 mm.
   Seasons – Winter, Summer, South west and north east.
   Variation exists between regions

5. **Temperature**

Plains–	Mean day	-	29^{o} to 38^{o}c
	Mean night	-	19^{o} to 27^{o} c
Hills	Mean	-	19^{o} to 24^{o}c
	Mean night	-	8^{o} to 11^{o} c

Questions

1. Mention the major disciplines of horticulture
2. What are different agro climatic zone sin India and Tamil Nadu
3. Mention the nutritional uses of fruit and vegetable crops

FACTORS LIMITING HORTICULTURAL CROP PRODUCTION

I	**Biotic**	-	a. Diseases b. Pests c. Nematodes d. other microbes e. plant genetic make up
II	**Abiotic**	-	Soil Climate – light, temperature, sunshine, wind speed, rainfall, evaporation Cultural practices Water Inputs – manures & fertilizers, Hormones & other chemicals

I. BIOTIC

a. Diseases

Banana	-	Bunchy top, Panama wilt, sigatoka leaf spot
Grapes	-	mildews, anthracnose
Tomato	-	spotted wilt, leaf curl, leaf spot
Chillies	-	anthracnose
Bhendi	-	yellow vein mosaic
Coconut	-	Thanjavur wilt

b.Pests

Mango	-	Stem borer, nut weevil
Coconut	-	rhinoceros bettle, eriophyid mite, red palm weevil
Tomato Brinjal	}	fruit, borer
Banana	-	pseudostem weevil

c. Nematodes - Banana, Crossandra, grapes, turmeric, potatoes, citrus, solanaceous veg.

d. other microbes

e. Plant genetic make up

1. A hybrid or selection
2. Vigorous feeder or not
3. Water loving or not
4. Resistance to biotic & abiotic stresses
5. Nature of life cycle

II ABIOTIC

a) Soil
b) Climate
c) Cultural practice
d) Water
e) Inputs-manures & fertilizers, hormones & other chemicals

a) Soil

i) Soil type

a) Sandy soil – coarse, large pore space, poor water & nutrient holding, suits ppgn activities
b) Loamy soils – have sand, silt & clay, classified accordingly. Sandy loam is suited for early crops, highly suitable for hort. Crops.
c) Clay soils – fine textured, very small pore space, not suited for horticultural crops. It should be improved with org.manure. It has better water & nutrient holding capacity
d) Organic soils (High org.matter – 20%)
   Microorganism – enzymatic digestion.
   (organic matter – plant & animal waste)
   Green manure cropping
   found in swamps, bogs, lake bottom & river beds.
   Peet – 50-90% org.matter – High water holding capacity – crops-tuber, root cole crops)

   Muck – 20-50% org.matter – low water holding capacity

ii) Soil fertility

- It is important to nourish & sustain the soil productivity
- Soil, air, soil moisture, soil microbes & humus help absorption

- Top layer is more fertile usually
- Crops like coffee, cardamom, pepper, ginger, clove and vanilla prefer fertile soils.
- Good soil management practices necessary.

iii) Soil reaction

- It influences nutrient availability eg. Boron-deficient in alkaline soil-unavailable in very acidic soil
- Activity of soil bacteria is also influenced and thereby nutrient status.
- Diseases are promoted – eg.club roots disease of cole crops high in acidic soil
- Slight acidic soil better for most crops.
- Apply Gypsum & aluminium sulphate to alkaline soils.
- Apply lime or epsum (mg. sulphate) to acidic soils
- Alkalaine soils –sodicity is dangerous
- Knoledge on soil salinity is important.

Classification of soils based on salinity tolerance.

Tolerant	-	8m.mhos. (eg.-Dates, Guava, Fig, Grapes)
Moderate	-	3-6 m.mhos (Pome, grape fruit, apple, pear & plum)
Sensitive	-	1.5-3 m.mhos (orange, peach, avocado, strawberry)

iv Soil depth

A depth of 2.0 m is essential for fruit crops
No hard & compact subsoil layers like Cankar, rock & heavy clay should be present

v. Soil drainage

- It depends on nature of subsoil
- Better tree stand in good subsoil
- Poor aeration-another effect
- Water table below 2.0m
- Higher water table-poor aeration
- Root rotting by prolonged submergence
- Higher disease incidence
- Eg. Sweet orange failed in U.P & Punjab

b.Climate

i) Temperature

- Specific temperature is recommended for each crop
- Classification – temperate – subtropical – tropical

If temperate crop is grown in tropical (or) vice-versa, growth & development will be affected.
Exception – eg. Grapes/temperate – tropical
Temperature requirement varies with stage also
Eg. Tomato at early stage – requires higher night temperature of 18-27^{o}C for fruit set it requires 13 to 17^{o}C

It affects flowering. Eg. Banana requires 10^{o}C -40^{o}C. At 10^{o}C (or) < chocking of bunches is observed.

Temperature affects quality of low temperature in grape-high acidity is noticed high temperature of grape-sweetness.

Winter kill –death by low temp/chilling injury
Hardy plants – Asparagus – resistant to cold injury
Tender plants – cucumber – susceptible to cold injury
Cold injury – ice formation
High temp. – dessication

ii) Light
Intensity
Quality
Duration
Influences all activities

Photoperiodism – Duration of light and dark hours in a day. It also affects sex of plants
eg. cucurbits – LD-Male Flowers
SD-Female Flowers
Coffee, Cardamon, Cocoa Filtered shade
Apple & mango -good light-good colour & quality

iii) Humidity
Humid zone
Semi arid
Arid

- ♦ High humidity at flowering & fruiting results in high pest and disease incidence mango, grapes, potato, tea
- ♦ Vegetative propagation methods more successful at high humidity levels.

iv) Rain fall

Quantum

Distribution

- The requirement varies with crop
- If continuous rains exist at flowering-pollen washing is resulted, insect pollination reduced thereby pollens get injured stigmatic fluid is diluted.
- Coffee-Feb-March (Blossom) showers decides flowering in the successive two years
- Cardamom-Feb-April-Panicle initiation
- Grape-rainy season crop-poor quality

Rainfall

1. Mango 025 to 250 cm/year
2. Pepper 125 to 200 cm/year
3. Cadamon 200 to 250 cm/year
4. Rubber 200 to 250 cm/year
5. Dates 015 to 025 cm/year

v) **Wind**

- Lower & fruit shedding-breaking of branches, trees uprooted-rapid moisture loss are some of the effects need for irrigation is very frequent

vi) **Air pollutants**

- 0_3, So_2, No_2 reduce assimilation rate, growth & development eg., mango orchards in Punjab, U.P., bihar, West Bengal are effected by black tip disorder since they were located 1.5 km from brick kiln.
- CO_2, So_2 and acetylene are responsible

vii) **Frost**

- Thin layer of formation of ice crystals during winter at 2000m.msl is noticed
- It damages tea, potato and cole crops.

viii) **Hail storms**

- Hails at pre-blooming or blooming of apple, plum, peach affect fruitset.

xi) **Altitude**

- Critical factor deciding climate particularly temperature
- For every warm temperature fruits require 1800m.msl. 100m elevation-1oc. To 2oc decrease is noticed
- Humid zone fruits & plantation crops -100-1800m
- Tropical fruits requires <1000m.
- Coconut at 1000-1200m takes 10-12 year for flowering
- Papaya at hills has only poor taste

- Tea-yield and quality is affected. High altitude resulted in good quality.

Questions

1. What are the factors limiting horticultural production
2. How climate influences production of horticultural crops
3. Temperate and arid zone horticulture- Differentiate

Methods of propagation of horticultural crops and their advantages and disadvantages

ASEXUAL PROPAGATION

Asexual propagation is the method of multiplication of a plant from a tissue other than zygote which is formed by the combination of male and female gametes. The cellular basis for this method of multiplication is mitosis viz., regeneration of a daughter plant from the somatic tissue. The different methods of asexual propagation are.

A) Cuttings

1. Root cutting – Red raspberry, Bread fruit etc.,
2. Stem cuttings
    a. Hardwood –fig, grape, gooseberry, rose etc.,
    b. Semi hard wood – coleus, geranium, sweet potato etc.,
    c. Softwood-lilac, jasmine etc.,
    d. Herbaceous – coleus, geranium, sweet potato etc.,
3. Leaf cutting
    Begonia, *Bryophyllum*, Sansevieria etc.,
4. Leaf bud cuttings – eg. Hydrangea

B) Layering

a) Ground layering

1. Tip layering : Black berry
2. Simple layering: Guava, Pomegranate, crotons etc.,
3. Mound layering : Goose berry, apple etc.
4. Compound layering : Grape, Honey suckle etc.,
5. Trench layering : Etiolation method eg. Cherry

b) Air layering (Gootee (or) marcotage) : Litchi, guava, crotons etc.

c) Grafting

1) Root grafting
    a) Whip graft-apple and pear
2) Crown grafting
    a) Whip and tongue graft – Persian walnut, apple
    b) Cleft graft – camellia, plums
    c) Side graft - Narrow leaved evergreen, mango
3) Top grafting
    a) Cleft – various fruit trees
    b) Notch graft
    c) Bark graft
    d) Side graft
    e) Whip and tongue graft

f) Veneer grafting

D) Budding

a) T budding (Shield budding) – Pomefruits, rose, ber etc.

b) Patch budding – Citrus

c) Ring budding – Walnut and pecan

d) Flute budding – Walnut and pecan

e) Chip budding – citrus

E) Tissue culture

F) Other special parts

1) Bulbs

Bulb is a specialized underground organ consisting of a short fleshy, usually vertical stem axis bearing at its apex a growing point or a flower primordium enclosed by thick fleshy scales (Eg.) Onion, garlic, tulip and Hyacinth.

2) Corm

Corm is a swollen base of stem axis enclosed by dry scale like leaves with distinct nodes and internodes eg. Gladiolus.

3) Stolons

Modified stems that grow horizontal to the ground eg. Grass

4) Tubers

It is a modified stem structure which develops below ground as a consequence of the swelling of the sub apical portion of a stolon and subsequent accumulation of reserve materials. Eg. Potato

5) Rhizomes

It is a specialized stem structure in which the main axis of the plant grows horizontally or just below the ground surface eg. Bamboo, banana, ginger etc.,

6) Crowns – Pineapple

7) Tuberous roots

Plants produce thickened under ground structures which contain large amount of stored foods. This thickened structures are tuberous roots eg. Sweet potato, Dahlia (massive enlargement of secondary roots)

Advantages of asexual propagation

1. In most horticultural plants, the genetic make up (genotype) is highly heterozygous. The unique characters of such plants are immediately lost if they are propagated though seed
2. It is necessary to grow cultivars that produce non viable seeds, eg. Bananas, fig and grape
3. Propagation of some species may not be easier through seeds . For eg. Cotoneaster seed – it has complex dormancy condition but it is easily propagated through cuttings
4. To reduce prebearing period/or to reduce long juvenile stage.
5. To induce dwarfness eg.in apple
6. To induce disease and pest resistance. 'Troyer citrange' is used as a rootstock for citrus. It is resistant to tristeza virus.
7. To induce hardiness in cultivars eg. 'Alnarp' apple used for its winter hardy properties

DISADVANTAGES

1. Longevity is not high when compared to the seedling progeny.
2. Asexual method is uneconomical and impractical in the case of vegetable crop propagation and grains (eg.tomato, brinjal, amaranthus etc.) since cost of cultivation is high when compared to sexual method
3. Most of the virus disease are not seed borne. When propagated vegetatively the virus are carried to the next generation eg. 'Katte' disease of cardamom.

Genetic variation in sexual propagation

- Gene or chromosome change
- By mitosis, it becomes permanent
- It is found in a part of the plant only
- The plants with normal and mutated cells are called 'Chimeras'
- Eg. Coleus, crotons, Bougain villeas.

Kinds of Chimeras

1) Sectorial Chimeras - growing point of the stem is found with two types of tissues.
- the leaves & lateral buds are also mutated

2) Periclinal - the mutated tissue occurs as a thin skin with several cell layers
- the most common type of chimeras
- relatively stable
- this type will revert back if propagated by seed or root cuttings

3) Mericlinal - similar to periclinal

- the outer of mutated cells does not surround fully
- it occupies as a segment of the whole part only

Budsport

- Budsport is one where a branch of a tree alone is found with genetic change from the rest of the part
- The characters of budsport are inheritable
- They can be vegetatively propagated
- Eg. Apple – varieties –'star kind' and Richa Red ar ebudsports from 'Delicious apple'

Seed propagation dormancy methods of breaking the dormancy

Seed germination

Seed is an embryonic plant surrounded with protective seed coat or covering and supplied with stored food. It is the physiological process through which development of seed into a seedling takes place when exposed to favourable environmental conditions. While germination radicle comes out first followed by plumule. The radicle gives rise to the rootsystem of plant while the plumule gives rise to shoot system

There are 3 factors which are associated with germination of seeds

i. Seed must be viable viz., embryo should alive
ii. Seed should be subjected to favourable environmental condition
iii. Internal conditions associated with seed which prevent the germination have to be eliminated.

Germination is a complex biochemical change, which involves mobilization of reserved food within seed and utilization by the embryo for growth.

Environmental conditions affecting seed germination

When seed is sown, it absorbs moisture. This is followed by increase in enzyme activity, respiration, cell division and elongation resulting in emergence of radicle. This will occur in favourable environment. The factors affecting seed germination are as follows.

1) **Water**

Imbibition of water by seed is the first step in germination process. There are two important factors which affect the water uptake. They are

1) Nature of seed and its covering
2) Amount of available water in the surrounding medium

Some seeds germination only above the 'permanent wilting point' of moisture in soil. Some can germinate below permanent wilting point (P.W.P)

According, vegetable seeds are classified as

Group I: Those, which germinate with moisture from P.W.P to above field capacity eg. Snap bean, peas, Beet.

Group II: only in soil with moisture near field capacity eg. Celery

Group III: Low moisture content and below field capacity eg. Spinach

2) **Temperature**

According to the requirement range of temperature for germination, seeds are classified into 3 groups

a) **Low temperature**

Here, seeds will germinate only at relatively low temperature eg. Alpine. For cool season plants, it is 4.5^{o}C and for warm season plants, it is 10-15^{o} C. These are the lower critical levels. Below these temperature ranges, seeds fail to germinate or chilling injury can occur.

b**) High temperature**

Seeds of all tropical plants require high temperature for germination. So, the upper limits of soil temperature for survival of most of vegetable seeds is between 80 ^{o}F (30c) and 104^{o}F (40c). over and above, heat injury will occur.

c) **Optimum temperature**

The temperature which is favourable for germination is called optimum temperature. In this temperature, highest rate of germination will occur. The optimum temperature for most of the plants is between 26.5^{o}c-35^{o}c

3. **Oxygen**

Seed gets O_2 through respiration. It is a must to produce energy.

Sugar + Oxygen = Carbon dioxide + Water + Energy

$C_6H_{12}O_6 + CO_2 = 6CO_2 + 6\ H_2O + 673$ K.cal

This will take place as long as the seeds are alive. After sowing, during germination the rate of respiration will increase considerably. Seeds of Bermuda grass, lettuce, petunia an rice will germinate even at low O_2 level. It is because of the presence of anaerobic energy liberating system within the seeds. Cate tails (*Typha latifolia*) give poor germination in air but prompt germination under water, because of anaerobic energy liberating system

4. **Light**

It has a significant effect on initiation of germination an on seedling growth. Normally when the seeds are sown in soil and light is cut off, it results

in start of germination. But, certain seeds will germinate only in the presence of light.

Eg. *Viscum album*
Ficus aurea
Lactuca sativa

But, in plants like Allium and Amaranthus, germination is affect by light.

A photo chemical reversible reaction, involving the response of pigment known as phytochrome , affects seeds germination

Light requirement can be partially replaced by alternating temperature, potassium nitrate, kinetin, GA, and thio-urea.

Germination process

There are 3 stages

1. In the first stage, water is absorbed by a dry seed and moisture content increase rapidly. This is purely a physical process called imbibition. As a result swelling seed takes place and the seed coat may break. Protein synthesis and enzyme action will also be initiated.
2. The second stage of germination involves digestion and translocation. Enzymes appear and begin to digest reserve substances like fats, proteins, CHO in the storage tissues to similar chemical compounds. These are translocated to growing points of embryonic axis to be used for growth and the production of new plant parts.
3. The third stage of germination consists of cell division. Here, fresh weight and dry weight of seedling increase but weight of storage tissue decreases.

Role of hormones in the process of germination

Three plant hormones play important role in germination. They are

1. Gibberellins – control of food mobilizing system
2. Cytokinins – Natural endogenous hormones will also control germination through DNA to RNA transcription system
3. Abscisic acid is an inhibitor that can prevent germination. It affects RNA synthesis.

Categories of seed dormancy

Dormant seed : Seed exposed to favourable environment for germination does not germinate which implies the presence of dormancy.

Four groups of Dormancy

Group I: Seed coat dormancy

a) Hard seed covering, impermeable to moisture. Eg. Leguminoceae, Malvaceae
b) Hard seed covering resistant to embryo expansion eg. Walnut

c) Seed covering containing chemical inhibitors. These are by leaching with water eg. Citrus. Cucurbits.

Group II: Seeds with morphologically undeveloped (rudimentary) embryos

Embryos are not well developed at the time of harvest and will grow before germination occurs. Eg. Palmae , Annona

Group III: Seeds with internal dormancy (endogenous)

Germination is regulated by the inner tissues of seeds – endosperm and inner integumental layer. There are three groups in this category.

a**) Physiologically shallow dormancy**

This type is present is most freshly harvested seed and disappears with dry storage over a period of days or months. It may be due to endogenous inhibitors in fresh seeds. Treatments with GA, Kinetine, Potassium nitrate may be used to over come.

b) **Physiologically intermediate dormancy**

Moisture chilling stimulate germination. This is found in conifers and in woody plants. Temperature just above freezing (2 to 7^{o}c) are generally most effective to break dormancy.

c**) Physiologically deep dormancy**

This will disappear with prolonged moist chilling. This is to regulate embryo and seed covering to facilitate germination. Eg.Temperate zone herbaceous plants.

Group IV: Combined or double dormancy

Both seed coat (external) dormancy and embryo (internal) dormancy occur. Here treatments must be given in sequency. Eg. Woody trees and shrubs of temperate region.

Pre-conditioning of seeds or breaking dormancy

1) Mechanical scarification

This is done to modify hard or impervious seed coats. Scarification is a process of breaking or scratching or mechanically altering the seed covering to make it permeable to water and gases.

1. Rubbing the seed on sand paper.
2. Cutting with a file
3. Cracking the seed cover with a hammer
4. Scratching in pestle and mortar.

For large scale operation, special mechanical scarifiers are used. Here, seeds may be tumbled in drums lined with sand paper or in concrete mixtures

combined with coarse sand or gravel. The sand and gravel should be of a different size than the seed to facilitate separation. Eg. Leguminous seeds

2) Acid scarification

Concentrated sulphuric acid is used to modify hard or impermeable seed covering

Dry seeds are placed in glass or earther ware containers and treated with concentrated sulphuric acid in the ratio of about one part of seed to two parts of acid. The mixture should be stirred in intervals to produce uniform results.

The length of treatment should be carefully standardized. This may vary from 10 minutes for some sp. to as much as 6 hours for other sp.

At the end of treatment , the acid is poured off and the seeds are washed with copious amount of water.

3) Soaking seeds in water

It is done to modify hard seed coat, remove inhibitors, soften seed coat and reduce the time of germination. This will overcome seed coat dormancy and stimulate germination. The seeds can be soaked either in cold or hot water depending on the species. Seeds of winged bean are very hard and normally soaked in cold water for 48 hours so as to hasten the germination.

In hot water treatment, temperature of water will range from 77^{o}c to 100^{o}c. After treating for one or two minutes, the heat is immediately removed, and the seeds are allowed to soak in gradullay cooling water for 12 to 24 hours. Following this, unswollen seeds can be separated from the swollen ones.

4. Stratification : (Moist chilling)

Here, seeds are exposed to low temperature. It permits physiological changes to occur in the embry. Temperature range is from 0oc to 10oc. So dry seeds should be soaked in water for 12 to 24 hours, drained, mixed with moisture retaining medium and then stored for the required period of time. The usual storage temperature is 2oc to 7oc. For most of the seeds, low temperature stratification ranged from 1 to 4 months. After it underwent the stipulated period, seeds are sown without drying.

5. Chemical stimulants

GA

It will promote germination in some kind of dormant seed. Seeds are treated with GA by soaking for 24 hour in water solution at concentration from 100 to 12000 ppm. This will improve seed germination.

Cytokinin (Kinetin)

Commercial preparation of kinetin are available. A common synthetic cytokinin is Benzyl Adenine. Seeds are soaked in 100 ppm kinetine solution for

three minutes. First, the chemical is dissolved in small amount of dil. Hel, then made up with water to get the required concentration.

Ethylene

When ethylene was applid to seeds, it stimulated germination of some seeds experimentally. In peanut or groundnut (Virginia type), ethylene is used in the form of ethrel to break the dormancy.

Potassium nitrate

Freshly harvested dormant seeds germinate better after soaking in potassium nitrate solution. Potassium nitrate solution of 0.2% concentration will improve seed germination in Kentucky bluegrass.

Thio-urea

It is used to stimulate germination of some dormant seeds, particularly those that do not germinate in darkness or at high temperature or that require a moist chilling treatment. Concentration varies from 0.5 to 3%. Soaking is done for 24 hours.

Seed invigouration

In most of the species, as the seed ages, it slowly looses the germination capacity due to a number of factors like accumulation of inhibitors etc., These aged seeds when treated with specific chemicals like potassium dihydrogen orthophosphate (KH_2 PO_4) sodium dihydrogen orthophosphate (NaH2 PO4), dipotassium hydrogen phosphate (K_2HPO_4) at a concentration of 200 ppm for 24 hours, drying to original moisture and then sowing has improved the germination tremendously. In some cases even water soaking has improved the germination eg. Papaya and chillies.

APOMIXIS

It is the occurance of an asexual reproductive process in place of normal sexual reproductive process of reduction division and fertilization. Simply, it is an asexual seedling developed from a seed viz., a seedling that arises from tissue of the seed other than embryo

Plants that produce only apomictic embryos are known as obligate apomicts, (Eg. Mangosteen) those that produce both apomictic and sexual embryos are facultative apomicts eg. Acid lime

Type of apomixes

Recurrent apomixes

Here, embryo develops from the egg mother cell which doesn't under go any meiosis. So., egg has normal diploid number of chromosome. The same as in the mother plant. The embryo subsequently develops directly from the egg nucleus without fertilization. In some cases, the embryo develops with

stimulus of pollination (eg. Allium) and in some cases, without stimulus of pollination (eg.Malus)

Adventitious or Nucellar embryony

Here, embryo will rise from a cell or group of cells either in the nucellus or in integuments. Here, embryo develops outside the embryo sac in addition to the regular embryos. Eg. Citrus

Nonrecurrent apomixes

Here embryo arises from the egg nucleus without fertilization. Since the egg is haploid, the resulting embryo will also he haploid. The case is very rare.

Vegetative apomixes

In some cases, vegetative buds or bulbils are produced in the inflorescence in place of flowers eg. Agave and grass species

Polyembryony

The phenomenon in which two or more embryos are present within a single seed is called polyembryony (Nucellar embryony)

Significance of apomixes

1. Apomictic seedlings are true to its mother and apomictic cultivar can be considered as a clone
2. They are uniform and vigorous
3. Virus diseases are not seed borne. So, it is the best method to rejuvenate virus affected plant crops.

Principles and methods of vegetative propagation by cuttings

Cuttings are vegetative plant portions such as stems, leaves and roots taken from plants to produce new independent plant which, in most cases, will be identical with the parent plant. This is one of the least expensive and easiest methods of vegetative propagation.

Cuttings are taken from 1)stem 2)leaf 3)leaf bud and 4) root

In the case of stem cuttings, it has four groups

1. Hard wood cutting - spring – February, March
2. Semihard wood cutting - summer – April, may
3. Soft wood cutting - fall (or) autumn – June, july & August
4. Herbaceous cuttings - Winter – September, October, November, December and January

Hard wood cutting: (Deciduous)

The cuttings are fully matured with more reserve food and anatomically, the maximum of sclerenchyma can be seen. The cuttings are prepared during dormant season (late fall, winter or early spring) from wood of previous season's growth. In some species, such as fig, olive and certain plum varieties , two year old wood can be used. Fruits propagated through hard wood cuttings are fig, olive, mulberry, grape, gooseberry, pomegranate, some plums and rose

Cuttings should be taken from healthy plant grown in full sunlight. Length may vary from 4 to 30 inches (Common 6-8") the diameter of cuttings may range from ¼ inch to even 2" depending upon the species.

At least, two nodes are included in the cutting. The basal cut is usually just below a node and a top cut ½ to 1" above a node. After preparing cuttings, bundles of cuttings may be buried out of doors in sandy soil or stored in a refrigerated room before planting in spring.

While planting, cuttings should be planted 3 or 4" apart and deeply enough (1/3 of its length placed inside the soil)

Evergreen hardwood

Grapes, pomegranate and some citrus fruits are propagated through hard wood cuttings. Length of cuttings range from 4-7" with 5 to 6 nodes. Cuttings are taken during late winter. Spring season is good for planting.

Semi-hard wood cuttings

Stem cuttings of trees and shrubs that are taken from current season shoots, which are partly matured are known as semihard wood. They have lesser reserve food compared to hard wood and similarly, the formation of sclerenchyma in the anatomical development is also comparatively less. Length of cuttings range from 3to6". Here we can retain one or two terminal leaves.

Soft wood cutting

Cuttings of 3-6" length prepared from soft, succulent and new growth may be called as soft wood cuttings eg. Vernonia

Herbaceous cuttings

This type of cuttings made from succulent herbaceous plants just near the terminal buds is called herbaceous cuttings (Geranium, Coleus, Alternanthra and Sweet potato) Length of cuttings is 3-5" with leaves

Leaf cuttings

Leaf blade are utilized in starting a new plant. Advantitious roots and an adventitious shoot form at the base of leaf. (eg.) Sansevieria, Begonia & Bryophyllum

Leaf bud cuttings

They consist of a leaf blade, petiole and a very short piece of stem with attached axillary bud.

This type of cuttings will be very useful in species which have a tendency to produce root from the leaf, stem or petiole but do not produce a shoot system out of any one of the three parts. In this case, the axillary bud serves as a source for new shoot system. Eg.Lemon, Rhododendron.

Root cuttings

Root piece of 2-4" length are planted horizontally at 1" to 2" depth
Eg. Bread fruit, Crab apple, Black berry, Rasp berry

Anatomical and physiological basis of rooting

The formation of adventitious roots in cuttings or layering can be divided into two phases. One is initiation which is characterized by cell division and the differentiation of certain cells into root initials and then into recognizable root primordia. The second phase is the growth and emergence of new roots, by a combination of cell division and cell elongation including rupturing of other stem tissues and formation of vascular connections with the conducting tissue of the cutting

These root initials are formed adjacent to vascular tissue. In herbaceous plants which lack a cambium, the root initials are formed near the vascular bundle close to the phloem. In woody perennials, the adventitious roots in stem cuttings usually originate in the young, secondary phloems although they may also arise from other tissues such as vascular rays, cambium or piths.

In some plants, adventitious root initials form during early stage of intact stem development and are already present at the time of preparation of cuttings. These are termed 'preformed' of latent root initials. These generally lie dormant until the stems are made into cuttings and placed under environmental conditions favourable for further development and emergence of the primordial as adventitious roots. Willow, Hydrangea, Poplar, jasmines, Citrons are some of the species which produce preformed root initials. The position of origin of these preformed root initials is same as that of other adventitious roots. After elaborate studies with easy and difficult to root plants, some insight into the physiological basis of rooting has been established. The important aspects are summarized below.

1. Auxin level is closely associated with adventitious rooting of stem cuttings.
2. Nutritional status of plants especially high carbohydrate levels with optimum N is associated with vigourous root growth.

3. Few organic compounds interact with auxin to affect rooting and they are called rooting co-factors

Principles and methods of propagation by layering

It is a propagation method by which adventitious roots are caused to form on a stem while it is till attached to the parent plant. The rooted stems are then detached and established in a medium to become a new plant growing on its own roots.

Types of layering

a) Air layering or Gootee
b) Ground layering
    1) Simple layering
    2) Compound layering
    3) Mound (Stool) layering

Air layering

In air layering, roots form on aerial part of plants where the stem has been girdled and covered with rooting medium. It should be done during humid months because root initiation will be high under high humid conditions

Steps:

1. The branch selected should be of pencil thickness
2. The stem should be girdled for about a length of 1cm to 1" to induce adventitious root formation above the cut. It should be given at 12-15" from the tip of the branch
3. A ball of slightly damp sphagnum moss is placed around the girdled stem.
4. A wrap of polythene film is placed around the sphagnum moss and tied airtight on both ends.

Time of removal

It is better determined by observing root formation through the transparent film. In some plants, rooting occurs in two or three months. Layering made in spring or early summer is the best and it will give high percentage of success.

The rooted layers should be potted in a suitable container and placed under cool humid conditions as a hardening process before it is used for planting.

Ground layering

1. Simple layering

Branches that have formed roots in one area only are called simple layers. Such layers are made by bending the branches to the ground and covering the portion with soil.

This should be done in early spring for temperate species before growth has started. For other tropical species an actively growing period is selected. The tip of the shoot is left exposed to carry out normal process of the plant.

Procedure

1. A healthy shoot of pencil thickness from a lower branch near the ground level has to be selected.
2. 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 as well as hormones manufactured by leaves. Injury is given 6-12" back from the tip
3. The bent part of shoot is inserted into the soil
4. the usual time for layering depends on species eg.for temperate species, it is done in early spring and for this, dormant, one year old shoots are used.
5. The rooted layers may be removed from the parent plant and kept under cool humid conditions for curing.

2**. Compound or serpentine layering**

It is essentially the same as simple layering, except that the branch is alternately covered and exposed along its length. So that, the roots strike wherever the plant is covered by soil

3. **Mound layering (or) stooling**

Here, the plant is pruned close to the ground level and all the branches are covered with soil. Striking of roots takes place at a number of places and the plant also produce new shoot system which come out of the mound. Each shoot with part of roots formed will be separated and planted in pots for further establishment. Apple rootstocks are propagated by this method.

The anatomical development of roots

Stem cuttings

Propagation through cutting/layering is common in dicotyledonous plants. However, cuttings of some monocots, such as asparagus can be rooted under proper conditions

Process of root initiation in stem

It is divided into three stages

1. Cellular differentiation of cambium leading to initiation of meristematic cells. Proliferation of certain cells to form root initials near vascular bundle.
2. These differentiated cells group into recognizable root primoridia
3. The growth and emergence of new roots.

Initiation of root primordia in herbaceous plants

1. Origin is usually just outside and between the vascular bundles (from cmbium)
2. Small group of cells, the root initials, continue dividing, forming groups of many small cells which develop into root primordial (it looks like root tip)
3. A vascular system develops in the new root and becomes connected with adjacent vascular bundle

Initiation of roots in woody plants

Origin is in the young secondary phloem, sometimes from vascular rays or cambium The time at which root initials develop after cuttings are placed in the propagating bed varies widely

Callus

After stem cuttings have been made and placed under favourable environmental conditions, callus will usually develop at the basal end of cuttings. This is an irregular mass of undifferentiated parenchyma cells. It was believed that callus formation would be essential for rooting. In most cases, formation of callus and formation of roots are independent of each other and if they occur simultaneous it is due to their dependence upon similar internal and environmental condition.

Principles of grafting and budding

It is the process of operation of inserting a part of one plant into another or placing it upon another in such a way that an union will be formed and the combination will continue to grow as one plant. The part of graft combination which is to become the upper portion if termed as the ‘scion’ (ion) and the part which is to become the lower portion or root is termed as ‘root stock’ or ‘understock’ or the ‘stock’ Rootstocks are commonly grown from seeds, cuttings or layers. All methods of joining plants are popularly termed as ‘grafting’ but when the scion part is only a small piece of bark (and sometimes wood) containing a single bud, the operation is termed as ‘budding’.

Reasons for grafting and budding

1. When other methods of asexual propagation is not successful in perpetuating a clone, eg.mango and sapota can be successfully propagated on commercial scale by grafting only.
2. Plants propagated on their own roots may be weak, susceptible to pests and diseases, or to any adverse environmental conditions may not adaptable to a particular soil or climate. For many plant species, rootstocks are available which tolerate all the above cases and hence they may be exploited as a rootstock through grafting or budding.
3. For converting poor trees into more desirable one by top-working
4. For overcoming pollination problems, self-fertile varieties may be grafted over self-sterile trees
5. For fancy purposes, different types of scion may be grafted in the same plant
6. To modify the growth of the plant as dearf one by employing suitable dwarfting rootstocks
7. Occasionally the roots, truck or large limbs of trees are severely damaged by winter injury, cultivation implements, certain diseases or rodent. But use of bridge grafting or in arching such damage can be repaired and the tree saved.

Questions

1. Mention difference between sexual and asexual propagation
2. What are specialized **plant propagules**

Rootstocks

Rootstocks also influence the growth and productivity of scion. Root stocks can be divided into two groups as follows.

1.Seedling rootstocks

Variation among seedlings can possible make them undesirable as rootstocks. Variability in rootstock seedlings may cause variability in the growth and performance of the grafted trees. Seedlings which are weak should be avoided. Seedlings of ½ to 2 years old with pencil thickness are considered optimum. In Tamil nadu seedling rootstocks are employed for mango, plums and peaches.

2. Clonal rootstock

To avoid variation in rootstocks, thus to impart uniformity in the scion, often rootstocks are also propagated by cuttings or layers. Such rootstocks which are perpetuated a sexually are termed as clonal rootstocks. Nucellar seedling (poly embryony) in certain varieties of mango and all the species in citrus (excepting *C.grandis*) can be also considered as clonal rootstocks as they arise from the tissues other than the true sexual embryo. In Tamil nadu clonal rootstocks are used in the propagation of apple and pear.

Factors for successful graft union

1. Botanically the closer a rootstock and scion, the more will be the compatibility between these two.
2. Proper season of grafting is essential. For deciduous plants, grafting is done at the winter season or early spring season and for evergreen trees, it should be done during its active growing season
3. Any grafting or budding method should ensure intimate contact between the cambium of scion and rootstock
4. Immediately after the grafting operation is completed all the cut surfaces must be carefully protected from desiccation.
5. Proper care should be given to the grafts for a period of time after grafting

Formation of graft union

In graftage, freshly cut scion tissue capable of meristematic activity is brought into close, intimate contact with similar freshly cut stock tissue in such a manner that cambial regions of both are in close proximity. The healing of graft union takes place in a sequential step as indicated below

1. Production of callus tissues (Parenchyma cells) by the cambium regions
2. Intermingling and interlocking of parenchyma cells of both graft components

3. Differentiation of certain parenchyma cells of the callus into new cambium cells connecting with the original cambium in the stock and scion
4. Production of new vascular tissues by the new cambium permitting passage of nutrients and water between the stock and scion.

Limitation of grafting or budding

One of the requirements for a successful graft union is the close matching of the callus-producing tissues near the cambial layers. Grafting is generally confined to dicotyledons. These plants have a vascular cambial layer existing as a continuous tissue between the xylem and phloem. For grafting, it should be borne in mind that the plants to be combined are capable of uniting. Generally, the more closely the plants to be grafted are related botanically, the more favourable is the chances of the graft union being successful.

1. **Intra-varietal grafting:** When a scion can be grafted back on the same plant or a scion from a plant of a given clone can be grafted to any other plant of the same clone eg.Elberta peach on Elberta peach
2. **Inter-varital grafting:** when different varieties of a species are employed as graft parents eg.mango
3. **Inter-specific grafting:** In this case, grafting between the species of the same genus is done. But this is usually difficult but widely used between species in the genus citrus. Japanese plum (*Prunus salicina*) is grafted commercially on peach (*Prunus persica*)
4. **Intergeneric grafting:** when the plants to be grafted together are in different genera but in the same family the chanes of union are more remote. But successful union has been reported in the following cases
   Citrus spp. on trifoliate orange (Poncirus trifoliatat)
   Sathugud (Citrus sinensis) on wood apple (Ferronia elephantum)
   Sapota (Achras sapota) on pala (Manilkara hexandra)

Graft incompatibility

The ability of two different plant when grafted together to produce a successful union and also to develop satisfactorily into one composite plant is termed as compatibility. The inability of two different plants to do so when grafted together is often defined as incompatibility or graft incompatibility. The distinction between a compatible and an incompatible graft union is not clear cut. On one hand, stocks an scions of closely related plants unite readily and grow as one plant. On the other hand, stocks and scions of closely unrelated plants when grafted together are likely to fail completely in union. Many graft combination lie between these extreme viz., compatible to incompatible and therefore the characterization of incompatibility is not distinct

Partial incompatibility

Where the stock outgrows the scion has been reported in certain fruit crops. For instance, mandarin when grafted onto trifoliate stock, the stocks outgrew the scion but the tree grew well and produced plenty of fruits of good quality. Incompatibility may be classified as translocated incompatibility and localized incompatibility. The former type refers those cases in which the incompatible condition cannot be overcome by the insertion of a mutually compatible interstock. This is due to apparently some labile influence moving across it. This type involves phloem degeneration and development of a brown line or necrotic, are in the bark. Hale's Early peach develops incompatibility when grafted on Myrobolan-B plus rootstock. But when a mutually compatible interstock. 'Brompton Plus'is introduced, the incompatibility still persists indicating that the incompatibility is due to some factors translocated from the rootstock to the scion through the phloem causing phloem degeneration

The second type viz., localized incompatibility includes a combination in which the incompatibility reaction apparently depends upon actual contact between stock and scion. Introduction of a mutually compatible interstock will normally overcome the incompatibility. Symptoms of this kind of incompatibility is that the graft is often mechanically weak with discontinuity in cambium and vascular tissue. A typical example of this kind of incompatibility is that when Barlett pear is grafted directly on quince stock, it is incompatible. When Old Home interstock is introduced in between these combination, the three part combination is completely compatible and it grows satisfactorily. Another example is that when Eureka lemon is grafted on trifoliate rootstocks, it proved to be incompatible, due to a toxic substance produced by the scion damaging the conducting tissues of the stock. When the interstock, Valencia orange was introduced, the combination proved successful.

In some cases, the stock-scion combination grows in an apparently normal fashion for varying periods of times-perhaps for many years and then difficulties arise. This is called as delayed incompatibility. A good example of the above phenomenon is the black line of walnut which occurs in certain Persian walnut orchards in California and France. When cultivars of *Juglens regia* are grafted on seedling rootstocks of *J.hindsii* or paradox rootstocks (*J.hindsii x Juglens regia*) the trees grow satisfactorily for 15 to 20 years or even more years of age, thereafter the trouble starts. A thin-layer of cambium and phloem and the dead tissue develop at one point and gradually extend around the tree at the graft union until the trees become girdled. The vertical width of the dead area may reach 30 cm. Such girdling may kill the plants above the graft union but the stock remains alive and sprout. Another example is that sapota on Bassia longifolia stocks. In compatibility is manifested by overgrowing of scion resulting in pronounced distortion at the bud joint and the graft dies prematurely. Delayed incompatibility has been also reported in many citrus species as indicated in Table 15.3

Symptoms of incompatibility

Graft union malformation resulting from incompatibility usually expresses the following external symptoms viz.,

1. Failure to form a successful graft or bud union with a high percentage of success
2. Yellowing of leaves in the latter part of the growing season followed by early defoliation accompanied by decline in vegetative growth, appearance of shoot die back and general ill health of the tree.
3. Premature death of the trees which may live only a year or two in the nursery
4. Marked differences in the growth rate or vigor of scion and stock
5. Over growth at, above or below the graft union.

Causes of graft incompatibility

1. **Virus infection:** one component of the graft combination may carry a virus and be symptomless, but the other component may be syceptible to it. For example, when Barlett pear is grafted on Pyrus pyrifolia, the tree declines due to virus infection of the susceptible rootstock while Bartlett on *P.communis* remains healthy, because *P.communis* is a virus – resistant variety
2. **Growth differences:** in certain graft combination, the differences in the time of resumption of cambium activity of the stock and scion or differential growth characteristics of the stock and scion are reported to be a causes for graft incompatibility
3. **Physiological causes:** Physiological incompatibility is due to the inability of the stock or the scion to supply the other components with necessary amount or quality or materials for normal functioning. There is some evidence that in certain graft combinations one component (Scion or stock) produces chemicals that are toxic to the other, killing the entire plant, eg. When pear is grafted onto quince rootstock, a cyanogenic glucoside, prunasin, normally found in quince is translocated into the phloem of the pear where it gets broken down in the region of the graft union into hydrocyanic acid. The presence of this acid leads to lack of cambial activity at the graft union, leading to graft incompatibility.

Stock-scion relationships

A grafted or budded plant can produce unusual growth patterns which may be different from what would have occurred if each component part of a graftage viz., rootstock and scion was grown separately or when it is grafted or budded in other types of rootstocks. Some of these have major horticultural value. this varying aspect of rootstocks in the performance of a scion cultivar or vice versa is known as stock-scion relationship.

Effect of stocks on scion cultivars

1. Size and growth habit: In apple, rootstocks, can be classified as dwarf, semi-dwarf, vigorous and very vigorous rootstocks based on their effect on a scion cultivar. If a scion is grafted on dwarf rootstocks eg. Malling IX, the scion grows less vigorously and remain dwarf only. On the other hand if the same scion is grafted on a very vigorous rootstock eg. Malling II the scion grows very vigorously,. In citrus, trifoliate orange is considered to be the most dwarfing rootstock for grapefruit and sweet oranges. On the other hand, in mango, all plants of a given variety are known to have the same characteristic canopy shape of the variety despite the rootstocks being of seedling origin. But recently, rootstocks of Kalapade, Olour have been found to impart dwarfness in the scion cultivars of mango. Guava cultivars grafted on Psidium pumilum are found to be dwarf in stature.
2. Precocity in flowering and fruiting : The time taken from planting to fruiting i.e., precocity is influenced by rootstocks. Generally fruiting precocity is associated with dwarfing rootstocks and slowness to start rootstocks are precocious than those grafted on sweet orange or sour orange or acid lime rootstocks
3. Fruitset and yield: The rootstocks directly influence on the production of flower and setting fruits in oriental Persimmon (*Diospyrous kaki cv. Hichiya*). When it is grafted on D.lotus, it produces more flowers but few only mature but when D.kaki is used as the rootstock, the fruitset is more. the influence of rootstock on the yield performance of cultivar has been well documented in many fruit crops. Acid limes budded on rough lemon register nearly 70 percent increased yield than those budded on troyer citrange, Rangpur lime or its own rootstock. Sweet orange var. Sathugudi budded on Kichili rootstock gave higher yield that on Jambhari or on its own seedling.
4. Fruit size quality: Sathugudi sweet oranges grafted on Gajanimma rootstocks produced large but poor quality fruits while on its own roots they produced fruits with high juice content and quality. The physiological disorder ‘granulation’ in sweet orange is very low if grafted on Cleopartra mandarin seedlings, on the other hand rough lemon seedlings stocks induced maximum granulation. the physiological disorder black end in Bartlett Pear did not appear if *Pyrus communis* was used as the rootstock. When *P.pyrifolia* was used as the rootstock, this disorder appeared, affecting fruit quality.
5. Nutrient status of scion: Roost stocks do influence the nutrient status of scion also. Sathugudi orange trees have a better nutrient status of alnutrients in the leaves when it is budded on *C.volkarimariana* rootstock than on its own rootstock or Cleopatra mandarin stocks
6. Winter hardiness: Young grape fruit trees on Rangpur lime withstand winter injury better than on rough lemon or sour orange. Sweet oranges and mandarins on trifoliate stocks were more cold hardy.

7. Disease resistance: In citrus considerable variability exists among the rootstocks in their response to diseases and nematodes. For instance, rough lemon rootstock is tolerant to tristesa, xyloporosis and execortis but is susceptible to gummosis and nematode. On the other hand, treyer citrange is tolerant to gummosis but susceptible to execortis virus disease. Similarly, guava varieties grafted on Chinese guava (Psidium friedrichsthalianum) resist wilt diseases and nematodes
8. Ability to resist soil adverse conditions: Among the citrus rootstocks, trifoliate orange exhibits poor ability, while sweet oranges, sour orange, Rangpur lime rootstocks exhibit moderate ability to resist excess salts in the soil. Im pome fruits, similarly, ariation exists among rootstocks to resist excess soil moisture or excess boron in the soilyrobolan plum rootstocks generally tolerate excess boron and moisture than Mananna plum root or other rootstocks viz., peach, apricot or almond.

B.Effect of scion on rootstock

1. Vigous of the rootstocks: In apple, it has been found that if apple seedlings were budded with the 'Red Astrochan' apple. The rootstock produced a very fibrous root system with few tap roots. On the other hand, if scion 'Golden burg' was budded on the seedlings, they produced two or three pronged deep roots without fibrous root system. In citrus, if the scion cultivar is less vigorous than the rootstock cultivar the rate of growth and the ultimate size of the tree is more determined by the scion rather than the rootstocks.
2. Cold hariness of the rootstock: Cold hardiness of citrus roots is affected by the scion cultivar. Sour orange seedlings budded to 'Eureka' lemon suffered much more from winter injury than the unbudded seedlings.
3. Precocity in flowering: Yound mango rootstock seedlings (6 months to one year old) were found to putforth inflorescence when the branches from old trees are inarched which can be attributed to the influence of scion on the rootstock.

Factors influencing the heeling of graft union:

1. Incompatibility: Certain rootstocks an scions are incompatible, therefore, the graft union between these two will not normally take place.
2. Kind of plant: Some species like oaks are difficult to graft, but apple and pears are very easy in producing a successful grant union.
3. Environmental factors during and following grafting: There are certain environmental requirements which must be met for callus tissue to develop and heel the graft union

a) Temperature has a pronounced effect on the proeducation of callus tissues. An optimum temperature is essential for production of callus tissues. In most of the temperature fruit crops callus production is retarded.

Mist chamber constuction use and maintenance

For successful propagation of plants, plant propagating structure or nursery structure are often used, because certain plants have special requirement for light temperature of humidity for germination of seeds or rooting of cuttings. The outdoor conditions may not be suitable for growing young plants. There are several kinds of plant growing structure, the most important ones are green house, mist units and shade hours.

The greenhouse is mainly used for providing controlled environment either for germination of seeds or rooting in 'difficult to root' plants and also to harden the propagated plants, whereas the shade house is used for hardening of young plants before they are transplanted to a permanent location.

Mist propagating beds are useful propagating units for the rooting of cuttings, especially those, which are difficult to root. Mist beds are constructed usually within the green house. A fine mist is sprayed over the cuttings intermittently usually during the day: During night, it is not necessary.

The lay out of the jest, which form the mist, is very important. All the hades (jest) should be at the same level. They may either be suspended from the roof of the glass-house above the beds or be fixed on stand – pipes attached to the beds. the jets are arranged in such a manner that each corner of the bed received mist spray equally and uniformly. This can be early achieved when sprays of two jest overlap.

There must be continuous supply of water for misting. Installation of a pressure tank and pump ensures consistent pressure for misting. The water for misting should be clean and uncontaminated. In hard-water areas, it is better to use rain water or install water treatment equipments, which remove dissolved salts from the water.

Guidelines for effective functioning of mist chamber

i The rooting medium should be pathogen-free and well drained
ii The water used for misting should not be alkaline in reaction.
iii Hygiene and cleanliness should be maintained inside the mist chamber.
iv The missing interval and time of interval should be decided on the basis of species an variety and avoid misting during night.
v Continuous mist is undesirable and harmful to rooting in several plant species and varieties.
vi The nutrients can also be applied if it is felt necessary.

vii Shade is to be provided against intense sunlight without interrupting sufficient sunlight falling on plants essential for full photosynthetic activity during rooting period.

viii During rooting period, air should not be allowed to stand still inside the mist chamber. Therefore cross ventilation should be provided

ix Keep mist propagation equipments clean and under workable condition and provide centrifugal pump with 1-2 HP motor

x The capacity of the motor is decided based on the size of the mist chamber. Water should be allowed to get filtered before being pumped into the mist chamber.

Pressure tank – It is a thick walled airtight metallic chamber. Water is filled automatically when pressure drops below the limit.

Time clock set (Timer) – It controls the mist spray at regular intervals

Nozzles – there are various types of nozzles. Deflection type of nozzles is best suited to mist chamber of medium size. Prior to installation of mist propagation, selection of site is important. In temperature region, it is essential to select the site which is in the open sun whereas in tropical and subtropical regions, where summer is very hot, the mist house should be installed either nearer to a building or large trees which could provide partial shade. A temporary structure can be made with polythene sheets.

Propagation by specialised plant parts

Certain plants posses specialized vegetative structure whose primary functions are storage of food and vegetative reproduction. If such structures are naturally detachable for propagation, this procedure is termed as ‘separation’ On the other hand such structure are to be can into sections for ht purpose of propagation, then this process is called as ‘division’ the following specialized vegetative structure are used in propagation

1. Bulb

A bulb is a specialized under ground organ consisting of a short, fleshy, usually vertical stem axis bearing at its apex a growing point or a flower primondium enclosed by thick flesh scales. The outer bulb scales are generally fleshy and contain reserve food materials whereas the scales towards the inner contain relatively less food materials an dare more leaf-like. Bulbs possessing dry and membranous outer scales are tunicate bulbs and bulbs which lack this cover is non-tunicate

2. Corm

A corm is the swollen base of a stem axis enclosed by the dry, scale-like leaves. It is solid stem structure with distinct nodes and internodes. the

propagation of cormous plants is principally by the natural increase of new corms. the development of miniature corms between the old and the new corms is termed cormels.

3. Tuber

A tuber is modified stem structure which develops below ground as a result of th swelling of the subapical portion of a stolon and sub-sequent accumulation of reserve materials. A tuber has all the parts of a typical stem. Certain plants produce aerial tubers in the axils of leaves which are known as tubercles.

4.Tuberous roots and stem

In certain plants, the adventitious roots become thickened and they do have external and internal structures of roots nodes and internodes. These are known as tuberous roots. In other plants such as tuberous Begonia, Cyclamen or Gloxinia, they have thickened structures which have arisen from enlarged hypocotyls tissue. They have a vertical arrangement and may show features of stems. Propagation of platn with such tuberous roots or stem consists of division of such materials.

5. Rhizome

It refers to a specialized stem structure in which the main axis of the plant grows horizontally at or just below the ground surface. A rhizome consists of nodes and internodes having leaf scars on the node. In determinate types of rhizomes each clump ends in a flowering stalk and growth continues only from lateral branches.

6. Runner

Runner is a specialized stem which develops from the axis of a leaf at the crown of a plant and grows horizontally along the ground and forms a new plant at one of the nodes

7. Offset

It refers to a special types of lateral shoot or branch which develops from the main stem in certain plants and is characterized by shortened, thickened stem of rosette-like appearance. Offsets which produce sufficient roots can be removed by cutting them close to the main stem with a sharp knife and used for propagation

8. Suckers

A sucker is a shoot which arises on a plant from below ground usually from an adventitious bud on a root. Suckers are further known as root suckers, ground suckers and shoot suckers if they arise respectively from root, near the ground and stem of the plant.

9. Crown

The term crown designates that part of a plant at the surface of the ground from which new shoots are produced. This kind of crown is observed in herbaceous perennials like strawberry, pyrethrum, Gerbera or African violet wherein the stem is a short and thickened structure from which the leaves are produced in a rosette like arrangement

Certain plants do have one or more of the above mentioned specialized structures useful for propagation. But particular structure is preferred for commercial propagation for obvious reasons. Strawberry can be propagated both by runners and splits from crown.

Questions

1. How root stocks influence the growth of scion
2. Graft incompatibility- Discuss

PRINCIPLES OF MICROPROPAGATION AND ITS ADVANTAGES

Micro propagation or in vitro propagation refers to the development of new plant in an artificial medium under aseptic conditions from very small pieces of plant, 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. The various applications of micro propagation are as follows

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 flower chamber – It is useful to perform all operation in aseptic culture
2. Auto-clave or pressure cooker – It is used to sterilize the media, containers, petridishes and the various accessories required in the transfer operation.
3. Alcohol lamps, disinfectant 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

Procedure for micro propagation

1. **Collection of explant:** The small piece of plant used to begin a culture is referred to as an explant. The size, age and type of explant affect the success of *in vitro* propagation.
2. **Surface sterilization:** Explants so collection from field grown plants harbor numberous fungi and bacteria, which when inoculated into a nutrient medium contaminates the entire in vitro system. Hence, surface sterilization is resorted to prior inoculation of explants. The efficacy of the sterilants used are found to vary depending upon the type of chemical, concentration used, time of exposure etc., A few drops of teepol are also added to facilitate better contact between the explants and the sterilant.

3. **Inoculation:** Transfer of the explant into the culture medium is known as inoculation. This must be done in an aseptic condition. This is achieved by surface sterilization of the working table of the laminar air flower chamber with absolute alcohol followed by UV light for 30 minutes.
4. **Sub-culturing:** After inoculation, the explant increases in volume or it proliferate. At this stage, it is divided into different components or parts and transferred into a fresh medium under above mentioned aseptic sterile condition. This process is known under above mentioned aseptic sterile condition. This sub cultured mass should produce a shoot and root system which is dependent upon the type of growth regulator and its concentration used in the medium. It is generally observed that if the concentration of cytokinins is high relative to auxin in a medium, shoots are induced and on the hand, when the concentration of cytokines is low to auxin, roots are induced and at intermediate concentration, the tissue grows as undifferentiated callus.

Various methods of culturing plant tissues and organs

There are five classes of plant tissues culture

1. **Callus culture:** A piece of sterile plant tissue with living cells is transferred to a culture medium to induce callus proliferation. Subculturing is then done onto a medium with or without altered growth regulator concentration, ultimately resulting in the induction of adventitious organs or embryos.
2. **Cell culture:** Cells are maintained in suspension cultures so as to produce free cells and are then subcultured to regenerate complete plants from single cells. This technique is now useful to induce variability in plant cells and slowly exposed to select desirable cell variants and regenerate complete plants from these variants.
3. **Meristem culture:** This technique involves aseptic culture of shoot meristems on nutrient medium so as to produce complete plants. Most important application of meristem culture is the production of virus free plant from these variants.
4. **Embryo culture:** involves aseptic excision of the embryo and its transfer to a suitable medium for development under optimum culture conditions. After the embryo has grown into a plantlet in vitro, it is transferred to sterile soild or vermiculite and grown to maturity in a green house
5. **Protoplast culture:** From different sources, protoplasts, the plant cells without any rigid cellulose wall but with plasma membrane only, is allowed to fuse to form a somatic hybrid. These are cultured in suitable media to regenerate the cell wall and are again cultured in suitable medium for differentiation and morphogenesis.

Hardening

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

Questions

1. What is micro propagation
2. Mention few horticultural crops propagated by tissue culture
3. What is sub-culturing

PLANNING, LAYOUT AND ESTABLISHMENT OF AN ORCHARD AND SOIL TYPES SUITED FOR HORTICULTURAL CROP PRODUCTION

There are different systems of planting of fruit crop which could accommodate a maximum number of trees in an efficient manner

1. Vertical row plant system, 2.Alternate row plant system, 3.Traiangular system, 4.Hexagonal system, 5.Quincunx system, 6.contour system.

We can select any one of the above systems of plant depending upon the slop of the selected area, purpose of utilizing the orchard, availability of space, water, convenience etc.,

1. **Square system:** This system is considered as the simples of all the system of planting and followed widely. In this system of planting, equal spacing is given fir all the trees. In this system, the plot is divided into square shape and trees are planted at four corners of the square in straight rows at right angle. Intercrops can be cultivated.
2. **Rectangular system:** Here also, trees are planted on each corner of a rectangle. The distance between any two rows is more than the distance between any two trees in a row. Like in square system, raining intercrop's is also possible in this system. The only difference in this system is, more plants can be accommodated in the row, keeping more space between the rows.
3. **Triangular shape:** The trees are planted as in square system but the difference being that those in the even-numbered rows are mid-way between those in the odd rows instead of opposite to them. It accommodates less number of trees than the square system. It is difficult both to layout and cultivate trees in this system. Only advantage of this system is, more open space is available for the spread of the trees and intercrops
4. **Hexagonal system:** In this system, trees are planted in each corner of an equilateral triangle. Here six trees form a hexagon with the 7^{th} tree at the centre. This system follows alternate row planting pattern as no tree in a row is perpendicular to a tree in the adjacent row. This system can be followed when there is ample supply of water in a highly fertile, valued land.
5. **Quincunx or diagonal system:** This is nothing but the square system with plants in the centre of the square. Eventhough this system of planting accommodates double the number of plants, it does not provide equal spacing between plants. the central 5^{th} tree, actually a filler tree, is quick and erect growing and early maturing, like banana, pomegranate, papaya which would be removed as soon as the main trees planted at the corners come to bearing.

6. **Contour system:** This system of planting is followed mainly in the hills with slopes, where the land is with undulating topography and greater damage of erosion and difficulty of irrigation persist. On undulated lands, generally bench terracing may be done after the trees are planted. Trees can be planted on terraces or along contours. As the tree position can be decided only on the spot, the trees will not be equal-distant. This type of system is good for shallow soils where terracing will expose rocky or poor sub soil. Irrigation and cultivation can be done along tree rows only.
7. **Fixing the base line:** Base line is a straight line marked at a determined space from a particular point, like road, fence, channel etc., It is the first row accommodating trees. It is at a distance equal to half the spacing to be given between the trees. Generally, it is 2 to 5 m from the road.

Questions

1. What are different systems of planting of orchard crops
2. Elaborate on HDP planting in mango

MANURES AND MANURING OF HORTICULTURAL CROPS

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.

Green manure

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 manure

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).*

Cattle manure or Farm Yard Manure (FYM)

- Manures produced by horse cattles or other animals.
- They contain 0.6% N, 0.35% P and 0.6% K.

Night soil

- Excreta of human
- Rich in nitrogen ie. 5.5% N, 4.4% P and 2.0% K.

Guana

- Excreta of sea birds.
- Used in Coast of Peru and South America.
- 10.15% N, 9.82% P

Bone

- Steamed bone meal
- 3.5% N, 23% Phoshoric acid also contain lime.

Oil cakes

- Residues left after the oil extracted from the seeds of groundnut, castor, gingelly, pongamia etc.
- 3 – 5% N, 1.5 – 2% P.

Leaf mould

- Withered and dry leaves and garden sweepings are used after decomposition.
- Rich in humus.

Wood ash

- Rich in potash

Coir compost

- Coir pith obtained from coir industry are decomposed by a fungus *Pleurotus sojarcaju*.
- C/N Ratio 25 : 1
- 1.4% N, 0.06% P and 1.2% K.

Vermicompost

- Organic waste materials and animal dungs when fed with certain species of earthworm.
- The exrements of worms are called `**Vermicompost'**

INORGANIC FERTILIZERS

1. Nitrogenous fertilizer

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

2. Phosphate fertilizers

These fertilizers supply phosphorus to the crops when applied to the soils. Eg. Super phosphate, basic slag and rock phosphate.

3. Potassic fertilizers

These fertilizers supply potassium to the crops when applied to the soils. Eg. Muriate of potash (potassium chloride) and potassium sulphate.

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.

Biofertlizers 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. ie.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

1. Broadcasting

The fertilizer is sprinkled uniformly over the cultivated surface. It may be done before last ploughing or planting or sowing of seeds as basal dressing. For top dressing, fertilizers are applied when crop is in field.

LIQUID FERTILIZERS

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 nutrietns 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.

Questions

1. What are different nutrients required for plant growth
2. Name some inorganic nitrogenous fertilizers
3. Mention about organic farming

METHODS OF IRRIGATION INCLUDING FERTIGATION

The water relations of plant are of extreme importance both for vegetative growth and for fruit production. It is necessary for rapid growth and satisfactory crops and to maintain turgor in cells for maximum photosynthetic activity. In arid and semi arid zones, irrigation is a very important cultural practice. Even in humid areas where distribution of rainfall is not satisfactory, irrigation is essential during the drought period.

The need for irrigation and also the amount of water that should be supplied 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 irrigation facilities are not available and the rainfall is also poor, extensive cropping with drought tolerant crops can be followed.
2. **Period of moisture shortage:** In south India, the period from December – March is totally free of rainfall and during this period, irrigation is a must even to perennial crops.
3. **Stage of the crop:** Irrigation requirements sometimes depend upon stage of growth the crop. For instance, fruit bearing mango trees are to be regularly irrigated at 10-15 days interval during the fruit development stage ie. From fruitset to full development stage.
4. **Type of crops and cropping:** Most horticultural crops have high moisture requirements. Some fruit trees have deeper root system and hence, during the period of drought, they suffer very little or not at all if the subsoil moisture is at a high level.

The frequency of irrigation is determined by the following factors

1. The nature of soil: Fine texture soil hold moisture longer than soil of coarse texture. Deep soils hold larger quantities of water than shallow soil. Presence of organic matter content also increases the same. When the water holding capacity of soil is increased the interval between irrigation can be extended.

Rate of absorption by plants: Transpiration rate of crop plants affects the rate of absorption of water and consequently influences the frequency of irrigation. Those plants with large leaf surface require more water than those with reduced leaf surface.

The root system of the crop: A shallow rooted crop requires more frequent watering than a deep rooted crop. There is no absolute method for determining when it is time to irrigate. Some growers can tell based on the external symptoms. The immediate symptoms of lack of water are wilting, drooping of leaves, curling of leaves, shrinkage of fruit etc. since the feel test is difficult to

describe and requires considerable skill, soil moisture meters like irritometers and Bouyoucos moisture meter are available which measure the moisture content of soil

Systems of irrigation

A. Surface irrigation

Supplying water to the soil without aerial application is known as surface irrigation. It depends on gravity for spread of water over the area. This system generally use more quantity of water. Different systems of surface irrigation are:

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.

Check: Check bunds for large areas enclosing a number of trees are provided with channels between two row. This is more economical than flood system.

Basins: This is widely practiced. The basins should be square or circular and should be sloping from the trunk to periphery

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.

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 on one side of the bed.

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 in areas near channels and less in areas away from the channels.

B.Sub 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 45-60 cm 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.

Special irrigation methods

1. Overhead irrigation

Overhead irrigation is by the use of sprinklers. Most widely used over head system. In this systems, 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 step and terraced lands. This is more widely adopted in Plantations.

2.Drip irrigation

Drip irrigation is known by various names like 'trickle irrigation or high frequency irrigation daily flower irrigation' This is a method of watering plants at a rate equivalent to its consumptive on so that plants would not experience any stress during the growin phase. In this the water is conveyed from a source under low pressure to the root zone of the crop only.

It has the following components

1. Water supply pump at the source of water
2. filters, fertilizer mixing tank,
3. Control system
4. pressure regulators,
5. monitor valve/water meter,
6. head lines or main lines for conveying water from pumpset to the field where water is to be delivered.
7. Laterals to carry water to plant rows and
8. the emitters/dripper through which water is finally released at a distance of 5 to 25 cm from the plant base.

Advantages

1. Water saving – water is applied directly to the root zone, eliminating wastage. 30 to 70 percent water saving
2. Labour saving – This is eliminates the need for constructing borders, bunds and labour intensive works associated with conventional irrigation techniques, there by saving about to 60to90%
3. Use of lower quality water – water is applied continuously and the root zone is kept wet constantly.
4. Increased yield and plant vigor – It maintains soil moisture at optimum level eliminating water stress resulting in greater vigour, better establishment and high productivity.
5. Reduced weed growth – Since water is applied to the restricted area, wide spread weed growth is inhibited due to restricted water supply
6. Saving of nutrients – nutrients are directly applied to the root zone along with water. Leaching losses are minimized. saving upto 30 to 60%

Disadvantages

1. Higher initial investment
2. Clogging of drippers due to oxidants, bi oxides and algae.

Fertigation

Fertigation is a new technique of applying fertilizers particularly soluble fertilizers along with irrigation water, through drip system. Optimum use of fertilizers, water and land is the need of hour which is easily achieved through fertigation. The inputs applied are more efficiently utilized than in any other system.

I system components

1. pump
2. Filtration system – sand filters/disk filters/screen filters
3. Injectors-venture/dosatron/closer pump/bladder tanks/fertilizer tanks/bulk injection systems
4. Back flow prevention equipment

II Types of fertilizers for fertigation

1. Water soluble fertilizers (WSF)
2. Liquid fertilizers (LF)

III Nutrient sources

N- urea, ammonium nitrate solutions, ammonium nitrate, calcium nitrate and KNO3

K-KCL, K2SO4 potassium thiosulphate, KNO3

P-The choice of phosphorus products is more limited. Phosphoric acid and ammonium phosphate solution are used most commonly.

IV prerequisites for fertigation

Soil nutrient status, nutrient requirement of the crop, water properties, experienced personalities for installation and execution, availability of speciality fertilizers (WSF or LF) crop and site specific nutrient requirement, crop nutrient demand specific to each stage of the crop

Questions

1. Name different irrigation methods
2. Advantage of micro irrigation
3. Mention about fertigation

HORTICULTURAL CROPPING SYSTEMS – INTER CROPPING COVER CROPPING

Orchard cultivation refers to the careful management of orchard soil in such a way that the soil is maintained in a good conditions suitable to the needs of the tree with least expenses. This involves maintenance of physical condition of soil, its moisture and nutrient content. A good system of orchard cultivation should ensure.

1. weed control and saving in moisture and nutrients
2. Very little disturbance to soil and preventing soil erosion and
3. Reduced cost of cultivation

Methods of soil management practices

I. Clean culture

This type of cultivation is extensively followed in India. This involves regular ploughing and removal of weeds. The clean culture has many disadvantages

1. Humus will be completely depleted rapidly due to frequent cultivation.
2. Frequent cultivation causes injury to the feeding roots and the trees may be short lived or stunted in growth.
3. Clean cultivation aids in more aeration leading to the depletion of nitrogen
4. Hard pan is created in the soil
5. Frequent cultivation causes more soil erosion

The above mentioned defects in clean cultivation can be minimized by avoiding deep and frequent cultivation and also cultivation when the soil is too wet.

2. Clean culture with cover crops

This type of soil management involves raising of a cover crop or green manure after removing the weeds. If clean cultivation is attempted during the rains, considerable erosion is almost sure to occur. It is probably best to plant a green manure crop between the trees early in the rains and plough it into the soil towards the end of monsoon season. In India, green manurecrops like sunnhemp, cowpea, daincha, lupin etc. are more commonly used. Legume cover cropping in grape, mango, guava and other fruit crops is becoming a common practice in the management of orchards.

Intercropping

In young orchards, there is a greater scope for utilization of vacant space. If the trees are properly spaced, there will be considerable land which will not be used by the permanent trees for several years. Similarly, in the case

of other long duration horticultural crop like tapioca, turmeric, ginger and banana, some area between adjacent plants will be remaining unoccupied by the main crop for few months. It naturally appeals to the grower to get some return from this vacant land especially when he is getting no return in the early periods.

1. Intercrops should not be occupy the area where the roots of the fruit trees are concerned.
2. Soil fertility should be maintained or improved when intercrops are grown/
3. Water requirement of the intercrops should not clash with those of the main fruit trees. The intercrop may require an irrigation at a time when it would be detrimental to the trees
4. Intercrops should be selected with reference to their effect on soil moisture. Grain crops remove excessive moisture to the detriment of fruit trees. The intercrops selected should not exhaust the soil water and nutrients and should not demand more water than is allowed for fruit trees.

Vegetables are the best intercrops when compared to millets. The intercropping should be stopped when trees occupy the entire orchard space.Many growers prefer some quick growing fruit trees to grow as intercrops. Short-lived trees are known as 'fillers' eg.papaya.

The recommended intercrops for some important horticultural crops are given

Mixed cropping

It refers to the practice of growing certain perennial crops in the alley spaces of the main perennial crops. The main advantage is the effective utilization of available area and increase in the net income of the farm per unit are. Increase in yield (upto10%) is obtained in the main crop due to the synergistic effect of the crop combinations arising out of beneficial micro organisms in the rhizosphere and the more availability of major nutrients in the active root zone of the crop mix as compared to the pure stand.

Mango upto 7 years Leguminous, vegetable, papaya
Grapes upto 8 months snake gourd or bitter gourd
Apple upto 5 years potato of cabbage
Banana upto 4 months sunnhemp,onion
Tapioca upto 3 months small onion, coriander
Turmeric upto 3 months small onion, coriander
Areacanut upto 10 years pineapple coconut upto 3 years Banana, tapioca, vegetables

MULTITIER CROPPING – MULCHING

Mulching

This is one of the important soil management practices adopted in certain countries. Crop residues like straw, cotton stalks, leaves, saw dust, pine needle, coir dust and other materials like polythene films or certain special kinds of paper are spread in the tree basins and in inner spaces between trees. Main objective of mulching is to conserve soil moisture and to control weed growth. The other advantages

1. Keep soil cool in day; warm at night hours
2. Reduces surface run-off
3. Add humus to the soil
4. Prevents soil erosion
5. Fruits are protected and kept clean since they fall on the mulches
6. It allows the absorption of more rain water and
7. It reduces irrigation frequency.

The following are some of the disadvantages

- Dry materials used as mulches encourage the risk of fire and consequent damage to trees
- Thick mulches may act as places for mice and rodents to live and multiply.
- **Sod**

In this method, permanent cover of grass is raised in the orchard and not tillage is given. This type of orchard cultivation is followed in USA and Europe. This may be useful in sloppy lands for preventing soil erosion. But they compete for soil moisture and available nitrogen.

Sod mulch

This is similar to sod and the only difference is that the vegetation is cut frequently and the cut material is allowed to remain on the ground. This is slightly better than the previous one, as the moisture loss is not so great as in sod – in both sod and sod mulch, more nitrogen should be applied to the fruit trees than usual application because the vegetation utilizes more soil nitrogen.

Multitier system of cropping

Certain horticultural plants like coconut and arecanut are grown for about 50 years in a particular land. It takes nearly 4 to 7 years for the above trees to reach the bearing stage. Adequate alley spaces (nearly 75%) are available in between these trees and being the palm trees, their root system will not also spread beyond one meter in diameter.

Questions

What is intercropping
Mention about soil mulching

PROTECTED CULTIVATION – CONTROLLED ENVIRONMENT

In West, the climate is extremely adverse for most of the year. For most part of the year, the temperature would be below 10 degree Celsius ruling out open cultivation of any crops. Hence greenhouses are the only means of cultivation in such countries. A green house is a structure which has enclosed frame work with provisions for heating, enrichment of CO_2, micro irrigation, fertigation, automated or semi automated light, humidity and temperature regulation.

Green house

Framed structures, covered with transparent (or) translucent materials, large enough to grow crops, under partial (or) fully controlled environment, to get greater productivity of the highest quality.

High value. Low volume crops – Slogan of green house cultivation.
India – 300 to 350 ha. area under cover.
Green house cultivation is commercial in 750 countries.

Advantages

a. Crops grown through out the year.
b. High yields of excellent quality.
c. Easy to control pests & diseases.
d. Labour & water requirement are minimum.
e. Control of environment results in higher productions is well proved.

Draw backs - 1. High cost.
2. Non-availability of various components

Lay out

Type, design & construction depend on climate.

A thorough knowledge of climate viz. maximum & minimum temperature, relative humidity, wind velocity, rainfall, sunshine hours, type of crops – necessary as essential.

In North India Kashmir & New Delhi Mean & Maximum 0°C & 40°C – So, cool in summer; heat in winter.

In South India – Mean & Maximum 12°C & 36°C, No heating required in winter, natural ventilation (30 – 40%).

Crops grown

1. Tomato (off season), capsicum, cucumber.
2. Roses, chrysanthemums, carnation & gerbera.
3. Vegetable seedlings, planting material, hardening of tissue cultured plants.

Growing a crops anytime in a year
Same crop throughout the year

Possible in green house

Tomatoes can be grown throughout the year – 300 to 400 t/ha/year.
Labour requirement heavy – 10 men/ha.
Open cultivation – 1 man / ha.

Green house farming is always

1. Capital intensive venture.
2. Construction
3. Equipping.

Potentials

Production of plant material	Range can be increased
	Production can be increased
	Quality can be increased

1. Supply of fresh produce to cities – off season production of vegetables.

2. Export of agricultural produce – cultivation near lifting points and facilitate this.

3. Cultivation of rare medicinal, aromatic & ornamental species – conservation, cultivation & exploitation.

4. Green house technology a base for other biotechs like hydroponics, nutrient film technique etc.

5. Cultivation in problematic regions & extreme climates – (75 million ha of barren & uncultivable land in India)

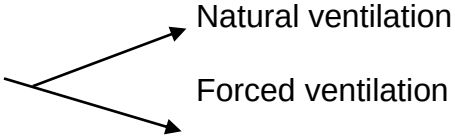
Temperature, light shade management

Temperature affects other factors alos.

Green house designed & positioned to collect maximum sunlight for maximum plant growth – leads to heating problems in summer sometimes.

Green house to be cooled when temperature crosses upper limit. If not, partial (or) total crop failure occurs.

Methods of cooling



Ventilation - Open circuit ventilation
Close circuit ventilation
Hybrid ventilation system.

Roof Shading

Solar energy – intensity reduced by applying opaque materials directly to glazing.

Fan & Pad system

Fan – exhausts out hot air – A vacuum is created enters fresh cool air thro' pad. Green house has to be maintained airtight.

All access, openings and door have to remain closed.

Green house heating

- Necessary in cold environments.
- Energy is used as heat.
- Heat supplied by burning fossil fues, feothermal & hydroelectric source. Artificial lighting is also practised.

Shading

- Application of shading paint to glazing.
- White paint is less expensive in general.

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CULTIVATION OF HORTICULTURAL CROPS IN GREEN HOUSE – OPERATION AND MAINTENANCE

States have sizable area under green house Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal, Maharashtra, Rajasthan, Utter Pradesh, Delhi & Haryana. Green house area in India 200 ha. It may increase to 500 ha in future. Crops grown – Roses, cornation, chrysanthemum, gerbera, anthuriums, liliums, orchids. Rose – 700 – 750 budded plants/100 m^2 area. Average yield 250 flowers / m^2/year – (7 plants/m^2). So, Rs.50,000/- will be the gross return for 100 m^2 area.

Operation and maintenance

A thorough knowledge of the environment on crop growth is essential.

Light, temperature, relative humidity, CO_2 and soil root medium are important.

Light – intensity, quality – many physiological process affected. – duration influences flowering & fruiting.

Classification

a. Photoperiod insensitive (or) day neutral. Eg. Tomato, brinjal, pepper, cucurbits.

b. Short day & long night plants. Eg. Potato, sweet potato, soybean, chrysanthemum.

c. Long day & short night – eg. Chinese cabbage, radish, spinach, peppermint.

Temperature

Quality & maturity rate affected.

Photosynthesis, transpiration & respiration increase with temperature.

Low temperature – active growth – low respiration – influences initiation & development of rep. Organs.

High temperature – higher senescence.

Relative humidity

Plants in humid – large sized fleshy leaves, stems & flowers.

Low humidity – injury to leaf margins, tips, petals, wilting and senescence. – Leaves & flowers weak & distorted.

Plants under high humidity continuously – soft, mushy & rotting.

CO_2

Main source for biomass production.

High CO_2 – high growth rate – short time for flowering.

Cultivation & management

Crops grown in ground beds – various soil & soil less media.

Physical & chemical properties adjused.

Soil - Common media

Amended with org. manure, compost, peat & others – nutrients, physical structure.

Soilless media – peat, sand, gravel, perlite, vermiculite, rockwool.

Ground beds

- Amended with range of materials – physico chemicals – nutrient availability – good aeration & drainage.
- Sterilized – nematodes & disease.
- Mulching – water & temp. of soil altered – soil borne disease fusarium – evaporation reduced – humidity reduced.
- No heavy soils – poor rooting – poor aeration – poor growth – high disease.

Containers

Sterilized media – polybags – placed on poly sheets – rooting inside the soil prevented.

Water management & Fertigation

Free from impurities – Ca, Na other salts – Ec influences absorption of nutrients.

Soil moisture – at field capacity.

Drip system – better.

Sediment free water for drip – filters.

Fertigation

Only water soluble fertilizer – N, P & K at required concentrations.

Spacing of crops – good air movement – ventilation – reduce – competition – light, water & nutrients.

Training – Tall growing plants – trained on strings.
Pruning - Pruned to single stem-remove few fruits & flowers to avoid collapsing – old senescent leaves to be removed.
Productivity of cropping sequence

- Cropping sequence round the year.
- Normally three
- Sweet pepper – Sweet pepper – okra 1052.9 quintals/ha/yr. –open field – 385.1 quintals/ha/yr

Pollination : Light tapping of flower clusters – good fruit set. Strings also help – use parthenocarpic types.
Pest & diseases Warm Temp. + humidity + still wind – timely control necessary.

Questions

1. What is green house
2. Mention different types of green houses in abroad
3. Difference between a shade net house and a green house

FLOWERING, POLLINATION AND FRUIT SET IN HORTICVLTURAL CROPS

- Pollination refers to transfer of pollen grains from anther to stigmatic surface.
- It is of two types viz., self-pollination and cross-pollination.

- If the transfer is from stamen to stigma of the same flower or to the stigma of another flower on the same plant or to the stigma of a flower on any plant of the same clonal variety, then this type of pollination is known as 'self-pollination'.

- If it is effected without the aid of any outside agency, such as wind or insect, then this process is known as 'autogamy'

- If the pollen is to be transferred to the flower of another individual or in the case ofpomological_varieties, to the flower of another variety, this process in known as 'cross-pollination'.

Cross-pollination may be required for a number of reasons in Horticultural crops.

1. Due to the dioeciously nature (eg. Papaya, Datepalm, Nutmeg) or monoecious nature (Cucurbits)
2. Due to the peculiar flo\ver structure, (eg. Brinjal, Delicious apples, Vanilla)
3. Due to the dichogamy nature (Onion, Carrot, Sapota)
4. Due to the behaviour of bisexual flowers as functionally unisexual (eg. Avocado and Allspice)
5. Due to self-incompatibility or self-sterility factors (eg. Apple).

- The pollen may be transferred from the anther to the stigma in a variety of ways. In most plants, pollen is shed at or after anthesis and is transferred to the stigmas by insects or by mechanical means primarily the wind.

- In majority of the horticultural crops, pollination is effected by insects and pollination by wind is not a common one.

- Fruit crops like sapota, jack and amla and nutcrops like walnut, chestnut and pecans are reported to be pollinated by winds.

- They normally produce large quantity of pollen grams which are light in weight so that they can be carried to distance places. In these nutcrops, the stigma is also feathery to facilitate wind pollination.

- Honey bees, ants and many insects aid in cross-pollination. Their activity is greatly affected by weather conditions especially low temperature and rain which sharply curtail their activity. Hence, honey bee keeping is important.

- In apple orchards, each honey bee usually forages 2-3 trees and visits 50-100 flowers per trip. Thus in a day, it visits about 50000 flowers. Hence, 10-12 colonies per hectare at. a distance of 150 metre are ideal for temperate fruit orchards.

- Recently, a chemical substance (proprietary product Name: Bee-Q) is used to attract the bees so as to increase the fruit set. It has been estimated that nearly double the number of flowers are pollinated in cardamom if such chemical is used at the time of early and mid flowering phases.

Artificial pollination

- Self-incompatibility is common in apple and pear. This has been recently overcome with the 'recognition' or 'mentor pollen' technique.

- In this technique, pollination is effected with a 2:1 mixture of Methanol killed or irradiated compatible pollen and self pollens which results in seed set.

- It is believed that the regualtory sub stance from the mentor pollen to the in compatible/incongruent pollen helps to overcome the crossing barriers.

- Another technique viz,`**pioneer pollen'** is also reported to increase the seed set in such Fruit crops'

- In this method, pollination twice with compatible pollen with an interval of 1-2 days is done. It appears that the first applied pollens promote the activities of the pollens in the second application, hence the first applied pollen is called **'pioneer pollen'**.

- In emergent situations, when adverse weather conditions prevail or the orchard has inadequate pollinizers, hand pollinaion can be resorted to.

- This is much helpful in temperate fruit orchards and is being practised in European countries and not yet in India.

The following are some of the methods by which artificial pollination is done.

1. Artificially collecting the pollens, mixing it with spores of *Lycopodium* (fern) and applying to flowers *w*ith a soft brush.

2. Placement of bouquets - in this method, branches of flowers of pollinizers

are hung in the trees to be pollinated.

FRUIT SET

- In an orchard, all the fruit trees do not bear equally or regularly. Sometimes one fails to bear and at the same time, another tree of the kind under similar conditions produces a heavy crop.

- This problem may be due to failure to set the fruits, unfruitfulness and sterility.

- The following terminologies are useful in understanding the problem of unfruitfulness.

- Fruit setting refers to the initial setting of fruit at or just after the time of blossoming and to its remaining on the plant until maturity.

- A plant is said to be fruitful which not only blossoms and sets fruit but carries it through to maturity.

- Plants which are unable to do this are also known as **'unfruitful'** or **'barren'**.

- **`Fertility'** on the other hand refers to the ability of the plant not only to set and mature fruits but to develop viable seeds.

- Inability of a plant to do this is known as **'infertility'** or **'sterility'.**

- Fertile plants are necessarily he fruitful and all the fruitful plants need not be **'fertile'.**

- **'Self fruitfulness**" indicates the ability of the plant to mature fruit without the aid of pollen from some other flower (or) plant and those plants are. known as **'self fruitful plants'**

Questions

1. How pollination occurs in horticultural crops
2. Mention different pollinating **agents**

BEARING HABITS OF HORTICULTURAL CROPS

Bearing habits

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

- A knowledge on the baring habit is a pre-requisite before resorting to pruning in any fruit crop.

- The position of flower or inflorescence on the shoot in relation to the growth of current season is characteristic of a species or variety.

- Position of fruit bunds bears a relationship with the growth habit and the trees are rather compact when compared to plants having lateral fruit bud bearing habit since they force the development of laterals below rather than beyond the flowers or flower clusters.

Different kinds of flower bearing shoots

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

Group 1	:	Fruit buds borne **terminally** which unfold to produce inflorescence without leaves **e.g. Mango**.
Group 2	:	Fruit buds borne **terminally** which unfold to produce leafy shoots that terminate in flower clusters **e.g. apples.**
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, papaya, 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**. avocado.**

Group 7	:	Fruit buds borne both **terminally and laterally** 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 (cauliflorus bearing)

FRUIT DROP – CAUSES AND PREVENTION

Fruit drop

Fruit trees usually bear a large number of flowers and only a small percentage of which are enough to give a normal yield. For instance, a single inflorescence of mango contains as many as 5000 flowers and an average of 5 fruits per inflorescence would provide a good and heavy crop, however, the actual percentage of fruit set will be much lesser. When the fruit set is much more that the tree can normally carry to maturity, there will be drop of fruits at various stage of fruit development as an adjustment by the tree to its resources.

First drop

It occurs a fortnight later than the first drop. Usually flowers with aborted pistils drop off at this stage. Lack of pollination, low stigmatic receptivity, defective flowers, poor pollen transference and occurrence of incompatibility are some of the causes attributed for this drop.

Second drop

It occurs a fortnight later than the first drop. This drop includes unfertilized flowers and some fertilized flowers. Fertilized flowers also drop off at this stage as a result of adjustment in the trees between nutritional factors and fruit set.

Third drop

This drop occurs when the fruits are of ‘marble size’ due to the formation of abscission layers in the young fruit stalks. This drop generally occurs in most deciduous fruit and as it coincides with the month of June, this drop is also know as ‘June drop’

Pre-harvest drop

Another kind of fruit drop which is a loss to the grower is referred as ‘pre-harvest’ drop. In this case, dropping or shedding of fruits occur before harvest. At this stage, half-developed and three-fourth developed fruits are shed due to many causes. This is a loss to a growers and is a serious problem confronted by them especially in apples, pear mango and citrus fruits

Causes of fruit drop

1. Mechanical – Wind and hailstorm cause fruit drop
2. Climatic factors – Climatic factors such as high temperature, low humidity and very low temperature hasten the formation of abscission layers and consequently the fruits drop. It has been observed in South

India that shedding of fruits in mango will be more if the temperature is high and humidity is low

3. Physiological factors – Abnormal fluctuations of soil moisture favour heavy fruit drop
4. Nutritional – Lack of available nitrogen and other nutritional factors may causes fruit drop. The shed is more in weak shoots than in strong ones and also more in young trees than in medium or old trees.
5. cultural practices – Deep digging or deep ploughing during the fruit development phase will injure the roots and cause the fruit to be shed. Drought or lack or irrigation especially in mango during the third drop stage increases the dropping percent.
6. Pathological causes – Incidence of pests and diseases will cause more shedding of fruits. For instance, high incidence of diseases like powdery mildew and anthracnose and pests like hopper and mealy bugs in mango favour more fruit drop
7. Varietal factor – Within a kind of fruit, the varieties differ among themselves in the extent of fruit drop. In one study, it has been found that under similar conditions, the extent of shed varied form 0.9% in Willard variety to 32.5% Jehangir variety of mango

Prevention

The pre-harvest drop may be reduced by controlling the causes to a certain extent. Proper and timely culture such as irrigation and manuring. Plant protection, provision of pollinisers and wind breaks will help to prevent or reduce the amount of fruit drop

A define relationship between the auxin content and the abscission of fruits during various stages of development has been established is apple fruits. In the final stages of fruit growth, a rapid decline in auxin content is correlated to degeneration of endosperm causing preharvest fruit drop. This led to the thought that high concentration of auxins supplied exogeneously may inhibit fruit drop

The possibility of reducing the preharvest drop by means of plant regulator sprays has been well established in many fruit crops. Napthalene Acetic acid and its related compounds are very effective in reducing the drop of fruits in pome fruits such as apple and pears.

Questions

1. Mention different flower bearing habits in horticulture crops
2. How flower drop can be prevented

PREHARVEST OPERATIONS FOR HORTICULTURAL CROPS

The quality of a crop at harvest can have a major effect on its post harvest life. There are numerous factors involved and these frequently interact. Giving complex interrelationships. IN tree crops, fruit produced on the same tree and harvested at the same time may behave differently. The factors which influence quality include obvious things such as harvest maturity and cultivar or variety, but also the climate and soil in which it was grown, chemicals which have been applied to the crop, and its water status.

Temperature

The temperature in which a crop is grown can affect its quality and post harvest life. For eg. Oranges grown in the tropics tend to have a higher sugar and total solids content than those grown in the subtropics. However, tropical-grown oranges tend to be less orange in colour and peel less easily.

Nutritional status of crop at harvest

- Excess of deficiency of certain elements from the crop can affect its quality and its post harvest life.
- Crops which contain high levels of nitrogen have poorer keeping qualities that the same variety of crop with lower levels.
- High rate of nitrogen fertilizer to apple trees can adversely affect the flavour of the fruit.
- Nitrogen fertilizer in crease their susceptibility to physiological disorders and decrease fruit colour.
- Eg.Apples called ‘bitterpit’. It is principally associated with calcium deficiency and influenced also by the dynamic balance of minerals in different parts of the fruit, as well as the storage temperature and levels of oxygen and carbon dioxide in the store.
- Strawberries are called ‘albinism’
- The ratio of K:Ca and N:ca was found to be greater in such fruit than in red fruit.
- Imbalance of fertilizers can result in the physiological disorder of watermelon called blossom end rot.

Flowering

- A physiological disorder of mangoes called ‘jelly-seed’ can develop during storage
- Tommy atkins is associated with flowering time delaying flowering by removing all the inflorescences from the tree greatly reduced jelly- seed in fruit which develops from the subsequent flowering. These fruits were larger than those produces from trees where the inflorescences had not been removed but the number of fruit per tree was reduced.

Light

Fruits on the parts of trees which are constantly exposed to sun may be of different quality and have different post harvest characteristics from those on the shady side of the tree or those shaded by leaves. Citrus and mango fruits produced in full sun generally had a thinner skin, a lower average weight, a lower juice content and a lower level of acidity but a higher total and soluble solids content.

Day length

This is related to number of hours of light in each 24 hour cycle. Certain crop species and varieties have evolved or been bred to require certain day lengths in which to mature. If this requirement is not met then the crop may still be immature at harvest. Eg. Onion

Water relations

Crops which have a higher moisture content generally have poorer storage characteristics. Some varieties of crop naturally have high moisture content. eg. Hybrid onion cultivars-a high yield of bulbs with a low dry matter content and very short storage life. If bananas are allowed to mature fully before harvest and harvesting is shortly after rainfall or irrigation the fruit can easily split during handling operations, allowing microorganisms infection and post harvest rotting.

The incidence of damage in carrots – heavy irrigation during the first 90 days after drilling resulted in upto 20% growth splitting, while minimal irrigation for the first 120 days followed by heavy irrigation resulted in virtually split-free carrot with a better skin colour and finish In leaf vegetables too much rain or irrigation can result in the leaves becoming more hard and brittle. Susceptible to damage and decay during handling and transport.

Chemical treatment

Besides fertilizers, which are applied to the soil and some times to the growing crop. Chemicals are applied for other purposes. The control of pests and diseases in commonly achieved by spraying chemicals directly onto the crop. These chemicals, particularly fungicides, can have a considerable effect on the post harvest life of the crop. Generally, if a fruit has suffered an infection during development, its storage or marketable life may be adversely affected. Bananas which suffers a severe infection with diseases such as leafspot may ripen prematurely or abnormally after harvest.

Chemicals may also be applied to certain crops in the field to prevent then sprouting during storage and thus to extend their storage period Growth regulating chemicals have been applied to trees to increase fruit quality and yield. Daminozide applied to Cox's Orange Pippin apples at 2500 ppm in late june and mid August caused more red colour in the skin and firmer apples than unsprayed fruits.

Pre-harvest infection or infestation

Frequently crops are infected with microorganisms or infested with invertebrate pests during production. Field infestation of yam tubers with parasitic nematodes was shown to increase when the tubers were stored in tropical ambient conditions, resulting in areas of necrotic tissue. However, when the tubers were stored at 13^{o}C, there was no increase in nematode population and no increase in necrosis. The potato tuber moth may infest tubers during growth if they are exposed above the soil. Mealy bugs on pineapples occur in the marketing chain from field infestation.

Preharvest fungicidal sprays for post harvest disease control

Many post harvest diseases of fresh fruits and vegetables begin during production. The time between infection and the symptoms of the disease developing may be lengthy, for example anthracnose (*Colletotrichium musae*) in bananas can take over 5 months. Fungal and bacterial infections can occur through mechanical injuries and cut surfaces of the crop, growth cracks or pest or disease damage. They also occur through natural openings in the surface tissue of the crop, such as stomata, lenticels and hydrathodes.

Eg. Mangoes – anthracnose diseases

Preharvest sprays with chemical fungicides have been shown to reduce post harvest disease but the effects have not always been consistent. In UK, single sprays of apples with 0.025% benomyl in June, July or August controlled rots caused by infection with Gloeosprorium spp. which developed in subsequent storage from September onwards at 3.3^{o}C in unsprayed fruit. The control of anthracnose in papaya also caused by C.gloeosporiodes, was achieved by preharvest sprays copper oxychloride 50% wettable powder at 400 g 100 litres^{-1} water applied at 7-10 day intervals.

Questions

1. Mention different preharvest sprays in horticultural crops
2. How the post harvest diseases in mango can be controlled

MATURITY INDICES – HARVESTING – HANDLING OF HORTICULTURAL CROPS

Methods to determine the proper time to pick the fruits

1. Maturity tests

Following are the rough but ready maturity tests of fruits employed to pick the well matured fruits

a. Colour changes – The changing of colour is one of the criteria to judge the maturity of fruits. The change of peel colour from green to yellow is the main criterion to test maturity in mangoes. Similarly in papaya changes of colour at apical end of the fruit indicates the full maturity stage. In the case of pineapples nearly 25% of the fruit surface should have turned to yellow colour.
b. Increasing in size
c. Softening of the tissue of the fruits eg. Figs and grapes
d. Ease of detachment from the stalk. eg. sapota and annona
e. Shrivelling of fruit stalk eg. Watermelon
f. Time elapsed from the date of flowering to picking maturity.
g. Sound by tapping-jack and watermelon when ripe produce hollow and dull sound on tapping but produce metallic sound if unripe
   i) Drying of foliage or top
   ii) Flowering/Bolting can generally included be taken as maturity indices

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 instalment 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. Firmness of the flesh can be assessed by removing a thin slice of the skin and flesh with a knife and using a special hand operated testder which records the kilogram of pressure for the plunger to penetrate the flesh.
c. Sugar/acid or Brix/acid ratio – This is based on the principle that acid content reduces and sugar increases on ripening.

Tomato: The maturity standards of tomato are grouped as follows.

i Immature: Before seeds have fully developed and jelly like substance surrounding the seeds have formed. Fruits are not suitable for consumption
ii Mahuv green : Fully mature, light green at bloom end and yellowish green in all other areas. Seeds are surrounded by jelly like substance, filling the seed cavity. this kind of fruits are artificially ripened and become suitable for long distance market.
iii Pink : 3/4th surface shows pink colour
iv Hard ripe : Nearly all the areas are red or pink but flesh is firm

v Over ripe: fully red coloured and soft
vi This is suitable for processing as it possesses good quality and colour development

Onion: Bulbs are considered mature when the neck tissue begin to soften and tops are about to abcise and decolourise.
Okra : development of crude fibre is used to determine the optimum stage of maturity
French 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
Tapioca: in tapioca, maturity is indicated by the cracks formed in the soil, yellowing and falling leaves.
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 while the colour will be milky white in fully mature tubers.
Dioscorea and amorphophallus: In these crops, maturity is indicated by yellowing, drying and then dropping of leaves.
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
Chillies : Development of uniform red colour is treated as maturity index.

II Harvesting

Harvesting of vegetables at optimal maturity and careful handling constitute the very key to their successful long storage life. Harvesting is done in two way viz., by hand, with or without mechanical aids or gadgets and mechanical harvesting. In India, most the vegetables are harvested manually.
Root crops: Beet root, Carrot, Radish, Turnip and tubers like Potato, Tapioca and Sweet potato are easily harvested by digging into the soil below the roots or tubers. then it is levered upwards so as to loosen the soil and to reduce the possibility of mechanical damage. In Punjab, tractor drawn potato diggers are used for harvesting potato.
Leaf vegetables: In spinach and methi, the lateral buds and they snapped off by hand.
Cabbage, cauliflower, knolkhol and lettuce: Here, the main stem is cut off with a sharp knife.
Bulbous crops: Green onions and leeks can be easily pulled out by hand from the moist soil whereas for harvesting of fully mature onions and garlic bulbs, soil is loosened first with a fork or how. simple tractor drawn implements are also available for loosening the soil in onion and garlic like crops. Onion could be

harvested. Harvesting og immature bulbs cause shriveling and rotting. Delay in harvest cause splitting and bolting

Tomato: Harvesting the fruits at breaker stage is recommended for long shelf life and optimum quality. Harvesting during evening hours in summer keeps the fruit firm and uniform ripening is effected.

Okra : Immature, green, tender fruits should be picked from 3rd -5th day of first pod formation.

Brinjal: Brinjal is harvested at tender stage ie. 15-20 days after fruit-set when the seeds are immature.

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

i Picking must be commenced from the lower branches of tree advancing towards the top in order to reduce dropping of fruits to the minimum

ii As far as possible, dropping of fruits from the tree should be avoided to avoid any possible physical damage.

iii 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

iv 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

v There should not be any bruises in the fruits while picking as it will lower the marketable quality

vi If picking is done in mid day or hot weather, fruits should be kept in a shed overnight to cool.

Handling

Handling includes all process from picking to deliver 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 treatment is the dipping the fruit in antiseptic solutions like 1-2% caustic soda to remove the dust and infestation of scale insects and washing with 1-15% 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 sow ripening and reduces deterioration prior to storage and shipments. Different methods are adopted to precool the fruits, the important ones are

1. Air cooling in which the fruits and vegetables in a cold room
2. hydro cooling-dipping of the fruits in cold water or by spraying cold water on the fruits and
3. 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 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 form blemishes and also size of the fruit. Grading is a good market practice which improves the mutual confidence of salesman and consumer

Agriculture prescribes the following grades to apples in the USA

1. US Extra fancy
2. US Fancy
3. US No.1
4. US commercial

In India, grading of fruits like apple plum, pear and mango varieties like alphonso, rumani, bangalora and sathugudi is done by agmark mainly based on size only.

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, pliofilm, cellophane paper, aluminium foils and alkathene paper etc. Wrapping has the following advantages.

1. it minimizes the loss of moisture in shriveling
2. it protects against the spread of diseases from one to the other.
3. it reduces bruises.
4. it reduces damage during transport or in storage and
5. it makes the fruit more attractive.

Care must be taken to see the wrap is not too impervious to the passage of oxygen and carbon-di-oxide. Pre-packing of banana fruits is done in 100 gauge polythene bags under room temperature and cold storage. Waxing: Another treatment given to the fruits during handling is waxing. 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. Boiling water free from hardness is slowly added to the molten ingredients and thoroughly stirred in order to make a stable emulsion. The harvested fruits are dipped in dilute wax emulsion for a minute and then these are completely dried for 10-15 minutes.

Packaging and 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 packaging 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 plast 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 stability and 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, pine apple, 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 form South to North and pineapples are shipped form North East India and Kerala to different regions. In these cases, it has been observed that the loss 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.

Questions

1. Mention different package material used for packing mango
2. Mention the maturity standards for mango and sapota

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