PRACTICAL MANUAL

Fundamentals *of* Horticulture

S.K. Pandey
C.S. Pandey

DEPARTMENT OF HORTICULTURE
College of Agriculture
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)

Fundamentals of Horticulture
(Practical Manual)

S.K. Pandey
C.S. Pandey

Department of Horticulture
College of Agriculture
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)

2018

Pub. No.: DFA/JNKVV/PM/Horti./2018/05-1

Citation:

Pandey SK, Pandey CS, 2018. Practical Manual on 'Fundamentals of Horticulture'. Department of Horticulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, MP.

Technical Support:

Dr. P.K. Bisen
Hon'ble Vice Chancellor
JNKVV, Jabalpur

Dr P.K. Mishra
Dean Faculty of Agriculture
JNKVV, Jabalpur

Dr. (Mrs.) Om Gupta
Dean, College of Agriculture
JNKVV, Jabalpur

Prepared by:

Dr. S.K. Pandey
Professor& Head (Horticulture)
Dr. C.S. Pandey
Scientist (Horticulture)

Published by:

Dean, College of Agriculture, Jabalpur
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur, Madhya Pradesh 482004
Tele-fax: 0761-2681236; web: www.jnkvv.org

Publication assistance: ICAR Development Grant

डॉ. प्रदीप कुमार बिसेन
कुलपति
Dr. Pradeep Kumar Bisen
Vice Chancellor

जवाहरलाल नेहरू कृषि विश्वविद्यालय
कृषि नगर, आधारताल, जबलपुर ४८२ ००४ (म.प्र.)
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Krishi Nagar, Adhartal, Jabalpur 482 004 (M.P.)
Phone: 0761-2681706; Fax: 0761-2691389
E-mail: bisenvcjnkvv@gmail.com

FOREWORD

Horticulture continues to play a major significant role in the overall development of the country. Horticulture dealing with fruits, vegetables, flowers, its post harvest management and allied branches is the core to Indian Agriculture and would continue to hold the belief that it is an important sector to make farmers and entrepreneurs to realize higher income and prosperity.The practical manual 'Fundamentals of Horticulture' is prepared according to syllabus of 5th Dean's Committee is a very timely and relevant initiative towards improving practical skills of undergraduate students. I am confident that the practical skills acquired by the students would be helpful to them in their professional career.

I hope that the manual would be of great help not only to the students but also to all those dealing with the field/laboratory exercises in horticulture. I congratulate the authors for their making efforts in preparation of this manual.

Jabalpur **(P.K. Bisen)**

Date: 31.03.2018

जवाहरलाल नेहरू कृषि विश्वविद्यालय
कृषिनगर, अधारताल, जबलपुर 482 004 (म.प्र.)
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Krishi Nagar, Adhartal, Jabalpur 482 004 (M.P.)

डॉ. पी.के. मिश्रा
अधिष्ठाता कृषि संकाय
Dr. P.K. Mishra
Dean Faculty of Agriculture

Phone : 0761-2681200; Fax: 0761-2681200
E-mail : dfajnkvv@gmail.com
pkmishrra_jnkvv@rediffmail.com

PREFACE

The practical manual on 'Fundamentals of Horticulture' is of immense importance for the students because the required information is compiled in detail and consequently more time can be diverted for practical purpose. The practical of horticultural fields are always fascinating as they provide an opportunity to the students to apply the art and scientific principles in few horticultural operations such as propagation of plants for quality planting material, potting and repotting, layout of the orchards and training and pruning of plant along with knowledge about garden tools. These practical skills acquired by the students would be helpful to them in their professional career. The Practical manual contains elaborated information on the field exercises. The exercises included in this manual are framed as per the prescribed syllabus.

I am sure that the manual will be helpful to the students, researchers, extension workers and nurserymen dealing with the field exercises of horticultural crops.

Date: 31.03.2018

(P.K. Mishra)

कृषि महाविद्यालय, जबलपुर
जवाहरलाल नेहरू कृषि विश्वविद्यालय
कृषिनगर, अधारताल, जबलपुर 482 004 (म.प्र.)
COLLEGE OF AGRICULTURE, JABALPUR
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Krishi Nagar, Adhartal, Jabalpur 482 004 (M.P.)

डॉ. (श्रीमती) ओम गुप्ता
अधिष्ठाता
Dr. (Mrs.) Om Gupta
Dean

Phone : 0761-2681236 (O); Fax: 2681236
PBX : 0761-2680771, 2681773, Extn.: 327
E-mail : dacjbp@gmail.com
omgupta_ jnkvv@rediffmail.com

PREFACE

The field of horticulture is like an ocean, which includes fruits, vegetables, ornamentals, plantation crops, spices and condiments, roots and tuber crops, Mushrooms etc. It has emerged as one of the most important sectors for the diversification of agriculture. The course 'Fundamentals of Horticulture' is taught to undergraduate students in almost all agricultural universities. However a practical manual covering the whole syllabus is limited, and if available, these not contain latest information in a simple and easy to understandable language. Considering the fact, practical manual 'Fundamentals of Horticulture' has been prepared as per the prescribed syllabus of 5th Dean's Committee in simple and easy to understand manner. These practical skills acquired by the students would be helpful to them in their professional career.

I hope that the manual would be of great help not only to the students, but also to all those dealing with the field/laboratory exercises in horticulture.

Date: 31.03.2018

(Om Gupta)

Department of Horticulture
College of Agriculture, Jabalpur
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, MP

PREFACE

The field of horticulture dealing with three main branches viz. pomology, olericulture and floriculture is helping mankind not only to diversify diet and to improve nutritional security due to richness in mineral & vitamins and providing aesthetic sense but also economic security, income and employment generation. The pomology is the study of different aspect of fruit growing; olericulture deals with vegetable growing and floriculture with all aspects related to flowering and ornamental plants. In the production of these horticultural crops, basic knowledge and skill of garden tools, proper identification of crop/plant, nursery bed preparation, propagation, training and pruning, methods of manures and fertilizer application etc. is necessary. This practical manual has been prepared to cover the practical aspects of 'Fundamentals of Horticulture' to undergraduate students in almost all agricultural universities containing latest information in a simple and easy to understandable language. The different aspects covered in the manual will be an asset to understand and improve the practical skills about production of horticultural crops. Besides, this manual would be of great help to all those dealing with the field exercises in horticulture.

The financial assistance received from the ICAR Development Grant for bringing out this manual is gratefully acknowledged.

Date: 31.03.2018

S.K. Pandey
C.S. Pandey

Contents

Exercise No.	Objective	Page Nos.
Exercise - 1	Study about garden tools and implements	1-7
Exercise - 2	Identification of horticultural crops	8-9
Exercise- 3	Preparation of seed bed/ nursery bed	10-14
Exercise - 4	Study of pots, potting, depotting and repotting	15-16
Exercise - 5	Study of orchard layout	17-18
Exercise - 6	Study about system of planting	19-22
Exercise - 7	Propagation through specialized vegetative structures	23-24
Exercise - 8	Study on propagation by cutting	25-28
Exercise - 9	Study on propagation by layering	29-31
Exercise - 10	Study on propagation by grafting	32-38
Exercise - 11	Study on propagation by budding	39-41
Exercise - 12	Study about micro propagation	42-48
Exercise - 13	Study about training and pruning	49-55
Exercise-14	Study of manures and fertilizers application	56-61

EXERCISE NO. - 1

OBJECTIVE - Study about Garden Tools and Implements

Knowledge of different garden tools and implement commonly used for various horticulture operations is very essential. A person should know the use of a right type of tool/implement for a particular operation to achieve maximum efficiency and quick outcome of work along with proper maintenance, repairs and storage of tools and implements. Some tools are simple and are used for simple operations. However, special equipments are required for specific operations. Therefore, adequate selection of suitable tools/implements is very important to exercise/ carryout various horticultural operations from the stage of land preparation to harvesting.

Some of the tools, implements and plant protection equipments required for different horticultural operations are described as follows:

S.No.	Name	Uses
1	Axe	Used for felling trees and cutting branches and pruning
2	Bill hook	Commonly used for cutting the big branches/ stems near the ground surface or to remove the old and dead branches from a tree
3	Budding knife	For budding purpose
4	Budding-cum-grafting knife	It has two sharp blades for budding and grafting specially with the back end made up of brass used to lift or loosen the bark for inserting the bud
5	Pick Axe	Used for digging hard, compact and stony soil, loosening the soil, pit digging, opening of trenches
6	Cultivator	
7	Carpenter's saw	To prune the thick and bigger branches, and useful in crown grafting
8	Crow-bar	An iron rod usually of 1.5m in length and 2.5 to 4.0 cm thick with one end pointed and the other end flattened. Used for digging pits in hard soil, breaking stone and moving rocks
9	Digging fork	Used for loosening the moist soil and mixing manures in pits
10	Drainage hoe	Used for making the drainage channel and to remove silt deposit in the channels.
11	Dibbler	To make small holes on the seed beds in order to place seeds or transplant seedlings
12	Forester's shear	To prune the medium sized branches (4-8cm) which are at higher height on the trees
13	Garden hand rake	For collecting stump and other residues of plant,

S.No.	Name	Uses
		removing stubbles, small stones, leveling of nursery beds and breaking clods, formation of small beds
14	Garden trowel	For lifting more number of seedlings
15	Grass shear	To cut the out growth of grasses planted in posts, carpet beds
16	Hand fork	Used for hoeing, compost handling and to break the clods.
17	Hand cultivator	To loosen the soil, remove clods, pebbles in nursery beds and mixing of manures and fertilizers.
18	Hand leveller	Used in small bed and nursery for levelling land and covering the seed after sowing.
19	Hatchet	To remove or cut down the bigger stems and broken stems
20	Hedge shear	To prune the tender parts of garden shear the plants, it is especially useful for trimming hedges, borders, topiary work
21	Hose pipe	To irrigate flower beds, lawns etc.
22	Kurpi-Varvari	For weeding and stirring the soil in the pots and beds.
22	Lawn mower	To cut the grass uniformly in the lawn. It is having a roller behind to pad the grass to have cushion.
23	Lawn sprinkler	For irrigating lawns.
24	Pruning saw	To prune the thicker branches (4-6cm girth) of an acute crotch (angle)
25	Pruning knife	For pruning of thicker branches and it has curved knife.
26	Pruning shear	For cutting small sized branches.
27	Rotary weeder	For cutting of grasses in lawn, carpet beds, edges etc.
28	Secature	To prune the branches, twigs, water suckers etc. of small plants.
29	Sickle	For cutting grasses, vegetables etc.
30	Scythe (Dabba)	For cutting lawn grasses, vegetables etc.
31	Spade	To loosen the soil, prepare irrigation channels, collect the soil in heaps and facilitate filling up of soil, manure etc. in the baskets.
32	Transplanting trowel	To lift the young seedlings along with a boll of earth for transplanting.
33	Tree pruner	To cut down the smaller branches of the trees without climbing.
34	Trenching hoe	For light collection of soil, irrigation purposes and opening of trenches.
35	Tree calipers	To measure the girth of trees trunks.

Axe

Budding knife

Bill Hook

Budding cum grafting knife

Pick axe

Carpenter's saw

Digging fork

Hand Hoes

Drainage hoe

Forester' shear

Cultivator

Crow-bar

Garden hand rake

Garden trowel

Grass shear

Hand fork

Hand cultivator

Hand laveller

Hose pipe

Kurpi-varvari

Lawn mower

Lawn Sprinkler

Pruning knife

Pruning shear

Pruning Saw

Rotary weeder

Secateur

Sickle

Spade

Tree pruner

Tree Calipers

S.No.	Name	Uses
36	Water can with rose head	To water the young seedling in seed beds, potted plants etc. the rose head facilitates with fine spray of water which prevents the washing down of soil.
37	Weed cutters	Special kinds of weed cutter have a serrated double edged steel blade and handle about 60 cm long. It is used with swinging strokes in two directions.
38	Wheel barrow	To transport manures, soil, seedlings, garden waste etc.
Plant Protection equipments		
39	Aspee back pak sprayer	For spraying of soluble fertilizers / plant protection chemicals on nursery beds, flower beds, potted plants etc.
40	Aspee Bolo-power sprayer	For spraying of soluble fertilizers /plant protection chemicals on large areas.
41	Aspee knapsack sprayer	For spraying nursery beds, flower beds, potted plants etc.
42	Automizer	For spraying growth hormone/ micronutrient solution on nursery beds, potted plants etc.
43	Hand Rotary Duster	For dusting the powdery chemicals on plants.
44	Hand sprayer	For spraying growth hormone/ micronutrient solution on potted plants
45	Rocker sprayer	For spraying plant protection chemicals particularly in plantations/orchards
46	Foot Sprayer	For spraying of soluble fertilizers/plant protection chemicals on nursery beds, flowerbeds, potted plants etc. It requires two labourers for operation.

EXERCISE No. - 2

OBJECTIVE - Identification of Horticultural Crops

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

Branches of horticulture

- **Pomology**- production and marketing of fruit crops.
- **Olericulure**- production and marketing of vegetable crops.
- **Floriculture and landscaping**- production and marketing of flower/ornamental crops, beautification through design and alteration of land using planting material etc.
- **Fruit & Vegetable Preservation**: - applied branch for protection and processing of horticulture produce to increase shelf life as well as preparation of value added products.
- **Plantation Crops**- cultivation and marketing of commercial crops on extensive scale like coconut, tea, coffee, Cashew nut etc.
- **Spices & Aromatic Crops** - cultivation and marketing of crops having aroma, taste and flavor value.
- **Medicinal and aromatic Plants**- cultivation and marketing of crops having potential source of drugs.
- **Roots and Tuber crops**- cultivation and marketing of root crops like radish, carrot, turnip, sugar beet and tuber crops like potato etc.

It is very important to familiar with botanical and horticultural features of plants for identification. Plant identification depends to a large extent on what criteria and whose system is used. Plant identification implies comparisons of certain characteristics and then assigning a particular plant to a known taxonomic group, ultimately arising at a species and variety in binomial classification system. Taxonomy the branch of botany deals with plant identification, nomenclature and classification.

Classification is a system of placing an individual or a number in various groups or to categorize them according to a particular plan or sequence. Basically, the horticultural crops/ fruit trees have been classified on the basis of their botany comprising taxonomical ancestry, morphological features, physiological functions, adaptability etc or on the basis of Agricultural and horticultural requirements. Identification of horticultural/fruit crops include the knowledge/ discussion of horticultural/ fruit species in the following manner:

1- Common name, botanical name and family of horticultural plant species.

2- Identification/Categorization of plant species on the basis of major and minor fruits, cotyledons (monocot, dicot), life cycle (annual, biennial and perennial), Stem morphology (Tree, Shrubs, Climber, ramblers) Soil and climatic requirements, tolerance to salinity, drought, water logging and frost etc

3- Familiarization with details of root, leaf, inflorescence, flower, fruit and seed.

4- Identification/ Categorization of plant species on the basis of flowering & fruiting behavior, ripening behavior, edible portion, specific nutritional importance and commercial methods of propagation, etc

EXERCISE No. - 3

OBJECTIVE - Preparation of Nursery Bed /Seed Bed

Nursery

Nursery is a place, where seedlings, saplings, trees, shrubs and other plant material are grown and maintained until they are placed in permanent place. Seedlings at early stages deserve special attention which is only possible in nursery. Setting up of a horticultural nursery is a long term venture and requires careful planning and expertise. Establishment, management and marketing are major considerations of nursery.

Establishment of nursery

The nursery should be established in such an area where cultivation of fruit crops is on sizeable area and there is need for a nursery, having demand for saplings. In such area/region, following considerations need to be observed for selecting an appropriate location.

1. Nursery should be established in the important production areas.
2. Nursery soil should be deep, fertile, well drained and free from pathogens.
3. The site should be well connected by different means of communication and must be easily accessible.
4. The area should be well protected.
5. Soil and micro-climatic conditions should be appropriate.
6. Availability of irrigation and power supply should be ensured.
7. Sufficient labour and skilled person should be available to handle different operation..
8. Availability of progeny/mother stock (bud wood source tree) and root stocks should be ensured.
9. Availability of propagating/growing structure, hardening chamber etc.
10. Availability of working shed, pot and packaging yard and sale unit etc.
11. Availability of office building, staff quarters etc.

Purpose - One of the important operation for horticulture crop is raising of seedlings (fruit trees, vegetables, shrubs and flowering annuals). In many plants, the seeds are first sown in seed beds and after sometimes seedlings are either directly transplanted in the actual field as in case of some vegetables, flowering annuals, shrubs, and trees or may used as root stock as in case of fruit trees like mango, guava, aonla etc. For healthy and good stand of seedlings proper preparation of nursery bed is essential. Since large number of seedlings are raised in small area, due consideration of adequate moisture and nutrients, protection from pest & diseases, strong sunlight and wind is very important. These factors will vary if seedlings are raised in protected structure.

Materials required- Spade, khurpi, rake, rope, pegs, measuring tape, water cane, plastic sheet, manures and fertilizer insecticide, pesticide, fungicide etc.

Procedure- Select the proper area for preparing nursery bed having well drained fertile loamy soil rich in organic matter and sunny situation. Mark out the area required for nursery. Dig the soil about 25-30 cm deep with the help of a spade or kudali. Remove weeds, weed roots and stones etc. Level the land with the help of rake. If the soil is heavy clay or silt then mix sand at the rate of 4-5 kg per sq. metre. After this spread well decomposed FYM (Farm Yard Manure) at the rate of 5-6 kg per sq. metre. Fertilizers like urea, single super phosphate and potassium chloride at the rate of 200-250 g per sq. metre.

Preparation of Nursery bed- Nursery beds of 1- 1.20 m wide and convenient length 5-6 m are considered ideal. In between two parallel beds a space of 50-60 cm should be provide for cultural operations. The height of bed should be 15-20 cm particularly during rainy season and 10-15 cm during winter season from the soil surface.

Type of Nursery bed

1- **Raised Nursery bed-** During rainy season, it avoids losses through water stagnation by facilitating proper drainage of excess water.

2- **Flat Nursery bed-**During winter and spring season, seedlings is raised in flat bed. In this case, cost of preparation is less.

3- **Sunken Nursery bed-** During summer, seedlings should be raised in sunken type of nursery bed. It protects the plants from hot dry winds.

Soil treatment/ Sterilization of Nursery beds- Several times, soil contains certain harmful pathogens, which interferes with growth and development of seedlings. These harmful insects can be eliminated by pasteurization, solarization, changing the sight of nursery or by chemical treatment.

Solarization- It is simple and effective method for soil sterilization. For this, soil mulching is done with black polythene of 200-300 gauge during the period of high temperature and solar radiation. The edges of polythene sheet should be pressed in the soil to minimize the air circulation. Soil should be kept moist before mulching to increase the latent heat and thermal sensitivity for resting he soil borne pathogen, harmful insects and weeds which can be reduced to a sustainable level.

Chemical treatment

Seed bed treatment-

1- Formaldehyde (Formalin) 1% can also be used for soil treatment. 5 litre of this solution is sprayed uniformly on soil surface per sq. meter. After spraying the beds should be covered with black polythene. The edges of the polythene need to be sealed with wet soil to make air tight. Polythene should be removed only after 10-12 days. The seed should be sown only after 6-7 days after removing the polythene.

2- Spray the bavistin 0.1% - 0.3% on the moist bed or Sevin dust 20-25 gm/sq.m area and leave the bed for 2-3 days.

3- 1% solution of Trichoderma virdi also can be used for seed bed treatment.

Seed treatment-Before sowing the seeds in the sterilized bed, seed should be treated with 0.3% suitable fungicide eg. ceresan, bavistin, thiram.

Sowing of seed- In well prepared beds, the seed should be sown in miniature furrows. The depth of furrows will depend upon the seed size. For bolder seeds of furrow should be kept 5-6cm kept and for smaller and fine seed depth should be kept 1-3 cm. The furrows should be covered with a mixture of leaf mould and sand (3:1).

Care and handling of Seedling- The protection should be against strong sun and rain, frost etc. Covering the beds with agro-net/ mosquito net at a height of a meter will protect the seedlings against strong sunshine and wind. Spraying with fungicide and insecticide as and when required proves very useful to the seedling health.

Components of modern nursery

A number of structures may be necessary for raising a nursery. To establish the nursery, the following structures need to be constructed:

1. Fencing: It is required to protect a nursery particularly from stray animals.

2. Progeny block (bud wood source tree)

In progeny block, true to type mother plant are maintained in the nursery. Suitable plant types with existing superior cultivars/varieties should be collected and maintained in the progeny block. The mother plants should be true to type, healthy, heavy bearer with standard quality fruit having tolerance to biotic and abiotic stresses. Care should be taken to label the plants properly.

3. Rootstocks and seed gardens-After establishment of scion bank, next priority should be given for the establishment of the rootstocks or seed garden. Seed propagation is the most usual way for mass production of rootstocks.

4. Growing structures:

There should be provision of modern propagation structure like greenhouse/polyhouse, mist chamber etc. these structure provide optimum growing conditions for seed germination, rooting of cutting, hardening of seedlings. Now a day's green house has become a prerequisite of Hi-Tech nursery. Shade nets are useful not only for reducing heat injury to young plants, but their use also reduces transpiration. Shade nets are available in different colours and densities.

5. High Humidity Chamber:

This technique resolves the common problem of grafts or cuttings dying due to desiccation (drying up) when planted in the soil for rooting, by ensuring a humid atmosphere around the cuttings, thus preventing excessive evaporation.

6. Use of Supplementary Light:

Several plants go into winter dormancy when the day length gets short. Additional light from tube lights, given after sunset, creates long-day condition that prevents the plants from going into winter dormancy.

7. Drought Hardening:

Plants that are raised under high atmospheric humidity and shade often die due to transplanting shock when shifted to the fields. To prevent this, the plants are hardened by allowing external dry air to enter the chamber gradually.

After having established the above infrastructure, the nursery establishment and planning involve division of the nursery into different units, viz., propagation unit, production unit, packaging unit and sale unit.

1. Propagation unit

Propagation unit is the major unit of nursery work and includes:

(i) Actual propagation structures such as green house, hot beds, cold frames and mist house.

(ii) Service structures such as head house.

(iii) The alley house connecting to the hot beds and cold frames with head house. It provide a passage for the transport of plants, propagation media, soil and fertilizers from head house to propagation structures, and must be sufficient wide to permit easy and quick movement.

(i) Primary nursery (Seedbeds)

Seed beds near to water source and to office so that they can be kept under vigilant control. The raised seedbeds of 6-8 cm height, 1 meter width and of convenient length, free from stones should be prepared with upper 2.5-5cm of the bed filled with sand. Soil can be prepared to fine tilth, add sufficient quantity of rotted FYM, vermin-manure or pig manure at least 10-15 days earlier of seed sowing. The bed may be treated with 1% Bordeaux or 0.1% Bavistin before sowing of seeds.

(ii) Nursery beds

Seedlings from seed beds are removed and transplanted in the nursery beds. Nursery beds should be located in an open area near to water source. Nursery beds should be prepared by adding sufficient organic manures and fertilizers. Nursery beds should be divided into section as per crop and varieties. The nursery beds should be laid out in such a way that there is an access to all the beds through roads or paths.

(iii) Pot yard

The pot yard should be in shade because the tender plants require shade as compared to hardy plants. This section should be near to water source. Trenches can be provided for keeping potted plants closely packed together.

2. Production Unit

The object of this unit is to rear the new plants from seedling to marketable stage. This unit is divided into different blocks, each block being meant for only one kind of plant or species. This helps on sorting of plants, easy record keeping and doing the operation as per the need of a plant species.

3. Packaging Unit:

The packing yard is used for packing the plants before sale or dispatch to out stations. The yard can be combined with working shed. It is near to sale counter.

4. Sale Unit:

The objective of the sale unit is to market the nursery plants effectively. The design and layout of this unit should be attractive to the customers. This should be usually located on a well travelled way and may be by the side of production unit. The sale unit is usually divided into three different parts such as display unit, sale and packing, and parking unit.

EXERCISE NO. - 4

OBJECTIVE - Study of Pots, Potting, Depotting and Repotting

Pots are containers in which seeds are sown, seedlings are raised or plants are maintained. Pot culture is the growing of plants in pots.

Purpose - Potting is one of the important horticultural operations for raising of seed propagated plants eg. Papaya, Acid lime etc. in polythene bag for direct sale and raising of seedling for rootstock purpose. One can also enhance the beauty of interiors by artistic arrangement of potted plants, especially the blooming seasonal, perennials and decorative foliage plants. A terrace or roof garden can be developed by growing fruit trees, shrubs, creepers, cacti, succulents and even vegetables in posts as well as large size tubs. The major limitation is that the space and the quantity of soil are limited in pots; as such growth of plants is restricted.

Types of Pot-Pots may be classified into following groups -

1- **On the basis of material used**- Earthen (clay) pots, Metallic pots, Plastic pots, Cemented Pots, Fibre pots, Ceramic Pots, Glass pots and Polythene bag, Portrays etc. Among them polythene bag and earthen pots are more common. Flower pot is the relative term used for all the containers.

2- **On the basis of Shape**- Conical, Square, Rectangular, Circular, Cylindrical, Bowl shape etc.

3- **On the basis of size**- Large, medium large, medium, medium small and small size.

4- **On the basis of Colour**- Green, Yellow, White, Red and multiple colour with different design.

Qualities of an ideal pot: It must have sufficient space along with holes for drainage and fulfill the purpose with desired shape and colour. Potted plants can be easily handled and shifted conveniently to any place for decoration purposes and as per requirements.

Potting mixture – Soil : Sand : FYM/ Vermicompost (1:1:1) enriched with or without Bio fertilizer and plant growth promoting substances

Potting: Generally, potting refers to first planting of seedling or a cutting in a container. It is a process of planting a new plant in pot with a suitable pot mixture for establishment. Although it is a simple operation, it requires certain degree of skill and practice.

Procedure for potting of earthen pot-

1. Select a good quality earthen pot and immerse in water for about one hour. If old pots are used, thorough cleaning is necessary.

2. Place a good crock on the drainage hole with its concave side facing the hole. Over this a large number of pot pieces are put (4-5 cm thick). On these crocks a layer of coarse sand or gravel or coconut fibre or sphagnum moss is spread to ensure adequate drainage and prevent clogging of drainage hole.
3. Remaining space in the pot is filled with suitable pot mixture leaving a head space of 2.5-5.0 cm.
4. The pot mixture should be sufficiently moist at the time of planting.
5. The plant is placed at the centre by scooping out the required amount of pot mixture, so that it accommodate the root system and held in position by packing the soil mixture with hand gently.
6. Water the pots immediately after planting.

Depotting:

It is a simple technique of taking the established plant out of the original container. A systematic approach is necessary for removing the plant intact from the pot. The pot is lifted by one hand, the palm spread over the top of the soil holding the stem between the fingers (Fore finger and middle finger) and then the pot is inverted. A gentle tapping of the rim portion of the inverted pot is inverted pot against a hard surface or edge of the bund is necessary so that the entire ball of earth with its entwining roots will slip out as one piece. If soil is too dry water the pots 1-2 hr before depotting.

Repotting:

It is generally referred to the transfer of a plant from one pot to another and replacing the soil mixture with the fresh one. The first step in repotting is the depotting. After depotting the plant with compact roots, with mother soil removed from it is placed in the centre of the new pot and then the sides are packed with the new garden mixture.

Repotting is necessary when, nutrients are exhausted, pots are broken due to wind or mechanical damage, the soil turns sourest due to continuous watering, under pot bound conditions, insect and disease infestation and for exhibition purpose.

EXERCISE No. - 5

OBJECTIVE - Study of Orchard Layout

Layout is done to locate the actual position of the trees, roads & sub-road, irrigation &drainage channels, store and buildings etc in the orchard. The mistakes committed in the initial stage of orchard establishment can cause loss throughout the life of an orchard, and it is very difficult or even impossible to correct them later. It is, therefore, essential that the layout of an orchard should be carefully planned and executed to facilitate proper care of the orchard.

Principles- A well considered layout plan should be followed for planting an orchard. The plan should provide optimum number of trees per unit area with sufficient space for the proper development of each tree and convenience in various orchard operations such as inter-culture, spray and harvesting etc.

Materials required- Rope, poles, pegs, Carpenters triangle or cross staff, measuring tape and planting board are required for laying out an orchard.

Procedure for layout

Steps:

1. First and foremost step in orchard layout is to draw the base line parallel to the road or fence or the boundary of the orchard. This should be drawn at a distance of half the spacing that is to be followed, for example, if the spacing is 10 metre the base line should be drawn at a distance of 5 metre from the periphery of the plot.
2. Towards the end of the base line, leave again a space equal to half the spacing from the boundary or road or fence etc. and put the peg on one end of the base line. From this peg, measure the planting distance and put the second peg on the base line. Thus, continue placing pegs at each of the planting distances till the total length of the base line is covered. The distance from the last peg to the boundary should also be half of the spacing given.
3. From the first peg and the last peg on the base line, draw perpendicular lines to the base line. The perpendicular lines may be drawn by adopting any of the following methods.

A. **Pythagoras theorem or Carpenters triangle:** In this case**,** by adopting a right angled triangle with the sides and hypotenuse in the proportions of 3:4:5, a perpendicular line can be drawn.

Pythagoras principle-In a right angle triangle

$$(\text{Length of Hypotenuse})^2 = (\text{Length of base})^2 + (\text{Length of Perpendicular})^2$$

$$(5)^2 = (3)^2 + (4)^2$$

$$25 = 9+16$$

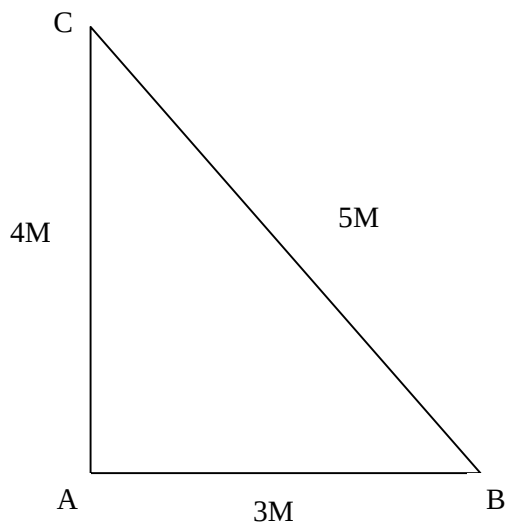
Thus a triangle with 3 meter base, 4 meter perpendicular and 5 meter hypotenuse will be a right angle.

Steps:

1. On the base line, mark the point A by a peg and place the point zero of measuring tape at point A. Measure and mark point B using a peg at 3 meter from the point A, with the mark of 3 meter of measuring tape on point B (AB=3m). .
2. Keep the mark zero of tape at point A and 3 m at point B, mark point C at 5 m from point B (BC=5m). At present the mark zero of tape is on point A, mark 3m at point B (AB=3m) and mark 4m on point C (CA=4m).
3. It is possible that CA of 4m length is not coming at point A; adjust it by moving point C or point B. Thus, it becomes right angle triangle.
4. Now extend a straight line from the position of the first peg by increasing the length of AB and AC. This gives a perpendicular line to the base line from the position of the first peg.

B. **Bilateral or Isosceles triangle:** In a bilateral triangle, the line bisecting the base will be perpendicular to the base of the triangle. The principle of Pythagoras theorem requires a scale to measure the distance in the proportion of 3:4:5. But by the bilateral triangle principle perpendicular lines can be drawn very easily even in the absence of any scale to measure the distances.

C. **Cross staff:** Cross staff comprises of a wooden block with two perpendicular slits made on its surface and fixed on an iron rod.



EXERCISE No. - 6

OBJECTIVE – Study about System of Planting

System or methods of plant layout- The plan showing the arrangement of plant in an orchard is known as plant layout. Although several systems of planting are followed, but selection of a suitable system, depending on soil, climate, plant type, system of training and pruning is very important. Adoption of improper system results in over lapping of plant parts and competition for water, light, nutrient and unequal distribution of water etc

There are several planting plans or systems which can be adopted for planting an orchard. The different system of planting is as follows:

1- Square System
2- Rectangular System
3- Triangular System
4- Quincunx System
5- Hexagonal System
6- Contour/ Terrace System
7- Hedge System

I. Square system:

This is the simplest of all systems. In this system of planting the plants are planted in straight rows running at right angle. The distance between plants and between rows remains same. Plants are planted at the corners of a square. Better watching and the possibility of cultural operations in two directions is the greatest advantage of this system. The major disadvantage of this system is that a lot of space is wasted in between the squares.

II. Rectangular system:

This system is similar to that of the square system in its layout except for the difference that the spacing between the rows and between the plants in a row is not equal. In this system, trees are planted on each corner of a rectangle. The wider alley spaces available between rows trees permit easy intercultural operations and even the use of mechanical operations. The major disadvantage in this system is that two way inter cultivation is not possible.

III. Triangular System:

This system is similar to the square system of planting except that in every alternate row the plants are planted in midway of two plants of the previous row. Thus, tree plants make a triangle where only two arms are of equal length.

IV. Quincunx system:

This is also known as filler or diagonal system. This system is essentially the square system except for an additional tree in the centre of each square. Thus the number of trees are nearly double than the square system, but does not provide equal spacing. Center (filler) trees may be short lived. This is difficult layout on ground and can be adopted when spacing for permanent tree is more than 10m. This is not satisfactory as a permanent plant but is satisfactory for putting temporary trees in the centre of squares. Filler should be removed after a few years when main trees come to bearing.

V. Hexagonal system:

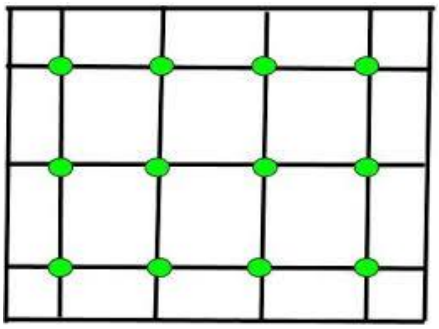
This system is also known as equilateral triangle system of planting. This system is also called septuplet because seventh tree is put in the centre of the hexagon. The plant in this system is planted at the corners of the equilateral triangle with one tree in the centre. Thus, six trees make a hexagon with an additional tree in the centre of the hexagon. The perpendicular distance between any two adjacent rows is equal to the product of 0.866 x the distance between any two trees. As the perpendicular distance between any two rows is less than unity this system allows 15% more plants than the square system. The limitation of this system is that it is difficult to lay out and the inter cultivation is not so easily done as in the square system. Besides, the watch and ward also becomes difficult as one cannot see in all the directions from a point.

VI. Contour system:

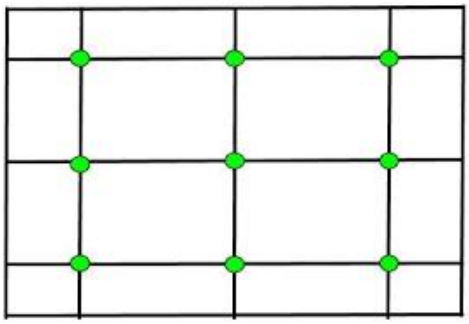
This system of planting is usually followed on hills with high slopes. The layout is started from the lowest level and the tree rows are planted along a uniform slope, at right angles to the slope, with a view to reduce loss of top soil due to erosion. This is necessary for rolling topography. Trees can be planted on terraces or along contours. Terraced fields rise in steps one above the other and help to bring more area into productive use and also to prevent soil erosion. In South India, tea is planted in contours either in single hedge system or in double hedge system. Double hedge contour planting system accommodates nearly 22% higher population than single hedge system.

VII. Hedge system:

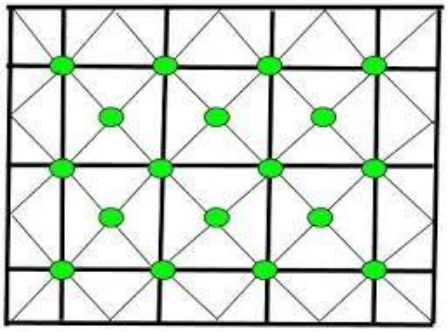
The layout is exactly same as rectangular system except that very wider spacing is maintained between rows and a very narrow spacing is followed between plants. This system permits easy movement of men, material and machinery and also effective cultural operations due to wider spacing. Therefore, this system is especially suitable where machines are employed for various farm operations.



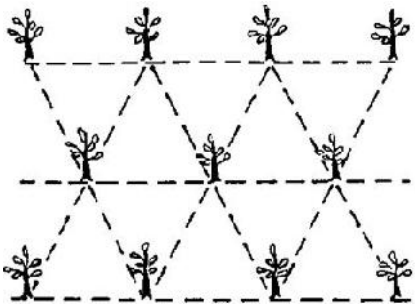
Square



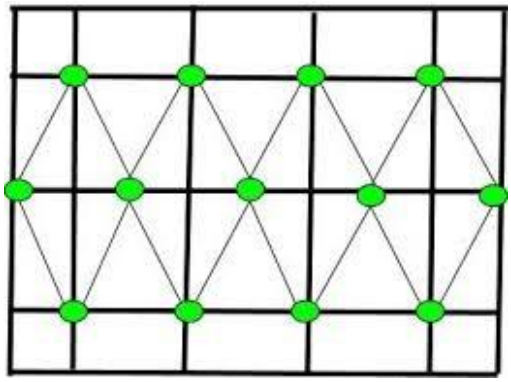
Rectangular



Diagonal/Quincunx

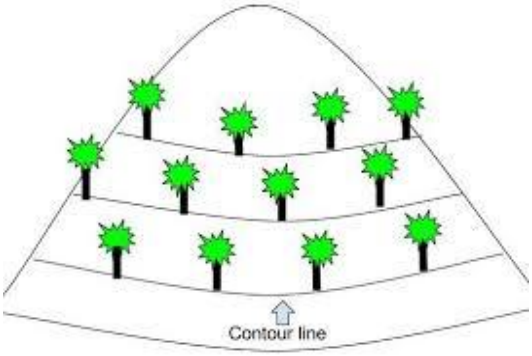


Triangular System



Hexagonal

Terrace System



Calculation of Number of Plants in different Systems of Planting.

The number of plants that can be accommodated by each of the systems in a unit area should be calculated by the formula shown against each system as under:

1. **Square System** = $\frac{A}{LXP}$

   A= Field Area
   L= Row to Row spacing
   P= Plant to Plant spacing
   Example- Area is 10000 sq. metre and planting distance is 10x10 (m) then

   Number of plants= $\frac{10,000}{10\times 10}$ = 100 Plants

2. **Rectangular System** = $\frac{A}{LxP}$

   A= Field Area
   L= Row to Row spacing
   P= Plant to Plant spacing

   Example- Area is 10000 sq. metre and planting distance is 10x 8 (m) then-
   Number of plants=10,000/10 × 8 = 125 Plants

3. **Quincunx System-**

   As the plants are planted additionally in the centre of the square, hence first the number of plants is calculated for square system of planting which is-

   No of Plants= Area in square metre/Planting distance in metre square=10,000/10 X 10 = 100 Plants.

   Additional plants = (No. of rows length wise - 1) × (No. of rows width wise -1)

   In 100 × 100 sq. metre field if planting distance is10 × 10 m. then number of rows length wise and width wise will be 10

   Hence, No of additional plants (10-1) × (10-1) = 9 × 9 = 81

   Total number of plants = Pants planted in Square system of planting + additionally planted plants in the centre of square ie. 100 + 81 = 181

4. **Hexagonal system** = $\frac{\text{Area}}{\text{Spacing}} \times \frac{115}{100}$

5. **Triangular system** = $\frac{S}{D^2 x 0.8666}$

   S= unit surface
   D = Length of the triangle side

EXERCISE No. - 7

OBJECTIVE - Propagation through specialized Vegetative Structures

Propagation-The multiplication of plant through seed or vegetative means is known as propagation. There are two methods of producing new plants-

1. **Sexual method-** The multiplication of plant through seed is known as sexual method of propagation.

2. **Asexual or vegetative method-** The multiplication of plant through vegetative means is known as asexual method of propagation. It may be through division or separation/division, cutting, layering, budding and grafting.

   There are certain plant modifications which are used for vegetative propagation of plants. These modified plant parts may be stem, root, or leaves and are usually specialized for food storage. Two principal methods are used for propagation of plants by using these modifications.

   A- Separation: naturally detachable structures, such as bulbs or corms are separated and planted individually and

   B- Division: The plants modification such as rhizomes, tubers etc., are cut into sections to obtain new plants from each section.

   1- Bulbs: Bulbs are produced by monocotyledonous plants in which the stem is modified for storage and reproduction. Bulb is a specialized underground organ consisting of a short freshly, usually vertical stem axis bearing at tip apex or growing points and enclosed by thick freshly scales. Bulb scales morphologically are the continuous sheathing leaf base. Growing points develop in the axils of these scales to produce miniature bulbs known as bulbets/ daughter bulbs. These daughter bulbs cane separated from the mother plant at the end of growing season and used as propagating material.

   Ex: Tulip, Daffodils, Tuberose, Onion, Garlic (cloves)

   2- Tubers: A tuber is the short terminal portion of an underground stem which has become thickened because of accumulation of preserved food material eg: Potato. Propagation by tuber can be carried out either by planting the whole tuber or by cutting into sections each containing bud or eyes.

   3- Tuberous roots: Certain herbaceous perennials produce thickened roots which contain large amount of stored food. The tuberous roots differ from the tubers in that they lack nodes and internodes. Adventitious buds are present only at stem end or proximal end; fibrous roots are produced towards the distal end. These fleshy roots are separated and used for propagation. For example- Sweet potato, Dhahlia. Tapioca (Cassava).

4- **Rhizomes:** The horizontal, thick and fleshy or slender and elongated stem growing underground are known as rhizomes. Rhizomes have nodes and internodes and readily produce adventitious roots. The rhizomes are cut into pieces, each containing vegetative bud and transplanted. Eg: Banana, Ginger, Ferns, Turmeric, and Cardamom.

5- **Corms:** A corm is solid underground base of a stem having nodes and internodes and is enclosed by a dry scale like leaves. After flowering one or more corms may develop just above the old one, which disintegrates. In addition several new corms called caramels develop below each new corm. These may be separated and grown for 1-2 years to reach flowering stage. Eg: Gladiolus, Amor phophallus.

6- **Runners**: Runners are specialized arial stems (stolons) arising in the leaf axils of plant having rosette crowns. New plants arise from nodes at interval along these runners. From these runners more new runners may arise thus developing natural clonal multiplication methods. The typical runner producing plant is straw berry which is photo sensitive with regard to its runner production. Long days favour runner production where as short days prevent runner formation.Eg: Strawberry.

7- **Suckers**: Adventitious shoot from the underground portion of the stem or from their horizontal root systems are known as suckers and when these strike roots, they may be utilized as propagation materials. Well developed suckers are dugout and separated from the mother plant and planted in the nursery for further growth. Suckers are usually treated like rooted layers.Eg: Pineapple, Chrysanthemum, Curry leaf, Banana.

8- **Offsets/ offshoots:** An offset is a shoot or thick stem of rosette like appearance arising from the base of the main stem of certain plant such as date palm, pineapple etc., Date palm cultivars are propagated vegetatively by separating away the offshoots and replanting them. However these are girdled and layered for about a year prior to separation, because offshoots do not root easily when directly separated from the mother plant and planted in the field.

EXERCISE No. - 8

OBJECTIVE - Study on Propagation by Cutting

Cutting- It is a detached method of propagation in which any vegetative part of the plant is separated and planted to regenerate the missing parts and develop itself into a new plant. This method is commonly used in plants which root easily and readily, thus, multiplication of plant is very quick and cheap.

Purpose- Multiplication of plants by cuttings includes stem, root and leaf cuttings. The stem cuttings are of four types i.e., hard, semi hard, soft wood and herbaceous cutting. The success in propagation by cutting depends upon factors such as conditions of mother plant, parts of the tree where cuttings are made, time of year, care while planting and after care.

Materials required- Secateur, rooting media, nursery bed/pots, khurpi.

A. Stem cutting

Next to seed, the stem cuttings are the most convenient and popular method of plant propagation. A stem cutting is any cutting taken from the main shoot of a plant or any side shoot growing from the same plant or stem. It is essential for the cuttings to have a sufficient reserve food to keep tissue alive until root and shoot are produced. The shoots with high carbohydrates content roots better. Cuttings from new shoots (less than one year age) root better as compare to older shoot of the plant. Based on maturity of shoots, the stem cuttings are classified as-

1. **Hardwood cutting-** Hard wood cuttings are made from the mature and lignified stems of shrubs and trees.

   Procedure- Select one year old shoots current year or of previous season's growth about lead pencil thickness from healthy, vigorous and young plants. The length of cuttings varies from 10-25 cm in length depending upon species. Each cutting should have at least two or three buds. While preparing the cutting, a straight cut is given at the base of shoot about 0.3 cm below the node while a slanting cut 1-2 cm above the bud is given at the top. Remove the leaves from the cuttings. Treating the cutting with 100-5000 ppm IBA before planting gives better results Make holes in the rooting media/ nursery bed and burry the 2/3 basal portion of cutting in the holes at 45 degree angle facing slant portion to sun in the east. Press the soil around cutting firmly. Sprinkle water as and when necessary. Record the data as per technical programme. It is commonly practiced in Grape, fig, pomegranate, mulberry and phalsa.

2. **Semi hardwood cutting**

   Semi hardwood cuttings are prepared from semi matured 6-9 month old, slightly woody shoot. These are succulent and tender in nature and are usually prepared

from growing wood of current season's growth. The length of cutting varies from 10-20 cm. The cuttings are prepared by trimming the cutting with straight cut below a node. However, it is better to retain two to four leaves on the top of cuttings. Treating the cutting with IBA before planting gives better results in guava, lemon etc.

3. Soft wood/ Green wood cutting

Softwood cutting is prepared from soft, succulent and non-lignified 3-6 month old shoots which have not become hard or woody. Usually the cutting size is 5-15 cm but it varies from species to species. Usually few leaves are retained and before planting, treatment with auxin (IBA) is beneficial. This is commonly used for root stocks of apple, peach, plum and cherry in mist condition.

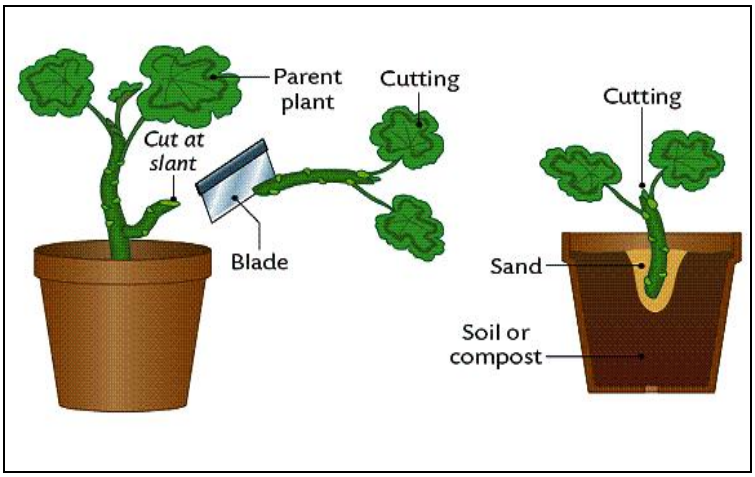
4. Herbaceous cutting- The cuttings are prepared from terminal soft, succulent and tender portion of 1-3 month old shoots of current growth under mist condition ensuring warm and humid condition. This is commonly used in ornamental plants.

B. Leaf/Leaf bud cutting

Leaf cutting should preferably be prepared during growing season because buds if inter in dormancy may be difficult to force to active stage. A leaf bud cutting consists of a leaf blade, petiole and shoot piece of stem with attached axillary bud of active growing leaves. In this cutting, 1-1.5 cm stem portion is used when propagating material is small. Leaf bud cutting are best made from material having well developed bud and healthy actively growing leaves. High humid condition is essential for better success in leaf cutting.eg. black berry, lemon, rasp berry.

C. Root cutting- This is commonly used in apple, pear, cherry, guava, black berry, fig, rasp berry, wood apple etc. The root cuttings should be taken from root pieces of young stock plants in late winter or early spring when the roots are well supplied with stored foods but before new growth starts. It is important with root cuttings to maintain correct polarity when planting as the new shoots develop from the proximal end ie. from the part close to the crown. The proximal end of the root piece should always be up.

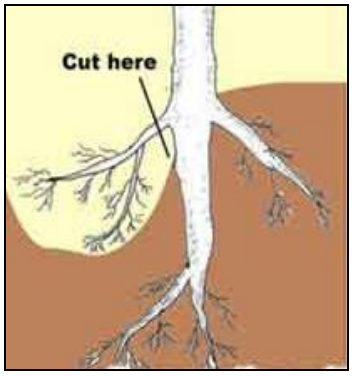
D. Others- Some different kind of cuttings are also used by propagators like Basal cuttings, Heel cuttings, Bud cuttings, Eye cuttings, Inter nodal and nodal cuttings, Irishmam's cuttings and Piping cuttings.



Herbaceous Cutting

Soft Wood Cutting

Semi Hard Wood Cutting ***Hard Wood Cutting***



Root Cutting ***Leaf Cutting with petiole*** ***Leaf cutting without petiole***

EXERCISE No. – 9

OBJECTIVE - Study on Propagation by Layering

Layering- The layering is the development of roots on a stem, while it is still attached to the parent plant. The rooted stem is then detached to become a new plant growing independently on its roots.

Purpose- Layering is the oldest technique used by nurserymen to propagate many horticultural plants. Plant multiplication through layering includes several forms of ground and aerial layering (Goottie).When branches running parallel to the ground are utilized, then the method is known as ground layering. When rooting is encouraged on the aerial part of the plant after girdling, then the method is called as air layering or goottie or marcottage.

Classification of layering-

A. Ground layering

1. Tip layering
2. Simple layering
3. Compound or serpentine layering
4. Trench layering
5. Mound or Serpentine layering

B. Air layering (goottie or marcottage)

Materials required- Secateur, budding knife, rooting media, nursery bed/pots, khurpi, sphagnum mass, polythene strip, sutali etc.

Propagation by layering

1. Tip layering

In tip layering, the tip of shoots is bend to the ground and the rooting takes place near the tip of current season's shoot. The tips of shoot buried 5-6 cm deep in the soil. Keep the soil wet where cane is buried for developing the roots. Rooting in the buried shoots takes place within a month. The new plants may be detached and transplanted in the nursery during spring. eg. Black berry, raspberry and gooseberry.

2. Simple layering

In simple layering, the flexible shoots of a plant are bent downwards over to ground in early spring or in rainy season. Remove a ring of bark or make a notch at a distance of 20-25 cm away from the tip to encourage rooting. The girdled portion is buried up to 7-10cm depth and covered with soil leaving the terminal end of the branch open. It is necessary to hold the cane/shoot in place with wire or wood stakes. Keep the soil wet where cane is buried for developing the roots. Rooting in the buried shoots takes place within a month. Eg. Grape, lemon etc.

3. Trench layering

In this method it is important to establish a permanent row of plants to be propagated. The mother plants are planted at the base of a trench at a angle of 45 ^{0} in rows. The long and flexible stems of these plants are pegged down on the ground to form a continuous line of layered plants. The young shoots that arise from these plants are gradually mounded up to a depth of 15-20 cm in autumn, winter or end of the season, depending upon the species. eg Apple rootstocks (M16 and M25), cherry, plum

4. Compound or Serpentine layering

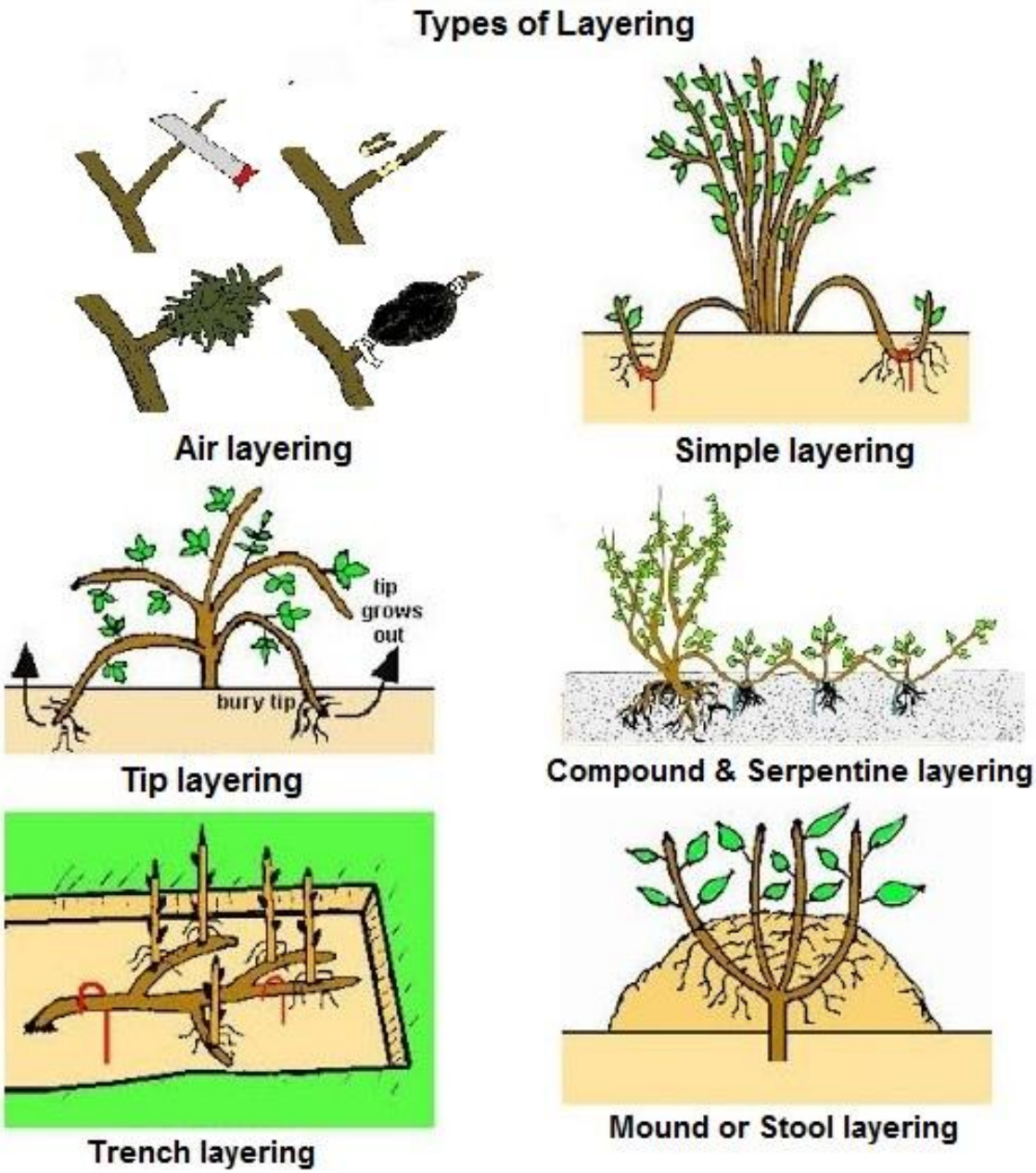
It is suitable for plant producing long, slender, and flexible shoots. It is modification of simple layering in which one year old branch is alternatively covered and exposed along its length. The stem is girdled at different point in the underground. However, the exposed portion of the stem should have at least one bud to develop a new shoot. After rooting, the section are cut and planted in the field eg. Jasmine, American grapes etc.

5. Air layering

Generally one to two years old, healthy and vigorous shoots having pencil thickness are used for air layering. First the leaves are removed near the basal – inter nodal portion which is away from 35 to 45 cm from apex of the selected shoots then the stem is given a notch or is girdled by removing a ring of bark about 2-3 cm wide. Application of root promoting hormones at the distal end at time of layering helps to get profuse rooting within a short time. Root promoting substances may be applied as powder or in lanolin or as a solution. IBA or a combination of IBA + NAA, both at the rate of 500ppm may be applied for better results. After application of hormones, ringed or girdled portion is covered with moist moss grass or handful of moist clay soil. This ball of earth may be again covered with sphagnum moss and wrapped with a 200 gauge polythene sheet. Air layering should be done either in spring or in monsoon. The rooted layers are either planted in pots or in the nursery beds in a shady place until they are fully established. Litchi, guava and pomegranate, lemon and Lime can be propagated by air layering.

6. Stooling/mound layering

In this method the mother plants are headed back to 10-15 cm above ground level during dormant season. The new sprout will arise within two months. These sprouts are then girdled and rooting hormone made in lanolin paste is applied to the upper portion of the ring. The concentration of rooting hormones are varies from plant to plant but in general 3000 to 5000 ppm is most commonly used. These shoots are left for two days for proper absorption of hormone before they are covered with soil. Care must be taken to keep the soil moist all times. The roots from shoots may emerge within 20-30 days depending on species. These rooted stools should be separated from the mother plant only after 60-70 days and then planted in the nursery beds. Eg. Guava, Apple rootstocks, quince, currants, raspberry etc.


Types of Layering
Air layering
Simple layering
tip
grows
out
bury tip
Tip layering
Compound & Serpentine layering
Trench layering
Mound or Stool layering

EXERCISE No. - 10

OBJECTIVE - Study on Propagation by Grafting

Grafting

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

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

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

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

ii. Production and interlocking of parenchymatous cells.

iii. Production of new cambial cell.

iv. Formation of new vascular tissues.

Different methods of grafting-

A- Attached method of grafting- Inarching, bridge grafting

B- Detached method of grafting – Whip, tongue, cleft, veneer, soft wood, epicotyl grafting.

1. Inarching

It is generally used for repairing or replacing damaged root system and hence also called as repair grafting. Selection of parent tree for taking the scion is an important factor for its success. The scion plant should be healthy, vigorous and high yielding. The stock is brought close to the scion. A thin slice of bark (6-8 cm long and about 1/3 inch in thickness at height) at about 20 cm above the ground level is removed from the stock with a sharp knife. A similar cut is made in the scion. Thus the cambium layers of both stock and scion are exposed. These cuts are brought together and tied firmly with the help of polythene strip. After successful union, stock above and scion below the graft union are looped of gradually. It is done soon after rainy season provided that temperature of the localities does not fall below the 15 0C. eg Mango, sapota, guava,litchi.

2. Veneer grafting

It is simple method of propagation and can be used in one year old rootstock seedlings having a diameter of 1.0-1.5 cm. For veneer grafting, 3-6 months old scion shoots are

selected. Usually, the terminal and next to terminal shoots are most ideal. The shoots are defoliated 5-10 days prior the grafting leaving the petiole attached. The rootstock is prepared by making a slating cut (5cm long) and an oblique cut is made at the base of first cut so that a piece of wood along with bark is removed. The base of the scion wood is then fitted into the rootstock in such a manner that the cut surface including the cambium layers of scion and rootstock face each other. The rootstock and scion are tied together with polythene tape. When scion growth begins the shoot of rootstock is removed above the graft union. Eg. Mango.

There are some other methods of grafting used for propagation of fruit plants.

3. Whip grafting

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

4. Tongue grafting- This method is practiced as whip grafting except one additional reverse cut is made on both scion and rootstock, so that cambial contact will be more with more success percentage.

5. Cleft grafting

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

6. Bark grafting

It should be done in spring when bark of the stock slips easily. It is important that scion used in bark grafting should be dormant. The stock is first sawed off at a point, where bark is smooth. Bark is split downward, about 5 cm from the top. Scion of 10-12 cm long, containing 2- 3 buds are collected from the dormant wood and are preparing by giving slating cut (5cm) downward along one side of the base. The prepared scion then inserted in the center of split between the bark and wood of the stock. The scion is kept firmly by using adhesive tape. eg Many fruit plant.

Special Grafting Techniques

7. **Epicotyl /Stone grafting-** This method is commonly practiced in mango. It is simple method of wedge grafting where the current season's scion shoot of the desired variety is inserted into the tender part of the stem of the sprouted stone (15-30 days old seedling) and tied with polythene sheet

8. **Top working-** This is commonly practiced to convert an old/ unproductive orchard of inferior variety in to productive one by grafting with desirable variety after head back of unproductive plant eg. Mango, ber, cashew nut, mulberry

9. **Soft wood grafting-** This technique is commercially used for raising Cashew nut, Mango, Jamun, Tamarind, Custard apple through wedge grafting. In this technique, grafting is done with mature, procured scion on the emerging soft, coppery red shoot of the rootstock, which is 60-70 days old.

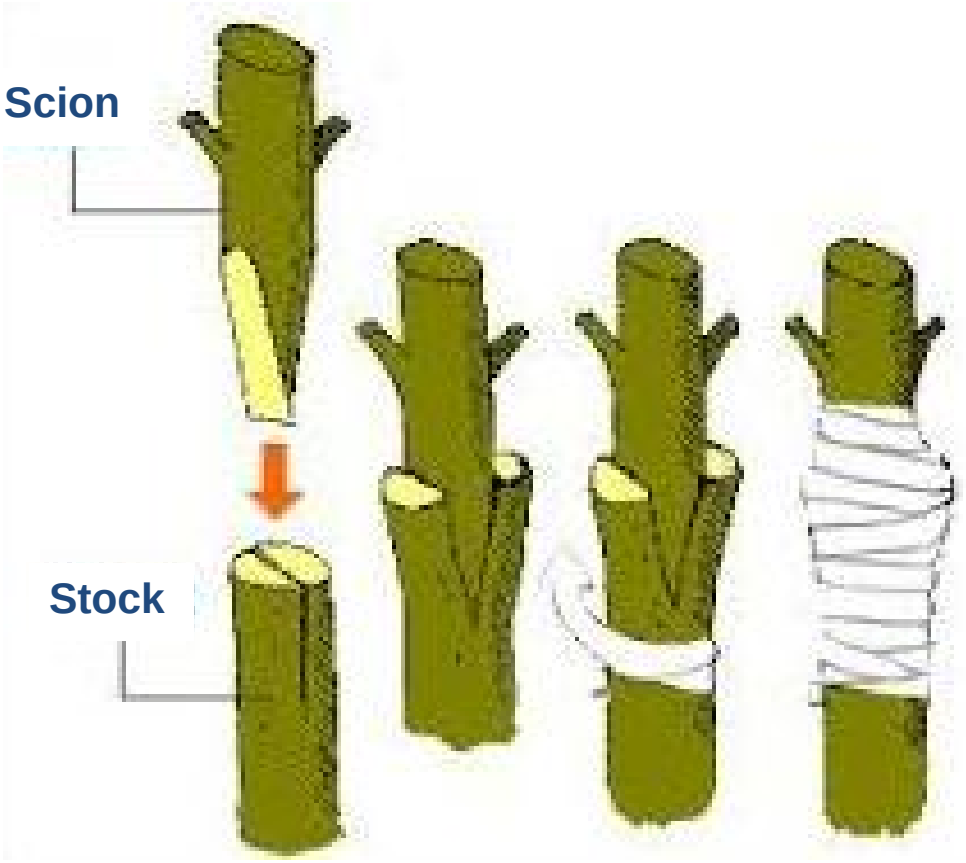
10. **Bridge grafting**- Bridge grafting is done with objective of repairing of damaged fruit plant. The scions are prepared by giving slanting cuts on one side of the top and base. These scions are inserted above and below the injury of the plant and tied properly.

11. **Double working-** Double working is a specialized technique of grafting in which the composite plant has three different components, the root stock, interstock and the scion i.e. the desired variety or cultivar. Thus the double worked plants have graft joints, one between the rootstock and interstock and other between the interstock and scion. It is done to overcome the incompatibility between the desired cultivar and stock.

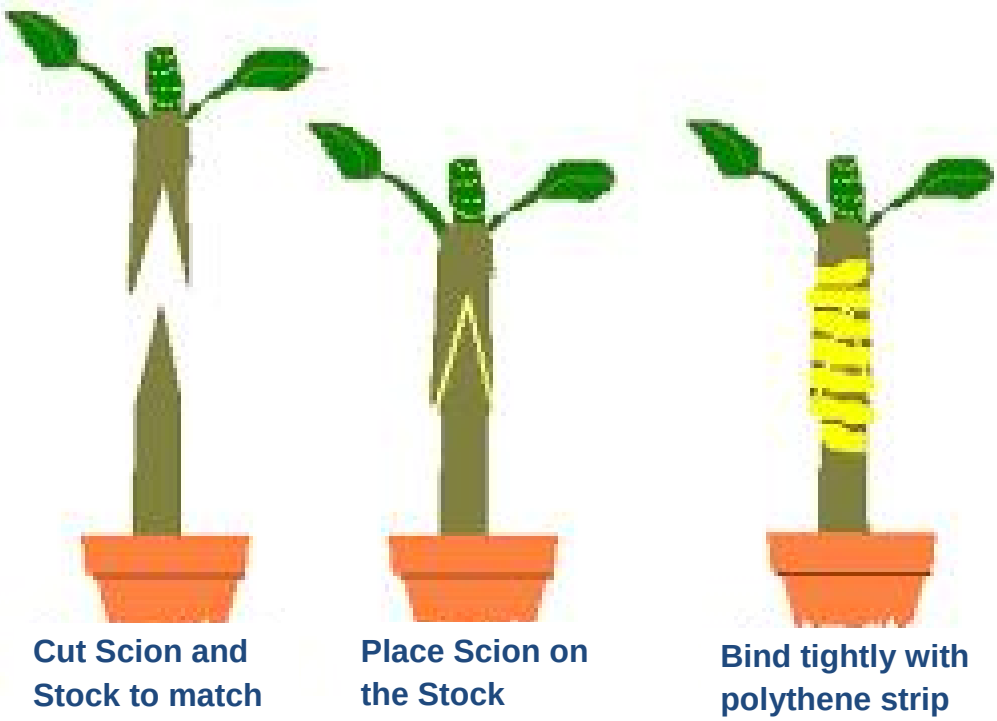
12. **Micrografting-** The grafting of tiny plant parts under asceptic and controlled environmental condition is called micrografting. Micrografting has been mostly used in citrus, apple and plum to produce virus free plants.

Inarching

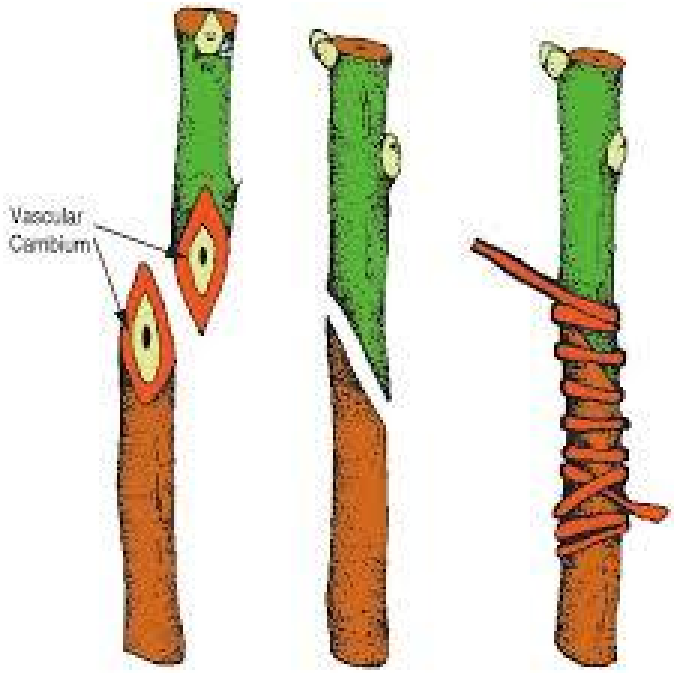
Veneer Grafting



Cleft/ Wedge Grafting



Saddle Grafting Inarching



Whip Grafting

Tongue Grafting

Epicotyl Grafting

Bridge grafting to repair damage

EXERCISE No. - 11

OBJECTIVE - Study on Propagation by Budding

Budding- Budding is also a method of grafting, wherein only a single bud with a piece of bark with or without wood is used as a scion material, which develops into plant after successful union of the stock and bud. Budding is generally done when the stock plant is in active growth and more cambial activity.

Bud Union- Like graft union, a series of changes takes place in the formation of successful bud union also. In general, four stages viz. pre- callus, callus, formation of cambial bridge and healing process etc. takes place for the formation of successful bud union.

Nurserymen employ various method of budding but according to convenience in performing the operations and percentage of success, the following methods are the commercially advocated in propagating various horticultural crops.

1. Shield or T-budding

A 'T' shaped cut is made on the selected portion of the stock with the help of sharp budding knife on one–year-old rootstock seedling having 2-2.5 cm thickness at 15-20 cm height. The bark of seedling should slip easily. The two flaps of bark are then loosened slightly with the help of budding knife. From the bud wood, which is selected from a healthy shoot of a current season's growth, the buds of middle portion are selected. These are removed from the bud wood by cutting shallowly about 5-6 mm below and 2-3 cm above the bud. This shield piece containing a bud is inserted carefully in 'T' shaped incision made on the stock. This bud then presses firmly and tied with polythene strip. After the bud has sprouted, the stock is cut to about 10-15 cm above the bud. eg citrus, aonla, custard apple, jamun, bael , plum, peach, cherry, ber, rose etc.

2. Inverted 'T' budding- As the name indicates, the cut is to be given on the root stock is reverse to that of 'T' i.e. inverted 'T' cut is given on the stock. This is widely used in high rainfall areas.

3. Patch budding

A rectangular patch of bark is removed completely from the one year old seedling stock and replace with a similar patch of bark containing a bud of desired variety. It is successfully used in species having thick bark such as aonla, bael, jamun, guava, walnut, pecan nut.

4. Ring budding

In ring budding, a complete ring of bark is removed from the stock and it is completely girdled. A similar ring of bark containing a bud is removed from the bud stick and is inserted on to the rootstock. In this budding both scion and stock should be of same size. It is utilized in peach, plum, ber, mulberry etc.

5. Modified ring budding.

In modified ring budding, complete ring of bark from the both scion and stock is removed by making one vertical cut on the opposite side of the bud, so that bud can be removed easily, eg. aonla, ber etc.

6. Chip budding

Chip budding is successful method of budding when the bark of the stock does not slip easily. A chip of bark and wood is removed from the smooth surface between the nodes of the stock. A chip of similar shape and size is then removed from the bud wood of desired cultivar. For which, a 2-3 cm long down ward cut is made through the bark and slightly in to the wood of the stock. Then a second cut of about 2.5 cm is made so that it bisects the first cut at an angle of 30-45 0.in this way the chip of wood is removed from the stock. The bud chip then slipped in the place of rootstock from where chip has been removed. eg grape.

6. Flute budding

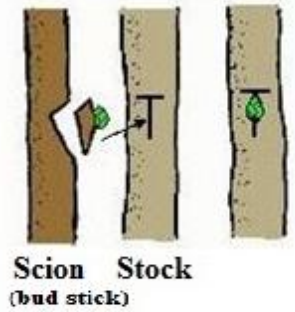
In flute budding a patch of bark (Flute) encircling the stock is removed leaving a narrow strip thereon. A similar patch of bark containing the bud is taken from the scion plant and placed on the cut surface of the rootstock followed by tying as usual when the bud exhibits the signs of growth, the top of the stock is cut back.

7. Forkert method of budding

It is modified method of patch budding, in which the bark flap of the patch is not removed from the stock plant but used to cover the bud on the stock plant. The bud is inserted in to the flap. It is covered with flap of bark on the stock plant and tied firmly with alkathene strip. Example- Aonla, ber bael and guava.

Types of Budding

Types Used When Bark is Slipping

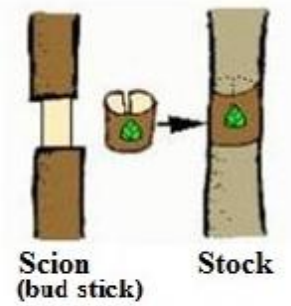


T-budding

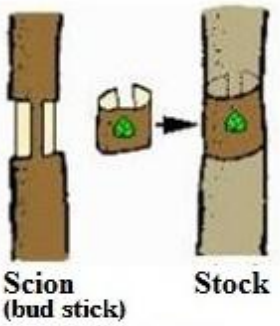
Inverted T-budding

I-budding

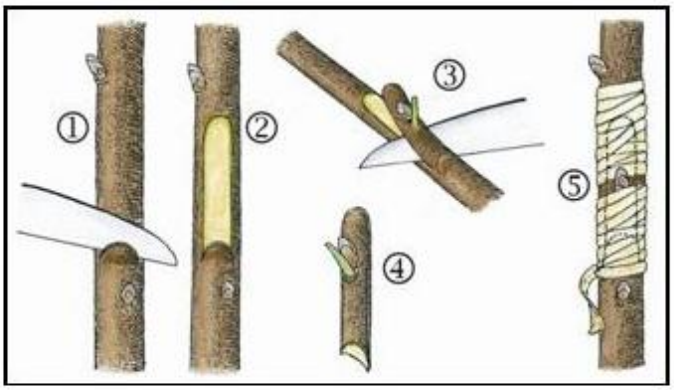
Patch-budding



Ring budding



Flute budding



Chip Budding

Exercise No. - 12

OBJECTIVE - Study about Micro propagation

Micro propagation refers to the production of plants from very small plant parts, tissue or cells grown aseptically in a test tube or containers under controlled nutritional, environmental and aseptic conditions. Tissue culture or *in vitro* culture is two broadly used term for micro propagation. Micro propagation is an advanced vegetative propagation technology for rapidly multiplying a large number of genetically superior and pathogen-free plants or genetically modified plants in a limited time and space throughout year.

Basic requirements for micro propagation-

1- A well equipped laboratory

2- Aseptic condition

3- Culture Medium (Nutrient media)

4- Controlled culture environment

5- Acclimatization/Hardening chamber

Principle- All the biological principle of micro-propagation technique are based on the phenomenon of *totipotency* of a cell, which is the capacity of a plant cell to regenerate in to a complete plant having different organ. German Plant physiologist, Haberlandt (1902) is known as the father of plant tissue culture technique, who for the first time coined the term *totipotency*.

Process-The process of tissue culture consists of five important steps: Initiation, Multiplication, Shooting & rooting, Primary Hardening in green houses and Secondary Hardening in shade houses. Strict adherence to aseptic standards and micro-climatic conditions and care during the hardening process alone can ensure success.

Stages of micro propagation

A) **Stage-1 Establishment-** It includes selection of an elite mother plant- Explant- Surface sterilization and washing- Inoculation in culture medium.

B) **Stage-2 Proliferation-** Transfer in proliferation medium – shoot and embryoid formation

C) Stage-3 Rooting and Hardening- Transfer of shoots to rooting medium and after rooting transfer in artificial medium or sterilized soil by gradual weaning process

Banana propagation through tissue culture

Purpose-The main method of vegetative propagation in banana is by means of daughter suckers formed at the base of the pseudo stem (5 to 10 in number depending on the variety). Traditionally, sword suckers with narrow leaves, weighing approximately 500-1000 gm are the preferred planting material for vegetative propagation. The major constraint for conventionally propagating banana is the lack of ready availability of large quantities of sword suckers at any given time. The problem is felt more acutely in non-availability of sword suckers consistently.

Besides, suckers generally may be infected with some pathogens and nematodes. Similarly, due to the variation in age and size of sucker, the crop is not uniform, harvesting is prolonged and management becomes difficult. Therefore, *in vitro* clonal propagation i.e. tissue culture plants (properly hardened secondary seedlings) are recommended for planting as they are healthy, disease free, uniform and authentic. The sterile operational nature of tissue culture procedures excludes fungal, bacteria, viral and pests from the production system. Banana plants produced from tissue culture are free from diseases at the time of supply. Since they are produced under controlled laboratory conditions using selected nutrients, they usually give yields one or two month earlier than conventionally propagated plants.

Advantages of Tissue Culture in banana:

1. Initiation and establishment of rapidly multiplying aseptic shoot cultures can eliminate the problem of low sucker multiplication rates effectively and economically.
2. Large number of uniform propagules can be generated in a relatively short period of time.
3. Variability encountered in size and propagules density can be minimized.
4. It could allow for rapid bulking of novel clones when used in concert with breeding programs.
5. It would facilitate transcontinental exchange of disease diagnosed planting material.
6. With refinement in preservation techniques, *in vitro* culture of bananas can be of immense value in germplasm conservation.
7. Pest and disease free seedlings. Round the year planting possible as seedlings are made available throughout the year.
8. Uniform growth, early maturity of crop - maximum land use is possible in low land holding country like India.
9. Two successive ratoons are possible in a short duration which minimizes cost of cultivation increases yield
10. 95% - 98% plants bear bunches. No staggered harvesting, higher yield.
11. New varieties can be introduced and multiplied in a short duration.

Process involved in Micro-propagation of Banana

The tissue culture process involves the micro-propagation of a sucker growing point under sterile conditions. A sucker is detached from the nursery parent plant and brought to a laboratory where the outside tissue is pared away until only the growing point remains inside a plug of 10 mm^3. This is placed in a jar on agar containing a nutrient solution in a sterile environment and under controlled conditions of temperature and light. The growing point subdivides into several shoots, which are subdivided and re-established on fresh agar. This process, called sub-culturing. The sub culturing, continues about five or eight times (one month per sub-culture) until approximately 1000 plants are produced from one original growing point These plants are then transferred to a rooting medium and when fully rooted, they are transferred from *in vitro* conditions (sterile under glass) to *in vivo* conditions (seedling trays in a greenhouse environment). After 6 to 8 weeks, the 5 cm plants are relocated from the greenhouse trays to nursery bags in a netted shade house. After another 6 to 8 weeks, the 20 cm plants are ready for

planting out in the field. The entire process from excavating the original sucker to planting out 200 mm plants in the field takes about 10 months.

Media details:

1. Initiation and multiple shoot induction: MS+ BAP 5 mg/L
2. Shoot Elongation: MS+ BAP 2 mg/L + IAA 0.5 mg/L
3. Rooting: ½ MS + IBA 0.5 mg /L + NAA 0.5 mg /L + 0.05% activated charcoal
4. Hardening: Ex-agar plants in mist chamber in coco peat and then in shade house for secondary hardening with sand: Red soil: FYM 1:2:1 ratio for 15-45 days.

STAGES:

Establishment (Explants Preparation, Disinfection, Inoculation and Incubation):

Sword suckers are carefully removed from field grown fruiting banana plants and traces of soil particles adhering over are removed by repeated washing thoroughly in tap water and in a solution of the diluted detergent teepol. The extraneous rhizome tissues are carefully chopped with a stainless steel knife. Trimmed suckers are now soaked in a solution of Bavistin (0.5%) –a fungicide and streptocycline antibiotic for six to eight hours.

To prevent the oxidation of phenolic compounds, the trimmed buds are stored in antioxidant solution (100 mg Ascorbic acid + 150 mg Citric acid per litre of sterile water.) till the buds are taken to laminar flow chamber for inoculation.

Shoot tips containing rhizome tissue and measuring 2.5 to 3.5 cm in length are isolated, surface sterilized using 70% ethanol for 1 min and then with mercuric chloride. Two different concentrations of mercuric chloride were used. First the sucker was sterilized using 0.12% mercuric chloride for 2 min. After that, the mercuric chloride was removed and the sucker was washed using sterile distilled water. At first, the sterile distilled water was added and the bottle was shaken for 1min., then the water was removed and fresh sterile distilled water was added, shaken for another one min and then the water was removed with the following timings 1 min, 2 min, 3 min, 5 min and 12 min.

After the first sterilization, a layer of the sucker is removed carefully. The suckers are again sterilized with 0.1% mercuric chloride for 5 min. After that they were washed with sterile distilled water following the timings 1min,1min, 2 min,3 min,5 min and 12 minute. Finishing the above process, another layer of the sucker was removed. The sterilized shoot tip explants are handled using sterilized stainless steel scalpels.

Cut surfaces of the rhizomatous tissue and leaf bases are further trimmed so that shoot tips finally contain at least six to eight overlapping leaf bases enclosing auxiliary buds. A vertical cut is given (to arrest the apical dominance) and the buds are inoculated in the semi-solid prepared for multiple shoot induction. The explants are now ready for inoculation and measures 1 to 2 cm. The optimum size of the explants depends on the purpose. For rapid multiplication, relatively larger explants (3-10 mm) are desirable despite its higher susceptibility to blackening and contamination.

When virus or bacteria elimination is needed, meristem tip culture is the preferred option. The explants are further reduced in size (0.5-1 mm length) leaving a meristematic dome with one or

two leaf initials. Meristem cultures have the disadvantage that they may have a higher mortality rate and poor initial establishment.

For banana micro propagation, MS based media are widely adopted. Generally they are supplemented with sucrose as a carbon source at a concentration of 30-40 g/L. Usually two types of growth regulators used, a cytokinin and an auxin, are added to the banana growth medium. Their concentration and ratio determines the growth and morphogenesis of the banana tissue. In most banana micro propagation systems, semisolid media are used. As a gelling agent, agar (5-8g/L) is frequently added to the culture medium. Media are poured in a glass bottle where suckers are propagated.

Cultures should be incubated in the basal nutrient media supplemented with plant growth regulators. Thereupon the healthy, contamination free explants should be taken for next multiplication stage.

Banana shoot tip cultures are incubated at an optimal temperature of 26 ± 2^{0}C in a light cycle of 12-16 h with a photosynthetic photon flux(PPF) of 60µE/m^2s.After 2 weeks, the suckers will become greenish in colour and the multiple shoots will arise from the base of the suckers. The shoots are cut at the base, separated and placed in a fresh medium. In each bottle, three-five shoots were inoculated. After 2-3 weeks, multiple shoots arise from the inoculated shoot. Again they are separated and placed in afresh medium. The sub culturing is done until the required quantity of plants is needed. The shoots are every day checked for contamination and the contaminated shoots are transferred to a fresh medium. Meanwhile a set of well grown healthy shoots are taken for rooting.

Mass Multiplication

Contamination free explants are further cultured on multiplication media supplemented with plant growth hormones (cytokinins) which help in proliferation of auxiliary buds into multiple shoots.

Rooting:

Plantlets from shooting media are separated and single plantlets are transferred to media containing charcoal and auxins or medium without any growth regulators. It will take 2-3 weeks for rooting and fresh roots arise at the base of the shoot. In this stage, roots will develop and plants will be ready for dispatch from laboratory.

Agar Weaning of Plants

Well developed single plantlets need to be removed from the culture incubation room and exposed to ambient conditions in the culture vessel for four to five days. The plantlets are then carefully removed and the roots washed in running tap water. The plants after being removed from nutrient media should preferably be transplanted within 72 hours.

Primary hardening will take at least 4 weeks depending upon the climatic conditions. In final week, these trays are gradually exposed to 50% shade by removing plastic sheets. These plantlets are sprayed with fungicides, bactericide, and water soluble fertilizers as per schedule.

Secondary Hardening

Primary hardened plants after 4 to 5 weeks are transferred to Poly bags (Nursery Bags) of suitable size. Soil mixture is prepared by mixing sand, soil and farm yard manual into 1:2:1 ratio. The plants are kept in these Poly bags for 6 to 8 weeks under 50% shades. Humidity is maintained around 60% to 70% and regular foliar sprays of plant protection chemicals and water soluble fertilizers are given regularly. Any possible variation if observed is discarded at this stage. The plant ready for sale will be having 5 to 6 opened leaves and almost 1 feet in height. The plantlets after acclimatization should be transported to the required place. Normal transportation is done where the plants are placed and grown in plastic bags. Well grown plants are removed to provide space in green house for the next cycle of plants and also to lower the cost of storage. Polybags is separated from the plant without disturbing the root ball of the plant and then plants are planted in the pits keeping the pseudo-stem 2 cm below the ground level. Soil around the plant is gently pressed. Deep planting should be avoided.

Problem of Banana Micro Propagation

Banana tissues often suffer from excessive blackening caused by oxidation of ployphenolic compounds released from wounded tissues. Therefore, during first 4-6 weeks, fresh shoot tips are transferred to new medium every 1-2 weeks. Alternatively, freshly initiated cultures can be kept in complete darkness for one week. Anti oxidants such as ascorbic acid or citric acid in concentrations ranging from 10-150 mg/L, are added to the growth medium to reduce blackening or the explants are dipped in anti oxidant solution (Cysteine 50 mg/L) prior to their transfer to culture medium.

Banana Vegetative Propagation

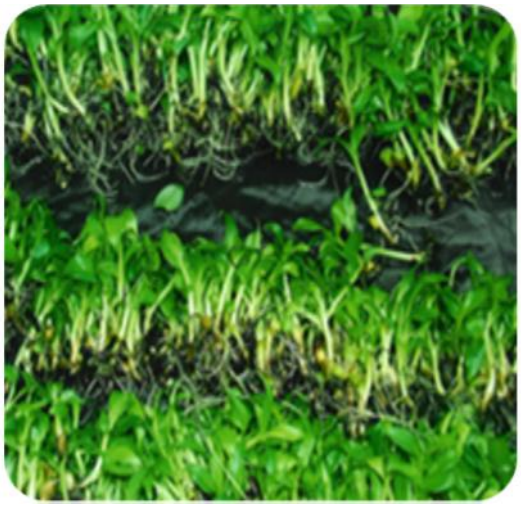
Trimming Explant For Propagation

Initiation Of Banana Micropropagation


Multiplication

Shoot Elongation

Invitro rooting



Weaning of Agar



Banana Hardening

EXERCISE No. - 13

OBJECTIVE - Study about Training and Pruning

Training and pruning are an important activity in fruit crops to have better frame work and optimum fruiting area. Training refers to giving a desired shape to the plants by tying or staking or supporting over a structure and or selective pruning for a good strong frame work. Pruning refers to cutting of certain portion of plants for maintenance of fruitfulness and quality besides vigour of the trees or vines. Pruning affects the functions of the plants and assists in better fruiting and in getting more quality fruits. It is one of the most crucial operations and requires some scientific knowledge regarding bearing behavior of the plants.

Objectives of Training

The major objectives of training are

i. To give a strong frame work to the tree for supporting good cropping.
ii. Provide good exposure of light and air to branches and leaves.
iii. To maintain tree growth in such a way that that various cultural operations, such as spraying, annual pruning, harvesting etc can be done at the lowest cost.
iv. To protect the tree from sun burn and damage.
v. To secure a balanced distribution of fruit bearing parts on them in limbs of the tree.
vi. Maintain the vitality of trees over a long period of time.

Methods of Training

There are three most commonly used training methods are followed in fruit crops based on the growth habit of the fruit tree. These are

1. Open Centre

In this system of training, the main stem is allowed to grow only upto a certain height, thereafter it (leader or main stem) is headed back to encourage lateral branching (scaffold branches). This system is also known as **Vase-shaped system**. This system allows better distribution of sunshine and to reach it to branches of trees and also facilitate cultural operations like spraying, thinning, harvesting etc.

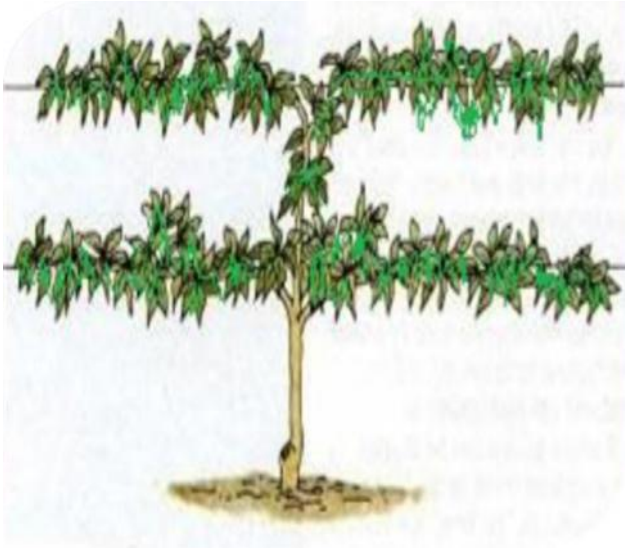
2. Central Leader

In this system of training, main stem (leader) is not headed back and is allowed to grow I its natural ways extending from surface level to the top of the tree. This results in robust close centre and tall tree and branches are more fruitful near the top as compared to lower branches. This system of training is also known as closed centere done.

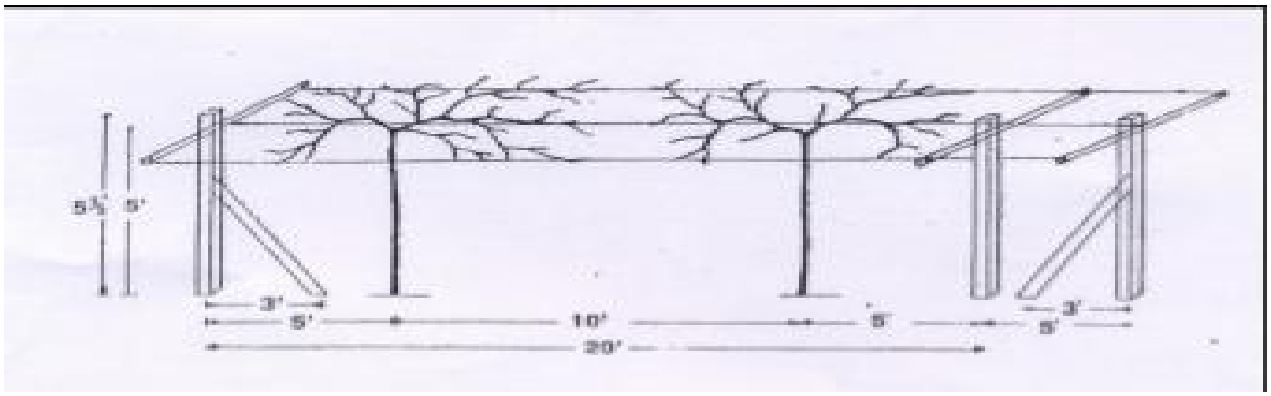
3. Modified leader

It is intermediate between the open centre and central leader training system. In this system main stem is allowed to grow unhampered for the first four or five years, thereafter it is headed back and lateral branches are allowed to grow as in the open centre system. Modified leader system produces fairly strong and moderately spreading trees.

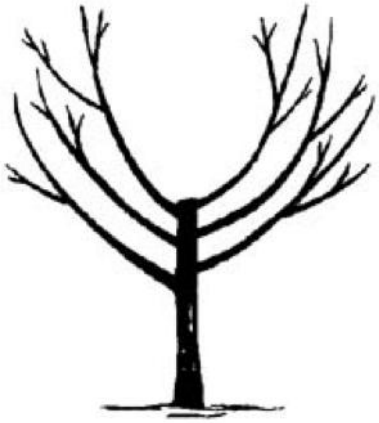
Trees are trained to different forms with or without the support of certain structures.



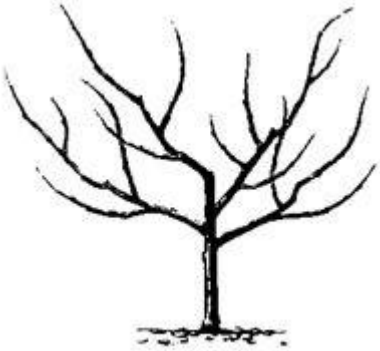
ESPALLIER SYSTEM/CORDON SYSTEM



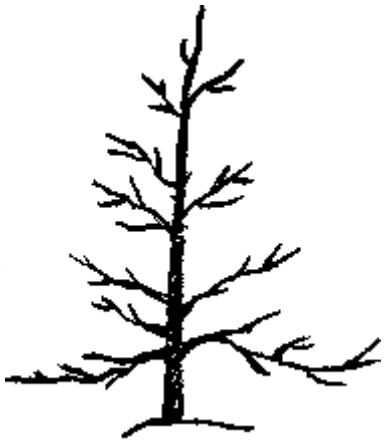
TELEPHONE SYSTEM



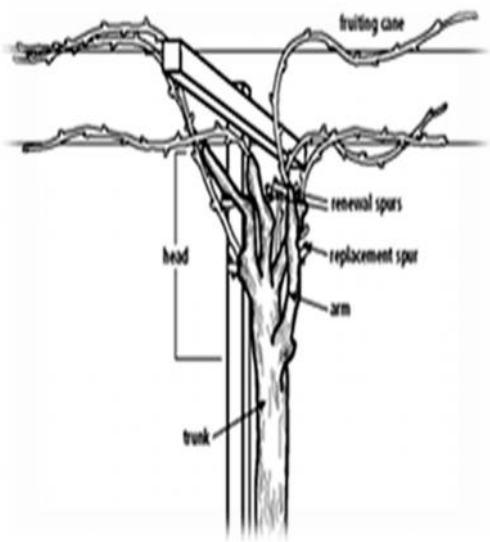
Open Center System



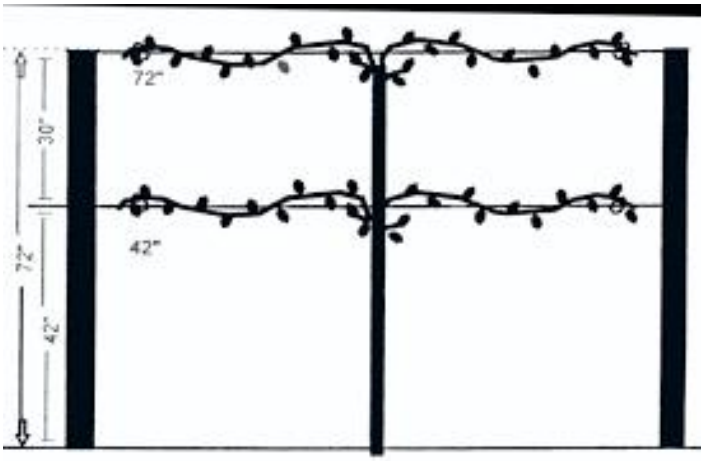
Modified leader System



Central Leader



HEAD SYSTEM



KNIFFIN SYSTEM

BOWER SYSTEM

Special methods of training-

Bower system

It is also called as 'Pandal' 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.

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 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. Vines are allowed to grow up to a height of 1.5 to 2.0 m and then trained on this system. Moderately vigorous cultivars with apical dominance are best trained on such system.

Head System

It is mostly used for spur bearing grape cultivars. In this system, vines are trained like a small bush. Vines are allowed to, grow up to 1.2 meters, and then headed back to produce laterals. Four laterals- one in each direction is allowed to grow and rest are thinned out. In next dormant season, these laterals are cut back to 2 buds and further two arms of 20-30 cm are allowed on

each secondary arm. After 3-4 years these vines will give a dwarf bush like appearance and requires no staking. Other training systems which require no staking are Palmette, Spindle bush, Dwarf pyramid and Head and spread systems.

Cordon and 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 system are called **'espaliers'**. An espalier with one shoot or two shoots growing in opposite or parallel directions are called a **'cordon'**.

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 60^0 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 60^0 from the horizontal.

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

The pome fruits such as apple, plum, pears and peaches are pruned every year in December - January. Under North Indian conditions, the grapes are pruned in first fortnight of January. Under South Indian conditions, old non bearing mango trees are pruned during August – September. 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 practice 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

This refers to reduce the plant height and to promote auxiliary branching for example Carnation, chrysanthemum

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 practice is commonly done in cut flowers like carnation, chrysanthemum, dahlia, marigold and zinnia etc.

Thinning

Fruit thinning 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.

Methods of thinning

1. Hand thinning
2. Chemical thinning

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

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

Time of thinning- At blossom time, at pea and marble stage of fruit, soon after the natural fruit drop of young fruits has started.

EXERCISE No. - 14

OBJECTIVE - Study of Manures and Fertilizers Application

In a general way, manures and fertilizers are the substance containing plant nutrients, which is applied to the soil for increasing crop production.

Manures -

Manures are plant and animal wastes that are used as source of plant nutrients. They release nutrients after their decomposition. Manures can be grouped into bulky organic manures and concentrated organic manures.

a. Bulky organic manures - Farm Yard Manure (FYM), compost from organic waste, night soil, sludge, sewage, green manures.

b. Concentrated organic manures - oilcakes (edible, non-edible), blood meal, fishmeal and bone meal.

Fertilizers-Fertilizers are industrially manufactured chemical containing plant nutrients. Nutrient content is higher in fertilizers than organic manures and nutrients are released almost immediately. The fertilizers have three groups;

Straight fertilizers – supplies single nutrient Ex: Urea, Muriate of Potash

Complex fertilizers - supplies two or more nutrient Ex: 17:17:17 NPK complex

Mixed fertilizers- supplies two or more nutrient Ex: Groundnut mixture.

Bio- fertilizers: Biofertilizer is an organic product containing a specific microorganism which has ability to convert unavailable nutrients in to available form through biological process eg. Rhizobium, Azotobacter, Azospirillum, Blue Green Algae, PSB,

Role of manures and fertilizers-

1. Organic manures bind the sandy soil and improve its water holding capacity.
2. Organic manures open the clayey soil and help in aeration for better root growth.
3. Organic manures add plant nutrients in small percentage and also add micronutrients, which are essential for plant growth.
4. Manures increase the microbial activity which helps in releasing plant nutrients to available form.
5. Organic manures should be incorporated before the sowing or planting because of slow release of nutrients.
6. Fertilizers play an important role in crop production as they supply large quantities of essential nutrient to crops

7. Fertilizers are manufactured in forms that are readily utilized by plants directly or after rapid transformation.
8. Fertilizers dose can be adjusted to suit the requirement as determined by soil testing.
9. Balanced application of nutrient based on crop requirement is possible by appropriate mixing of fertilizers.
10. Fertilizers applied as straight fertilizers (providing single nutrient) or complex and mixed fertilizers (supplies two or more nutrients) based on crop requirement.

Enhancing fertilizer use efficiency-The following are the agronomic measures to improve the Fertilizer use efficiency (FUE).

1. Using best fertilizer source
2. Using adequate rate & diagnostic techniques
3. Use of balanced fertilization
4. Integrated nutrient management
5. Utilization of residual nutrients

Nutrient assessment in Fruit crops-

Management system adopted for fruit trees are quite different, especially with regard to nutrient than that adopted for field crops. The shift in management system could be commenced 3-4 years after planting depending on the tree size. Nutrients are required for flowering and fruiting while at the same time trees are allowed to grow and maintain sufficient vigour for producing high yields in following years. To maintain productivity of trees in long run and maintain the sustainability of tree production capacity, application of nutrient should be based on actual requirement and availability of nutrient in the soil. Application of plant nutrients economically at correct time with right amounts in a way that nutrients could be taken up by plants efficiently with minimum losses. The purpose of assessment of nutrient requirement of fruit trees is to keep mineral nutrient levels in the tree with in the desired range to have the growth and development effects and fruiting of trees as desired.

The most important thing in nutrient management for bearing trees is to analyze the importance of timing of nutrient application in relation to tree phenology or growth cycle.

Factors influencing nutrient content of the soil

- Type of vegetation cover; e.g. with legume cover there could be higher N, etc.,
- Application of manures and fertilizers.
- Application of soil amendments.
- Inherent status of soil

Factor affecting nutrients content of the leaf

- Fertilizers input
- Type of vegetation cover; e.g. with legume cover there could be higher N, etc.,
- Factors inherent in the tree; genetic make-up, age of crop, time of sampling; yearly (seasonal) variation, age of leaves, position of leaves, yield of crop.

Leaf Samples

Leaf analysis is an important tool to estimate nutritional requirement of fruit trees. Leaf nutrient content can be obtained by analyzing leaf tissues at proper growth stage. Thereafter, nutrient requirement of fruit trees can be calculated based on optimum norms of tissue nutrient in different fruit crops.

Application of manures and fertilizers: It depends mainly on basic principles of what to apply, how much to apply, how to apply, when to apply and where to apply.

Methods of application of solid manures and fertilizer-

Fertilizer recovery is greatly influenced by method of its application. Method of application varies according to the spacing of crop, type of fertilizer material, time of application. Various methods of application of fertilizers are in vogue and following are few important practices widely adopted.

A - Broadcasting – It refers to spreading fertilizers uniformly all over the field on entire area or in basins. It is of two types-

i. Basal dressing- Spreading of fertilizers before sowing or planting of the crops and mixing them by cultivating the soil during seed bed preparation is termed as basal application through broadcasting.

ii. Top dressing and side dressing- Spreading of fertilizer in standing crops without considering the crop rows is termed as top dressing. But when the crop rows are taken into account and the material is dropped on the ground surface near the crop rows then it is called as side dressing.

B. Placement-This refers to applying fertilizers into the soil from where the crop roots can take them easily. Placement could be done in following ways:

i. Plough sole placement-When the fertilizers are applied in open furrows at plough sole level while ploughing then it is termed as plough sole placement. Such furrows are covered immediately during the next run of the plough.

ii. Deep placement-The method is adopted in dry land condition where the fertilizers are placed deeper than plough sole level then it is called as deep placement.

iii. Sub-soil placement-When fertilizers are placed still deeper than the seeding or planting depth and also deeper than the previous two methods the method is termed as sub-soil placement.

C. Localized placement

There is distinction between placement and localized placement. The former refers to applying fertilizer into the soil without special reference to the location of seed or plant while the latter implies the application of fertilizer into the soil close to the seed or plant. The method could be adopted in following ways:

a. **Contact placement/combine drilling-**When fertilizer is placed along with seed then it is called as contact placement. This is done by using seed-cum-fertilizer drill. Sometimes fertilizer is drilled by implement and seed is sown in the same furrow.

b. **Band placement-**This is a localized placement of fertilizers by the side of plants or seeds (about 5 cm apart). This may be of two types as the bands may be continuous or discontinuous:

   i. **Hill placement (discontinuous band)-**In the hill for widely spaced plants like cucurbits, and castor etc fertilizers are placed on either of both sides of plants along or across the row but not along the entire row. This method is also termed as discontinuous band application.

   ii. **Row placement (continuous band)-**Along the entire rows of closely spaced crops like vegetables-potato and flowers fertilizers are applied continuously at 2-2.5 cm depth. This method has a definite relationship of fertilizers with seedlings or seed as the fertilizer is placed to the side of seedlings or seeds some distance away from them or at the level of the seed, above or below or by the side of the seed level. When the soil surface is dry, this method gives very promising results.

   iii. **Ring placement (continuous band)-**Fertilizer is applied in a circle around individual plant or hill base at a depth of about 2.5-5 cm. It is most common method in fruit crops.

c. Pocket/spot placement-

When fertilizers are placed at a fixed spot by the help of a bamboo peg having a hole at the bottom in case of very widely spaced crops then the method is termed as pocket/spot placement method. Fertilizers are placed deeper into the pocket (dibble) and seeds are sown in the same pocket about 5 cm above the fertilizers.

d. Pellet placement

This method is adopted specially in case of deep water(rice cultivation) where it is difficult to apply fertilizers in normal methods as the fertilizer granules get dissolved in water before reaching to the ground level. In this method fertilizers (especially nitrogenous ones) are mixed with clay soil in the ratio of one part of fertilizer into 10-15 parts of soil. The fertilizer is well mixed with soil after slight moistening then filled in gunny bags and stored for two-three days. Now small mud bolls are prepared and these boll or pellets are dropped near the crop rows under deep water conditions.

Method of application of liquid fertilizers

Use of liquid fertilizers is not very common practice but in advanced countries, this is the most common method. It is the most suitable method under dry land agriculture and in the areas which are prone to erosion problems. Liquid fertilizers may be applied in following ways:

1. **Starter solution**- As the name indicates, this type of fertilizer application helps the plant in starting the growth quickly after plant establishment. Starter solutions usually contain N, P, K in 1: 2: 1 or 1: 1: 2. This method is used for transplanted crops where in place of irrigation water this solution is applied just to wet the field.

2. **Fertigation**-The required quantity of fertilizer material is dissolved in irrigation water and can be used in surface, sprinkler or drip irrigation systems. This method has got popularity after advent of drip irrigation.

3. **Nutrient injection method** - In USA and some other countries anhydrous ammonia is injected into the soil at a depth of about 20-25 cm and at a pressure of about 200 pound per square inch. Injecting hormonal solution and some micro nutrient solutions in the phloem region of the fruit trees is also becoming a distinct possibility in correcting the nutrient deficiency.

4. **Foliar spray of nutrient solutions**-In this method of fertilizer application urea, micro nutrients and other required materials are dissolved in water, filtered and sprayed over the crop foliage by the help of a suitable sprayer.

5. **Aerial application**-In areas where ground application is not practicable, the fertilizer solutions are applied by aircraft particularly in hilly areas, in forest lands, in grass lands or in sugarcane fields etc.

Time of application: Depending upon crop, annual, biennial or perennial or variety, stage of crop growth etc, the time of application varies. The time of application also varies according to type of nutrient one would like to supply. Usually FYM/compost is applied at the time of land preparation at least 15 days before sowing or planting in respect of annuals or short duration crops. However, in the case of perennials, they are applied to pits at the time of planting and to basins during subsequent years. Similarly, if a green manure crop is grown it will be ploughed

back to the soil before flowering and well before the crop is sown/planted to ensure proper decomposition and availability of nutrients for early growth and development. The P & K are applied basally at the time of sowing or planting. But nitrogen is applied in varying number of splits depending on the crop and its duration. In any case fertilizers should be made available at right time in right quantity.

Calculation of quantity of fertilizers based on nutrient requirement

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

$Q = (N_1 \times 100) \div N_2$

Where,

Q = Quantity of fertilizer

N1 = quantity nutrient required

N2 = nutrient present in fertilizer

Or

Q = quantity of nutrient required x factor

Calculation of quantity of complex fertilizers

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

Calculation of quantity of chemicals for spray solution

$V_1 = (C_2 \times V_2) \times C_1$

Where,

V_1 = quantity of chemical or commercial product

V_2 = volume of spray solution to be prepared

C_1 = nutrient content in chemical or commercial product

C_2 = concentration of spray solution

Or

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

Factor for calculating quantity of different fertilizers:

Fertilizers	**Factor**
Nitrogenous fertilizers	
Urea	2.17
Calcium Ammonium Nitrate	3.85
Ammonium Nitrate	2.94
Ammonium Chloride	4.00
Calcium Nitrate	6.45
Ammonium Sulphate	4.84
Phosphatic fertilizers	
Single Super Phosphate	6.25
Rock Phosphate	5.56
Bone Meal	5.00
Potassic fertilizers	
Potassium Sulphate	1.92
Potassium Chloride	1.66
Potassium Magnesium Sulphate	4.55

****

3/4/5/6

35/36/37/38

27/28, 47/48

31/32, **41**/42, 49/**50**, 51/**52**

DEPARTMENT OF HORTICULTURE

College of Agriculture
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)