የሥራና ክህሎት ሚኒስቴር
Ministry of Labor and Skills

Crop Production Level -IV

Based on March, 2022 Version 4 Occupational standard



Module Title: Planning Horticultural Crops Propagation Program

LG Code: AGR CRP4M050124 (LO 1-3) (LG 24-26)

TTLM Code: AGR CRP4 TTLM05 01 24 v1

January, 2024

Addis Ababa, Ethiopia

Contents **Page**

Introduction to the module 3
LO #1- Carrying out preliminary planning activities 4
Instruction sheet: 4
Information Sheet-1 6
Self-check-1 44
Operation sheet -1 46
LAP Test -1 50
LO #2 Develop propagation plan 51
Instruction sheet: 2 51
Information sheet -2 53
Self-check-2 86
Operation sheet 2 88
LAP Test -2 89
LO #3 Monitor success of propagation activities 90
Instruction sheet: 3 90
Self-check-3 100
References 102

Introduction to the module

This unit covers the knowledge, skills and attitude of carry out preliminary planning activities for a plant propagation program, develop the propagation plan, prepare parent material and monitor success of horticultural crop propagation activities.

LG #24	LO #1- Carrying out preliminary planning activities

Instruction sheet:

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Confirming and understanding management and marketing requirements
- Evaluating space requirements
- Determining propagation techniques
- Determining environmental parameters
- Determining budget for the propagation program
- Identifying OHS hazards ,assessing risks and implementing controls

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Confirm and understand management and marketing requirements
- Evaluate space requirements
- Determine propagation techniques
- Determine environmental parameters
- Determine budget for the propagation program
- Identify OHS hazards ,assess risks and implementing controls

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

.

Information Sheet-1

1.1 Confirming and understanding management and marketing requirements

Introduction

Plant propagation is the process of creating new plants from a variety of sources: seeds, cuttings, bulbs and other plant parts. Plant propagation can also refer to the artificial or natural dispersal of plants. The simplest method of propagating a tree vegetatively(non-sexually) is rooting or taking cuttings. The most common method of propagating fruit trees, suitable for nearly all species, is grafting or budding a desired variety onto suitable rootstocks.



Figure 1.1 propagated plants

Plan ahead to ensure adequate resources including staff, facilities and propagation material are available when required. Propagation facilities are usually costly so they need to be at or near to full capacity for as much of the year as possible. Propagation nurseries produce pre-finished plant material (liners), such as ornamental trees, shrubs, and grasses, fruit trees, and annual and perennial flowers. Some nurseries specialize in growing and selling prefinished plants to other growers, making propagation their sole business. However, some wholesale nursery operations have their own propagation areas where plants are produced for in-house use.

1.1.2. Input management

Water and nutrients are the two important inputs having direct relationship with quality of seedlings. Water quality and its proper availability to plants ensure better growth of seedlings. It may be used effectively by sprinkler irrigation system. Irrigation of seedling with the required quantity alone reduces the occurrence of weed, pathogens, etc. Availability of nutrients to seedlings depends on the Ph of the media, watering and character of species. Proper solarisation of media, mixer media preparation, container filling, filled container arrangement, using well decomposed farm yard manure (FYM), quality water and crystal colloids will ensure minimum input cost.

1.1.3. Quality assessment of seedlings

Nursery is an area where young/infant seedlings are maintained under intensive care for up to their planting. Quality seedlings production starts from the collection of quality seed, nursery establishment and maintenance after its germination. Even though quality is a qualitative gradable trait it can be measured indirectly by its correlation with growth, productivity, vigor and quality index. If the quality of a specific group of seedlings is to be assessed, destructive sampling through random selection of some seedlings of the group and computing Dickson Quality Index (DQI) as below is quite useful.

$$DQI = \frac{\text{Total seedling dry weight (g)}}{\{\text{height (cm)} / \text{stem diameter (mm)}\} + \{\text{shoot dry weight (g)} / \text{root dry weight (g)}\}}$$

The limitations of this index are

- It will be useful to evaluate the quality of even age seedlings; comparison of different age groups doesn't exist
- DQI will be derived after destructive sampling. Hence, its implication on live seedlings may be suitable only for academic purpose

1.1.4. General quality standards for nursery plant

- The shoot and root development of nursery plant should be in proper ratio. The nursery plants should be free from weeds
- Color of leaf, morphology of leaf should be in proper standard in accordance to variety and species
- The nursery plant should be free from disease and pest and have a vigorous growth
- The graft union should be healthy and the size of scion and rootstock should be equal
- After shifting and transporting, seedling should not show symptoms like leaf drying, yellowing,

stress, etc.

At present, there is no legislation to regulate production and sale of seedling and vegetative propagules by nurseries. A mechanism to ensure the quality of planting material needs to be developed through registration and quality control.

1.1.5. Marketing

Liners are typically sold in bulk quantities to other wholesale nurseries, landscape nurseries or retail nurseries, which grow the plants to a larger size. These sales can, but do not necessarily, involve a contract between the propagation nursery and the customer. In some cases, with proper planning, propagation can be conducted year-round. For example, cuttings of some woody plant species can be taken for propagation almost year-round, while others must be collected during certain seasons or even a very narrow window of development. Some cuttings can be ready to sell as liners in 10 to 12 weeks. Each nursery owner must analyze and organize his or her own marketing channels, develop a sales programme, prepare the product for distribution, extend credit, and make collections.

Possible approaches to defining your market and customers are:

- Define the types of customers within your target market
- Determine customer preferences for products and services by investigating the local competition
- Use local and national association and government data to determine market trends anticipate future preferences on the types and number of plants to grow
- Promote plants that you or other colleagues consider outstanding.

- **Marketing strategy**

Marketing strategy is based on becoming an option for contractors and the general public to fill their plant and agroforestry needs and must include performance in the following areas:

✓ Customer service
✓ Knowledgeable staff
✓ Affordable prices
✓ Great location
✓ Quantity and quality of plants, seedlings, trees and saplings

- **Sales strategy**

Factors that influence primary sales:

- ✓ Excellent customer service
- ✓ Exceptional product knowledge
- ✓ Large and varied offer of trees and saplings
- ✓ Good location
- ✓ Good quality of saplings
- ✓ Affordable prices

- **Managing staff and the workplace environment**

It is important to rotate staff periodically to avoid fatigue and so maintain productivity, especially during busy periods; as a guide, try to do this at least once a day so that team members don't spend all day every day repeating the same task. Many nurseries use seasonal, part-time staff and employ shift working for highly repetitive work such as this. This usually works well, providing staff are supervised and correctly trained. Staff are always more productive when their working environment is safe and comfortable, so ensure there is adequate shade and ventilation during bright, hot periods and background heat is provided when required. Give careful thought to the location and layout of the work area; often this is centrally located on site but needs to be near the propagation structure; they are not always the same thing, leading to excessive handling time and costs. On large or multi site operations, consider mobilizing the work so it can be located close to the propagation structure to minimize transport time

Generally management and marketing requirements may include:

- ✓ Propagation technique depending on the type of crop to be propagated.
- ✓ Controlling the growing environment
- ✓ Plant species
- ✓ Growth habits and cultural requirements
- ✓ The purpose or intended use of the propagated plants
- ✓ Maintenance services for propagation after-care
- ✓ Quality specifications and timelines for the program
- ✓ Budget limitations and infrastructures
- ✓ Basic tools, equipments and materials required to undertake propagation.

1.2. Evaluating space requirements

Introduction

Before collecting any seed or cuttings you will need to get permission from the landowner and may need a permit from the government. Make sure you do not collect from any threatened species .Propagation can be done in the field, orchard, forest, outdoor raised beds, and in protected culture environments such as greenhouses, poly covered houses, and tissue culture laboratories. The plant propagation period is generally a very narrow segment of a plant's life, ranging from several weeks for fast-growing herbaceous plants to one to two years for woody perennials. Following propagation, the rooted cuttings, seedlings (plugs), layers, or tissue culture produced plants are transplanted as liner plants. The liner plants are grown in small pots and then transplanted into larger containers or directly transplanted into field production. In other production systems plants may be propagated and produced in the same container or field location without going through a liner stage.

To enhance the propagation of plants, commercial producers manipulate the environment of propagules (cuttings, seeds) by managing:

- microclimatic conditions (light, water ,relative humidity, temperature, and gases)
- edaphic factors (propagation medium or soil, mineral nutrition and water)
- biotic factors—interaction of propagules with other organisms (such as beneficial bacteria, mycorrhizal fungi, pathogens, insect pests, etc.)

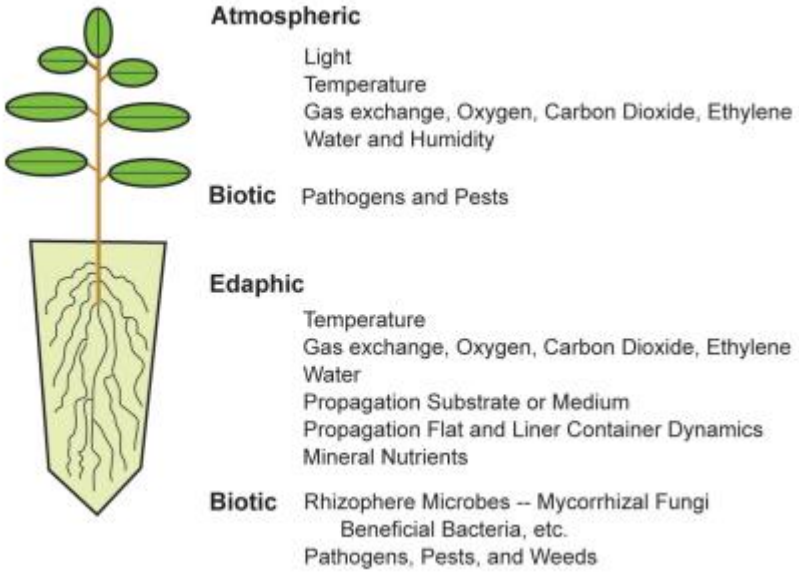


Figure 1.2 the propagation environment

1.2.1. Availability of land

It is important that the site selected for the nursery has enough land to raise the number of seedlings needed, and if possible, room for expansion. A small nursery raising 20,000 plants in 4 by 6 size pots, and keeping the plants in a nursery for a year could require about 500m2 of land; this includes potting beds, 20 per cent extra for losses and damage, paths between the beds, soil storage, thatched shelter, and the compost making area. But for sloping sites the land requirement may be double the size, that is, 1000 m2. The size of the nursery depends on the number of plants to be produced, the time they will remain in the nursery, as well as the quality and slope of the site. It is also important to ascertain who owns the land. If it is institutional or privately owned land it is important to formalize the use of the land by obtaining a letter from the owner agreeing to its use as a tree nursery for a defined period of time**.**

1.3. Determining propagation techniques

Introduction

There are two types of propagation: sexual and asexual. Sexual reproduction is the union of the pollen and egg, drawing from the genes of two parents to create a new, third individual. Sexual propagation involves the floral parts of a plant. Asexual propagation involves taking a part of one parent plant and causing it to regenerate itself into a new plant. The resulting new plant is genetically identical to its parent. Asexual propagation involves the vegetative parts of a plant: stems, roots, or leaves.

The advantages of sexual propagation are that it may be cheaper and quicker than other methods; it may be the only way to obtain new varieties and hybrid vigor; in certain species, it is the only viable method for propagation; and it is a way to avoid transmission of certain diseases. Asexual propagation has advantages, too. It may be easier and faster in some species; it may be the only way to perpetuate some cultivars; and it bypasses the juvenile characteristics of certain species.

1.3.1. Sexual Propagation

Sexual propagation involves the union of the pollen (male) with the egg (female) to produce a seed. The seed is made up of three parts: the outer seed coat, which protects the seed; the endosperm, which is a food reserve; and the embryo, which is the young plant itself. When a seed is mature and put in a favorable environment, it will germinate (begin active growth).

1.3.1.1. Seed

To obtain quality plants, start with good quality seed from a reliable dealer. Select varieties to provide the size, color, and habit of growth desired. Choose varieties adapted to your area which will reach maturity before an early frost. Many new vegetable and flower varieties are hybrids, which cost a little more than open pollinated types. However, hybrid plants usually have more vigor, more uniformity, and better production than non-hybrids and sometimes have specific disease resistance or other unique cultural characteristics.

Although some seeds will keep for several years if stored properly, it is advisable to purchase only enough seed for the current year's use. Quality seed will not contain seed of any other crop, weeds, seeds, or other debris. Printing on the seed packet usually indicates essential information about the variety, the year for which the seeds were packaged, and germination percentage you may typically expect, and notes about any chemical seed treatment. If seeds are obtained well in advance of the actual sowing date or are stored surplus seeds, keep them in a cool, dry place. Laminated foil packets help ensure dry storage. Paper packets are best kept in tightly closed containers and maintained around 40◦F. in a low humidity. The door shelves in a refrigerator work well.

Some gardeners save seed from their own gardens; however, such seed is the result of random pollination by insects or other natural agents, and may not produce plants typical of the parents. This is especially true of the many hybrid varieties.

1.3.1.2. Seed pre-sowing Treatments

Pre-sowing treatments are methods applied to overcome seed dormancy to ensure rapid, uniform and timely seed germination that facilitates seedling production. Pre-sowing treatments are applied to seeds immediately before sowing. Most methods require only a few minutes to 24 hours. However some pre-sowing methods require a few to several days. Appropriate pre-sowing treatment methods depend on the dormancy characteristics of the seed being treated.

https://www.youtube.com/watch?v=7OrwnZXi2SQ

- The most common pre-sowing treatment methods

✓ Soaking in cool water

- ✓ Soaking in hot water
- ✓ Boiled water treatment
- ✓ Scarification (acid, mechanical, manual) methods
- ✓ Fire or heating methods
- ✓ Soaking in chemicals
- ✓ Alternate wetting and drying



Figure 1.3. Seed treatment

Advantages of Sexual Plant Propagation

- Plants which are difficult to propagate by vegetative method e.g. papaya, phalsa, coconut, etc. can only be propagated by seed
- The rootstocks for budding and grafting are obtained by means of sexual propagation
- Sexually propagated plants are more resistant to pests and disease
- Poly embryonic varieties (give rise to more than one seedling from one seed) can be propagated by seed

Disadvantages of Sexual Plant Propagation

- Seedlings take more time to bear fruits (late bearing)
- Quality of existing plants cannot be improved by sexual propagation
- Plants propagated sexually are large in size, thus the cost of maturing, pruning and spraying increases
- Due to cross pollination and segregation, there is no assurance about genetic purity

- Plant Identification of sex in seedling is not possible

The main requirement of this method is the fresh, viable and quality seeds. Mother bed (raised/sunken), containers (Polybags / pots / dona / root trainers), nursery mixture (Forest soil, sand, FYM @ 2 :1 : 1 ratio) are the other requirements

1.3.1.3. Seed sources and nursery management practices

Standard nursery management aims at the most rapid production of healthy and quality planting materials. The success depends on the kind of materials and management practices to be employed.

- Nursery management practices
- ✓ Sourcing, collection and selection of seeds for propagation
- ✓ Handling of seeds to hasten germination
- ✓ Management practices of germination beds
- ✓ Techniques of sowing the seeds in the germination beds
- ✓ Pricking out and transplanting
- ✓ Weed and pest control

The plant selected as mother plant for seed propagation should have the following characteristics.

- ✓ Plants of good quality and high yielder
- ✓ High adaptability to local climate and soil conditions.
- ✓ Grow strong/vigorous healthy plants ,which have desirable characteristics
- ✓ Free from diseases
- ✓ comparability, timing,
- ✓ Disease and insect resistance, drought, tolerance, and hardiness.



Figure 1.4. Nursery

1.3.2. Asexual Plant Propagation

Vegetative parts of plants such as leaves, stems, and roots are used for propagation. These plants may be taken from single mother plant or other plants. The vegetative methods most often used to produce trees are cuttings, air layering, grafting and micro-propagation. It requires the explants from the improved/selected mother tree

A seedling is a young plant that is grown from a seed. It is any young plant, especially one grown in a nursery for transplanting. Seedling development starts with germination of the seed

Advantages of asexual plant propagation

Some of the benefits that could accrue from the application of vegetative propagation will include among others:

- Multiplying ‘true-to-type’ elite material
- Controlling male to female tree ratios on farms

- Propagation of seedless plants
- Avoidance of long juvenile periods control of growth form
- Combination of clones
- Economics: elimination of the juvenile phase thus shortening the time to reach the reproductive maturity.
- Plants propagated by this method are true to type and uniform in growth, yield and quality of fruits
- Some fruits such as banana, pineapple, seedless guava and seedless grape varieties can only be propagated through vegetative means
- Vegetative propagated fruit tree comes into bearing earlier than seed propagated plants and have assured genetic configurations
- Plants produced are of manageable size and have uniform fruits making harvesting easy
- Some diseases can be avoided in susceptible varieties by grafting them on a resistant rootstock e.g. use of rangpur lime as rootstock for budding mandarin orange to avoid gummosis disease
- Repairing of damaged portion of plant is possible by asexual methods through bridge grafting or buttressing. These methods can be used for healing of the wounds caused by rodents
- Inferior quality crown of the existing plants can be improved. For example, side grafts and crown grafting in mango
- It is possible to grow multiple varieties on the same plant. One can grow numerous varieties of roses and mangoes on different branches of the same stock
- Number of plant per hectare is more due to its small canopy and restricted growth
- Vegetative propagation helps in rapid multiplication with modern techniques like tissue culture and other micro propagation techniques

Disadvantages of asexual plant propagation

- Plants propagated by this method are not hardy and fall easy prey to adverse conditions of soil, climate, diseases, pests, etc.
- It is difficult and more expensive method of propagation in some plants like papaya, coconut, etc.

- Plants are generally not so vigorous and long lived as seedling plants and they require special skill for propagation
- Hybridization in these plants is not possible because there is no variation in the progeny; these methods are not suitable for development of a new variety

Asexual propagation of plants can also be called 'vegetative propagation' because it involves the use of vegetative parts of plants like leaves, stems, roots, or modified organs. It's the best method to use to clone your plants, which means to produce plants identical to their parents. It involves methods like cutting, division, layering, grafting, budding, and tissue culture techniques. These techniques are commercially exploited mainly to produce horticulture plants.

- **Cutting**

This is cutting the vegetative part of the plant (leaf, stem, and root) and then planting it again to regenerate the whole plant. The three types of cutting are named after the plant part being detached/cut:

- ✓ Stem cutting
- ✓ Leaf cutting
- ✓ Root cutting

Types of cutting

- ✓ Leaf cutting
- ✓ Stem cutting
- ✓ Root cutting

Types of Leaf cutting

- ✓ leaf bud
- ✓ leaf petiole
- ✓ Leaf blade

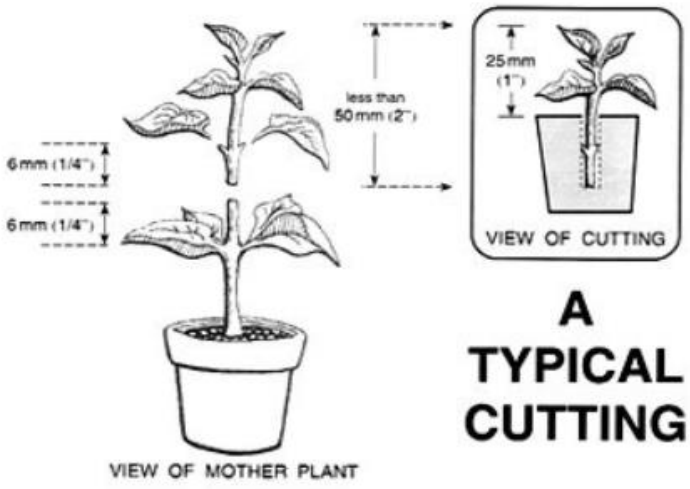
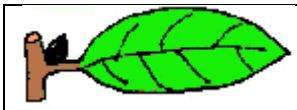
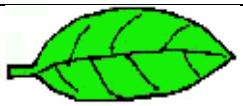


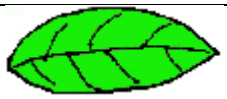
Figure 1.5.cutting



Leaf bud



Leaf petiole



Leaf blade

Figure: 1.6. Leaf cutting

Types of stem cuttings

Based on the age and maturity of shoots detached for vegetative propagation, stem cuttings are classified as follows:

- ✓ Herbaceous or softwood cuttings
- ✓ Semi-hardwood cuttings
- ✓ Hardwood cuttings.



Figure: 1.7.stem cutting

Root cuttings are just that, pieces of roots that form new shoots. These are often made in winter or early spring before plants begin growing. Roots should be the thickness of a thick wire. Cut into one to two inch lengths, place on a moist rooting medium, cover, and keep moist but not wet.

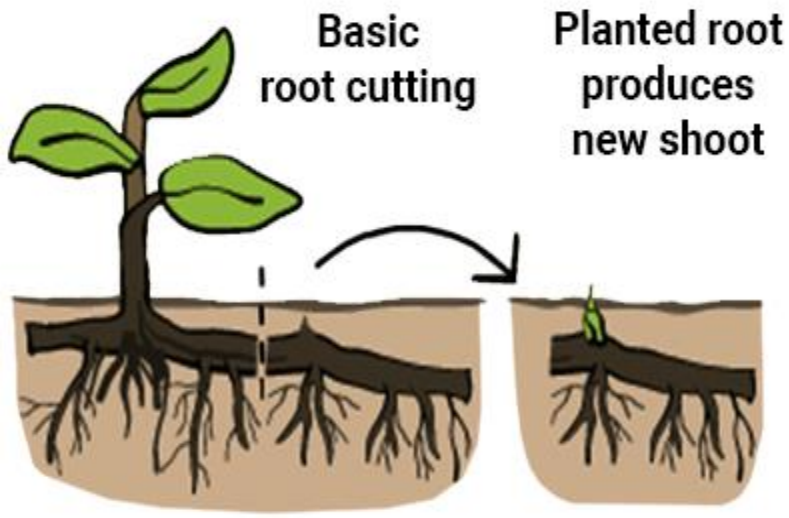


Figure: 1.8. Root cutting

- **Division**

This is a suitable technique for perennials (plants that live for more than two years). It involves dividing the plant by digging and moving it to an already prepared site. This helps the plant to rejuvenate and reduce water and nutrient competition.



Figure 1.9. Dividing perennial plants by using a garden fork.

Source: https://www.gardenersworld.com/plants/five-method...

Crown division: Separating the daughter plants from the mother propagates species that form suckers or tillers at the crown, such as raspberry and strawberry. Usually dormant plants are dug up, and the crown is divided so that each subdivision has a bud and some roots.

- **Grafting**

This involves cutting a twig of one plant and joining it with the stem of another plant in such a manner that they form a unit and function as one plant. It is a bit of a complex process but allows you to bring the desired character to your plant. However, be sure to sterilize your hands and tools to make sure you don't transfer any infections during the process.

Scion: the upper portion of the graft.

Rootstock: the lower part of the grafted plant which provides the root system is known as the rootstock or under stock or sometimes simply the stock. It determines the vigor of the plant, resistance to root disease and pest.



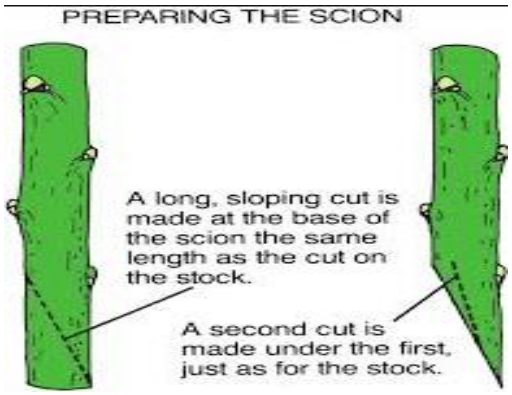


Figure 1.10. Rootstock and Scion

- **The purpose of grafting**
  - ✓ For multiplying good or desired clones and cultivars which cannot be propagated easily in large numbers by other methods of plant propagation, such as seeds, cuttings, layers, etc.
  - ✓ For imparting the beneficial effects of rootstocks and inters tocks, such as dwarfing effect, as in apple; hardiness respect of unfavorable soil and environmental conditions, as in citrus and peach ; for improving the edible quality of fruit .as in various citrus species;
  - ✓ For controlling insects affecting the lower portion of stem, as for phylloxera in grapes.
  - ✓ As an aid in rejuvenation of old and seedling plants by top working (adopting various grafting methods) .
  - ✓ Repairing the damage in the stem portion of the fruit trees caused by rodents or diseases, by bridge grafting.
  - ✓ Virus indexing, as grafting makes it possible to test the presence and transmission of virus in plant showing little or no symptoms.
  - ✓ To bring about early fruiting by reducing vegetative phase in hybrid seedlings or other seedling selections as in apple or mango.

Disadvantages of grafting

- ✓ Only closely related species grow together
- ✓ Disease can transmit easily

Incompatibility

Most of the related plants which when grafted together unite satisfactorily and function as one plant, are termed as compatible. Unrelated or distantly related plants grafted together, do not unite and the scion portion mostly dies. This phenomenon is known as incompatibility. Sometimes the union takes place and plants grow for a few years and then die due to poor union. This is termed as delayed incompatibility. Symptoms of incompatibility include: Leaf yellowing and abscission, overgrowth or swelling below, above or at the graft union, marked differences in the growth rate of stock and scion.

- The compatibility of graft/bud will be affected by:
  - ✓ The kind of plant: the scion and rootstock must be capable of uniting
  - ✓ Growth activities of stock plant: some grafting and budding depends on bark slipping which means the bark should be easily peel-off
  - ✓ Growth activity and quality of scion/bud wood materials: the scion materials or bud wood is normally one year old or less.
  - ✓ Propagation method used: different method suited to different species. The best method should be selected.
  - ✓ cambial contact: the cambial regions of the scion must be placed intimate contact with that of rootstock
  - ✓ Virus contamination, insect and disease: infection of graft union can cause difficulties with union
  - ✓ Equipment: proper tools and accessories should be used
- Four conditions must be met for grafting to be successful:
  - ✓ The scion and rootstock must be compatible
  - ✓ Each must be at the proper physiological stage;
  - ✓ The cambial layers of the scion and stock must meet; and
  - ✓ The graft union must be kept moist until the wound has healed.
- **Graft union formation**

The most important part of grafting is the formation of a successful graft union; it is an intricate process and depends on several variables and conditions for its success. The first step in the healing of the graft

consists of aligning the freshly cut scion and stock tissue to fit tightly. It is necessary when grafting that the cambium layer of the scion and the stock be in contact so that callus cells from cambium tissues may intermingle.

The outer layers of cells in the cambium of the stock and scion produce parenchyma cells which soon interlock, forming the callus tissue. Cells of the new callus tissue begin to differentiate into new cambium cells along the lines of the two intact cambiums between the stock and the scion.

These cambium cells produce vascular tissue, consisting of xylem to the inside and phloem to the outside, which establishes a continuity between the cambiums of the scion and the stock. As a result of formation and joining of the new vascular tissue, the water and nutrients are transported from stock to scion and from scion to stock.

- **Methods of grafting**

  https://www.youtube.com/watch?v=SOu15VsEIuM

There are essentially two general forms of grafting: detached scion and approach. The first is the most commonly used; roots are present only on the rootstock and the scion is detached from the donor plant. The second method involves the grafting of two plants, both of which are self-sustaining. After the union is formed, the scion is severed from the donor plant. This method is employed with plants that difficult to graft.

- ✓ **Stem grafting:** A rootstock can be grafted or top worked with a desirable scion cultivar in several ways, depending on stock diameter, the time of year, and the species. Each method has its advantages and disadvantages. Stem grafting is divided into two types. One is mature cutting, which is usually used in spring before bud germination. Another is shoot cutting, which is used in growth season. The main methods of stem grafting
- ✓ **Cleft Grafting:** This method is useful for grafting older pants with thick stem. The stock is sawed at an appropriate height. A vertical split 7-9 cm down the center of the stock is made. This straight vertical split is kept open with the help of a wedge placed in the center of the stub, Scions 8 to 9cm long and having 2 to 3 buds are selected and made into a tapering wedge

Two such scions are inserted in the sides of the vertical split so that cambium layer of the stock matches with that of the scion, and secured tightly with waxed cloth or plastic strips. Two advantages of this method are that it is easy and that it can be done in late winter when the bark is not yet slipping. The

main disadvantage is that the cleft leaves a large wound, which may allow infection by wood-rotting organisms.



Figure: 1.11. Cleft grafting

- ✓ **Cut-grafting:** If stock is thick, cut grafting is used. Cut scion into two sections. The longer section is about 2.5 centimeter. The shorter section, the reverse side, is about 1 centimeter, cutting vertical at the side of xylem of the rootstock, cut width and length is fit for the section of grafting bud, inserting grafting bud, enabling the cambium of longer section of grafting bud to align with cambium of stock. Then tying them tightly.

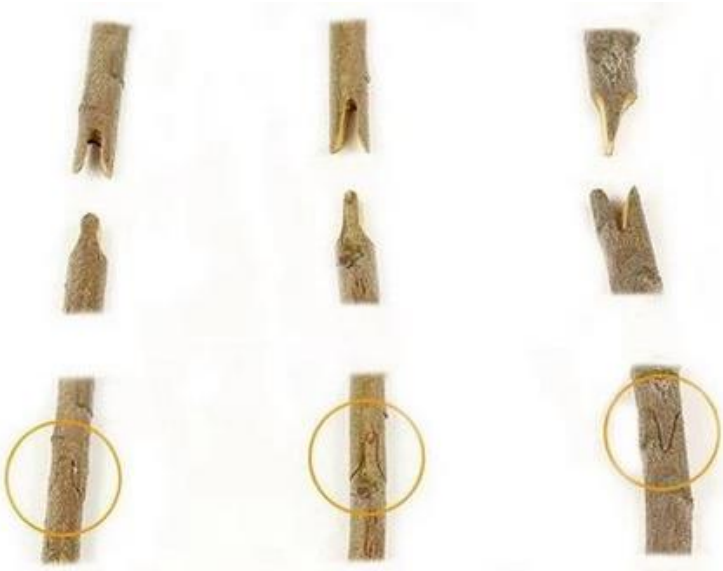


Figure: 1.12. Cut grafting

- ✓ **Bark Grafting:** Scions are prepared for bark grafting by making a long beveled cut on one side and a short one on the opposite side. The scions held against the stock, and a band of bark of equal width to the stock is cut; the uppermost 5 to 8 mm portion of the bark is then removed.

The scion is slid behind the bark and nailed in place with three wire brads, 2 to 3 cm in length. The main advantage of this method is easy and rapid. Its disadvantage is that it cannot be used until the bark begins to slip in the spring.



Figure: 1.13. bark grafting

- ✓ **Whip grafting:** this is a good method for young stock plants up to 1.0-1.5 cm in diameter. In this a 2 to 5 cm long cut at the top of the stock and a corresponding cut at the bottom of the scion are made .It is better to make the cut in one single stroke of the knife so that the cuter surface is very smooth. On each of these cut surface reverse cuts are made, which when stock and scion are joined fit into each other, giving a large area for coming together of cambium layers of stock and scion. After joining the stock and scion, they should be tied securely with plastic tape or banana fiber.

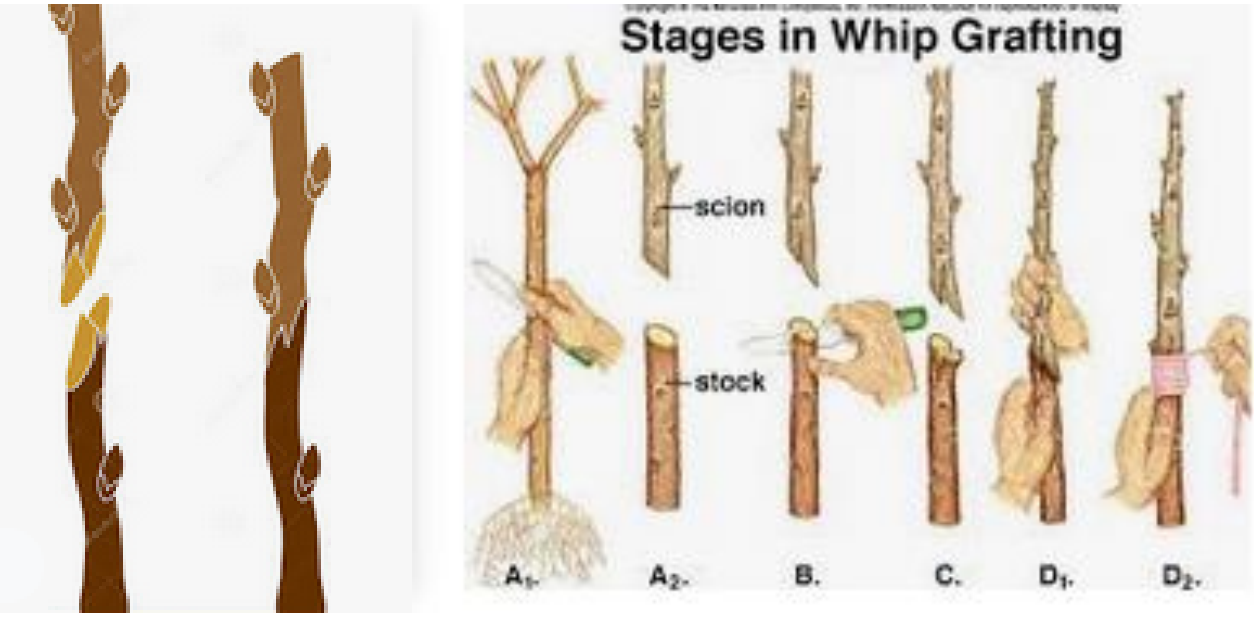


Figure: 1.14. Whip grafting

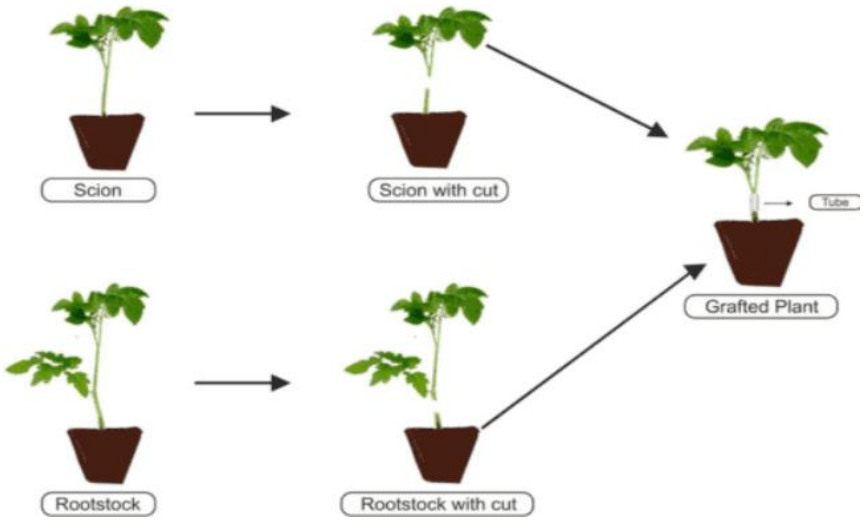


Figure 1.15. .A schematic diagram of the grafting technique.

Source: https://www.toppr.com/ask/question/explain-grafti..

- **Layering**

In this technique, the attached and bent branch of the plant is covered with soil and allowed to root. After the emergence and development of roots that specific part of the plant is cut and allowed to grow as a new plant. This is called ‘layering’.

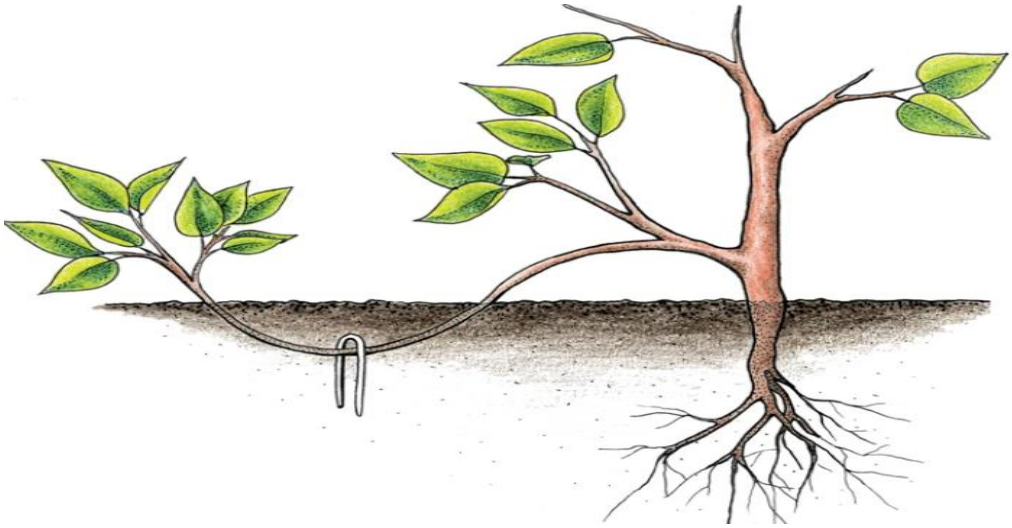


Figure 1.16. Layering

Methods of layering

I. **Mound or stool layering**: in this method a plant is cut back to ground level during the dormant season, the soil is heaped around the base of the newly developing shoots. After allowing sufficient time for root development, individual rooted layers are separated from the mother plant and planted. This method is practiced to propagate and multiply apple rootstock and also plants like guava**.**



(i) Mound layering

Figure: 1.17. Mound layering

II. **Trench layering:** it is a modification of mound layering, a tree or vine of a desirable cultivar is headed low and allowed to grown vigorously the first season. Long branches are girdled, 5 to 8 cm apart, with each girdled segment having one or two buds. The girdled portion may be treated with IBA before burying the branch in a shallow trench and covering the horizontal portion but leaving the shoot tip exposed. In the spring, the buried buds develop into shoots, and roots are initiated on the stem segments between girdles. The rooted pieces are separated from each other during the dormant season. Plants with long canes, for example, trailing blackberry, are multiplied in this manner.



Figure: 1.18. Trench Layering

III. **Tip layering:** Brambles are commonly propagated by burying tips of canes during their growing season. If the soil is kept moist, the shoot continues to grow while roots are initiated below the soil surface. These newly rooted shoot tips are severed from the parent plant and transplanted. Grapevines may be propagated in this fashion to fill in an adjacent missing vine

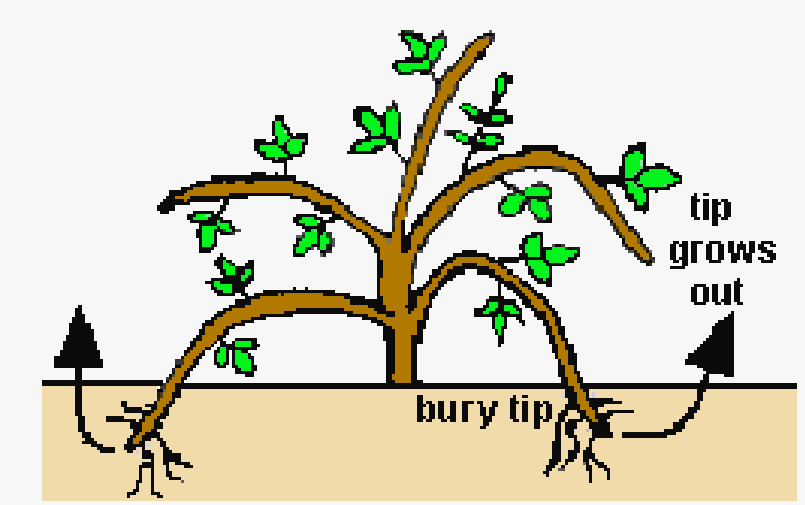
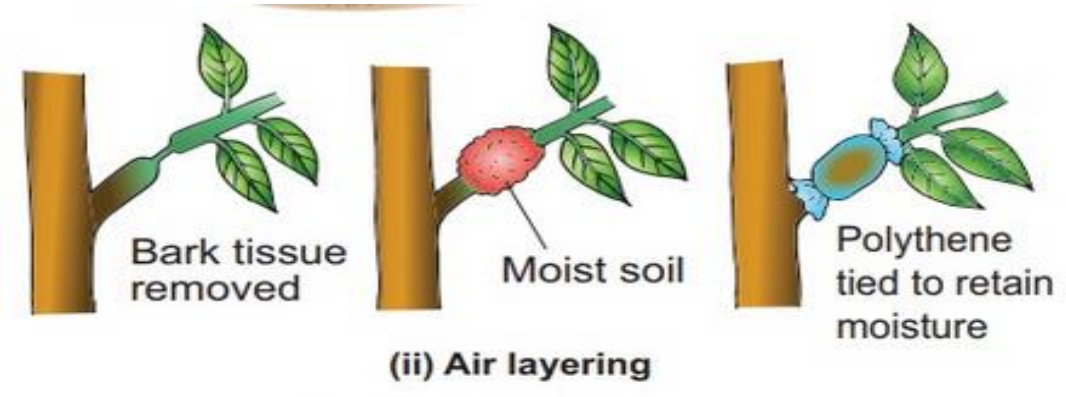


Figure: 1.19. Tip layering

IV. **Air layering**: In air layering, roots develop on aerial shoot where the stem has been girdled. The stem is usually stripped of lateral branches and leaves in the springs, and a girdle is made at the base of the cleared region. For getting root initiation, the girdled portion is treated with IBA and covered with a plastic band or a sheet of aluminum foil, which is filled with moist sphagnum moss which is the best rooting medium for air layering as it holds large amount of water till root initiation and their development.

When sufficient roots develop, the rooted stem is severed from the mother plant below the girdle and transplanted into soil. Some species require two growing seasons to form a good root system. This method is not commonly used for fruit trees because it is time-consuming, but it may be the only way to propagate some cultivars that do not readily form root initials by other techniques.



(ii) Air layering

Figure 1.20. Air layering

Inarching

Inarching is also known as ‘approach grafting’ or ‘scion attached’ method of grafting. It is done in evergreen plants which are generally unsuccessful when using other methods of grafting.e.g. Mango, sapota, litchi.





Figure: 1.21. Inarching grafting

Budding

In this method, a cut is made in the rootstock and a single bud with little or no wood is inserted into it in such a way that they unite and grow as a new plant. It is a special aspect of grafting in which the scion is a small piece of bark or wood with single bud. The bud develops into a plant after successful union with the rootstock.

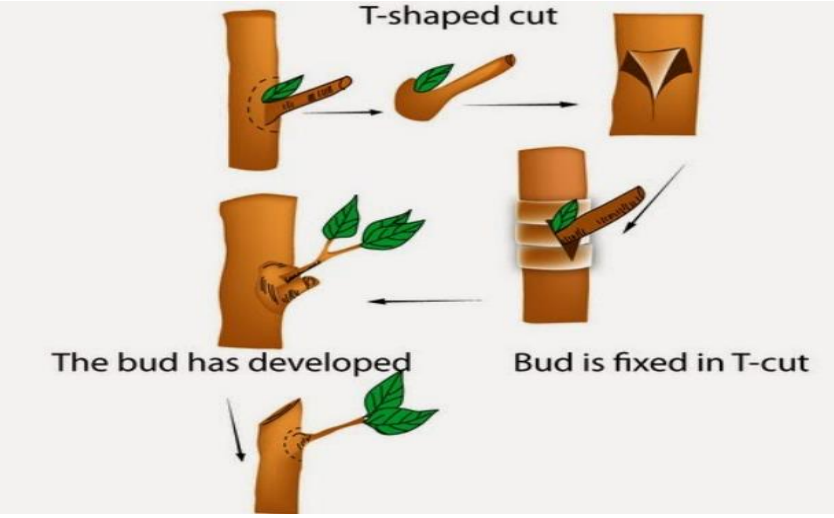


Figure 1.22. Budding

Source: https://www.toppr.com/ask/question/bud-grafting-i...

- **Purpose of budding**

The purpose of budding are:

- ✓ To perpetuate the clone that cannot readily reproduced by other methods of propagation.
- ✓ To obtain the benefits of certain rootstocks (for cold hardiness, disease resistance, salt tolerance. Etc.) and
- ✓ For changing the cultivar of established plants by top working.
- ✓ To induce precocity of bearing.
- ✓ For virus indexing.

- **Limitations of budding**

Since one of the requirements for a successful bud union is the close matching of the callus producing tissue (cambium layers), budding is generally confined to the dicotyledons and cone-bearing plants. Both have a vascular cambium layer existing as a continuous tissue between the xylem and the phloem.

Time of budding is done when the stock plant is in active growth and the cambium cells are actively dividing so that the bark separates readily from the wood. It is also necessary that well-developed buds of the desired cultivars are available at the same time.

Methods of budding

- **T—shape bud grafting (shield budding):**

Steps in T-budding

- ✓ A vertical cut about 3cm is made in the stock
- ✓ A 2cm long horizontal cut is made at the top of the vertical cut
- ✓ Remove the bud from the scion –beginning 1cm above the bud a slicing down ward cut is made to 2cm bellow the bud : horizontal cut is made to remove the at the base.
- ✓ The bud is inserted by pushing down ward
- ✓ The bud union is tied with a water proof materials but the bud left Showing.
- ✓ After the bud healed, the top of the stock is cut off just above the bud

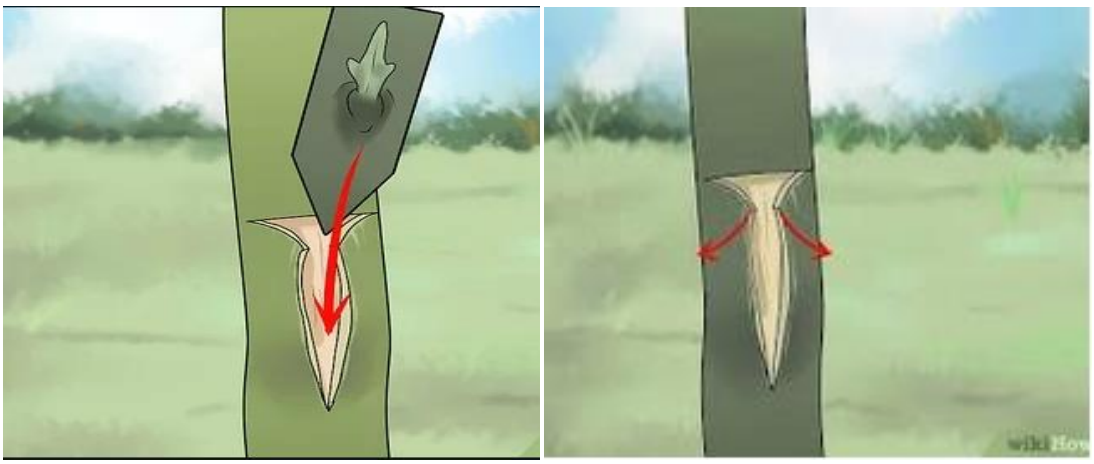


Figure: 1.23. T-shape budding

- **Embed bud grafting or chip budding**

Steps in chip budding

- ✓ A 45 degree angle down ward cut is made in scion just above the bud
- ✓ A second cut is made going in ward until it meets the first cut and remove a chip of wood containing the bud.
- ✓ Identical cut is made on the stock the chip is inserted.
- ✓ The bud area is then wrapped with bud left exposed.



Figure: 1.24. Chips budding

- **Flute budding**: In this method, a rectangular patch of bark removed from the stock almost completely encircles it. Leaving only a narrow connection of about 1/8th of its circumference, between the upper and lower parts of the stocks, and replaced with a patch of bark of the same size containing a bud. The bark of both stock and bud stick should be slipping easily.



Figure:1.25. Flute budding

- **Ring budding:** In this method, a complete ring of bark from the stock and a complete ring with a bud from the bud stick are removed. In order that the two match, the size of the stock and that of the bud stick should be about the same.

The complete ring with a bud should be properly replacing the position of the stock bark.

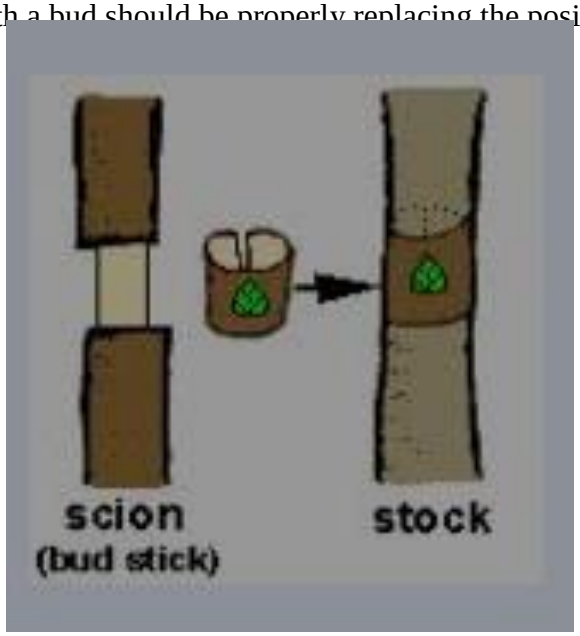


Figure: 1.26. Rings budding

- **Other vegetative propagation**

  Rooted Suckers: suckers that arise at the base or at some distance from the trunk, as in banana, may be excavated and transplanted. Spraying or dipping the roots of suckers in an IBA solution produced a better stand of plants than if they are untreated.



Figure: 1.27. Root sucker

Tissue culture propagation: this is the most recent and advanced technique in which plant tissues are grown in media under controlled and sterile conditions/environments. It is extensively used for

commercial purposes to produce clones of plants or mass produce plants. It also provides several advantages over all the traditional methods explained above.

Advantages of tissue culture technique:

- ✓ It allows for the production of clones or exact copies of the mother plant.
- ✓ Plants with desired traits or characters can be grown using this technique.
- ✓ It is beneficial in propagating plants without seeds.
- ✓ It allows the production of plants in a shorter period of time compared to traditional techniques.
- ✓ Plants that are difficult to grow by traditional methods can be grown by this method.
- ✓ Disease-free plants can be produced.
- ✓ Mass production of plants is possible with this technique.
- ✓ Enhance productivity.
- ✓ Easy transportation of plants.

Which technique you should choose depends on what type of plant you want to propagate, the purpose of your propagation, and how much time and effort you can put into the process. So, make your choice and get started working on your greeneries!

Cloning is a process by which individual organisms are multiplied asexually – a process of vegetative regeneration or reproduction .Consequently, the individual plants forming a clone are genetically identical. Cloning can be both a natural and an artificial process. The natural process embraces the lateral spread of creeping plants by their shoots or roots, and the production of new plantlets from dispersed, separated, or fragmented plant parts. Vegetative regeneration is a common characteristic of undesirable and invasive weeds. It is often associated with organs that have evolved as part of a perennial life form involving specialized storage organs (e.g., tubers, bulbs, rhizomes, etc.). However, vegetative regeneration also has advantages in agriculture: first, some of the specialist storage organs are good sources of carbohydrates for human food and so become crops – potatoes, yams, cassava, onions, etc. In addition, the capacity to regenerate asexually can be used to multiply these crops without the alteration of their genetic characteristics during the segregation phase of sexual reproduction. This also applies to many trees and other plants which can be artificially regenerated by stem cuttings, grafting, budding, or marcotting (air layering).

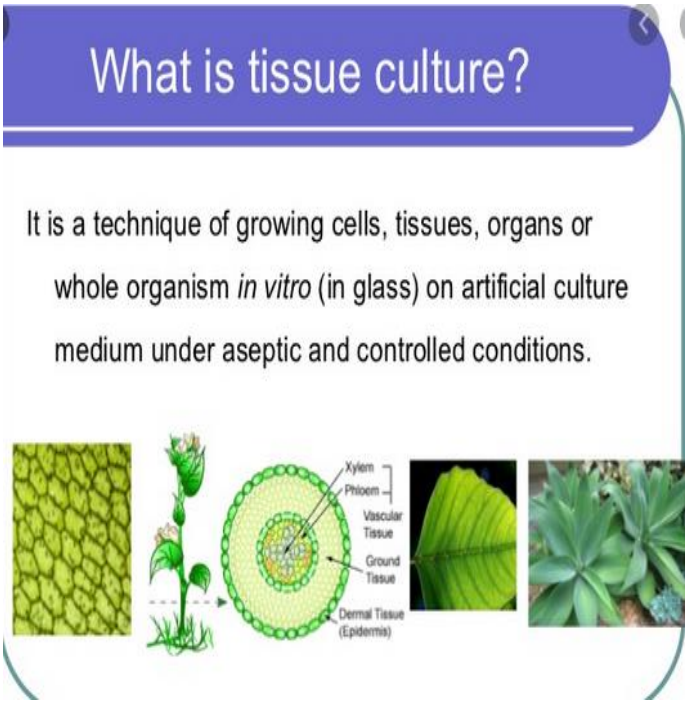


Figure: 1.28. Tissue culture

Important methods of vegetative propagation for selected fruits mango, guava, citrus and apple

- Mango can be propagated by veneer grafting, stone grafting, softwood grafting;
- Guava can be by softwood grafting, air layering, ground layering;
- Citrus by side bark grafting, T-budding, cut-grafting, chip-budding;
- Apple by chip-grafting, approach grafting, T-budding, tongue grafting and air layering.

Runners are stems that grow horizontally above the ground. They have nodes where buds are formed. These buds grow into a new plant.

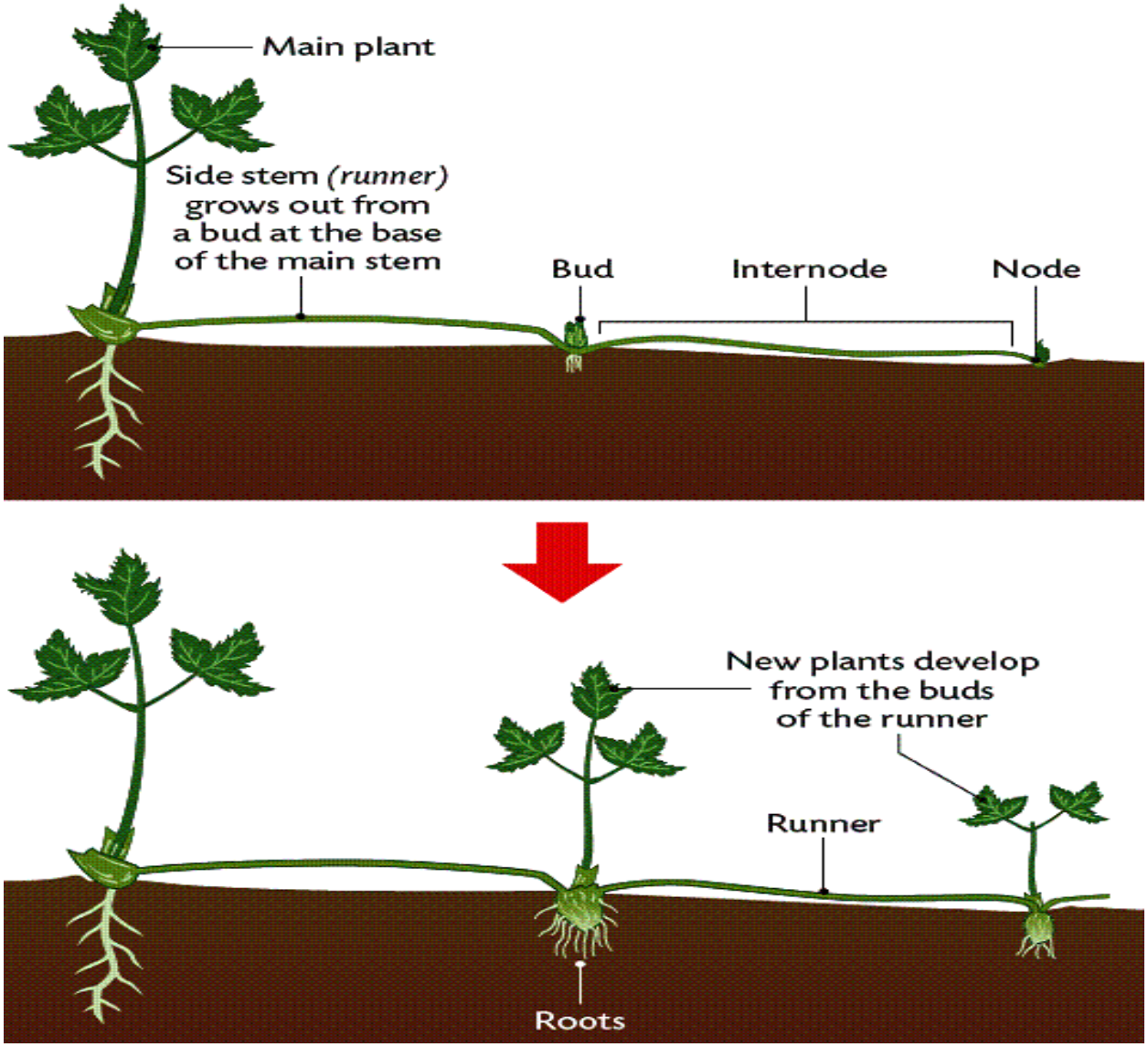


Figure: 1. 29. Propagation by runners

1.4 Determining environmental parameters

1.4.1. Environmental parameters for success of plant propagation

The success or failure of plant propagation is highly dependent on careful plan, the method of propagation and the major environmental factors. To undertake successful propagation program, highest attention must be given to the major environmental factors affecting the success of plant propagation.

Therefore, before starting the crop propagation program, determining and adjusting all the environmental parameters (factors) affecting the operation depending on the crop type is an important step in plant propagation. Some of environmental parameters that may apply to a field nursery or environmentally controlled structure may include Temperature, wind, light, humidity and frost. Too high or low amount of these parameters leads to the failure of propagation operation. Since each crop has its own optimum amount these environmental factors, it is utmost important to determine these factors depending on the crop type to be propagated.

1.4.2. Environmental Requirements for Propagation

To enhance the propagation of plants, commercial producers manipulate the environment of propagules (cuttings, seeds) by managing:

- microclimatic conditions (light, water relative humidity, temperature, and gases)
- edaphic factors (propagation medium or soil, mineral nutrition and water), and
- biotic factors—interaction of propagules with other organisms (such as beneficial bacteria, mycorrhizal fungi, pathogens, insect pests, etc.)

Newly propagated plants or seedlings must be healthy and adhere specified standards. To achieve this, the following factors are monitored closely:

- Humidity
- Aeration
- Light quality and quantity
- Temperature
- Moisture

Humidity

Humidity, also referred to as relative humidity, is the amount of water vapour in the air at a given temperature, and is expressed as a percentage. This means that at 20% relative humidity, 20% of any given volume of air will consist of suspended water molecules. Humidity levels are especially important in allowing the plant to carry on with its metabolic processes at desired rates.The ideal relative humidity for propagation ranges between 80% and 95% for seeds and cuttings, and in the region of 60% outdoors for budding, grafting and seedbed methods. Seed germination is faster at higher humidity levels, as is

the case in cuttings. In warm and dry areas, the level of humidity often falls below 55% on hot summer days, making budding and grafting more delicate and requiring close monitoring.

Light

All green plants require light for growth to take place. Some plants (most species) prefer growing in direct sunlight, while others prefer growing in the shade where they are subjected to indirect sunlight. Light is essential for photosynthesis, while light quality, which is determined by the wavelength of the light, also influences germination and flowering. Plants in grown under protection such as greenhouses and shade-houses, require adequate light for the process of photosynthesis. If the plant does not receive enough light, which may be due to shading or over-crowding, it displays symptoms of retarded growth.

Temperature

If heat and light, which cause an increase in temperature, is not controlled properly, plants may suffer from heat injury. The ideal temperature for propagation is 29°C,and it must be monitored closely. In propagation chambers the temperature can often be maintained at this ideal level by heating and cooling systems. The heat is also used for increasing the humidity in the chambers, by drenching the trays and dampening the floor.

Moisture

Moisture is essential for germination and healthy plant growth. Too much water suffocates the plant roots, and can cause diseases such as root rot, damping off, and collar rot. The other extreme is insufficient water supply, ordrought, and is detrimental to all plants, but even more so to cuttings and young seedlings. A uniform and constant water supply is required for seed germination to produce healthy and vigorous seedlings, and for seedlings to grow into healthy plants.

In all propagation methods, the properties of the growth-medium determine the quality and quantity of water that will be available for uptake by the plant. A good medium is one that has a low salinity level, a water holding capacity, being the amount of water that the medium retains, of between 55% and 60%, make it available easily, and the ability to allow lateral water movement. In the case of germination, the seed, and the later seedling stage, has to be kept in media wetted to field capacity, being the maximum amount of water that a particular soil can hold.

1.5 Identifying OHS hazards, assessing risks and implementing controls

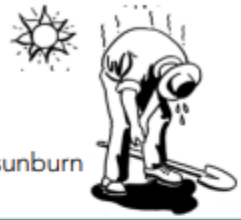
Introduction

Identifying of different OHS hazards associated with the propagation program is appropriate to take the corresponding care. Poor handling propagation operation and different propagating materials, tools and equipment's will leads to:

- Loss of propagation compatibility
- Failure of the propagation program
- Technical errors which leads to the development of undesirable characters.
- Contamination with disease and it highly affects the worker in different ways.

Therefore, strict care has to be given for workers and propagation activities when operating different propagation activities based on the crop type and propagation techniques.Some of the OHS hazards associated with the propagation program may include air- and soil-borne micro-organisms, chemicals and hazardous substances, sharp hand tools and equipment, manual handling, solar radiation, dust, noise, machinery and machinery parts, slippery and uneven surfaces.

Table 1.1. Risk assessment and control in propagation

HAZARD and what can happen = the risk	What to do about it?
SUN EXPOSURE Risk of: Heat exhaustion, deyhydration and sunburn 	• Wear protective clothing • • •
WORKING WITH SOIL Risk of: Soil borne diseases 	• Wet potting mix before use • • •
TRIP HAZARDS Risk of: Injury from falling over 	• Clear walk way of any hazards – boxes, tools etc. • • •
WET SLIPPERY AREAS Risk of: Injury from slipping over 	• Walk slowly • • •
USE OF CHEMICALS Risk of: Poisoning 	• Read label and understand what the chemical is used for • • •

SAFE USE OF CHEMICALS

The use of chemicals (such as fertilisers) when carrying out any propagation work requires some extra special precautions.

Keep all chemicals locked in an appropriate chemical cabinet. Only people with the right training should use chemicals.

The following PPE should be considered when using chemicals.

1. PVC or chemical resistant gloves.
2. Goggles or protective glasses – protect your eyes as they easily absorb chemicals (a full face shield is needed for mixing some concentrated chemicals).
3. Dust mask or respirator – prevents the inhalation of dangerous chemicals.
4. Cotton hat – protects the head from chemicals and can be washed clean after each use.
5. Rubber boots – prevents spray getting onto your feet – the overalls should cover the outside of the boots so drips don't run down the inside of the boot.
6. Cotton overalls – suitable for general chemical work and will protect work clothes underneath – wash after each use or use disposable overalls.
8. PVC apron – used to protect clothing when mixing concentrated chemicals (a PVC suit may be necessary for some dangerous chemicals).

RISKS WHEN HANDLING POTTING MIXES

The handling of potting mixes requires special care to protect yourself from getting sick.

Some potting mixes contain a harmful bacteria called Legionella. The bacteria can cause Legionellosis, a type of pneumonia (this is not Legionnaires disease which is caused by a different Legionella bacteria found in air conditioner cooling towers).

To reduce the risk of infection when handling potting mixes follow these recommendations:

1. Handle all mixes with care to avoid breathing in dust.
2. Moisten the mix to avoid creating dust.
3. Wear suitable PPE to avoid contact with skin and eyes – gloves, dust mask, protective eyewear.
4. Avoid transferring the potting mix from hand to mouth – wash your hands before smoking, eating or drinking, even if you wore gloves.
5. Wash work clothes regularly.
6. Clean work area by wet-sweeping or vacuuming.
7. Seal any opened bags or containers after use and store in a cool location.





Legionella bacteria

Self-check-1	Written test

Part I: Write true If the statements is correct or false statement is incorrect

1. Propagation can be done infield, orchard, forest, outdoor raised beds or in protected culture environments.

2. The plant propagation period is generally a very narrow segment of a plant's life, ranging from several weeks for fast-growing herbaceous plants to one to two years for woody perennials

3. To enhance the propagation of plants, commercial producers manipulate the environment of propagules (cuttings, seeds)

4. Cleft grafting is useful in the rootstock is quite thicker than scion

5. Toung grafting is useful in the root stock is equal to scion.

6. Asexual propagation is the combination of two parental system

Part II: Choose the correct answers from the given alternatives

1. Each propagation nursery owner must analyze and organize the following except
   A. Marketing channels, B. Develop a sales program,
   C. Prepare the product for distribution D. Extend credit and make collections E. None
2. Possible approaches to define market and customers are:
   A. Define the types of customers within your target market
   B. Determine customer preferences for products and services
   C. Use local and national association and government data to determine market trends
   D. Promote plants that you or other colleagues consider the least.
3. Factors that influence primary sales include the following except:
   A. Excellent customer service B. Exceptional product knowledge
   C. Large and varied offer of trees and saplings D. poor location
4. Which one of the following is types of cutting methods?
   A. stems cutting C. tip layer
   B. cleft grafting D. All of the above
5. Which one of the following is types of grafting methods?

A. side grafting C. veneer grafting

B. Cleft grafting D. All of the above

6. Which one of the following term is used when green plants take up CO2 & use energy from light to produce food?

A. photosynthesis B. Light C. Respiration D. Dormancy

7. Which one of the following is a requirement for successful propagation

A. Light B. Humidity C. Aeration D. All of the above

8. Which one of the following is the ideal relative humidity ranges for seed & cutting propagation

A. Between 60%-75% B .Between 80%-95% C. Between 85%-95% D. Below 55%

Part III. Give short answers for the following questions

1. What is propagation?
2. Mention the methods of propagation and give examples for each one
3. Why space requirement is evaluated in propagation activities?
4. What are the factors for the size of the nursery?
5. Discuss on the advantages and disadvantages of sexual and asexual propagation?
6. List all the environmental factors affecting plant propagation?
7. List all the OHS hazards that may occur in plant propagation program?
8. What are the control measures that should be used in propagation to control the risks
9. What is your recommendations to reduce the risks in handling the potting mix?
10. Briefly mention the precautions that should be taken during chemical handling in propagation tasks
11. Explain shortly equipments used to reduce risks in propagation activities

Part IV. Define the following words

1. Grafting
2. Budding
3. Cutting
4. Layering
5. Tissue culturing

Operation sheet -1	**Performing propagation**

Objective: To know how to apply different techniques of propagation

Materials required:

- Scalpel
- Autoclave and alcohol
- Wheelbarrow, Shovel, water sprays container, dibblers and rubbish bins.
- Plant material
- Container (Tray, pots, sleeves)
- Rooting hormone
- Measuring tape
- Budding knife
- Grafting knife
- A fine-tooth saw for cleft grafting
- Pruning shears
- Dormant scions (cultivar labeled)
- Tying material such as grafting tape, adhesive tape, rubber strips
- Asphalt water emulsion compound for covering grafts
- A light hammer for bridge grafting

1. Procedure of stem cutting

step1 Select suitable PPE and wear

step2 To take your cuttings, select healthy and vigours growth that's 7.5 to 15cm long

step3 Then, cut off a section of stem

step4 Remove the lower leaves

step5 Clip off the leaves on the lower half of the shoot so you have a bare stem to insert into your potting mix.

step6 Pot up your cutting

2. Cleft graft procedure

step1 Select suitable PPE and wear

step2 Then, take scion from mother plant selected

step3 Slice scion in both side by sharp knives

step4 After that the root stock is cut off squarely and

step5 Split vertically with a knife to a depth of about 5 to 7.5cm

step6 Keep the knife in position or insert a chisel to keep the split open and insert the scions

step7 Wax, Wrap and secure wound part or joining point

3. Inarch grafts procedure

step1 Select suitable PPE and wear

step2 Then, take scion from mother plant selected

step3 Slice scion in side by sharp knives

step4 Prepare rootstock by trimming the edges of the girdled section back to sound bark

step5 Place the scion along the trunk so that the beveled edges rest on sound bark

step6 Mark and remove the bark rectangles.

step7 The stem piece to be inserted should be slightly longer than needed to ensure a homely fit.

step8 Insert the scion and then secure with two number 16 or 18 wire nails at each end

4. Bark graft procedure

step1 Select suitable PPE and wear

step2 Then, take scion from mother plant selected

step3 Slice scion in both side by sharp knives

step4 After that the root stock is cut off squarely and

step5 Split vertically with a knife to a depth of about 5 to 7.5cm

step6 Keep the knife in position or insert a chisel to keep the split open and insert the scions

step7 Wax, Wrap and secure wound part or joining point

5. T-budding procedure

step1 Select suitable PPE and wear

step2 Cut a T shape through the bark of the rootstock tree that selected

step3 Open the flaps of the side of the T

step4 Collect a bud from a bud wood stick by inserting the knife at the base of the bud & carefully cut out the bud including a sliver of wood

step5 Make a horizontal cut just above the bud to sever it and the sliver of wood from the bud wood stick

step6 Insert the bud, right side up, into the opening of the T cut

step7 Slide it tightly into the cut and secure it with a rubber banding strip

step8 Wrap the banding strip above and below the bud, stretching the banding strip to make a tight wrap that will prevent moisture loss

6. Chip budding procedure

step1 Select suitable PPE and wear

step2 Cut a T shape through the bark of the rootstock tree that selected

step3 Open the flaps of the side of the T

step4 Collect a bud from a bud wood stick by inserting the knife at the base of the bud & carefully cut out the bud including a sliver of wood

step5 Make a horizontal cut just above the bud to sever it and the sliver of wood from the bud wood stick

step6 Insert the bud, right side up, into the opening of the T cut

step7 Slide it tightly into the cut and secure it with a rubber banding strip

step8 Wrap the banding strip above and below the bud, stretching the banding strip to make a tight wrap that will prevent moisture loss

7.Tip layering procedure

step1 Select suitable PPE and wear

step2 Dig a hole 7.5 to 10 cm deep

step3 Insert the shoot tip and cover it with soil

step4 Then, the tip grows downward first

step5 Then bends sharply and grows upward

step6 Roots form at the bend, and the recurved tip becomes a new plant.

step7 Remove the tip layer and plant it in the early spring or late fall.

8. Air layering procedure

step1 Select suitable PPE and wear

step2 Select stems of pencil size diameter or larger are best

step3 Choose an area just below a node and remove leaves and twigs on the stem 7.5 to 10cm above and below this point. This is done on a stem about 30cm from the tip.

step4 The cut is held open with a toothpick or wooden match stick.

step5 Surround the wound with moist, unmilled sphagnum moss (about a handful) that has been soaked in water and squeezed to remove excess moisture.

step6 Wrap and cover with plastic and hold in place with twist ties or electrician's tape.

step7 Fasten each end of the plastic securely, to retain moisture and to prevent water from entering

step8 After the rooting medium is filled with roots, sever the stem below the medium and pot the layer. The new plant will usually require some pampering until the root system becomes more developed. Provide shade and adequate moisture until the plant is well established.

LAP Test -1	**Demonstrate performing propagation**

Instructions: You are required to perform any of the following tasks:

Task1. Perform stem Cutting activities

Task2. Perform cleft grafting activities

Task3. Perform inarch grafting activities

Task4. Perform bark grafting activities

Task5. Perform T-budding activities

Task6. Perform chip budding activities

Task7. Perform Tip layering activities

Task8. Perform air layering activities

LG #25	**LO #2 Develop propagation plan**

Instruction sheet: 2

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying labor, materials, equipment and machinery needs
- Determining propagation media requirements
- Determining strategies to modify environmental conditions
- Identifying type of plant and propagation method
- Determining selection criteria for the propagation material
- Determining hygiene requirements
- Communicating propagation plan and schedule of activities

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify labour, materials, equipment and machinery needs
- Determine propagation media requirements
- Determine strategies to modify environmental conditions
- Identify type of plant and propagation method
- Determine selection criteria for the propagation material
- Determine hygiene requirements
- Communicate propagation plan and schedule of activities

Learning Instructions:

1. . Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information sheet -2

2.1 Identifying labor, materials, equipment and machinery needs

2.1.1 Labor requirement

Labor: Nursery is a labor intensive activity. Skilled and permanent labor engagement ensures quality seedling production and their maintenance in nursery. The propagation plan must consider the identification of all the requirements including labor, materials, equipments and machinery depending on the aim of plant propagation and type of crop propagated. This accounts for the success of our plant propagation operation. Basic considerations during the identification of labor, materials, equipment and machinery for propagation operation are:-

- Number of laborers and skilled man power required to perform the task
- Available budget based on the total number of workers, scheduled time, propagation method and crop type to be propagated.
- All the necessary materials, equipment and machinery required to accomplish the propagation operation with available maintenance cost.

Table 2.1 Tools, materials and equipments for propagation

Tick off the items you think you will need for your propagation activity.

		ACTIVITY ✓			
Buckets			Trowel		
Bleach			Dibble stick (can use an ice cream stick, plant label or a shallow spoon)		
Methylated spirits			Rooting hormone		
Broom			Watering can		
Secateurs			Hoses		
Knife			Forks		
Trays, pots, tubes, and containers			Fertiliser		

Potting mix		
Wheelbarrow		
Shovel and Spade		

Plant labels		
Pencils		
Rubbish bins		

Table 2.2 Safety check list of PPE for propagation

Before you begin, use this checklist to confirm you have followed good safety procedures and have all the right resources.

SAFETY CHECKLIST ACTIVITY		✓
Long trousers, shirt and boots		
Hat and gloves		
Sunscreen, insect repellant and sunglasses		
Dust mask		
Additional PPE as needed		
Water		
First aid kit		

2.1.2 Equipment and Machinery

The nursery operations like transporting, watering and sales depend on the vehicle and machineries and equipments in the nursery. Among them tractor with trolley, disc plough, water tanker are necessary. The nursery potting media filling machine or automated container filling

machines for nursery mixture preparation and filling, grafting machine facilitate the speedy operation of nursery in cost effective way.



Figure 2.1. Automated container filling machine

2.1.3 Plant propagation structures

For propagation, framed structures such as green house, poly tunnels, culture room, hardening chamber and mist chamber are some important structures. A greenhouse is a framed, infrastructure covered with a transparent material in which crops can be grown under at least partially controlled environment. Various designs of greenhouse viz., shade net house, plastic film green house, glass house and natural green houses may be designed according to the need and resource availability.

Light is necessary for photosynthesis, which provides energy for plant growth. For light loving species, more light results in more growth but, green house light levels are often too intense to grow some species of tropical plants. As a result, growers apply shade cloths to lessen light intensity and the resultant heat. Shade cloths are rated by the amount of shade they produce, ranging from 30 to 80 percent. Black has been the traditional color because it is relatively inexpensive, but now shade cloth comes in white, green, and reflective metal. Because black absorbs sunlight and converts it into heat that can be conducted into the propagation structure,

black shade cloth should never be installed directly on the covering of any propagation structure, but instead needs to be suspended above it to facilitate air movement. Although more expensive than black shade cloth, white or aluminized shade fabrics are better for tropical environments and will do a much better job of cooling the propagation environment while still keeping light levels high. Applying a series of shade cloths, each with a lesser amount of shade, over a period of time is a good way to gradually harden nursery stock and prepare it for outside conditions.

2.1.3.1 Greenhouse Coverings

A wide variety of greenhouse coverings are available and the selection of a particular type is usually based on cost, type of structure, and the environmental conditions at the nursery site Polyethylene tarps are relatively cheap but require replacement every 2 to 4 years depending on the grade of plastic. Double layers of polyethylene sheeting that are inflated with a fan are stronger and provide better insulation longer than a single layer. The two layers are attached to the framing with wooden furring strips or specially designed fasteners. This process is relatively simple so many growers change their own coverings. Because they are so well insulated and airtight, polyethylene greenhouses require good ventilation to prevent condensation. Polycarbonate (“polycarb”) panels, the most popular permanent greenhouse covering, have about 90 percent of the light transmission properties of glass. Polycarp is strong and durable but is one of the more expensive coverings.

2.1.3.2 Controlling greenhouse temperatures

One of the most challenging aspects of a greenhouse is controlling temperature. Sunlight is converted into heat that can become lethal to plants. A sophisticated control system that can maintain a designated temperature through a series of heating and cooling stages is a necessary and wise investment to minimize energy costs. Vents and fans are used to keep air moving inside the greenhouse and exhaust heat from the structure. In dry, windy environments, wet walls use the power of evaporation to cool incoming air. Growers can also use short bursts of their irrigation system for cooling. Automatic sensing instruments are available that can be connected with cooling equipment to trigger a cooling cycle for the greenhouse. Mechanical thermostats

provide the best and most economical form of temperature control and can be used to activate motorized vents and fans within a greenhouse.

2.1.4 Intermittent-mist rooting systems

These rooting propagation environments are either enclosed or open. Rooting cuttings is much easier in these environments because intermittent-mist rooting chambers have a high degree of environmental control .Clock timers control the timing and duration of misting from specialized nozzles. Frequent misting maintains high humidity that reduces water loss from the cuttings, and evaporation of the small droplets moderates air and leaf temperature.

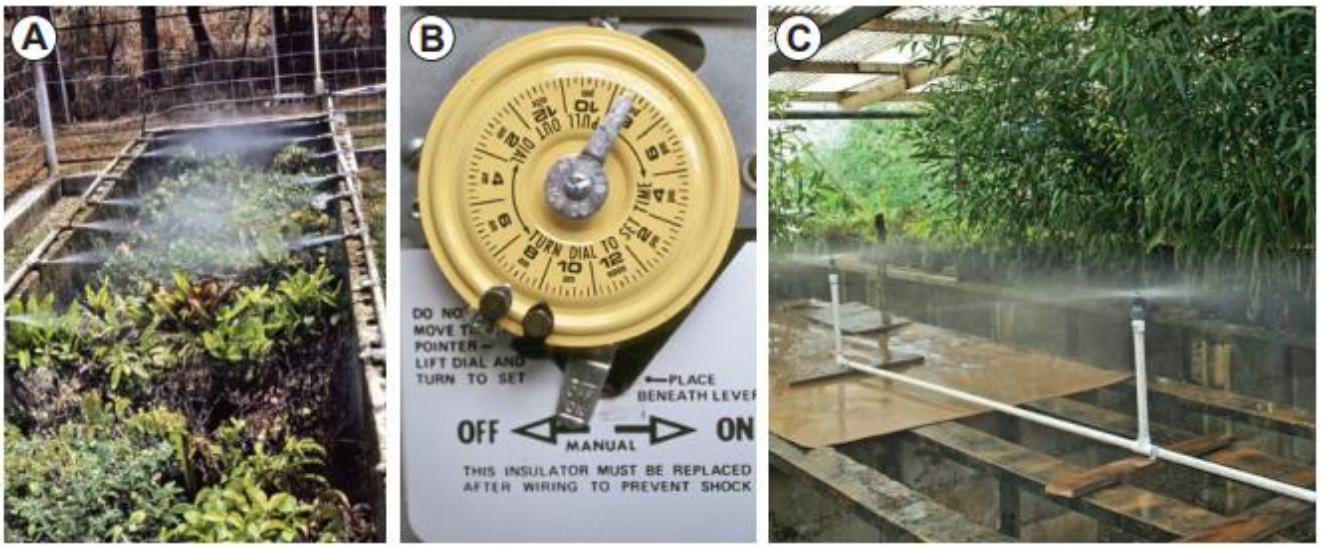


Figure 2.2. Intermittent-mist systems are easily controlled environments (A) specialized mist nozzles (B) Programmable timers control the timing and duration (C), which keep humidity levels high, reduce transpiration, and provide cooling.

Source: Photos A and C by Tara Luna, and photo B by Thomas D. Landis.

2.1.5 Tools for propagation

Scissors are essential when taking and preparing cuttings. Small stainless steel nail scissors are ideal. But keep them clean at all times to prevent the spread of diseases.

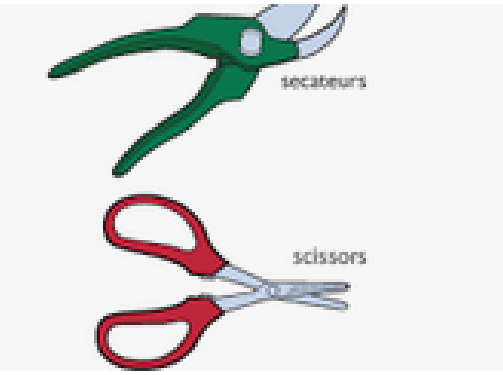


Figure: 2.3 propagation scissors

The following tools are used in the propagation methods described above.

I. **Grafting knives-**This has to be a sharp knife, which should be sterilized before use



Figure: 2.4 Different types of grafting/budding Knifes Stainless Steel

II. **Grafting wax:** after the graft is made, some covering must be used to keep it drying out. Either hand wax or brush wax may be used.Hand wax is most commonly used for home grafting. It is softened by the heat of the hand and can be easily applied.



Figure: 2.5 Grafting wax

III. **Grafting tape: t**his is a special tape with a cloth backing that decomposes before girding can occur. Electrical and masking tapes are also used. Masking tape is suitable where little pressure is required e.g. in the whip graft. Other materials used are polythene strips so long as they are sterilized. One can sterilize using domestic detergent such as jik.



Figure: 2.6 Poly Budding tape

IV. **Budding strips: b**udding strips are elastic bands and look like a wide rubber band that has been cut open. Budding strips secure several types of grafts with small stocks and scions.



Figure: 2.7. Rubber budding and grafting strips

V. **Nails:** veneer and bridge grafts require long, thin nails. Half-inch nails are long enough for most grafts, except for bridge grafting, which may require ¾ inches nails. These help to hold the graft in place.

VI. **Chain saw:** the chain saw is used to do top working of big trees.

VII. **Temporary shade:** this is used to prevent newly grafted scions from rainwater and wind. This could be shade nets, or rafters or loose thatch. This is also to protect the grafted seedlings from intensive sunshine.

VIII. **Budding knife: a** razor sharp knife used to make cuts on the seedlings and to cut off the bud-eye. The knife must always be sharp and in a good working condition to prevent tissue damage to the plant when cutting through it. If tissue damage occurs, the graft will most likely fail.

IX. **Budding tape:** clear polyethylene strips, used to maximize contact between the bud and the rootstock until the union and the healing is complete. It also prevents drying and excess water from getting in and rotting the bud.

X. **Pruning shears:** bud-wood is cut using pruning shears. Pruning shears are also used where cuttings are used for propagation.

XI. **Sharpening stone:** all blades become blunt with use and require periodic sharpening. A sharpening stone, or wet stone, and honing oil are required.

XII. **Sterilization liquid**: knives and shears must be periodically cleaned and sterilized properly with a solution of 10% bleach (Jik).

XIII. **Perfect cut grafting tool**: makes perfect grafting cuts every time for more consistent grafts and healthier growth. With three different blades, an omega shaped blade, a "V" shaped blade and a budding cut.



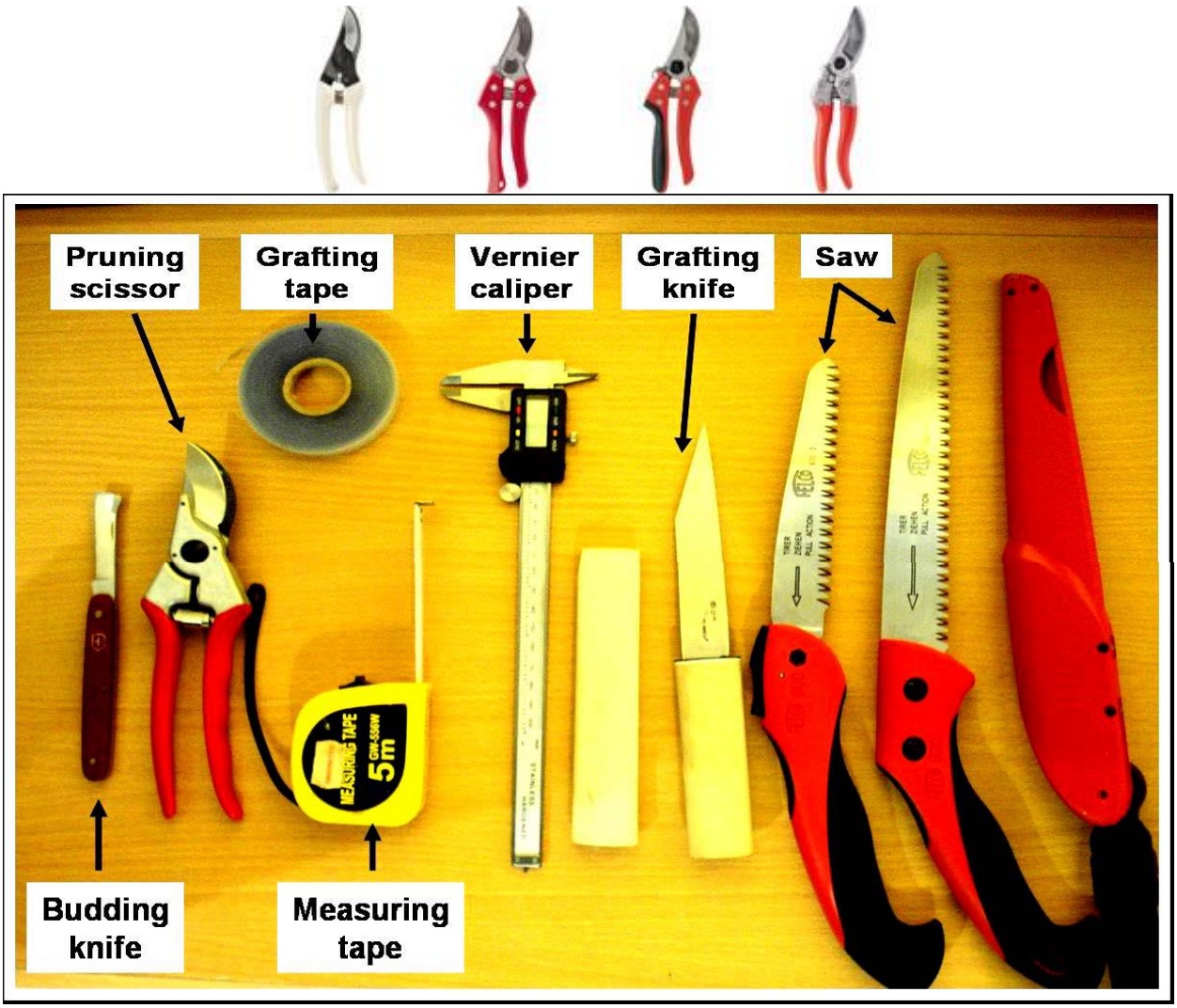


Figure: 2.8. Propagation tools

2.2 Determining propagation media requirements

2.2.1 Propagation media requirements

https://www.youtube.com/watch?v=2Q39WMmToAM

Propagation program can be takes placed on varieties of growth media depending on the plant species, aim of propagation and availability of materials. Mostly the operation can be takes placed on soil, in controlled environment, laboratories and culture media.

- Types of propagation media may include
  - ✓ Sand
  - ✓ potting mix
  - ✓ gravel, scoria
  - ✓ rock wool
  - ✓ Sawdust
  - ✓ pine bark
  - ✓ perlite,
  - ✓ vermiculite
  - ✓ water (hydroponics) and
  - ✓ conditioners/additives.

Propagation media requirements will be specific to the species and method of propagation, and may need to be determined:

- ✓ using recognized testing procedures for pH
- ✓ drainage and aeration
- ✓ salinity, nitrate levels and water repellence to ensure that it meets the needs of the propagation plan

There are many methods of vegetative propagation that is used. The choice depends on the propagator and his/her goals **.**An understanding of all factors influencing plant growth in a nursery environment is needed for the successful growth and production of high-quality container plants.

Propagation medium is a substance in which plant parts are placed for propagation. It provides initial support and favorable conditions for Plant Propagation. A good propagation medium is made up of components that provide optimum aeration, drainage and moisture holding characteristics. These are usually made up from combinations of peat moss, perlite, vermiculite, sand or similar materials. The primary role of a propagation medium is to provide support and moisture while the plant is developing.

Maximum yield explains growing media have three major functions:

- ✓ Physically support plant growth
- ✓ Allow for maximum root growth
- ✓ Supply roots with necessities such as water, air, and nutrients

Media for plant growth and seed germination has great significance in nursery business. The material for rooting and growing media may be used either alone or Incorporated with one or more products in combination.

To prepare growing media use the following ratio

- ✓ For heavy (clayey) soils 1:2:2
- ✓ For medium (loamy) soils 1: 1:1
- ✓ For light (sandy) soils 1: 0:1

Most commonly this ratio is applicable 3(topsoil).1(sand), 2(compost).

For good results, the following characteristics of the medium are required:

- ✓ The medium must be sufficiently firm and dense to hold the cuttings or seeds in place during rooting or germination. Its volume must be fairly constant when either wet or dry; excessive shrinkage after drying is undesirable.
- ✓ It should be highly decomposed and stable (preferably with a 20C:1N ratio) to prevent N immobilization and excessive shrinkage during production.
- ✓ It must be easy to wet (not too hydrophobic) and retain enough moisture to reduce frequent watering.
- ✓ It must be sufficiently porous so that excess water drains away, permitting adequate penetration of oxygen to the roots all containers produce a perched water table that creates a zone of saturated growing medium at the bottom of the container.
- ✓ It must be free from pests: weed seeds, nematodes, and various pathogens.
- ✓ It must have a low salinity level.
- ✓ It should be capable of being steam-pasteurized or chemically treated without harmful effects.

- ✓ It should have a high cation exchange capacity (CEC) for retention of nutrients that may be applied pre incorporated and/or in a supplementary soluble and/or controlled-release fertilizer program.
- ✓ It should be of consistent quality from batch to batch, and reproducible.
- ✓ It should be readily available, and economical.

Examples of propagation media are:

- Soil- sand, silt, and clay
- Sand – decomposed quartz particles 0.05 to 2.0 mm in diameter.
- Peat Moss – decomposed bog vegetation used to hold water in soil mixes
- Vermiculite – a hydrated magnesium-aluminum-iron silicate mica mineral that expands when heated
- Perlite - a gray-white volcanic silica material. Size range is from 1.6 to 3 mm in diameter
- Pumice – Volcanic rock used in mixes to increase aeration and drainage.
- Shredded Bark - wood products made from redwood, cedar, fir, pine, hemlock, or various hardwood bark species as a component in growing and propagating mixes
- Farm Yard Manure(FYM)



Figure 2.9. Coco peat: Soil-less medium used in nursery

2.2.2 Preparing soilless growing media

Although amendment combinations may vary, basic objectives in the preparation of a growing media are alike. An effective program should produce a growing media that is:

- Porous and well drained, yet retentive of sufficient moisture to meet the water requirements of plants between irrigations;
- Relatively low in soluble salts, but with an adequate exchange capacity to retain and supply the elements necessary for plant growth;
- Standardized and uniform with each batch to permit the use of standardized fertilization and irrigation programs for each successive crop;
- Free from harmful soil pests; pathogenic organisms, soil insects, nematodes and weed seeds
- Biologically and chemically stable following pasteurization; primarily free from organic matter that releases ammonia when it is subjected to heat or chemical treatments.

Since innumerable amendment combinations can produce a growing medium with these characteristics, it is important to consider both the economic as well as cultural optimums. Factors that determine the cost of a growing medium include: transportation, labor, equipment, materials and handling. In many cases the cost of mixing a "custom" growing medium exceeds that of the commercially prepared materials. These factors should be studied carefully before making a decision.

2.2.3. Properties of soil growing media

The material or combination of materials that you use as a propagation media should have the following properties:

- **Physical Properties**
  - ✓ The media should provide good physical support to the plants
  - ✓ The media should be reasonably light, easy to handle and easy to stick cuttings into. Sharp-edged materials, such as scoria, may be a problem with germinating seedlings. The materials used should not readily degrade or break down once in use.

- ✓ The media should have good aeration. This will aid water penetration and drainage, give adequate provision for the exchange of gases (i.e. root absorption of oxygen and release of CO_2), and provide space for roots to grow.
- ✓ A mixture of particles ranging in size from around 1mm to 5mm, with the addition of very fine particles from materials such as peat or pine bark generally provides a suitable mix.
- ✓ Once a medium is watered the volume of pore space containing air is reduced. A propagation medium should have an air space of at least 27% evenly spread throughout its volume, although this figure will vary according to the plant you are cultivating.
- ✓ The provision of misting will also generally require an increase in the air space of the medium. The upper limit should be no more than about 35 - 40%.

- **Chemical Properties**

Propagation media should have the following chemical properties:

- ✓ It should be chemically stable during use.
- ✓ For most plants it should have a pH in the range of 4-6 (some plants will grow better at a higher pH). The pH can be increased by the addition of lime and decreased by increasing the percentage of materials with low pH such as peat moss and pine bark.
- ✓ It should be low in salts and other harmful chemicals.

- **Biological Properties**

The propagation media should be as free as possible of harmful organisms such as weed seeds, spores, and insects.

To have success with plant propagation the following biological conditions should be provided:

- ✓ Buds must be present on each section of plant material used for propagation.
- ✓ Plant material from younger parent plants should be used as this is more likely to produce new roots and shoots.
- ✓ Current year's growth should be used because it will produce roots faster from cuttings and layering than older plant material.
- ✓ Healthy good looking stock/parent plants free from virus diseases.

- ✓ Parent plants that have had good nutrition and water in the months before the cuttings are taken or the layering or division is carried out.
- ✓ Plant material used for propagation must be large enough to contain enough stored energy to sustain it while new roots and shoots grow.
- ✓ Plant hormones can be used to encourage root formation.

2.3. Determining strategies to modify environmental conditions

Determining strategies to modify environmental conditions according to the type of plant and propagation method used have a vital role on the success of plant propagation. Strategies that may be employed to modify the growing environment include:-

- Cooling by manual or automatic processes such as the use of vents, exhaust fans, evaporative coolers, wetting walls;
- Heating by manual or automatic processes such as the use of wall heaters, ducts, heating lines or under-bed heating systems;
- Controlling air circulation to maintain uniform temperatures and relative humidity, such as ventilation or wind breaks;
- Use of artificial light; carbon dioxide enrichment, and irrigation.

Strategies to modify environmental conditions

A good nursery manager knows how to “think like a plant,”and create a propagation environment that modifies all physical and biological factors that may be limiting to plant growth.To have success with asexual plant propagation the following environmental conditions should be provided.

Table: 2.3 Environmental conditions to favourable asexualplant propagation

Environmental condition	Reason provided
A controlled (warm and humid) environment	Prevents water loss from transpiration, especially for softwood and leaf cuttings.
Air circulation	Air is needed around developing roots and shoots to stop disease and rotting.
Time of year has suitable environmental conditions for the type of propagation	Ideal air and soil temperature and light levels available.
Hygienic conditions including clean containers, tools and growing media	To prevent disease. Fungicides and insecticides are used only if needed.
Media used: • •	A balance of air and water around the developing roots so respiration can take place and the cutting doesn't dry out. Clean media prevents disease. Well-drained media prevents rotting. Water should be available for developing roots
Warm temperatures near the base of cuttings	Warm temperatures increase the rate of plant processes, therefore there is faster development of roots.
Light	Leaves on cuttings need light to carry out photosynthesis. This will give the cutting sugars that can be used for developing new roots and shoots. Developing shoots need light to carry out photosynthesis.
Hardening off newly propagated plants	Weaning the plant material from a protected environment and hardening it off once new roots

	and shoots have developed so it becomes a self-supporting plant.

Table 2.4 Key conditions required for successful asexual plant propagation

Plant material	Method of propagation	Key conditions
Root tubers, stemtubers, corms, bulbs	Division	•Healthy young plant material used. •Each piece of plant material willhave a healthy bud. •Each piece of plant material should be large enough to have a food store to support the development of new roots and shoots. • The cut surface of the plant pieces should be left to dry in a warm airy place to seal the cut surface from diseases. • Cut pieces should be placed in clean, friable, well-drained loam or growing media that is kept moist (field capacity). • Plant the new plant in a hole twice the depth of the size of the piece of plant material. • Light is required once the shoots appear so the shoots can carry out photosynthesis. • Protect developing shoots from adverse environmental conditions, e.g. frost. • Time of year –propagate in early spring when plant material is still dormant but just before it is about to grow shoots.
Rhizomes (e.g.	Division	• Healthy young plant material used.

Bearded iris), fibrous crowns (e.g. herbaceous perennials such as Chrysanthemum)		• Each piece of plant material must have a healthy bud. • Cut back leaf material to reduce water loss. • Remove old plant material. • Replant plant material at the same depth as the parent plant. If planted too deep, rhizome may rot or shoots may struggle to reach the soil surface. • Keep media moist and protect from adverse weather. • Time of year – propagate after flowering or when dormant.
Root or stem tuber or fibrous crown e.g.Chrysanthemum	Softwood cuttings	• Healthy young plant shoots used. • Shoots 7–10 cm long. • Cut straight under a node – a nodeis more resistant to fungal rots than other parts of the stem. Cells at the node will divide and produce roots faster than in other parts of the stem. • Placed shoots in well-aerated media. Media is well-aerated to prevent rotting of the cutting and the media will be warmer. • Media used for the plant material should be friable, aerated, well drained, moist and warm (if appropriate). The higher the temperature around the plant material forming roots, the faster the chemical reactions and therefore the faster the root

		formation. • Provide cutting with high humidity to prevent water loss. • Provide warm temperatures at the base of the cutting to speed up root development in a disease free controlled environment (bottom heat 21°C). • Good light levels needed so the cutting can carry out photosynthesis. • Time of year – take cuttings late spring after the buds have started to shoot.
Offsets and runners	Division	•Replant healthy young offsets or rooted runners in a clean, friable, well-drained loam or growing media that is kept moist (field capacity). •Place offsets in a warm sheltered area. •Offsets from succulents need to be in a non-humid environment or they will rot. •Time of year – late spring, early summer.
Evergreen flowering shrubs	Semi hardwood stem cuttings or layering Remember: •cuttings take less space than layering •cuttings produce more plants than layering •when layering the plant material is still provided with energy for growth	•Use young vigorous non-flowering shoots. •Use young parent material where possible. •Shoots 7–10 cm long. •Cut large leaves in half to prevent water loss. •Cut straight under a node – a node is more resistant to fungal rots than other parts of the stem. Cells at the node will divide and produce roots faster than in other parts of the stem.

	from the parent plant therefore more likely to form roots successfully	•Media used for the plant material should be friable, aerated, well drained, moist and warm (if appropriate). The higher the temperature around the plant material forming roots the faster the chemical reactions and therefore the faster the root formation. •Rooting takes place during the growing season when layering. •Prevent the cuttings or parent plant drying out when layering. •Encourage fast rooting so it has taken place before the food supply in the stem is all used up. •Prevent drying out and water loss. •Light is needed for photosynthesis. •Use rooting hormone. •Time of year – late spring, early summer or just after flowering.
Shrubs and trees and conifers	Hardwood cuttings	•Wound the stem to stimulate root production. •Use plant rooting hormone. •Keep a cool environment for the tip to keep shoot growth to a minimum and prevent water loss and to stop energy

2.4. Identifying type of plant and propagation method

Introduction

Plants are the most fundamentally important things given to life exist on this world by providing the basic and immediate needs of humans for food and shelter as well as acting as an essential component of the biosphere for maintaining life on the planet that evolved to survive, thrive, and grow by adapting to ever-changing conditions

2.4.1 Some horticultural crops and their propagation methods

- **Propagation of potato** (Solanum tuberosum L.) by tuber: Potato is propagated by vegetative propagation '**division**' of tubers. Tubers are divided into sections each containing one or more eyes. Tubers are thickened underground stems that often develop at the tip of stolon's or rhizomes and serve as storage organs.

  Potato can be planted directly as whole or divided to smaller parts of tuber which have a bud at the node for shoot development

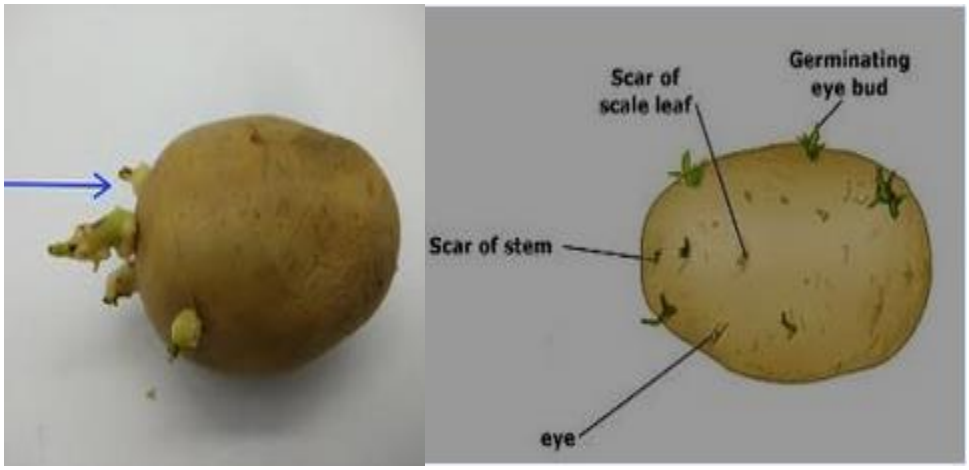


Figure: 2.10. Propagation of potato

- **Propagation of sweet potato** (Ipomoea batatas L.): The sweet potato is modified root called tuberous root is perennial which grown as annual. It is an important traditional crop which is grown extensively in tropical countries for its nutritional and economic benefits. The sweet potato crop can be planted either for food and/or for animal feed depending on the purpose and season of production. The propagation sweet potato can be done by **two methods viz**. by stem cuttings and by its **sprout**s (slips). The sprout (slips) propagation is very important to produce virus free plant and to produce vigorous tuber.



Figure 2.11. Propagation of sweet potato

- **Propagation of ginger** (Zingiber officinale) by rhizome: Ginger is herbaceous perennial plant that is grown as an annual in commercial production which is widely used as aspice crop plant. It is a subterranean stem (rhizome) modified for the vegetative propagation and storage of food materials. A rhizome is a swollen modified stem that runs horizontally under the ground that has contained vegetative buds which can be used for propagation by cutting into sections that each has at least one bud.



Figure: 2.12. propagation of ginger

- **Propagation of onion** (Allium cepa L.) by bulbs: Onion (Allium cepa L.) is an important vegetable crop that is grown worldwide. It is propagated either by seed or bulb There are two kinds of bulbs; tunicate and non-tunicate bulbs. The tunicate bulbs have outer modified leaves, which are dry and paper thin. non-tunicate or scaly bulbs lack this protective (papery) covering and are more easily damaged.

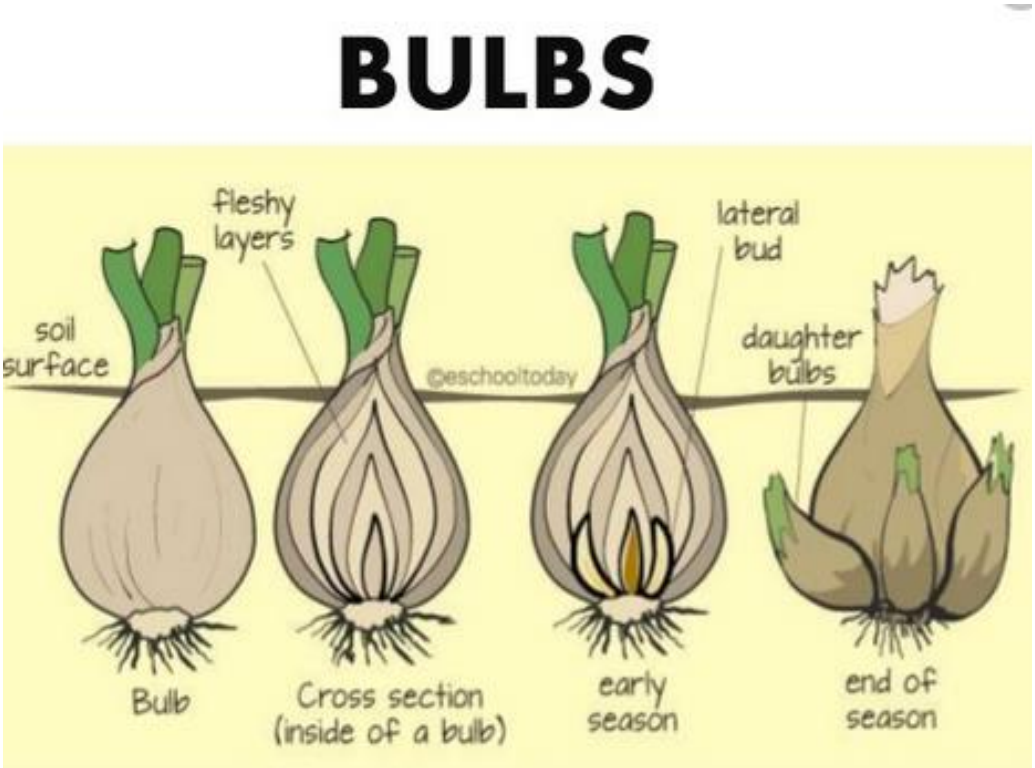


Figure: 2.13. Propagation of onion

- **Propagation of strawberry** (Fragaria × ananassa) by runner: strawberry is one of the most important fruit crops which produced by specialized stems called runner that develops from the axial of a leaf at the crown of a plant which grows horizontally along the ground and forms a new plant at one of the nodes. One plant may have several runners and one runner may grow several nodes.

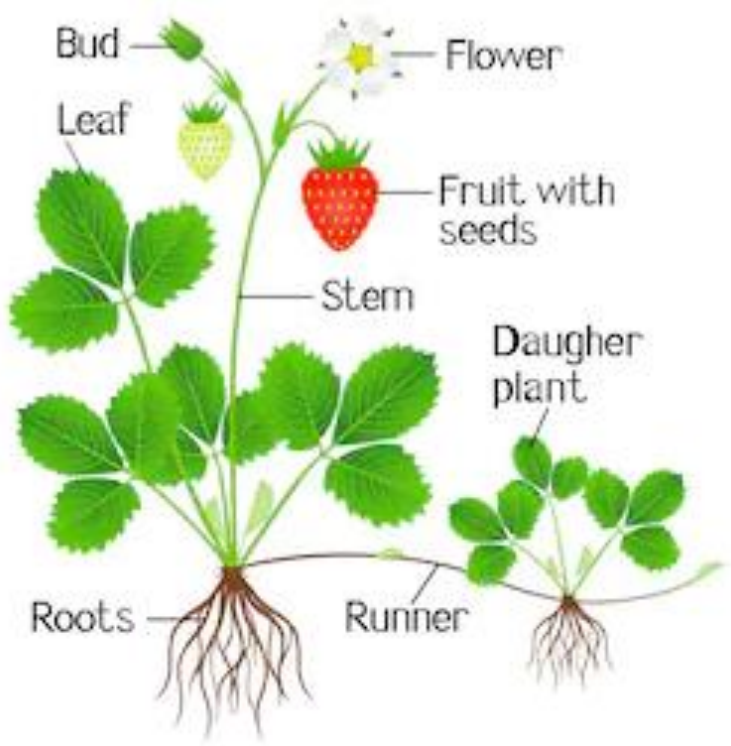


Figure: 2.14. Propagation of strawberry

- **Propagation of banana** (Musa spp.) by sucker: banana is one of the most important fruit crops which have produced by sucker separation. A sucker is a lateral shoot that develops from the rhizome and usually emerges close to the mother plant. Sucker is the primary and major source of propagation material in banana .Propagation by sucker follows digging the sucker, separating from the mother plant, and growing as individual plants. The number of suckers produced varies with the type of cultivars



Figure: 2.15 Bananapropagation

- **Propagation of pineapple** (Anana cosmos L.) by sucker: Pine apple is an important tropical fruit crop which is propagated by crowns, suckers and slips. The production of pineapple plants is mostly carried out by means of crowns propagation.



Figure: 2.16 Pineapple propagation

- **Propagation of enset** (Ensete ventricosum (welw.) Cheesman) by corm Enset (EnseteVentricosum (Welw.) Cheesman) is a perennial herbaceous and monocotyledonous crop which is propagated by its corms. The corm is a short, solid and thickened underground modified stem with basal plate.



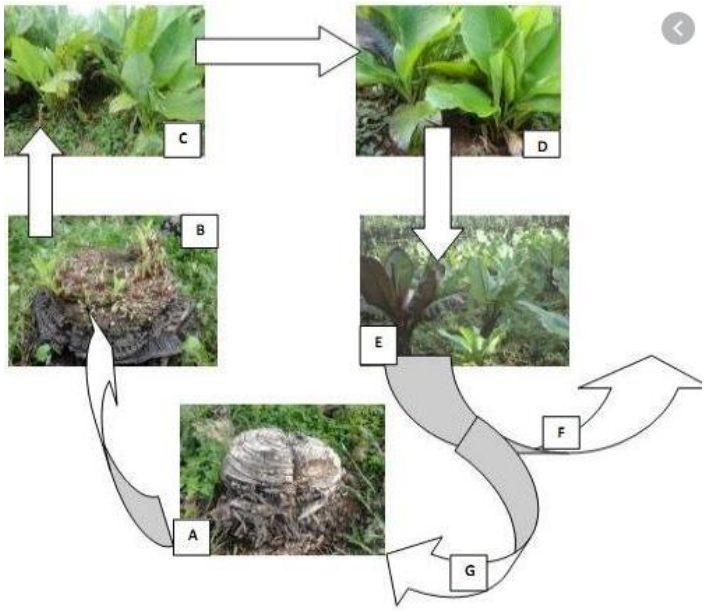


Figure: 2.17. Enset propagation

- **Propagation by Corm**: this consists of one or more internodes with at least one growing point. Examples of plants with corms include banana, arrowhead and cocoyam



Figure: 2.18. Corm propagation

2.5. Determining budget for the propagation program

Plant propagation is an operation which requires a great deal of budget, available materials and skilled man power. Most crop propagating materials are very expensive and needs excess budget to perform the propagation program successfully. Moreover, some of the propagation activities depending on the type of crop take more time to accomplish the task and this consumes a great budget and resources. Therefore, negotiating budget for the propagation program is important to:

- Successfully finish the propagation without fluctuation within scheduled time
- Buy and use advanced and available propagating materials, tools and equipments based on the crop type
- Fulfill necessary infrastructures regarding the operation
- Perform the operation in large scale basis.

Negotiated budgeting is a budgeting process that combines both top-down budgeting and bottom-up budgeting. The negotiated budgeting process does not impose the budget preparation process on a single level, but rather allows shared responsibility between superiors and subordinates.

Unlike top-down budgeting, negotiated budgeting increases the involvement of lower-level managers, which makes it easier to set realistic targets. Employees also demonstrate a more personal interest in the budget preparation, since they feel that their contribution is recognized by management. The top managers agree to solicit suggestions from subordinates who are responsible for implementing the budget. Companies (propagators) follow the process below when preparing negotiated budgets:

Superiors set targets

The process starts with management preparing the targets for the next financial period. Usually, the top management uses historical performance data as a benchmark for setting the targets to be achieved. Sometimes, the top-level executives may seek suggestions from lower-level managers on the targets for the next financial period. The prepared targets are then passed on to the lower-level managers for consideration.

Targets sent to subordinates

The department-level managers receive the targets from the top-level managers and are required to prepare action plans based on the given targets. Unlike top-down budgeting that limits the subordinates' action plans to the budget allocation, negotiated budgeting gives employees the flexibility to negotiate the projected revenue and costs. The departmental projections can be higher or lower than the management targets. Such flexibility creates an incentive for employees to make suggestions.

Parties meet to discuss the subordinates' action plan

After the creation of the action plans, both the superiors and subordinates meet to discuss the budget. The meeting acts as an open forum where subordinates can educate their superiors on the realities of the budget since they are the people tasked with implementing it. The forum allows each party to present its views and negotiate the differing points until they come to a consensus. The goal is to reduce the difference in the cost estimates presented by each party until they agree on a budget that is acceptable to both sides. Subordinates are often encouraged by their superior's positive response in their suggestions, and they may surrender some of their demands to the superior's advantage. However, the management retains the upper hand in the negotiations, and they can adjust the figures arrived at through the bottom-up budgeting process.

Budget approval

Once both parties have discussed and made suggestions on the budget, the changes should be incorporated into the budget. Usually, the departmental managers will be required to revise their budgets and projections to reflect what was agreed on. Once the budget has been finalized, it is presented to the management for approval. The budget is then sent to the finance department for funding, based on the projections agreed upon by management and subordinates.

2.6. Determining hygiene requirements

Propagation operation requires careful and strict handling with available hygiene requirements. This contributes to the success of propagation operation. Hygiene requirements may involve:

I. hand washing,

II. removing all media and organic matter from production surfaces, tools and equipment;

III. disinfecting production surfaces, tools and equipment;

IV. disinfecting/sterilizing propagation media;

V. disinfestations and removal of plant and media waste, footbaths;

VI. access restrictions and handling practices which minimize cross contamination, including enterprise quarantine policies and legislation

- Poor handling and less hygiene in plant propagation may result in:
  - ✓ Contamination of materials with virus, insect, disease and other dangerous microorganisms.
  - ✓ Causing difficulties with union of scion and rootstock.
  - ✓ Developments of undesirable characters after propagation
  - ✓ Wastage of time, money and other resources.

2.7. Communicating propagation plan and scheduling of activities

After preparing all the necessary pre-conditions to undertake propagation program, it is important to make discussion and communication concerning the propagation plan and schedules of activities to concerning bodies.

- Discussion and communication may include:
  - ✓ When, where and by whom the propagation plan will be done.
  - ✓ The supply of available materials and resources
  - ✓ The way in which risk, hazard, and environmental factors will be managed etc

Communication does not "just happen." Effective communication requires effective strategy - a coherent plan of action. To be effective, strategy must take three factors into account simultaneously:

- ✓ Your goals and objectives
- ✓ Operational constraints and imperatives - things you must do and things you cannot do
- ✓ Pertinent conditions in the environment

Implementing effective communication strategies to ensure personnel safety and smooth flow of operations plays a great role in:

- ✓ Solving different problems associated with harvesting operation
- ✓ Creating safe working environment
- ✓ Minimizing OHS hazards and using the corresponding care
- ✓ Facilitating the workers etc

When your objectives involve communicating with others (when do they not?), the most pertinent environmental conditions consist of the ideas that your publics have about you and your objectives. It is sometimes said that "perception is reality."more to the point: your publics' perception is your reality

Self-check-2	Written test

Part I .Choose the best answer for the following question (2pts each)

1. Which one of the following is using for prevent newly grafted scions from rainwater and wind?

A. Pruning C. shading

B. Budding D. Grafting

2. Which one of the following is using for covering after grafting made to keep it drying out?

A. Grafting wax C. Pruning Shears

B. Grafting knives D. budding strips

3. Which tools or equipments are using for plant watering

A. Grafting wax C. water cane

B. Budding Tape D. Budding knife

4. Which one of the following is an atmospheric factor?

A. light C. humidity

B. temperature D. all of the above

5. Which one of the following is a chemical property of propagation media growing

A. P^H Values C. Texture

B. Structure D. all of the above

6. Which one of the following is using to promote root formation?

A. Rooting hormones C. Rooting Hair:

B. Rooting Zones D. all of the above

7. Which one of the following is using the activity of self-supporting plants?

A. Pruning C. Hardening off

B. Thinning D. all of the above

8. Which one of the following is play important role of light?

A. Faster root development C. Newly developed shoot & Root

B. Photosynthesis D. all of the above

9. Which one of the following is a hygienic condition

A. growing media C. clean containers

B. Clean tools D. all of the above

10. Which one of the following crops is propagated by sucker?

A. Ginger C. Strawberry

B. Banana D. All of the above

11. Which one of the following crops is propagated by Rhizomes?

A. Sweet potato. C. Garlic

B. Ginger. D. Corm

12. Which one of the following crops is propagated by Bulb?

A. Onion C. Garlic B. Ginger D. Corm

13. Which one of the following are hygiene protocols during propagation?

A. Cutting material and seed collection C. Hardening off

B. Propagating D. all of the above

14. Which one of the following is an effective communication requires?

A. Effective strategy B. Coherent plan of action C. Effective production D. All of the above

15. Which one of the following is an effective strategy factors into account simultaneously

A. Your goals and objectives B. Pertinent conditions C. Operational constraints D. All of the above

Part II Give short answers

1. What is the difference between of tunicate and non-tunicate bulb?
2. What is the importance of budget negotiation for propagation activities?
3. What are the processes that propagators should follow?

Part III. Write true If the statements is correct or false the statement is incorrect

1. Seed treatment reduces the possibility of infections of pest, weed & any diseases

2. Poor hygienic standard propagation a results of sufficient & healthy plant growth

Operation sheet 2	**Propagation media preparation**

Propagation media preparation

Objective: To know how to prepare media for propagation

Procedures

step1 Understand the main purpose of propagation program and select a soil type (clay, sand and silt)

step2 Fix and schedule appropriate time for the media growing preparation program depending on the aim and plant species to be propagated.

step3 Allocate the budget depending on your purpose of media preparation and scheduled time to accomplish the task with contingency.

step4 Select all the necessary materials, facilities and infrastructures depending on your objectives of media growing.

step5 Carefully evaluate space requirements for media growing preparation program depending on your objectives of program, the nature of plant species, availability of materials and the techniques.

step6 Strictly determine the ratio of soil growing media techniques according to the plant species you have selected and availability of materials, tools and equipment's and labor force you have.

- Most commonly this ratio is applicable
  - ✓ 3(topsoil).
  - ✓ 1(sand),
  - ✓ 2(compost).

step7 Carefully, determine environmental parameters that affect the program during the preparation and establish suitable controlling measures

step8 Depending on the identified environmental factor.

step9 Identify OHS hazards associated with the prepare appropriate protection techniques.

step10 Discuss and communicate with concerning bodies other personnel about the preparation.

step11 Finally start your media growing preparation on your schedule.

LAP Test -2	**Propagation media preparation**

Instruction: You are required to perform any of the following

1. Perform propagation media

LG#26	LO #3 Monitor success of propagation activities

Instruction sheet: 3

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying and recording variances from plan and scheduled activities
- Assessing propagated plants
- Planning remedial procedures

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify and record variances from plan and scheduled activities
- Assess propagated plants
- Plan remedial procedures

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

3.1 Implementing Propagation based on propagation plan and following standard procedures and principles

Introduction

Selection criteria for propagation material may include company specifications and quality standards; the use of certified parent stock; ensuring parent stock is well nourished and healthy, free from disease, pest, frost or mechanical damage; results from recognized testing procedures, such as leaf tissue analysis; and the season.

3.1.1 Quality propagules production

Following are the steps to produce quality propagules

- ✓ Seeds should be collected from seed orchard. If no seed orchard is available for the species, selection of candidate plus tree has to be done by comparison tree method and seed should be collected from the Candidate Plus Trees (CPTs) only
- ✓ Well mature pod/fruits should be collected just prior to falling and seeds should be extracted as early as possible without damage to the seed. Using fresh seed for seedling raising purpose is generally advocated. If seed has the viability period it can be stored and used. In case of vegetative propagules fresh scion or buds should be collected from the identified mother plant and used for grafting or budding within 12 hours
- ✓ The seedling germination energy or grafting/budding success percentage needs to be increased by following appropriate pre-sowing and growth regulator treatments of seeds and vegetative propagules respectively
- ✓ Follow the standardized propagules management practices by placing them in nursery beds or under shade net house

Generally, the plant selected as mother plant for propagation purpose should have the following characteristics (criteria).

- ✓ Plants of good quality and high yielder
- ✓ High adaptability to local climate and soil conditions.
- ✓ Grow strong/vigorous healthy plants

- ✓ have desirable characteristics
- ✓ Free from diseases
- ✓ comparability, timing,
- ✓ Disease and insect resistance, drought, tolerance, and hardiness
- ✓ Actively growing portion

- **Selection of elite mother trees**
  - ✓ It should be of known identity
  - ✓ It should have production potential
  - ✓ It should have commercial acceptance
  - ✓ It should be free from pests and pathogens

https://www.youtube.com/watch?v=I-I7YeNhqmE

3.1.2 Selection of scion wood, rootstock and inter stocks

- **Selection of scion wood**
  - ✓ The scion should be from mature shoot i.e. at least one year old
  - ✓ A scion wood of diameter 0.6-1.2 cm is satisfactory for better bud wood
  - ✓ The scion shoot should have healthy, well-developed round and plump buds
  - ✓ Scion should be selected from elite trees known for quality production of fruits
  - ✓ Scion wood should be free from any bacterial, fungal and viral diseases
  - ✓ The scion should be dormant, while selected for grafting on rootstock
  - ✓ The best scion wood can be obtained from the central portion or from the basal Portion of shoot.
  - ✓ The terminal sections, which are generally succulent, pithy and low in store of carbohydrate (CHO), should be discarded

3.1.3 Collection and storage of bud wood

The best quality scion wood usually comes from shoots grown in the previous season. Scions should be severed with sharp, clean shears or knives and placed immediately in moistened plastic bags. It is good practice during the harvesting of scions and the making of grafts to clean the cutting tools regularly. Flaming or immersing them in a sterilizing solution may do this.

Isopropyl alcohol also works well as a sterilant, although it evaporates quite readily. An alternative sterilizing solution may be prepared by mixing one part household bleach with nine parts water (by volume) However, this bleach solution can be highly corrosive to certain metals. For best results, harvest only as much scion wood as can be used for grafting during the same day.

- If large quantities of scion wood must to be harvested at one time, follow these steps:

  - ✓ Cut all scions to a uniform length, keep their basal ends together, and tie them in bundles of known quantity (for example, 50 scions per bundle).
  - ✓ Label them, recording the cultivar, date of harvest, and location of stock plant.
  - ✓ Wrap the base of the bundles in moistened burlap or sphagnum, place them in polyethylene or waterproof paper bags, and seal the bags.
  - ✓ Store the bundles for short periods, if necessary, either iced down in insulated coolers or in a commercial storage unit at 32° to 34°F
  - ✓ Never store scions in refrigerated units where fruits or vegetables are currently kept or have been stored recently
  - ✓ Keep the scions free from freezing during storage

- **Selection of rootstock**
  - ✓ Rootstock should have a proper vigor and growth habits
  - ✓ Rootstock should be resistant to soil born diseases and other pests
  - ✓ Rootstock should be tolerant/ resistant to toxic salts like Na, Mg, and Ca etc.
  - ✓ It should have wide range of edaphic adaptability (all soil and climatic factors).
  - ✓ Should have wide range of graft compatibility
  - ✓ Should be easy to propagate
  - ✓ It should not go under any mutation
  - ✓ Its age should be one to one and half years and not more than 2 years
  - ✓ Its diameter should be greater than 1 cm (pencil thickness)

- **Selection of Inter stock**

Inter stock is a piece of stem inserted by means of two graft unions between the stock and scion. It is used to

- ✓ Avoid incompatibility between the stock and scion.
- ✓ Make use of winter hardy trunk.
- ✓ Take advantage of dwarfing rootstock. E.g. Apple: to restrict tree size and improve rooting.

3.1.4 Bud wood certification

The commercialization of different fruit plants and with the urge to produce superior quality cultivars, there is uncontrolled importation of varieties within the country and across the countries. Such movement of bud wood across the globe results in spread of viral diseases from one region to the other, which needs to be controlled. Bud wood certification has a prominent role in this direction, provided if done in each and every case of germplasm movements within and across the countries.

3.1.5 Bud Wood Packaging

The bud wood should not be allowed to dry out and be kept in polythene bags containing damp sawdust/wrapped in moist pieces of gunny bags/polythene bags Although, essential requirements are to keep the wood moist and viable, but not so wet as to rot, and maintaining a cool enough temperature to prevent premature bud swelling and protecting against freeze damage. For temperate fruits store scions in tightly sealed plastic bags with some moisture in refrigeration until ready to use.

3.1.6 Bud wood labeling

Clearly labeled outside packaging where there is no regulatory guidance, the label may include:

- ✓ Type of material
- ✓ Plant species with cultivar
- ✓ Date of preparation

- ✓ Permit Number (where applicable)
- ✓ Permit Number for import and / or Phytosanitary Certification (where applicable)
- ✓ Amount of material shipped
- ✓ Location of the stock plant
- ✓ Genetically modified or not

3.2 Identifying and recording variances from plan and scheduled activities

Introduction

It is known that before any propagation activities planning should be performed.In doing so errors /variances should be identified and recorded.

- Common possible errors in nursery activities
  - ✓ Containers not filled properly
  - ✓ Cylindrical shape of container not maintained
  - ✓ Container not in upright position
  - ✓ Soil or sand used in germination beds not changed after each production cycle
  - ✓ Sowing seed too deep
  - ✓ Lifting transplant seedlings individually and wrenching them
  - ✓ Exposure of seedlings to air after lifting
  - ✓ Bad transplanting and delayed transplant to container beds
  - ✓ Leaving air space around the root of the young seedling after transplanting
  - ✓ Bad root pruning while transplanting
  - ✓ Inadequate attention paid to root pruning in transplanted containers before transporting to field
  - ✓ Same knapsack sprayer used to apply weedicides and fungicides
  - ✓ Hardening off process starting too late or neglected
  - ✓ Dumping of seedlings in nursery without placing them as per species, size, etc.

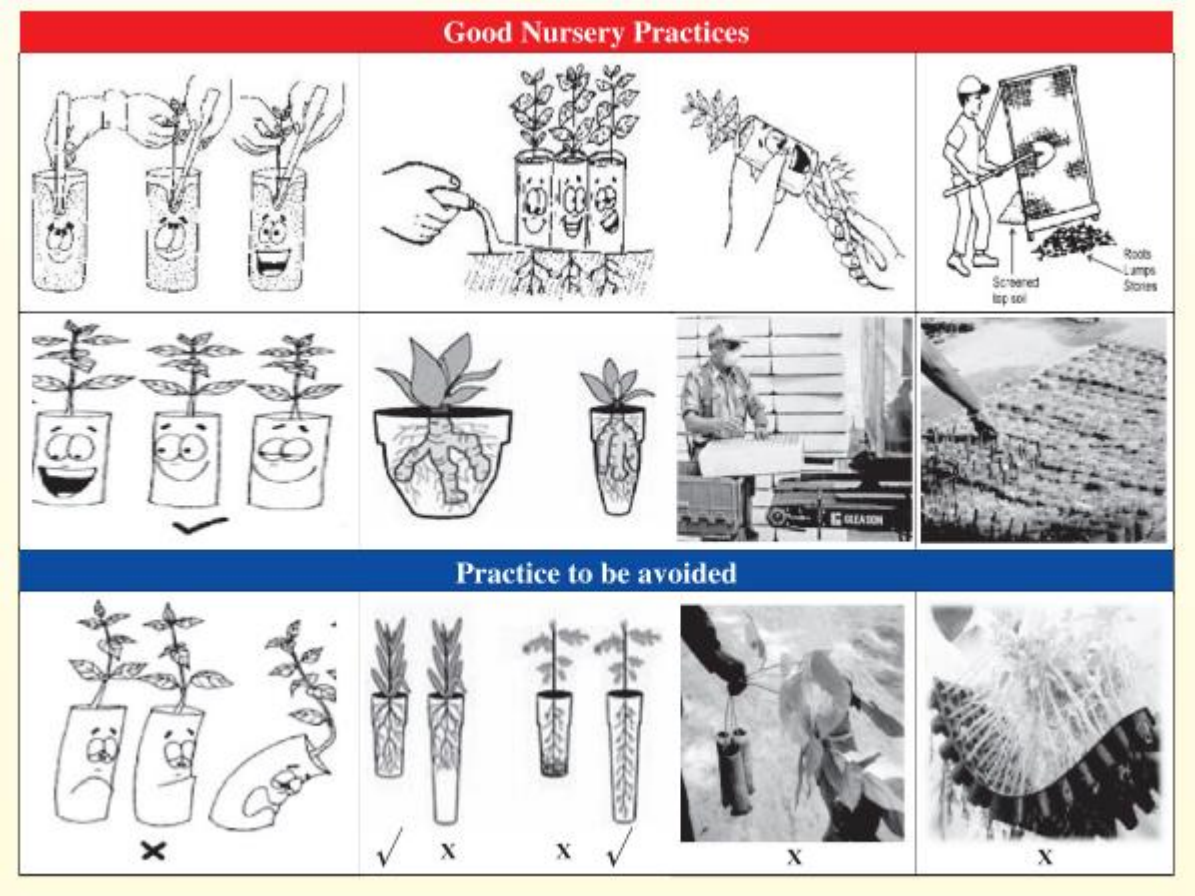


Figure: 3.1. Good and bad nursery practices

3.3. Assessing propagated plants for health, quality and viability

Introduction

After the propagation operation has been completed, there is a need of careful management, observation and assessing the propagated plants regarding their health, viability, remedial and quality. Assessment will involve Inspection, recognized analytical procedures, and recording and interpreting production statistics. Importance of assessing propagated plants after propagation operation has been completed is:

- ✓ To provide available management care to the propagated plant
- ✓ To analyze the changes that occurred after propagation
- ✓ To protect from some infections, diseases and other factors that affecting the operation

- ✓ To assess the health, quality and viability after propagation.
- ✓ To record and interpret production statistics and so on.

Propagated plants provide high quality pathological and genetic testing to the vegetable seed, fruit tree, grapevine, and strawberry industries by approved or in-house improved methods at competitive prices.

- **Seed health**: Seed Health Lab offers pathogen testing for various seeds (vegetables, field crop, flower seeds, etc). We use standard or improved methods.
- **Plant health:** Plant Health Lab provides fast and accurate diagnosis of plant diseases to help farm and nursery managers take the correct steps on a timely basis.
- **Genetic:** genetics lab provides variety identification, resistance screening, and hybrid purity tests.
- **Remedia**l: provided or intended for children with learning difficulties.
- **Viabilit**y
  - ✓ ability to work successfully.
  - ✓ ability to survive or live successfully

The environmental conditions listed below must be maintained to ensure successful propagations of healthy, disease-free, and true-to-type plants.

- ✓ Temperature
- ✓ Light
- ✓ Aeration
- ✓ Humidity

3.4. Planning remedial procedures

Introduction

Remedial procedures may be required in response to damage or loss, pest and disease problems, and marketing requirements.

- Remedial procedures may include:

- ✓ Quarantine/isolation procedures,
- ✓ Schedule amended,
- ✓ Integrated pest management,
- ✓ Cultural intervention such as fertilizing, misting, tip/root pruning,
- ✓ Spraying growth hormones,
- ✓ Light manipulation, temperature changes, increased/decreased humidity,
- ✓ Tying, staking, taping; removing and disposing of damaged plant material, and irrigation.

- **Economic and procurement considerations**

In most cases, propagation by seed is the most labor and cost effective method of reproducing plants, given that genetic variability, such as germination requirements, can be managed within acceptable limits. Seed may be gathered by commercial collectors on a contractual basis or by the restoration staff directly. Raw fruit requires proper storage prior to cleaning, processing to some clean product level, inventorying, and proper storage prior to sowing. Large amounts of seed can be planted outdoors in woody production beds with relatively simple machinery. For a given species in which seed is readily available, viability high, dormancy requirements known and minimal, and cultural techniques established; sexual propagation represents a low cost, labor and facility efficient method of multiplying plants.

As the conditions for the collecting, sowing, and culturing of seed become less than ideal, asexual propagation by cutting becomes an increasingly viable production option. As noted earlier, seed availability may be low, available seed expensive, or a lengthy or difficult dormancy mechanism involved. Although seed may be in abundant supply, its viability may be low--a condition that may be a regular or periodic phenomena. Once acceptable collection sites have been identified and the propagules collected, verification of origin and the maintenance of the sampled genetics is necessary throughout all stages of production. It may even be necessary to isolate seed or cuttings by individual parent plant, depending on the restoration strategy. For this reason, the purchase of bulked lots or propagules of questionable origin may not be an acceptable option for National Park and Forest projects.

Managers need to recognize the additional expense associated with site specific propagate collection and the cost of verification and maintenance of these sources. Other factors may increase the cost of production as well. A lack of commercial incentive has resulted in less propagation research being conducted on the native woody species in comparison to ornamental selections that have been through breeding or selection programs. Project-specific wild land collections are often small and irregular in amount and viability, preventing economies of scale from being reached.

These factors in combination will increase the cost of production. Procurement specifications need to reflect these needs and resources allocated accordingly. One option may be to reimburse commercial growers in two stages, one for attempting to produce a difficult-to-grow species and the second on a “per plant” basis for the actual product grown. Given some level of success, the sum of the two contracts might approximately equal the per plant cost of producing some relatively easy-to-grow species

Self-check-3	Written test

Part I: say true for correct statements or false otherwise (2 points each)

1. Propagation by seed is the most labor and cost effective requirement system

2. Asexual propagation by cutting becomes an increasingly viable production option

3. Asexual propagation represents a low cost, labor and facility than sexual method of multiplying plants.

Part II .Choose the best answer for the following question

1. Which one of the following is a Selection of Elite Mother Trees?

A. It should be of known identity C. It should have commercial acceptance

B. It should have production potential D. all of the above

2. Which one of the following are criteria for selection of rootstock?

A. should have a proper vigor and growth habits. C. should be tolerant/ resistant to toxic salts

B. should be resistant to soil born diseases and other pests. D. all of the above

3. Which one of the following is a selection criterion of scion?

A. from mature shoots C. Free from any diseases

B. Wood diameter 0.6- 1.2cm D. all of the above

4. Which one of the following is performed to ensure successful propagations of healthy, disease-free, and true-to-type plants?

A. Light monitoring C. Humidity monitoring

B. Aeration monitoring D. All of the above

5. Plant health mean:

A. Free from diseases C. Viability

B. True to type D. all of the above

6. Which one of the following is chief important of propagation plants

A. Temperature C. humidity

B. light D. all of the above

Part III. **Give short answers.**

1. What are the variances in propagation activities?

2. What is the activity next to variance identification

3 What is the importance of assessing propagated plants after propagation?

4 What are the major points to be included in assessment of propagated plants?

5. What do mean by planning remedial requirements?

6. What will be included in the remedial plan of plant propagation?

7. Develop remedial plan for plant propagation?

8. What are the remedial procedures?

References

Abellanosa, A.L. and Pava, H.M.. 1987. An Introduction to Crop Science. CMU, Musuan, Bukidnon: Publications Office

Bryant, G. 1995. *Propagation Handbook*. Stackpole Books: Mechanicsburg, Pennsylvania

Chandra. A. Chandra. A. Gupta. I.C, 1994. Arid fruit research, Scientific Publishers, Jodhpur, India .

Dumroese, R.K.; Luna, T.; Landis, T.D. 2008. Nursery manual for native plants: volume 1, a guide for tribal nurseries. Agriculture Handbook 730. Washington, DC: U.S. Department of Agriculture, Forest Service. 302 p.

Dirr, M. A. and Heuser, C. W., 1987. *The Reference Manual of Woody Plant Propagation:* From Seed to Tissue Culture. Varsity Press: Athens, Georgia

Hartmann, H. T., Kester D. E., Davies, F. T. and Geneve R. L., 1996. *Plant Prop, Principles and Practices*. 6th ed. Prentice Hall: Upper Saddle River, New Jersey.

Horticultural crop material's transportation. *https://www.youtube.com*

Kamprath. H, 2003. Proposal for a fruit tree orchard, GTZ DED, Blantayre, Malawi.

Landis, T.D. 1994. Using "limiting factors" to design and manage propagation environments. International Plant Propagators' Society, Combined Proceedings. 43: 213–218.

L.A. Hammedand M.A.O.Okelanahrt 504: propagation of horticultural crops sexual propagation Instructors Pdf.

McMillan Browse, P. D. A. 1978. Plant Propagation. Simon and Schuster: New York

Stoltz. L.P. Strang. J., 2004. Reproducing fruit trees by graftage, Budding and Grafting. University of Kentucky College of Agriculture.

web address

https://ncert.nic.in/vocational/pdf/kegr103.pdf

https://resourcecentral.org/plant-propagation-meth...

https://en.wikipedia.org/wiki/Plant_propagation

https://extension.umaine.edu/gardening/manual/prop...

https://en.wikipedia.org/wiki/Plant_tissue_culture

https://www.toppr.com/ask/question/explain-graftin...

https://www.groworganic.com/blogs/articles/how-to-...

https://www.gardenersworld.com/plants/five-methods...

https://www.majordifferences.com/2013/03/d

http://www2.dpi.qld.gov.au/horticulture/4736.htmlGrowingavocado

https://www.youtube.com/watch?v=7OrwnZXi2SQ

https://www.youtube.com/watch?v=SOu15VsEIuM

https://www.youtube.com/watch?v=I-I7YeNhqmE

https://www.youtube.com/watch?v=2Q39WMmToAM

Acknowledgement

Ministry of Labor and Skills and Ministry of Health wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

The trainers who developed the learning guide

No	Name	Qualification	Educational Level	Region (College)	Phone number	E-mail
1	Eyob Birhane	Agronomy	**MSc**	Alage ATVET college Oromia Region	**09 13047105**	**yeroosaan@yahoo.com**
2	Dabi Kebede	Agronomy	**MSc**	Agarfa	0922685140	dhabik@gmail.com
3	**Tefera Merga**	**Plant protection**	**MSc**	**Oromia, Holeta**	**0956052325**	**mergatafe@gmail.com**
4	Isa Ibrahim	MSc	**MSc**	Gewane	0917388460	isaibrahim67@gmail.com
5	Muftah Mohammed	Horticulture	**MSc**	Mizan	0979729703	muftahkawo@gmail.com