

Crop Production

Level-III



**Based on April, 2022, Version 1 Occupational
Standard**

**Module Title: - Managing and Propagating
Horticultural Crops**

LG Code: AGR CRP3 M02 LO (1-6) LG (7-12)

TTLM Code: AGR CRP3 TTLM 0523v1

May, 2023

Addis Ababa, Ethiopia

Table of Contents

Introduction to the Module	2
LO #1 Prepare Planting Plan	3
Instruction Sheet.....	3
Information Sheet 1	5
Self-Check 1	32
LO #2 Implement Horticultural Crop Management	33
Instruction Sheet.....	33
Information Sheet 2	35
Self-Check 2.....	57
Operation Sheet 2.....	58
LAP Test 2	61
LO #3 Prepare Propagating Media	62
Instruction Sheet.....	62
Information Sheet 3	64
Self-Check 3.....	79
Operation Sheet 3.....	80
LAP Test 3	81
LO #4 Prepare Parent Material	82
Instruction Sheet.....	82
Information Sheet 4	84
Self-Check 4.....	110
LO #5 Undertake Propagation	111
Instruction Sheet.....	111
Information Sheet 5	112
Self-Check 5.....	141
Operation Sheet 3.....	142
LAP Test 5	146
LO #6 Complete Propagation Activities	147
Instruction Sheet.....	147
Information Sheet 6	148
Self-Check 6.....	152
Reference Materials	153

Introduction to the Module

This module covers the knowledge, skills and attitude required to participate in processes to prepare planting plan, implement horticultural crop management, prepare propagating media, prepare parent material, undertake propagation and complete propagation activities

Page 2 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

LG #1

LO #1 Prepare Planting Plan

Instruction Sheet

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

- Introduction to the module
- Accessing and adhering workplace information sources
- Identifying manual handling components with work policies and procedure
- Identifying and reporting manual handling risks and incident procedures.
- Assessing Risks within level of responsibility
- Determining the type and method(s) of horticultural crop planting
- Type of horticultural crop and method (s) of planting
- Assessing and calculating the resources required for the planting operations.
- Selecting and organizing the chemical applications
- Preparing production plan and ensuring any potential environmental impacts.
- Ensuring proper disposal of containers, drums and other waste.
- Identifying and assessing occupational health & safety hazards
- Identifying sought and obtained approvals required for the planting operations.
- Determining measurable indicators, specifications and targets

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:

- Access and adhere workplace information sources
- Identify manual handling components with work policies and procedure
- Identify and report manual handling risks and incident procedures.
- Assess risks within level of responsibility
- Determine the type and method (s) of horticultural crop planting

- Determine the type of horticultural crop and planting method (s)
- Assessing and calculate the resources required for the planting operations.
- Select and organize the chemical applications
- Prepare production plan and ensuring any potential environmental impacts.
- Ensure proper disposal of containers, drums and other waste.
- Identify and assess occupational health & safety hazards
- Identify sought and obtained approvals required for the planting operations.
- Determine measurable indicators, specifications and targets

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 Accessing and adhering workplace information sources

Workplace Information

The trainees need to collect necessary information before preparing the plan. The information needed may include: agro-ecological data, socio-economic data, market information, propagation material availability, assessing services and site modifications required propagation techniques, sequence of operational activities in the propagation of horticultural crops and production guidelines for different horticultural crops (spacing, seeding rate, fertilizer requirement, types of chemicals used for control of insect pest and diseases of fruits, yield per hectare, etc) and monitoring the activities. This can be done by visiting nearby metrological center, farmers' field, market, etc.

Hazards and Risks

A hazard is a source of potential damage, harm or adverse effect. It can affect something or someone. A hazard has the *potential* to cause illness or injury to people, or damage to property or equipment. A risk is the likelihood of an adverse event due to exposure to a hazard. A risk assessment determines the likelihood that an incident would take place because of the hazard, and the severity of the potential incident.

In essence, an incident is a risk that has materialized because of: 1) the presence of a hazard, and 2) exposure to the hazard (contact, interaction, close proximity, etc).

It is theoretically possible for a hazard to exist without any serious risk of incident. But that's not the proper mindset to adopt. All hazards should be taken seriously and investigated for their potential to cause harm. Once a hazard is identified, it can either be eliminated, or control measures can be used to reduce risks of incidents caused by the hazard. The hierarchy of controls shows the effectiveness of control measures.

Page 5 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

Sources of workplace information

An effective workplace safety program consists of identifying and mitigating safety risks. You need to be aware of workplace hazards to properly identify safety risks. To help with hazard identification and assessment, start by creating and maintaining a list of all sources of information on workplace hazards. The sources should be consulted periodically, or whenever a new process or job task is introduced. The following are sources of information on hazards that may already be available in your workplace and that are mentioned in OSHA's document on Recommended Practices for Safety and Health Programs:

- Equipment and machinery operating manuals.
- Safety Data Sheets (SDSs) provided by chemical manufacturers.
- Self-inspection reports and inspection reports from insurance carriers, government agencies, and consultants.
- Records of previous injuries and illnesses, such as OSHA 300 and 301 logs.
- Reports of incident investigations.
- Workers' compensation records and reports.
- Patterns of frequently occurring injuries and illnesses.
- Exposure monitoring results, industrial hygiene assessments, and medical records (appropriately redacted to ensure patient/worker privacy).
- Input from workers, including surveys or minutes from safety and health committee meetings.
- Results of job hazard analyses or job safety analyses.
- Documentation from other existing safety and health programs (lockout/tagout, confined spaces, process safety management, PPE, etc.).

There are also external sources of information that you can use, such as:

- Websites, publications and other government agencies from around the world.

Page 6 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- Best practices or other publications made available by industry groups or trade associations.
- Labor unions, state and local occupational safety and health committees/coalitions, and worker advocacy groups.
- Safety and health subject matter experts and consultants.



Figure 1.1: Workplace sources of information

(<https://www.youtube.com/watch?v=dp3GYCOTUhl> , Accessed date: May 22, 2023)

It is important to make sure that all internal sources of information are always up-to-date, and monitor the external sources. Finally, don't be reactive by simply waiting for a hazard to be documented somewhere. Be proactive by encouraging workers to report observations and near misses directly in the field through mobile devices. Events reported by workers can help you identify new hazards.



Figure 1.2: Workplace sources of information
 (<https://www.youtube.com/watch?v=Z06GoEyt9jk>, Accessed date: May 22, 2023)

1.2 Basic plant physiology

What is plant physiology?

Plant physiology describes the physiology and functioning of the plants. It is a sub-discipline of botany. It primarily describes the key processes such as the respiration, photosynthesis, hormone functions, nutrition, nastic movements, tropisms, parthenogenesis, phototropism and circadian rhythms. It also deals with the topics including seed germination, environmental stress physiology, stomata function and dormancy. Besides, the subject is closely connected to the fields such as plant morphology, phyto-chemistry, plant ecology, biophysics, genetics, molecular biology and cell biology.

It is a sub-discipline of botany that studies the key processes and functions of plants, such as photosynthesis, nutrition, hormone functions, etc. It also covers how plants interact with the environment and other fields of science.

Page 8 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

In order to understand the plant way of life, knowing the structure and functioning of is crucial. Plant Physiology provides information on how the plants survive. Therefore, studying the subject is necessary to get a deeper insight into the plants. Now our from assignment help online experts will tell you about the role of Plan Physiology in detail. Plant physiology is an important field of study that helps us understand the internal workings of plants.

Key areas of plant physiology: Some of the main topics in plant physiology are:

- Plant biochemistry: It studies the chemical compounds produced by plants for various purposes, such as defense, photosynthesis and drought tolerance.
- Plant cell biology: It studies the unique features and functions of plant cells, such as cell wall, chlorophyll and vacuole.
- Plant anatomy: It studies the structure and organization of plant cells, tissues and organs, and how they perform different tasks, such as transport, reproduction and growth.
- Plant ecology: It studies how plants interact with their biotic and abiotic environment, and how they cope with stress, competition and climate change.

Role of plant physiology in knowledge development

Plant physiology helps to understand the plant way of life, how they survive, grow and respond to different conditions. It also helps to improve agriculture, horticulture and genetic engineering by developing new crops, enhancing crop quality and protecting plants from pests and diseases.

Plant physiology focuses on studying every internal activity of the plant. The key physical and chemical processes are analyzed in the subject. It also covers the activities of different scale of time and size. In other words, molecular interactions such as photosynthesis, internal diffusion of minerals, water and nutrients are studies as part of the subject. Along with it, the large scale activities such as seasonality, plant development, reproductive control and dormancy.

Page 9 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

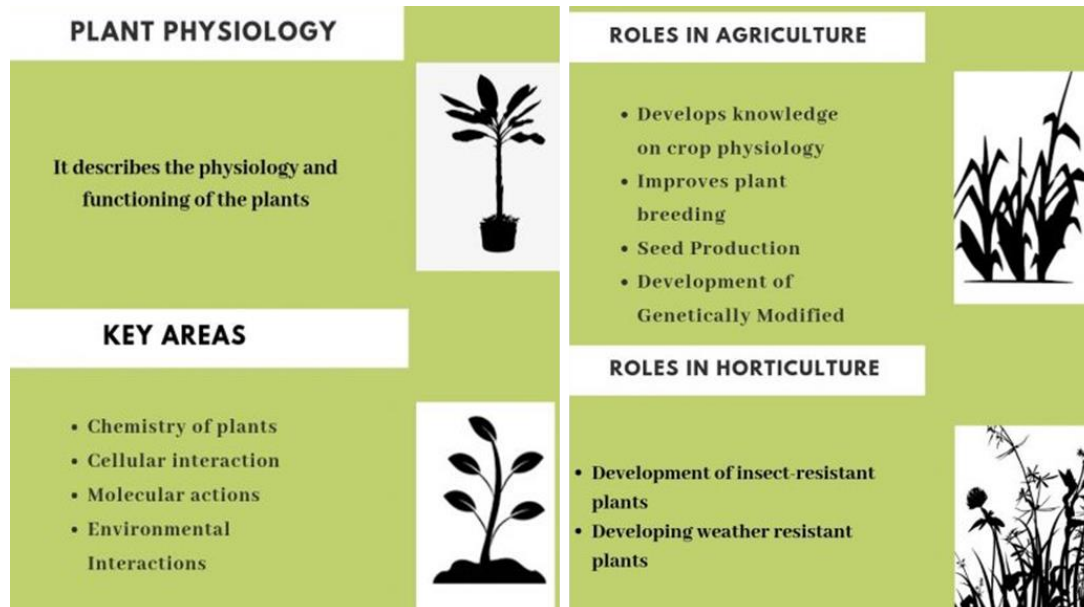


Figure 1.3. Roles of plant physiology

1.3 Determining the type and method(s) of horticultural crop planting

Scholars define that horticulture is the science of cultivating plants. Horticulture, the branch of plant agriculture dealing with garden crops, generally fruits, vegetables, and ornamental plants. The word is derived from the Latin hortus, “garden,” and colere, “to cultivate.” As a general term, it covers all forms of garden management, but in ordinary use it refers to intensive commercial production. It includes the cultivation of fruits, vegetables, flowers, and ornamental plants. Horticulture is divided into several branches such as pomology (fruit cultivation), olericulture (vegetable cultivation), floriculture (flower cultivation), and landscape horticulture (ornamental plant cultivation).

Pomology deals with fruit and nut crops. Olericulture deals with herbaceous plants for the kitchen, including, for example, carrots (edible root), asparagus (edible stem), lettuce (edible leaf), cauliflower (edible flower buds), tomatoes (edible fruit), and peas (edible seed). Floriculture deals with the production of flowers and ornamental plants; generally, cut flowers, pot plants, and greenery. Landscape horticulture is a broad category that includes plants for the landscape, including lawn turf but particularly nursery crops such as shrubs, trees, and vines.

1.4 Type of horticultural crop and method (s) of planting

The major methods of horticultural planting include **seed propagation, vegetative propagation, and tissue culture**. Seed propagation is the most common method of planting in horticulture. In this method, seeds are sown in soil or other growing media. Vegetative propagation is another method of planting in which a part of the plant is used to grow a new plant. This method includes cutting, layering, grafting, and budding. Tissue culture is a modern method of planting that involves growing plants from small pieces of plant tissue in a laboratory.

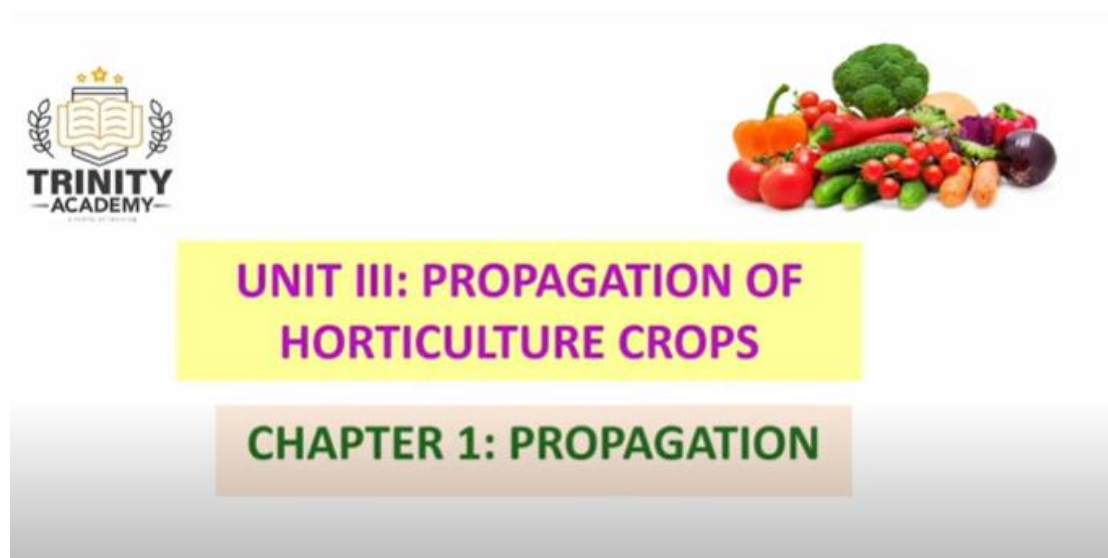


Figure 1.4. Propagation of horticultural crops
<https://www.youtube.com/watch?v=P34w9wRFEmw> Accessed date: May 23, 2023)





1.5 Assessing and calculating the resources required for the planting operations.

Among the required resources (including common tools and equipment's) for example shade cloth, plastic fencing, tape, support structures, labels, irrigation equipment, heaters, coolers, fans, vents, fogging/ misting systems, screens are shown in the following figure.







The major resources required for horticultural crops production are listed below:

Page 11 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023









No.	Horticultural tools	Description and their use
1	<p>Hoe</p> 	<ul style="list-style-type: none"> • Long handled with flat and perpendicular blade at the end. • Used to remove weeds by agitating and grooming the soil surface. • Used to dig, move and hill soil during preparation for planting
2	<p>Mattock</p> 	<ul style="list-style-type: none"> • For digging hard soils
3	<p>Axe</p> 	<ul style="list-style-type: none"> • Axe is multipurpose cutting tool used for felling and delimbing of trees, splitting of logs for firewood and dressing of logs for timber conversion.
4	<p>Spade</p> 	<ul style="list-style-type: none"> • A long handled tool traditionally used for • Digging, shoveling soil and compost, • Moving shrubs of plants


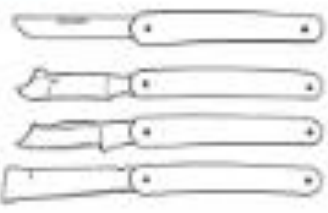




5	Round Point Shovel 	<ul style="list-style-type: none">• All-purpose shovel, rounded, sharp point widely used garden tool.• Used to dig large holes and transport heavier materials such as wet soil and rocks• Its sharp edges can cut the roots and sods as well as break up compacted soil.
6	Square Point Shovel 	<ul style="list-style-type: none">• Good for scooping and transferring heavy materials (soil, rock, cement, etc.)
7	Cultivators 	<ul style="list-style-type: none">• Used to break up compacted soil, spread fertilizers and compost, remove shallow rooted weeds without disturbing the roots of surrounding plants
8	Forks 	<ul style="list-style-type: none">• Used for digging of soils in situations where the use of spade may be difficult for turning of soils,• Used to till large areas of soil and break up compacted clods,• To rake out weeds and stones
9	Trowels (planting/digging) 	<ul style="list-style-type: none">• A small hand held tool used to dig small hole (for planting & transplanting small plants/saplings),
10	Garden Rake (or "soil rake") 	<ul style="list-style-type: none">• A long handled tool used to create a fine tilt and level the seedbeds (Short steel tines ideal for raking soil or moving heavy material),• Collect plant debris and stones from the seedbed surface,• Break soil clumps and spread fertilizers or compost








11	Leaf Rake 	<ul style="list-style-type: none">• Long, flexible steel tines for raking leaves
12	Watering can 	<ul style="list-style-type: none">• A portable water container used for watering smaller areas and containers
13	Pegs 	<ul style="list-style-type: none">• Used for securing net, line or fleece to the ground
14	String (Garden Twine)  <small>Nylon string</small>	<ul style="list-style-type: none">• Used for lay outing activities and tying plants to stakes• Available in natural jute and coated
15	Wheelbarrow 	<ul style="list-style-type: none">• It is carrier, usually having only one wheel, a tray bolted to two handles and legs• Used to transport seedlings soil, compost as well as small loads
16	Anvil Clippers 	<ul style="list-style-type: none">• One blade & one flat surface, best for extremely hard wood







17	Shears 	<ul style="list-style-type: none">• Shears for different purposes (Pruning, Harvesting)
18	Budding Knife 	<ul style="list-style-type: none">• A small knife designed for delicate budding - grafting with a single eye or bud.
19	Budding/grafting tape 	<ul style="list-style-type: none">• Used for wrapping graft-union point while grafting and/ or budding fruit species.
20	Lopping Shear 	<ul style="list-style-type: none">• Long handles provide extra leverage for pruning thick branches



21	Pruning Saw 	<ul style="list-style-type: none">• Short, sharp saw for cutting limbs too thick for hand or lopping shears
22	Hedge shears 	<ul style="list-style-type: none">• Hedge shears are gardening tool used for trimming (cutting, pruning) hedges or solitary shrubs (bushes).
23	Machete 	<ul style="list-style-type: none">• A large, strong blade usually around half a meter long.• Effective in cutting small branches and heavy underbrush.
24	Measuring tape 	<ul style="list-style-type: none">• Made from steel or wooden and used for layout of seedbed, plots and plant spacing
25	Gloves 	<ul style="list-style-type: none">• Used to protect hands and fingers from cuts, blisters, calluses, sun damages, abrasions and dirt.



26	Footwear 	<ul style="list-style-type: none">• Used to protect feet from stones, falling items or tools.
27	Fruit Harvester 	<ul style="list-style-type: none">• Clip and pick fruit picker
		<ul style="list-style-type: none">• Fruit Tree Picking Pole with Basket
		






		<ul style="list-style-type: none"> Hydraulic platform (fruit picking lift) for harvesting, pruning and spraying operations in orchards
28	<p>Ladders</p> 	<ul style="list-style-type: none"> Different types ladders (that fold out into an A-shape) commonly used in fruit orchards (tree pruning, harvesting etc.) There are also ladders that sit straight against a stabilizing object (used for pruning and harvesting tree fruits).
29	<p>Crates</p> 	<ul style="list-style-type: none"> Crates (plastic, wooden) used for collecting harvested fruits

Figure 1.5. Horticultural tools and equipment and their use

Resources required for horticultural planting operations include soil, water, seeds or seedlings, fertilizers, pesticides, and labor. The type and amount of these resources depend on various factors such as the crop type, soil type, climate conditions, and planting method.

i. Land preparation

When establishing a new date plantation, certain actions need to be implemented to ensure the long term success of the plantation. One of these actions involve the initial land preparation which should be done prior to transplanting of the plant material (offshoots or tissue culture-derived plants). The purpose of land preparation is to provide the necessary soil conditions which will enhance the successful establishment of the young offshoots or the tissue culture plants received from the nursery. The aim is to enable the date grower to plan and structure the implementation process in advance, ensuring the successful establishment of the date plantation. Planning forms part of the initial preparation and will help to limiting unnecessary stoppages during the implementation phase.

Critical factors to consider during this planning exercise are summarized as follows:

- Availability and quality of irrigation water;
- Field selection;
- Mechanical actions to be implemented;
- Chemical needs for pre-plant soil improvement;
- Tools and equipment needed for date cultivation;
- Labour needs;
- Irrigation design and installation;
- Leaching schedule;
- Hole preparation;
- Financial requirements and
- Time schedule.

A) Field selection

The area selected for the establishment of the date plantation can influence the cost of land preparation to the extent that it may not be viable to proceed with the development at all. The authors' aim is to highlight the critical areas to be considered when selecting the land for the establishment of a new date plantation.

i. Availability of water

Critical factors regarding water for irrigation purposes are:

- The sustainability of the water source,
- The quantity of water available for irrigation,
- The distance to the field, and
- The quality of the water.

ii. Soil depth

Besides the importance of root development, soil depth also influences drainage and leaching possibilities. Any obstructive layers must be evaluated to determine whether they will influence root development and whether they can be corrected.

iii. Soil quality

The soil quality is related to its drainage capacity mainly when soils are salty or the irrigation water is characterized with a high salt content. Sandy soils are common in most date plantations of the old world.

When evaluating the soil quality, attention must be given to:

- The soil texture which will influence the water retention capacity, and

Page 20 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- The nutrient content to determine the corrective measures necessary for soil improvement.

iv. Soil salinity or acidity

Plant growth is influenced by either saline or acid soil conditions which, in the end, will result in a loss of potential yield.

Saline and alkaline soils are common in date plantations and are characterized by a high concentration of soluble salts, and exchangeable sodium, respectively. Soluble salts present in these soils belong to cations: sodium, calcium and magnesium and to chloride and sulphate anions.

Saline and alkaline soils are usually the result of:

- An increase of the underground level caused by excessive drought situations (high evaporation);
- The use of high salt content water, and
- Very poor drainage system.

B) Physical land preparation

Once a suitable area for establishing the plantation is selected and the planning operation is finalized, the actual preparation can be activated. These activities are divided to structure and pace the implementation process in order to be ready for planting at the most suitable time, according to the specific regional climatic conditions.

i) Mechanical field preparation

Page 21 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

The mechanical or initial soil preparation concerns mainly the preparation of a field for further detailed preparation such as irrigation system installation, hole preparation, etc. Actions, if applicable to the area, include:

- Debushing/bush clearing;
- Removal of stones and rocks;
- Ripping; and
- Levelling of the soil.

ii) Irrigation system installation

The type of irrigation system to be used will be determined by the availability of water, topographical and soil conditions. When the initial soil preparation is completed, the installation of the required irrigation system will be implemented according to the prescribed design.

iii) Soil improvement

The scheduling of the soil improvement programme will depend on the date grower, as certain applications could be combined with the initial actions of soil preparation.

If new soils are considered, the soil improvement programme will mostly deal with:

- The application of organic matter; and/or
- The elimination of soil salinity.

Organic material

In general, most soils are poor in organic matter content and the improvement of this situation plays an important role in soil fertility. Some of the advantages of a higher humus content in the soil are summarized as follows:

- Enhances crumb formation which improves the respiration of the roots;
- Increases the water infiltration rate;
- Increases the water holding capacity;

Page 22 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1 May 2023
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- Lowers soil compaction and crust formation; and
- Limits the harmful effects of alkalinity and improves the leaching of salts.

1.5.3 Planting operation

This is probably the most critical phase in the establishment of a new date plantation. Mistakes at this point may lead to a poor survival rate of offshoots or tissue culture-derived plants, regardless of the efforts put in during the preparation phases. The aim is to assist the date grower to execute the planting operation in a way that will ensure a high transplanting survival rate in the newly established plantation. The planting operation should take place including different activities such as plant spacing, time of planting, transplanting stage, planting time and depth, basin preparation, mulching, irrigation, and crop protection.



Figure 1.6: Methods of planting crops

(<https://www.youtube.com/watch?v=z82jzfE2TFI> Accessed date: May 23, 2023)

1.6 Selecting and organizing the chemical applications

Page 23 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

Chemical applications are used in horticultural crop production to protect crops from pests, diseases, and weeds. The main classes of crop protection chemicals are herbicides, insecticides, and fungicides. Selective herbicides control the growth of weeds that would otherwise grow among a crop, competing with it for water, nutrients, and sunlight. Without crop protection chemicals, agriculture would be less efficient. There are also new technologies for the chemical application of horticultural crops such as computational fluid dynamics (CFD), target detection, dynamic fluid mechanics, application planning, and precise spray control. These technologies aim to improve the efficiency of chemical application in horticultural crops. Therefore, it is crucial to choose chemicals with minimal environmental impact or explore alternative methods such as biological control or natural remedies whenever possible. Proper disposal of empty chemical containers and leftover chemicals is also essential in protecting water quality and minimizing environmental harm. Overall, selecting and organizing chemical applications requires careful consideration of both effectiveness and environmental impact to ensure successful crop production for years to come.



Figure 1.7. Chemical application techniques

(<https://www.youtube.com/watch?v=ocwhcnjp7fQ;>

<https://www.youtube.com/watch?v=yyEYvvIANHw> Accessed date May 23, 2023)

1.7 Preparing production plan and ensuring any potential environmental impacts.

Preparing a production plan is a crucial element in achieving success in horticultural crops production. A production plan helps farmers to schedule activities such as planting,

Page 25 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1 May 2023
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irrigation, fertilization, spraying, and harvesting, among others. The production plan must be detailed and well organized to ensure that every aspect of crop production is accounted for. It is important to factor in the specific requirements and needs of each crop to achieve optimal yields. The plan should also identify potential challenges such as pests, diseases, and environmental factors that may affect production. By taking a proactive approach, farmers can ensure they have sufficient resources and time to address any issues that may arise during the production process.

In addition to preparing the production plan, it is also essential to consider the potential environmental impacts of horticultural crop production. Some of the potential environmental impacts include pollution of water sources through run-off from chemical fertilizers and pesticides, soil erosion due to poor land management practices, and depletion of groundwater resources due to over-irrigation. Farmers must take measures to minimize these impacts through the use of sustainable farming practices. This can include utilizing organic fertilizers and pest management practices instead of chemical treatments, practicing crop rotation to prevent depletion of soil nutrients, and implementing soil conservation measures such as terracing and cover cropping to reduce erosion. Overall, a well-prepared production plan with consideration for potential environmental impacts is essential in ensuring the sustainable production of horticultural crops in the long term.

Developing a production plan for a horticultural enterprise involves establishing product specifications, researching site factors and land use issues, selecting and sourcing plants or plant material for seeding or propagation, designing and incorporating infrastructure into planning, specifying a monitoring program to cover the operation from sowing to sale, and documenting and costing the production plan.

1.8 Ensuring proper disposal of containers, drums and other waste.

Ensuring proper disposal of containers, drums, and other waste is important in horticulture to prevent environmental pollution. The Environmental Protection Agency (EPA) recommends that containers and drums should be triple rinsed with water or a solvent to remove any remaining residue before disposal.

Page 26 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

Hazardous waste should be disposed of in accordance with federal, state, and local regulations. In addition, horticultural waste such as plant debris, soil, and other organic matter should be composted or recycled. Composting is an effective way to recycle organic waste into a useful soil amendment that can be used to improve soil quality and fertility. It is important for horticultural businesses to have a waste management plan in place that outlines procedures for the proper disposal of waste. This plan should include information on how to handle hazardous waste, how to properly store waste, and how to dispose of waste in accordance with regulations. By following these guidelines, horticultural businesses can help protect the environment while also ensuring compliance with regulations.

Proper disposal of containers, drums, and other waste is important to prevent environmental pollution. The Environmental Protection Agency (EPA) recommends that containers and drums should be triple rinsed with water or a solvent to remove any remaining residue before disposal. The EPA also recommends that hazardous waste should be disposed of in accordance with federal, state, and local regulations. Proper waste management is essential to ensuring sustainable horticultural practices and minimizing environmental impact. One crucial aspect of waste management in horticulture is the proper disposal of containers, drums, and other waste. These waste materials can contain harmful chemicals and substances that can pollute the environment if not disposed of properly. As such, it is important to have a well-defined system for managing such waste materials throughout the entire production cycle.

One way to ensure proper disposal of containers, drums, and other waste is to minimize their use in the first place. This can be achieved by adopting sustainable farming practices that emphasize the use of environmentally-friendly and biodegradable materials. Horticulturists should strive to use containers and drums made of materials that have minimal environmental impact and can be recycled or disposed of safely. This would reduce the amount of waste generated and make it easier to manage these waste materials.

Overall, implementing proper disposal practices for containers, drums, and other horticultural waste materials is essential for maintaining a sustainable environment and ensuring the long-term viability of horticultural practices. By adopting environmentally-friendly practices, reducing the use of potentially harmful materials, and ensuring secure storage and proper handling of waste materials, horticulturists can help to protect the environment while still maintaining productive agricultural operations.



Figure 1.8. Dispose of garden wastes

(<https://www.youtube.com/watch?v=DBkufEKsViE> Accessed date: May 23, 2023)

1.9 Identifying and assessing occupational health & safety hazards

Identifying and assessing occupational health and safety hazards is an important part of ensuring a safe work environment. To identify and assess hazards, employers and workers should collect and review information about the hazards present or likely to be present in the workplace. They should also conduct initial and periodic workplace inspections of the workplace to identify new or recurring hazards.

Page 28 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1 May 2023
----------------	--	--------------------------------	-----------------------

Health hazards are workplace hazards that have the potential to harm employees internally if not properly addressed by management. Examples of health hazards include viruses in the workplace such as flu or common colds. Health workers face a range of occupational risks associated with infections, unsafe patient handling, hazardous chemicals, radiation, heat and noise, psychosocial hazards, violence and harassment, injuries, inadequate provision of safe water, sanitation and hygiene.

Occupational health and safety (OHS) is important in all industries, including horticulture. Horticulture workers face a range of hazards, including exposure to pesticides, noise, and ergonomic hazards. Employers in the horticulture industry should take steps to identify and assess hazards in the workplace, develop a plan to control or eliminate hazards, and provide training to workers on how to work safely. They should also provide personal protective equipment (PPE) to workers when necessary.

In general, Occupational Health and Safety (OHS) is a crucial aspect of working in the horticulture industry. Horticulture jobs often involve working with potentially hazardous machinery, chemicals, and environments, such as working with pesticides or operating tractors and other heavy equipment. Employers are responsible for ensuring the safety of their workers by providing adequate training, proper safety equipment and implementing safety measures in the workplace. Accidents in the horticulture industry can have serious consequences for workers, their families, their employers, their clients, and the environment. It is important for all parties to understand the importance of OHS in horticulture.

Moreover, in OHS in horticulture crops production and management may include, but not limited to:

- Air- and soil-borne micro-organisms
- Chemicals and hazardous substances
- Sharp hand tools and equipment
- Manual handling
- Solar radiation, dust, noise

Page 29 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- Machinery and machinery parts
- Slippery and uneven surfaces



Figure 1.9. Safely dispose of hazardous wastes

(https://www.youtube.com/watch?v=w_xI_17u7ro Accessed date: May 23, 2023)

1.10 Identifying sought and obtained approvals required for the planting operations.

Identifying the required approvals for horticultural crop planting operations is essential to ensure compliance with legal requirements and to avoid potential legal or financial penalties. Some of the common approvals that may be required include permits for **water use, land use, and pesticide** use. In addition, certain environmental requirements such as soil testing and erosion control may also need to be met. It is important for horticultural businesses to be aware of these regulations before undertaking any planting operations. Obtaining necessary approvals can take time, so it is advisable to start the approval process early on in the planning stages. Once the necessary approvals have been obtained, it is important to maintain proper documentation to demonstrate compliance with all regulatory requirements.

1.11 Determining measurable indicators, specifications and targets

Page 30 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

Determining measurable indicators, specifications, and targets in horticultural crop planting operations is critical for achieving set goals and objectives. These tools help provide a clear understanding of the outcomes the business is aiming to achieve. Indicators allow businesses to monitor progress and determine if their efforts are successful or need improvement. Specifications define the specific parameters or standards the business will strive to meet in their operations while targets set a desired level of achievement for each specification. By defining these metrics, horticultural businesses gain increased clarity, focus and direction in undertaking plant operations.

Measurable indicators, specifications, and targets also provide a useful tool for communication between all stakeholders involved in the horticultural crop planting operation. Setting clear expectations ensures that everyone understands their role and responsibilities towards achieving the desired outcomes. Regular tracking of measured progress against set targets can also identify performance gaps and improvement opportunities. Overall, measurable indicators, specifications and targets help increase accountability, ensure effective management of resources, and improve decision-making processes in the horticultural crop planting businesses which ultimately leads to the success of the business.

Self-Check 1	Written test
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Name..... ID..... Date.....

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. Seed propagation is the most common method of planting in horticulture.
2. Olericulture deals with fruit and nut crops.
3. Vegetative propagation is another method of planting in which a part of the plant is used to grow a new plant.

Test II: Matching

A

1. External
2. Internal
3. Informal sources
4. Sexual propagation
5. Asexual propagation

B

- A. Seed
- B. Annual reports
- C. Grafting
- D. Conversations with colleagues
- E. Books
- F. Workplace

Test III: Short Answer Questions

1. List the advantages of mulching in horticulture
2. List the major resources required for horticultural planting operations.
3. Explain the roles of proper disposal of containers, drums and other waste in horticultural crops production and propagation
4. Write down all types of workplace information?
5. Write three basic types of information sources?
6. Define the following terms?
 - ✓ Horticulture
 - ✓ Olericulture
 - ✓ Pomology
 - ✓ Floriculture
 - ✓ OHS

Page 32 of 157	Ministry of Labor and Skills	Crops Production Level -III	Version 1
	Author/Copyright		May 2023

LG #2

LO #2 Implement Horticultural Crop Management

Instruction Sheet

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

- Undertaking measurement of soil moisture to calculate soil water percentage
- Calculating water requirements according to soil analysis data, standing crop, and weather conditions forecast.
- Assessing soil amendments and nutrient requirements for crops and identifying deficiencies.
- Marking out the planting pattern.
- Factors affecting horticultural crops production
- Implementing sustainable land management.
- Monitoring and planning horticultural crops to maintain water and nutritional requirements for optimal production.
- Monitoring pest levels and modifying the control program.
- Assessing benefits from fertilization methods and documenting analysis for future management programs.
- Monitoring and documenting cropping programs efficiency and effectiveness.
- Documenting relevant data for continual analysis and effective horticulture crop management.

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:

- Undertake measurement of soil moisture to calculate soil water percentage
- Calculate water requirements according to soil analysis data, standing crop, and

weather conditions forecast.

- Assess soil amendments and nutrient requirements for crops and identifying deficiencies.
- Marke out the planting pattern.
- Determine factors affecting horticultural crops production
- Implement sustainable land management.
- Monitor and plan horticultural crops to maintain water and nutritional requirements for optimal production.
- Monitor pest levels and modifying the control program.
- Assess benefits from fertilization methods and documenting analysis for future management programs.
- Monitor and document cropping programs efficiency and effectiveness.
- Document relevant data for continual analysis and effective horticulture crop management.

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. Undertaking measurement of soil moisture to calculate soil water percentage

What is soil moisture?

- Moisture content is defined as the percentage of the weight of a saturated object that is associated with water.
- Soil moisture is the critical parameter in agriculture. If there is a shortage or overabundance of water, plants may die. At the same time, this data depends on many external factors, primarily weather conditions and climate changes. That is why it is so vital to understand the most effective methods for analyzing soil moisture content. Modern farmers have a wide range of options: in addition to traditional sensors, there is modern satellite technology.
- This term refers to the entire quantity of water in the ground's pores or on its surface. The moisture content of soil depends on such factors as weather, type of land, and plants.

Why is soil moisture important for agriculture?

- The parameter is vital in monitoring farming activities, predicting natural disasters, managing water supply, etc. This data may signal a future flood or water deficit ahead of other indicators.
- Soil moisture affects:
 - Content of air, salinity, and amount of toxic substances;
 - Ground structure and thickness;
 - Temperature and heat capacity of the ground.
- Also, this parameter prevents weathering and **determines the field's readiness for agricultural processing**. Such possibilities demonstrate the importance of soil moisture measurement.

Impact of soil moisture on plant growth?

Page 35 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- It reflects not only the water content in a particular zone but also the health of the field. The roots of plants absorb water first, so their condition directly depends on its amount and aeration. Ultimately, the soil moisture effect on plants and the yield is vital.

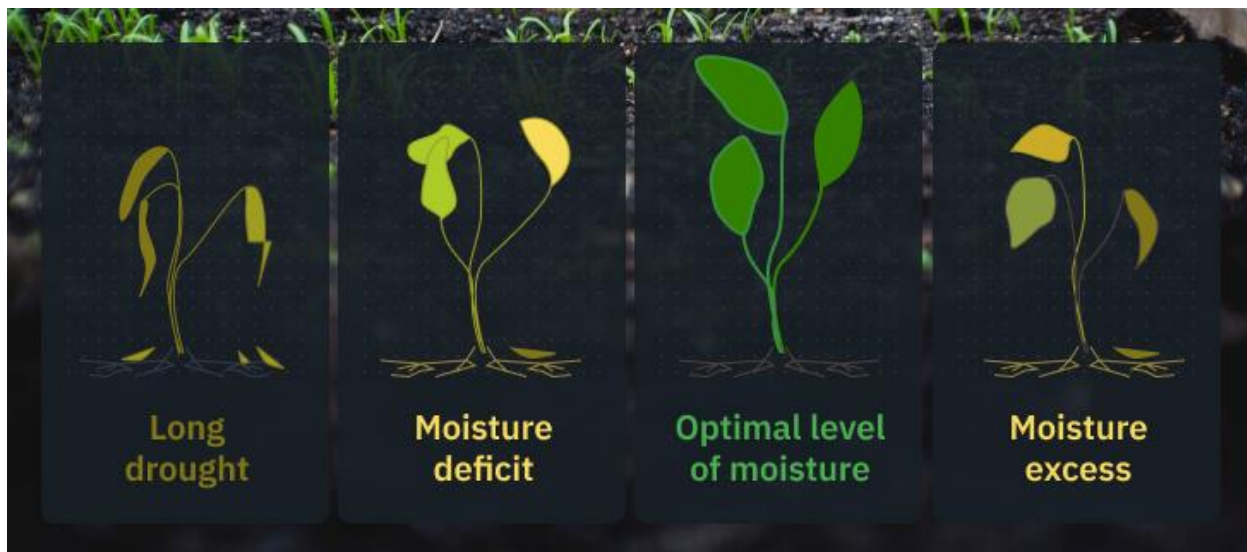


Figure 2.1: Levels of moisture

The optimal range of soil moisture content for crops depends on the specific plant species, but the range for most crops is between 20% and 60%.

Factors affecting soil moisture

This parameter depends on various indicators such as topography, vegetation, and climate. The main soil characteristics are:

- **Texture:** the finer it is, the more pores and, therefore, better moisture retention.
- **Structure:** porous structure with a high level of aggregation improves water retention.
- **Organic matter content:** The more organic matter there is, the more significant the water-holding capacity.
- **Density:** The higher it is, the less water penetrates inside.
- **Temperature:** moisture content is higher at lower temperatures.

- **Salinity:** the higher the salt content, the less water the plants can absorb, as salt is a natural absorbent.
- **Depth:** this factor affects the amount of water available, i.e., the deeper the soil is, the more water and nutrients the plants can get.

Optimum moisture content of soil

The desired soil moisture content depends on the field capacity (FC) and the permanent wilting point (PWP).



Figure 2.2. Optimum moisture content of soil

FC means how much water the soil can hold after the excess drains off. It displays the balance of water and air in the ground's pores. There is not enough oxygen if the moisture percentage is too high. PWP reflects the temperature threshold below which plants begin to wither and die, because they don't receive enough water. Both depend on type of soil, so it is critical to conduct an appropriate analysis to specify the optimal soil moisture range.

What is soil moisture deficiency?

It is the difference between the exact water content in the ground and the water it can hold.

Also, an important indicator is total available water (TAW), i.e., how much of it plants can get. It is the contrast between the moisture content of the ground according to FC and PWP. Above FC, crops can take it only for 1-3 days; below PWP, crops cannot absorb the needed water any more.

How to measure soil moisture?

How to calculate moisture content of soil? There are several methods. They differ in the data source that is used for this. In general, you can single out gravimetric (or direct) measurement, analysis using soil moisture sensors, and remote sensing.



Figure 2.3. Measuring soil moisture using digital soil moisture meter

i. Gravimetric Soil Moisture Detection

This method extracts water from a soil sample through **evaporation, flushing, and a chemical reaction**. The gravimetric soil moisture is calculated based on measuring the difference between the wet and dry sample weight.

$$\text{GWC (\%)} = [(\text{mass of moist soil (g)} - \text{mass of dry soil (g)}) / \text{mass of dry soil (g)}] \times 100$$

ii. Soil moisture analysis with sensors

The type of a sensor depends on the used technology: measuring volumetric water content (VWC) or soil water tension (SWT), also known as soil Water Potential (SWP).

iii. Volumetric Water Content (VWC)

Page 38 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

This parameter (in a percentage) means the water volume to the ground volume. For example, 0.30 cubic inches of water per 1 cubic inch of ground is displayed as 30%. It can be calculated by the formula:

$$\text{VWC (\%)} = [\text{volume of water (in}^3\text{)} / \text{volume of ground (in}^3\text{)}] \times 100$$

VWC is used to calculate the water deficit in the field. It allows growers to plan precision irrigation works. In this case, soil water deficit is the ratio of general field capacity and current volumetric soil moisture content.

While VWC helps clarify water balance in the ground, calculating water potential is usually more helpful because it shows how it moves from the ground to the crop. Moreover, this parameter is suitable for specifying whether water is available to crops.

iv. Soil Water Tension (SWT)

SWT is used to specify the energy that crops need to get water from the ground. Tension increases as moisture level decreases. Conversely, it is very low when the ground is filled with water. Usually, SWT is measured in centibar. You should constantly refine data to get accurate results. For example, try to analyze this parameter when signs of water stress appear so that you can irrigate your plants until the indicators return to normal.



Figure 2.4. Signs of water stress

2.2. Calculating water requirements according to soil analysis data, standing crop, and weather conditions forecast.

Accurately calculating water requirements is crucial to the success of horticultural crop planting operations. This process involves taking into account soil analysis data, the standing crop, and weather conditions forecast to determine the amount of water required for optimal growth and development of the crops. Soil analysis data for example provides information on soil type, texture, organic matter content, and nutrient levels which can influence water uptake and retention. This data is used to make strategic decisions on irrigation frequency and duration. Furthermore, by considering variables such as the standing crop age, root depth, and soil moisture tension levels, an accurate estimation of water requirements can be achieved. Finally, weather conditions are a critical factor to consider in calculating water requirements as precipitation events and temperature fluctuations can create variations in crop water uptake and irrigation requirements.

By using a combination of expertise in horticultural practices and data-driven insights from soil analysis, weather forecasting, and standing crop information, farmers can adopt irrigation strategies that optimize crop growth while reducing water usage. Accurate irrigation management leads to crops being able to maintain optimal levels of hydration resulting in high yields, better produce quality, and lower operating costs. With advances in technology such as digital soil moisture sensors, it is now easier than ever before to monitor soil moisture content in real-time allowing for precision irrigation strategies that conserve water resources whilst optimizing crop productivity.

2.3. Assessing soil amendments and nutrient requirements for crops and identifying deficiencies.

Effective nutrient management requires the quantification of crop nutrient requirements and the nutrient-supplying capacity of the soil through soil testing. Nutrients applied in excess of crop

Page 40 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

requirements increase residual nutrient reserves that, if not utilized or recovered in subsequent crops, may result in offsite transport.

Nutrient deficiencies occur when an essential nutrient is not available in sufficient quantities to meet the requirements of a growing plant. Healthy soils have a functioning biogeochemical cycle that supplies nutrients in the required amounts for crop growth. Overcoming nutrient limitations in modern agricultural systems is one of the challenges facing agriculture today.

There are fourteen nutrients that are supplied to crops from soil and fertilizer sources. Of these, six are required in large amounts: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S). The remaining eight are required in smaller amounts: iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), chlorine (Cl), and nickel (Ni).

2.4. Marking out the planting pattern.

- Type and arrangement of crops in time and space is called cropping pattern.
- It can also be defined as the proportion of area under various crops at a point of time in a unit area. It includes yearly sequence and spatial arrangement of crops and fallow on a given area.
- The cropping pattern is determined by rainfall, climate, temperature, soil type and technology; thus it changes over space and time.



Figure 2.5. Cropping pattern

Cropping system

- Cropping pattern and its management to derive benefits from a given resource base under specific environmental condition is called cropping system.
- It is location specific, so it changes when place and environment are changed.
- The objective of any cropping system is efficient utilization of all resources viz. Land, water, solar energy etc. And to maintain stability in production and get higher returns.
- Management practices along with planting geometry and genetic makeup of seed are primary pillars of any cropping system.

Types of cropping system

1. **Mono cropping-** it is a system of growing the same crop or a single crop on the same land year after year. It is also called monoculture or single cropping. Cropping intensity is thus always 100%.
2. **Multiple cropping-** it is defined as cultivation of two or more crops on the same field in a year without deteriorating soil fertility. It is the intensification of cropping in time and space dimensions both. Thus more crops within a year and more crops on the same piece

of land during a single growing season. There are mainly **four types of multiple cropping** as described below:

Intercropping

- It is the practice of growing two or more crops simultaneously on the same piece of land in a fixed ratio or with a definite row arrangement. e.g. **wheat + mustard = 9:1**
- Intercropping includes alley cropping, strip cropping, contour cropping, paired row cropping, parallel cropping, skip cropping etc.

Read also... intercropping- definition, example, benefits

Mixed cropping

- Cultivation of two or more crops simultaneously on the same land without any fixed row pattern.
- Generally sowing of seed is done by broadcasting method and commonly practiced in dry land areas.
- The main objective is to lessen the risk of total crop failure and to satisfy the farmers in food and fodder. So it is subsistence farming.

Sequence/sequential cropping

- It can be defined as growing of two or more crops in quick succession on the same piece of land in a farming year. It means sowing of succeeding crop and harvesting of preceding crop is done in quick succession or may be done simultaneously.
- Since there is no overlap between the two or more cropping, it is also called non-overlapping cropping. E.g. Just after harvesting of maize, potato is sown, and just after digging of potato, chili is sown.

Relay cropping

- Growing two or more crops simultaneously during the part of life cycle of each. Succeeding crop is planted before the harvesting of preceding crop. It means 2nd crop is planted after the 1st crop has reached its reproductive stage of growth, but before it is ready for harvest.

Page 43 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- For example potato is planted before the harvesting of maize, and radish is sown before harvesting of potato.

Factors affecting cropping pattern

The cropping patterns are affected by-

- Changes in agrarian policy,
- Availability of agricultural inputs,
- And improvement in technology.
- Thus, the cropping patterns are beneficial in improving the fertility of the soil, thereby, increasing the yield of the crops. It ensures crop protection and availability of nutrients to the subsequent crops.

2.5. Factors affecting horticultural crops production

Internal factors

Internal factors are related to genetic make-up of plants and thus less influenced by environmental factors. These are called **genetic factors** which attributes crop yield and other desirable characters for crop production.

- High yielding ability
- Early maturity
- Resistance to lodging
- Tolerance to insect pests and diseases
- Drought, flood and salinity tolerance
- Chemical composition of grains (oil content, protein content) and Quality of grains (fineness, coarseness)
- Quality of straw (sweetness, juiciness)

External factors

1. Climatic
2. Edaphic

Page 44 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

3. Biotic
4. Physiographic and
5. Socio economic factors.

1. **Climatic factors**

The climatic factors are the atmospheric weather variables which influences the crop production. In fact, success and failure of crops is intimately related to the weather during the crop periods. Nearly 50 % of yield is attributed to the influence of climatic factors. However, by adjusting cropping pattern and by following suitable agronomic practices one may mitigate the adverse effect of weather in order to get high yield. The factors are-

(a) Precipitation- It includes all water which falls from atmosphere such as rainfall, snow, hail, fog and dew. Total precipitation in amount and distribution greatly affects the choice of a cultivated species in a place. Rainfall is one of the most important factors influences the vegetation of a place.

- Distribution of rainfall is more important than total rainfall to have longer growing period especially in drylands.
- In heavy and evenly distributed rainfall areas, crops like rice in plains and tea, coffee and rubber in Western Ghats are grown.
- Low and uneven distribution of rainfall is common in dryland farming where drought resistance crops like pearl millet, sorghum and minor millets are grown.
- In desert areas grasses and shrubs are common, because of hot desert climate exists.

Though the rainfall has major influence on yield of crops, yields are not always directly proportional to the amount of Precipitation as excess above optimum reduces the yields.

(b) Temperature- Temperature is a measure of intensity of heat energy. Most of the agricultural plants require temperature between 15 and 40⁰C for growth. The minimum, maximum (above which crop growth ceases) and optimum temperature of individual's plant is called as cardinal temperature. The temperature of a place is largely determined by its distance from the equator (latitude) and altitude.

Page 45 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- Germination, growth and development of crops are highly influenced by temperature. It affects leaf production, expansion and flowering.
- Physical and chemical processes within the plants are governed by air temperature.
- Diffusion rates of gases and liquids changes with temperature.
- Solubility of different substances in plant is dependent on temperature.

(c) Atmospheric Humidity (Relative Humidity-RH)– Water present in the atmosphere in the form of invisible water vapour, known as humidity. RH is the amount of water vapor present in air expressed as a percentage of the amount needed for saturation at the same temperature. If relative humidity is 100% it means the entire space is filled with water and there is no soil evaporation and plant transpiration.

- Relative humidity influences the water requirement of crops.
- Relative humidity of 40-60% is suitable for most of the crop plants.
- When relative humidity is high there is chance for the outbreak of pest and disease.

(d) Solar radiation (without which life will not exist)– It is the source of energy for all the physical processes taking place in the atmosphere. It drives the process of photosynthesis, evaporation and heating the soil and air.

(e) Wind velocity– The basic function of wind is to carry moisture (precipitation) and heat. The moving wind also supplies fresh CO₂ for the photosynthesis.

- Wind movement for 4 – 6 km/hour is suitable for more crops.
- When wind speed is very high, it causes mechanical damage of the crops like it removes leaves and twigs and damages crops like banana, sugarcane.
- Pollen and seeds are dispersed by wind, what we call wind dispersal and is necessary for certain crops.
- Helps in cleaning produce to farmers.
- Causes soil erosion, increases evaporation and spread of pest and diseases.

(f) Atmospheric gases on plant growth

Page 46 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1 May 2023
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- CO₂ is important for Photosynthesis and is taken by the plants by diffusion process from leaves through stomata.
- CO₂ is returned to atmosphere during decomposition of organic materials, all farm wastes and by respiration.
- O₂ is important for respiration of both plants and animals while it is released by plants during Photosynthesis
- Nitrogen is one of the important major plant nutrients, Atmospheric N is fixed in the soil by lightning, rainfall and N fixing microbes in leguminous/pulses crops and available to plants.

2. Edaphic factors (soil)

The soil factors that affect crop growth are-

(a) Soil moisture- Water is an essential constituent of growing plant which it extracts from soil.

(b) Soil air- Aeration of soil is absolutely essential for the absorption of water by roots.

(c) Soil temperature-It affects the physical and chemical processes going on in the soil.

(d) Soil mineral matter- The mineral content of soil is derived from the weathering of rocks.

(e) Soil organic matter- It is composed of humic and non-humic substances and supplies all the major and micro nutrients to crops.

- OM is source of plant nutrients which are liberated in available forms during mineralization.
- It improves soil structure, its drainage and aeration, water holding capacity buffer and exchange capacities, influences the solubility of minerals.
- It is a source of food for most microorganisms.
- Nearly 95% of Nitrogen and 33% of Phosphorus of soil are obtained from OM.
- It has the capacity to control soil temperature.

(f) Soil organisms- The raw organic matter in the soil is decomposed by different micro-organisms which in turn releases the plant nutrients. Atmospheric nitrogen is also fixed by

Page 47 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

microbes in the soil and is available to crop plants through symbiotic (Rhizobium) or non-symbiotic (Azospirillum) association.

(g) Soil reaction (pH)– Soil reaction is the pH (hydrogen ion concentration) of the soil.

- Soil pH affects crop growth and neutral soils with pH 7.0 are best for growth of most of the crops.
- Soils with low pH is injurious to plants due high toxicity of Fe and Al.
- Low pH also interferes with availability of other plant nutrients.

3. Biotic factors

Beneficial and harmful effects caused by other biological organism (plants and animals) on the crop plants.

(a) Plants

- Competitive (allelopathy) and complimentary nature among field crops when grown together.
- Competition between plants occurs when there is demand for nutrients, moisture and sunlight particularly when they are in short supply or when plants are closely spaced. Competitive interaction may be also due to release of chemical substances or toxins called allelopathy.
- When different crops of cereals and legumes are grown together, mutual benefit results in higher yield (synergistic effect).
- Competition between weed and crop plants as parasites eg: Striga parasite weed on sugarcane crop.

(b) Animals

- Soil fauna like protozoa, nematode, snails, and insects help in organic matter decomposition, while using organic matter for their living.
- Insects and nematodes cause damage to crop yield and considered as harmful organisms.

- Honey bees and wasps help in cross pollination and increases yield and considered as beneficial organisms
- Burrowing earthworm facilitates aeration and drainage of the soil as ingestion of organic and mineral matter by earthworm results in constant mixing of these materials in the soils.
- Large animals cause damage to crop plants by grazing (cattle, goats etc).

4. Physiographic factors

(a) **Topography** is the nature of surface earth (leveled or sloppy) is known as topography. Topographic factors affect the crop growth indirectly.

(b) **Variation in aspects and elevation** influence the climatic factors. Altitude – increase in altitude cause a decrease in temperature and increase in precipitation and wind velocity (hills and plains).

(c) **Steepness of slope:** it results in run off of rain water and loss of nutrient rich top soil.

(d) **Exposure to light and wind:** a mountain slope exposed to low intensity of light and strong dry winds may results in poor crop yields (coastal areas and interior pockets).

5. Socio-economic factors

1. Society inclination to farming, land tenancy, size of land holdings, fragmentation of field.
2. Availability of labour, capital.

The economic condition of the farmers greatly decides the input/ resource mobilizing ability.

1. Government policies.
2. Appropriate choice of crops by human beings to satisfy the food and fodder requirement of farm household.
3. Breeding varieties by human invention for increased yield or pest & disease resistance.

2.6. Implementing sustainable land management

Sustainable land management practices for horticultural crops production include developing improved crop management practices such as good agricultural practices, integrated production and pest management, integrated soil health management, and organic

Page 49 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

farming. These practices aim to increase the availability of high-quality and safe horticultural produce while ensuring sustainable and environmentally friendly horticultural crop production systems.



Figure 2.6. Sustainable land management

(<https://www.youtube.com/watch?v=8RdTnkEcbFs>;

https://www.youtube.com/watch?v=IXW05_jM2bM Accessed date: May 23, 2023)

2.7. Monitoring and planning horticultural crops to maintain water and nutritional requirements for optimal production.

To maintain water and nutritional requirements for optimal production of horticultural crops, it is important to monitor and plan the crops. Controlled environment systems such as greenhouses can minimize external environmental impacts and increase water (~40 %) and nutrient (~35 %) use efficiency. The influence of the crop type on the crop water need is important in two ways:

Page 50 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- i. The crop type has an influence on the daily water needs of a fully grown crop; i.e. the peak daily water needs: a fully developed maize crop will need more water per day than a fully developed crop of onions.
- ii. Nutritional quality formation and maintenance of horticultural crops depend on intrinsic characteristics of horticultural crops

Horticultural crops require careful monitoring and planning to ensure that water and nutritional requirements are met for optimal production. Adequate water supply and balanced nutrition is critical for plants to grow strong, fight off disease and pests, and produce high-quality yields. In this regard, horticulturists must be meticulous in their approach to crop monitoring and planning.

Once all necessary approvals have been obtained, horticulturists should set clear goals and determine measurable indicators and specifications for their crops. It would be best to use data-driven insights derived from soil testing, weather data, and other relevant sources to optimize plant growth, reduce water usage, and maximize yields. This approach ensures that resources are used efficiently, and the crop output is produced according to target market specifications.

Monitoring crop health is essential for effective management of water and nutrient requirements. Regular soil testing can help determine moisture levels, soil quality, salinity, and other vital indicators that influence crop productivity. It's also important to keep an eye out for pests and diseases which might damage the crops. Early detection can save a lot of money in losses incurred due to crop damage.

In conclusion, monitoring and planning are critical aspects of horticultural crop planting operations. It's important to obtain the necessary approvals, set clear goals, use data-driven insights, monitor plant health consistently while adhering to legal requirements. This approach will help farmers increase crop yields while reducing wastes through effective water usage and nutrient management practices.

2.8. Monitoring pest levels and modifying the control program.

Page 51 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

Horticultural crop production is sometimes plagued by pests, which can hinder the growth and yield of crops. Pests such as insects, fungi, bacteria, and rodents pose a significant threat to plants and can compromise their health and productivity. In this regard, it is essential to monitor pest levels and modify control programs regularly to maintain healthy crops.

Management of horticultural farm is the most important activities that influence the production and productivity. In this session fertilization and watering, pest management as well as harvesting of vegetable crops have been considered.

Water supply throughout the growing cycle is essential for vegetable crops production where water requirements of vegetable crops differ with environmental and edaphic conditions as well as the type and growth stages of vegetable crops. Fertilizer application is also the other important management practice in the production of vegetable crops which can be organic or inorganic in nature. fertilizers are applied to support the growth of vegetable crops in especially none-fertile soils. The types and rates of fertilizers are therefore determined based the fertility status of the soil, the types and growth stages of vegetable crops as well as environmental conditions. Throughout the growing period, vegetable crops should be properly cultivated to remove weeds and improve aeration and percolation of irrigation water. Some vegetable crops like tomato needs staking to prevent the contact of fruits with ground soil and reduce occurrence of diseases and insect pests.

Vegetable crops can be seriously damaged by various pests including diseases and insect pests. Diseases can be caused by weeds, fungi, bacteria and viruses (biotic) as well as environmental factors and lack or excess of nutrients.

Insect pests damage horticultural crops directly by their feeding activities or indirectly by transmitting pathogens from diseased to healthy plants.

Pests can be controlled using various methods including physical, mechanical, cultural, biological, and chemical methods. The best management option currently practiced is Integrated Pest Management (IPM). Matured Vegetable crops can be harvested manually using hand tools and equipment or mechanically using machines where their maturity is determined using different methods including computational, physical, chemical, and physiological methods

Monitoring pest levels and modifying the control program is an important aspect of horticulture crops production. Integrated pest management (IPM) is a sustainable approach to managing pests that combines multiple strategies including biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. IPM programs are designed to monitor pest levels and only use chemical pesticides when necessary. This approach reduces the risk of pesticide resistance and minimizes the impact on non-target organisms.

In conclusion, monitoring pest levels and modifying control programs are crucial for preventing or significantly reducing pest damage in horticultural crops. Horticulturists must implement ongoing efforts to identify pests early while considering remedies proven safe for humans and the ecosystem. Finding an appropriate balance in all pest management strategies will ensure the production of healthy crops with high yields, contributing significantly to the success of horticulture plants worldwide.

2.9. Assessing benefits from fertilization methods and documenting analysis for future management programs.

Fertilization methods and documenting analysis for future management programs in horticulture crops production are important. The maintenance and the increase of fertility rely on the use of management practices and the application of different products from natural origins, which have the aim of providing high availability of nutrients for plant crops in agricultural soils³. Smart practices in horticultural crop production involve:

- (i) Nano-formulation-based fertilizers or pesticide delivery systems, which increase the dispersion and wettability of nutrients;
- (ii) Nano-detectors for pesticide or fertilizer residues; and
- (iii) Remote-sensing-based monitoring systems for disease incidence and crop growth.

There are a few common fertilization methods used in horticulture crop production. These include:

Page 53 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- i. **Organic fertilizers:** These are derived from natural sources, such as compost, manure, fish emulsion, and bone meal. They provide essential nutrients to plants and improve soil health.
- ii. **Inorganic fertilizers:** These are typically synthetic fertilizers that are made from chemicals. They are often used when specific nutrients are lacking in the soil, and can be tailored to meet the specific needs of the plant.
- iii. **Controlled-release fertilizers:** These are fertilizers that release nutrients gradually over a period of time. They are often used in situations where frequent fertilization is not practical.

To document analysis for future management programs in horticultural crop production, it is important to keep detailed records of all fertilization practices. This includes the type of fertilizer used, the application rate, and the timing of fertilization. In addition to fertilizer records, it is also important to document other aspects of horticultural crop production, such as irrigation practices, pest and disease control measures, and yield data. By keeping comprehensive records and analysing the data regularly, growers can make informed decisions about future management programs and optimize their crop production processes.



Figure 2.7. Organic farming

(<https://www.youtube.com/watch?v=lRyXlvIJFWI>;

<https://www.youtube.com/watch?v=WhOrIUlnPo> Accessed date: May 23, 2023)

Page 54 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1 May 2023
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2.10. Monitoring and documenting cropping programs efficiency and effectiveness.

Monitoring and documenting cropping program efficiency and effectiveness is essential for optimizing crop growth, reducing resource waste, and improving overall productivity. A well-documented program can help growers identify the factors that lead to success or failure, allowing them to continuously improve their process.

There are several aspects of a cropping program that should be monitored and documented to assess its efficiency and effectiveness. These include:

- i. **Crop yield:** Tracking crop yield is critical for monitoring the success of a cropping program. Yield data can help growers identify which crops are performing well, what factors lead to successful harvests, and which crops may need additional care or resources.
- ii. **Resource usage:** Monitoring resource usage is essential for identifying areas where growers can reduce waste, such as water or fertilizer use. By tracking input data such as water usage and fertilizer application rates, growers can make informed decisions about how much of these resources they need to apply in the future.
3. **Pest control:** Monitoring pest control measures helps growers identify which strategies are most effective. Documentation of pest pressure and control methods can help growers adjust their pest control practices to maximize crop protection.
- iii. **Record-keeping:** Keeping comprehensive records of all practices involved in a cropping program is important for analysing its effectiveness. Records should be kept of practices such as planting dates, soil preparation techniques, irrigation methods, and fertilizer inputs. Any malfunctions or issues encountered during the cropping program should also be noted for future reference.
- iv. **Data analysis:** Once data has been collected, it is important to analyse it in order to make informed decisions about the cropping program. This may involve comparing current data to previous years' records to identify trends or utilizing data analysis software to create graphs and charts to visualize the data.

By monitoring and documenting all aspects of a cropping program, growers can optimize their processes and achieve greater efficiency and effectiveness in their production practices. Continuously analysing this data can help growers make informed decisions and set goals for future cropping programs.

2.11. Documenting relevant data for continual analysis and effective horticulture crop management.

To ensure effective horticulture crop management, it is crucial to collect and document relevant data for continual analysis. By keeping accurate and detailed records of crop growth, fertilization programs, pest and disease control measures, and weather patterns, farmers and growers can gain valuable insights into the performance of their crops and make informed decisions about future management practices.

One key aspect of data documentation in horticulture is the tracking of fertilization programs. Using a combination of soil tests and plant tissue analysis, farmers can monitor nutrient levels in their crops and adjust fertilization programs accordingly. By keeping detailed records of each application of fertilizer, including the type, rate, and method of application, farmers can track the efficiency of their fertilization practices over time and make adjustments as needed.

Another important area of data documentation is pest and disease management. Monitoring and documenting pest populations and outbreaks can help growers identify potential risks early on and take proactive measures to mitigate these threats. In addition, by recording the types of control methods used, such as chemical sprays or biological controls, growers can evaluate the effectiveness of these strategies and adjust their pest management plans accordingly.

Effective horticulture crop management requires a comprehensive and evidence-based approach that relies on continual analysis of relevant data. By documenting all aspects of crop growth and management practices, farmers can gain valuable insights into the performance of their crops and optimize their operations for maximum efficiency and profitability.

Page 56 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

Self-Check 2	Written test
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Name..... ID..... Date.....

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Write True or False

1. To ensure effective horticulture crop management, it is crucial to collect and document relevant data for continual analysis.
2. Mono cropping is a system of growing the same crop or a single crop on the same land year after year.
3. The disadvantage of remote sensing is that it can gauge moisture over much larger areas than conventional methods.
4. Gravimetric Soil Moisture Detection method extracts water from a soil sample through evaporation, flushing, and a chemical reaction

Test II: Fill in the black space

1. _____ is defined as the percentage of the weight of a saturated object that is associated with water.
2. _____ is used to specify the energy that crops need to get water from the ground.
3. _____ is used to specify the energy that crops need to get water from the ground. Tension increases as moisture level decreases.

Test III: Short Answer Questions

1. What are the major factors can affect crop production?
2. What % age of relative humidity suitable for most of the crop plants?
3. What is Biotic & A-biotic factors?
4. What is Integrated Pest Management (IPM)
5. List and explain the major fertilization methods used in horticulture crop production
6. What are the factors affecting soil moisture

Operation Sheet 2

2.1. Cultivation, fertilizer, and water application in vegetable farm

A. Equipment

- Hand cultivator
- Spade/ shovel
- Wheelbarrow
- Weighing scale
- Watering can
- Drip irrigation system
- Personal Protective Equipment (PPE) such as overall, Boots, Gown, helmets and Hand glove.

B. Consumables Materials

- Organic fertilizers (compost, FYM, etc.)
- Inorganic fertilizers (urea, DAP, NPS, etc.)
- Woods for staking
- String (Garden Twine), rope
- Water source

C. Procedures of cultivation, irrigation and fertilizer application

- The teacher should instruct the students to perform the following observations and or activities properly. In case of tomato production, show the videos that show how tomato plants are supported by staking.
1. Remove weeds and cultivate the soil if necessary throughout the growing season using appropriate methods and tools
 2. For vegetable crops like tomato support plants by constructing staking materials
 - 2.1 Draw 180-240 cm length wood into the soil to the depth of 30 cm (wood length depends on tomato varieties)

- 2.2 Place the stake 7.5 to 10 cm from the base of the plant on the side away
- 2.3 Draw the stakes in the ground right after transplanting of seedlings
- 2.4 As the plant grow, tie a strip of string, rope, nylon stocking or coated wire tightly to the stake and loosely around the plant
3. Evaluate the fertility status of the soil in the laboratory or using nutrient deficiency symptoms
4. Determine the type and quantity of fertilizers based on the fertility status and the type of vegetables grown



Figure 2.7. Staking of Tomato

5. Apply the selected and recommended rate of fertilizer using appropriate method and irrigate the field
6. Evaluate the moisture level of the soil throughout the growing period by hand feeling method or in the laboratory and irrigate if necessary using available and suitable methods

Note: Quantity of irrigation water depends on the type and growth stages of vegetable crops and weather conditions

7. Record costs of cultivation, fertilization and irrigation throughout the practical session



Figure 2.8: Furrow and drip irrigation methods used in vegetable production

LAP Test 2

Name.....ID.....Date.....

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **60** minutes. The project is expected from each student or in a group to do it.

Task 1: Perform cultivation, fertilizer, and water application in vegetable farm

LG #3

LO #3 Prepare Propagating Media

Instruction Sheet

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

- Selecting media components based on propagation method and plant needs.
- Testing and treating propagation media is to ensure media specifications
- Handling of media and components following OHS requirements
- Selection of storage requirements for the unused propagation media.
- Selecting conditioning and storage requirements for maximum viability of propagating material
- Preparation of growing site is suit species and propagation method

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:

- Select media components based on propagation method and plant needs.
- Test and treat propagation media is to ensure media specifications
- Handle of media and components following OHS requirements
- Select of storage requirements for the unused propagation media.
- Select conditioning and storage requirements for maximum viability of propagating material
- Prepare growing site is suit species and propagation method

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 3

3.1. Selecting media components based on propagation method and plant needs

Selecting media components

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 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.

Page 64 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- 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.

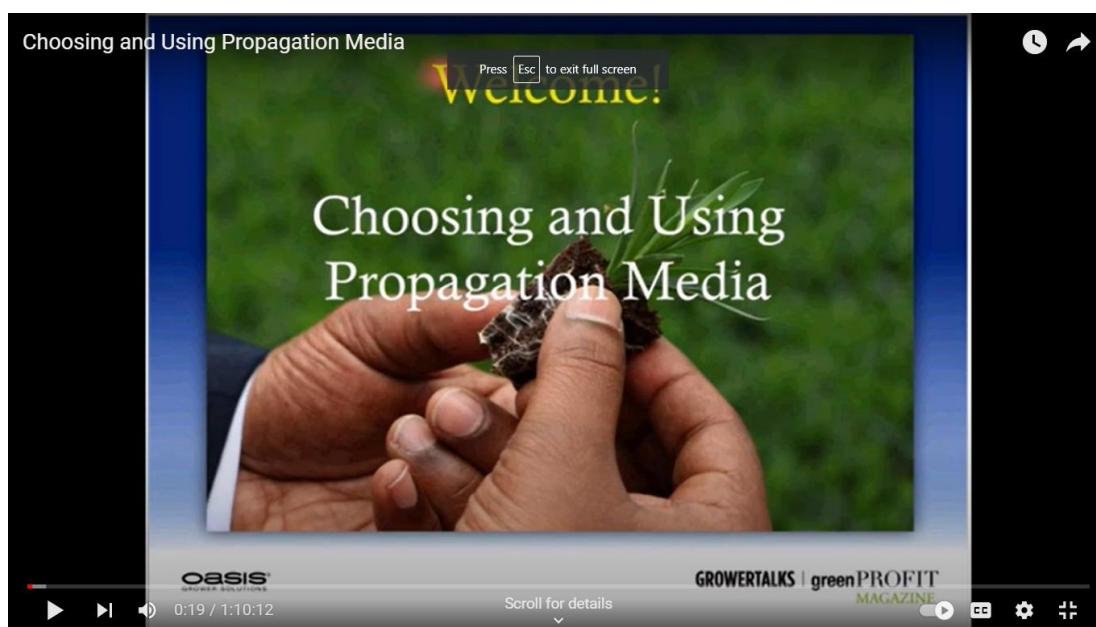


Figure 3.1. Choosing and using propagation media

(https://www.youtube.com/watch?v=gQ_OaMP1Jp4 Accessed date: May 23, 2023)

Page 65 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

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 3.2. Coco Peat: Soil-less medium used in Nursery

1.2 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:

Page 66 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

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



Figure 3.4. Preparing soil less media

(<https://www.youtube.com/watch?v=v4jmJv3pW-c> Accessed date: May 23, 2023)

Page 67 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

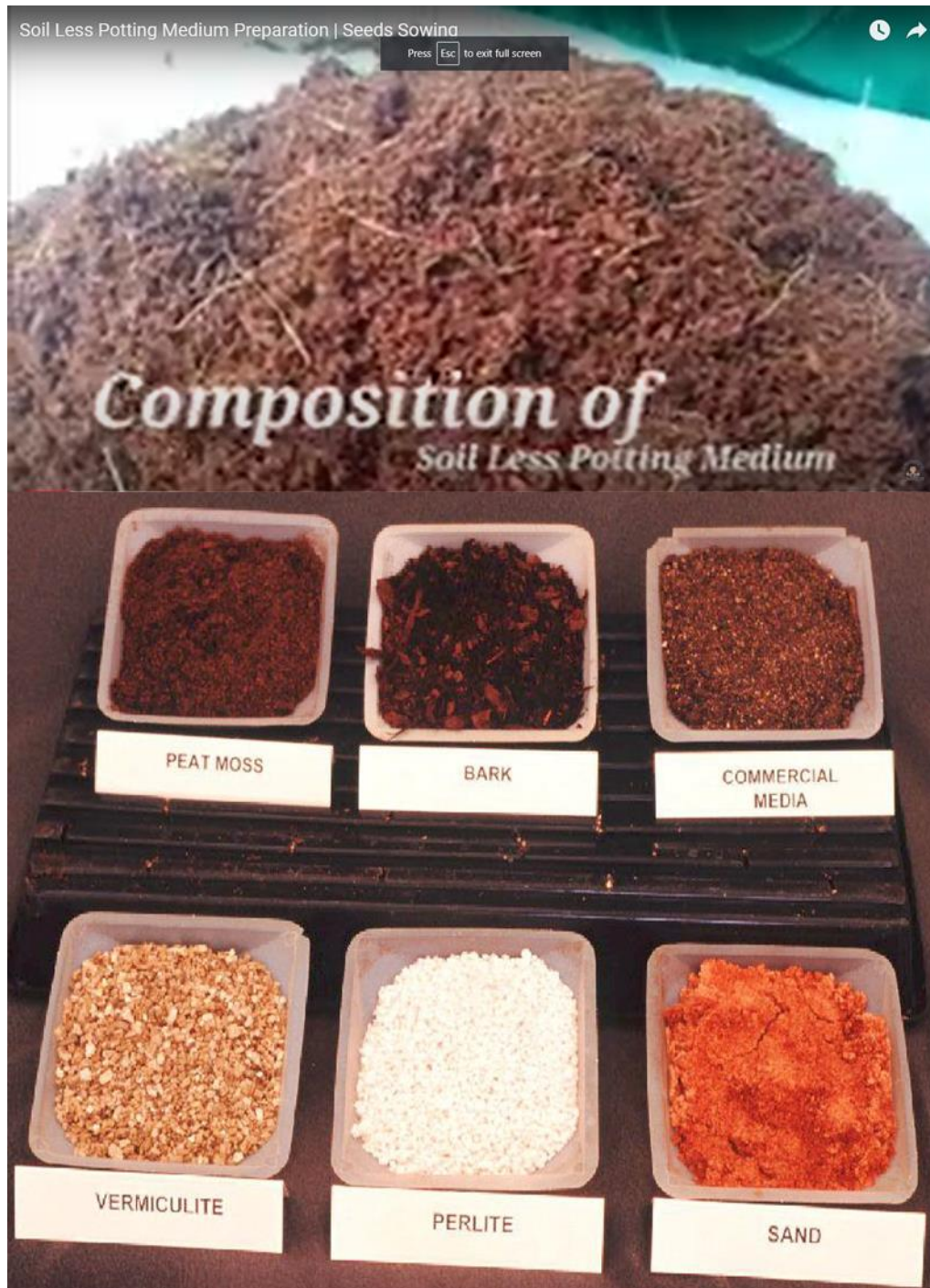


Figure 3.5. Propagation of growing media component

(<https://www.youtube.com/watch?v=a27poKtUSWA> Accessed date: May 23, 2023)

Page 68 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

3.2. Testing and treating propagation media is to ensure media specifications

i. Testing propagating media

Pasteurization of Propagation Media: Propagation mixes such as bark, sand, and peat moss can contain pathogens and, ideally, should be pasteurized. The containers (bins, flats, pots) for such pasteurized mixes should, of course, have been treated to eliminate pathogens. Never put pasteurized mixes into dirty containers. New materials such as vermiculite, perlite, pumice, and rock wool, which have been heat-treated during their manufacture, need not be pasteurized unless they are reused.

Pasteurization of propagation media at lower temperatures with aerated steam is generally preferable to fumigation with chemicals. After treatment with steam, the medium can be used much sooner. Steam is nonselective for pests, whereas chemicals may be selective. In heating the soil, which should be moist but not wet, a temperature of 82°C for 30 minutes has been a standard recommendation because this procedure kills most harmful bacteria and fungi as well as nematodes, insects, and most weed seeds. However, a lower temperature, such as 60°C for 30 minutes, is more desirable since it kills pathogens but leaves many beneficial organisms that prevent explosive growth of harmful organisms if recontamination occurs.

ii. Disinfection and Sanitation of Physical Propagation

Facilities-disinfection refers to the reduction of pathogens and algae, while sanitation refers to the level of cleanliness. The space where the actual propagation (making cuttings, planting seeds, grafting) takes place should be a light, very clean, cool room, completely separated from areas where the soil mixing, pot and flat storage, growing, and other operations take place.

At the end of each working day, all plant debris and soil should be cleaned out, the floors hosed down, and working surfaces washed with disinfectant solutions of sodium hypochlorite solution (Clorox), chlorine dioxide (Selectocide), benzylkonium chloride, or pine disinfectant diluted according to directions. Benzylkonium chloride is long-lasting and can be used for several days.

Hydrogen dioxide (Zerotol, Oxidate) is a strong oxidizing agent used in sanitation of propagation facilities for the control of algae and pathogens.

iii. Quality control tests

Quality control tests should be carried out by the end-user laboratory to ensure that the performance characteristics of the medium are within specification and that the methodology of medium preparation is satisfactory. Each lot/batch of prepared medium should be subjected to a minimal testing programme which will ensure that it is acceptable and will demonstrate a typical bacterial performance.

1. **PH value:** Check that the pH of the prepared medium, when tested in final form at ambient temperature (25°C) lies within the range given on the product label. The medium should be discarded if the pH value lies outside the specified range.

2. **Sterility:** a representative sample of each lot/batch of medium should be incubated for 2-5 days at 35-30°C and 50-55°C. As a general rule, for a lot of 100 or less units a 3-5% sample should be tested. For a larger lot, 10 random plates or tubes are taken. There should be no evidence of microbial growth after incubation. Discard all sterility samples when the tests have been completed.

3. **Growth performance:** test the growth support properties of the product by inoculating the medium with appropriate stock cultures and/or fresh isolates. Use a standard inoculation procedure and examine the quantitative and qualitative results obtained. If testing new lots/batches of media, inoculate old and new lots in one test and compare the performance of the two lots side by side.

4. **Stability:** periodically perform the above procedures on stored prepared media in order to determine whether the storage conditions will give optimal results.

Page 70 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

iv. Propagation techniques

In selecting propagating material, use only seed and those source plants that are disease and insect free. Some nurseries maintain stock plant blocks, which are kept carefully “clean. It is best to select cutting material from the upper portion of stock plants rather than from near the ground where the plant tissue could possibly be contaminated with soil pathogens. As cutting material is being collected, it should be placed in new plastic bags. After the cuttings have been made and before sticking them in flats, they can be dipped in a dilute bleach solution, or treated with various fungicides for broad-spectrum control of damping-off organisms before any Auxin treatment. However, once a cutting or seedling becomes infected with a bacterium, there is no effective control other than rouging-out and destroying the plant propagules.

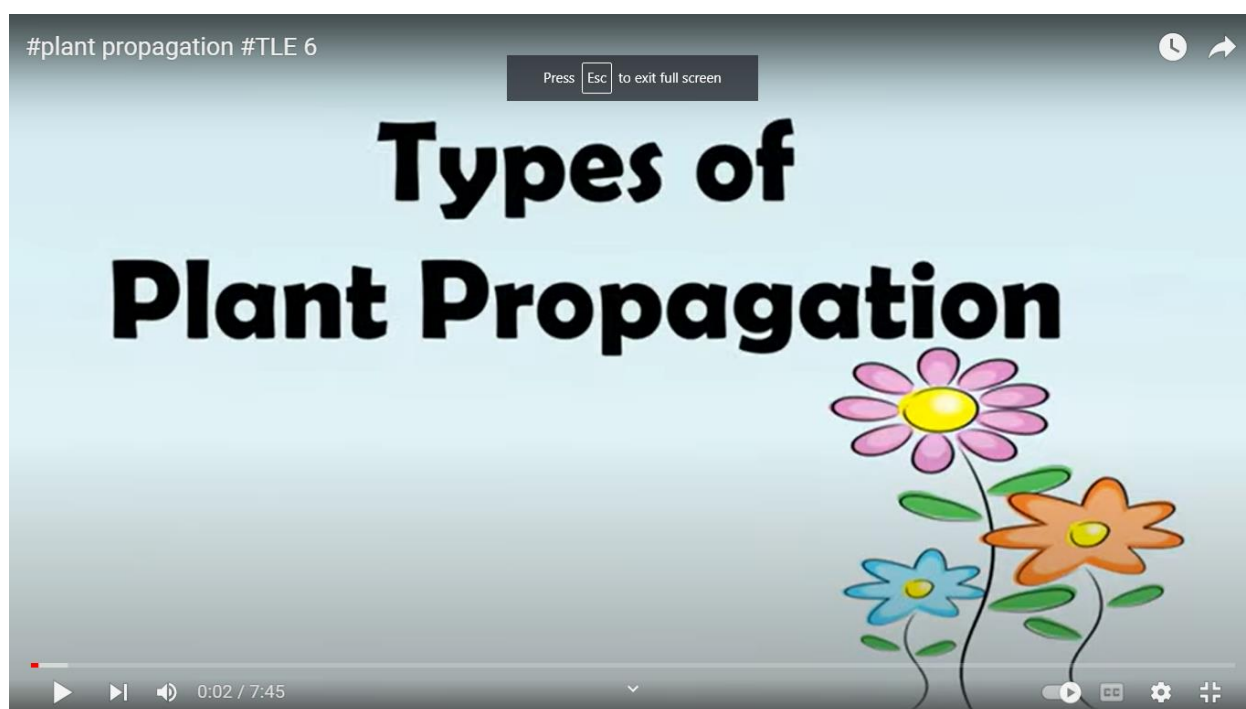


Figure 3.6. Propagation techniques

(https://www.youtube.com/watch?v=kyUcsuo_zGU Accessed date: May 23, 2023)

v. Identifying media specification

Page 71 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

An artificial, soilless mix also provides the desired qualities of a good germination substrate. The basic ingredients of such a mix are sphagnum peat moss and vermiculite, both of which are generally free of diseases, weed seeds, and insects. The ingredients are also readily available, easy to handle, lightweight, and produce uniform plant growth. “Peat-lite” mixes or similar products are commercially available or can be made at home using this recipe: 4 quarts of shredded sphagnum peat moss, 4 quarts of fine vermiculite, 1 tablespoon of superphosphate, and 2 tablespoons of ground limestone. Mix thoroughly. These mixes have little fertility, so seedlings must be watered with a diluted fertilizer solution soon after they emerge. Do not use garden soil by itself to start seedlings; it is not sterile, is too heavy, and will not drain well.

A. Media for Transplanting

Seedling growing mixes and containers can be purchased or prepared similar to those mentioned for germinating seed. The medium should contain more plant nutrients than a germination mix, however. Some commercial soilless mixes have fertilizer already added. When fertilizing, use a soluble house plant fertilizer, at the dilution recommended by the manufacturer, about every 2 weeks after the seedlings are established. Remember that young seedlings are easily damaged by too much fertilizer, especially if they are under any moisture stress.

B. Containers for Transplanting

There is a wide variety of containers from which to choose for transplanting seedlings. These containers should be economical, durable, and make good use of space. The type selected will depend on the type of plant to be transplanted and individual growing conditions. Standard pots may be used, but they waste a great deal of space and may not dry out rapidly enough for the seedling to have sufficient oxygen for proper development.



Figure 3.7 growing media for planting

3.3. Handling media and its components

The following media components can be used in propagation systems.

Soil

A mineral soil is composed of materials in the solid, liquid, and gaseous states. The solid portion of a soil is comprised of both inorganic and organic components. The inorganic part consists of the residue from parent rock after decomposition, resulting from the chemical and physical process of weathering. The organic portion of the soil consists of both living and dead organisms. Propagation in commercial horticulture is generally done with flats, containers, and/or pot systems using **“soilless” media**. Some exceptions to this are field budding and grafting systems, stooling and layering systems, field propagation of hardwood cuttings without intermittent mist, direct seeding of crops, and utilizing outdoor seedbeds.

Sand

Sand consists of small rock particles, 0.05 to 2.0 mm in diameter, formed as the result of the weathering of various rocks. Sand collected near the ocean (beach sand) may be too high in salts.

Page 73 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1 May 2023
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Calcareous sand will raise media pH and should be tested prior to mixing with vinegar or a dilute acid.

Peat

Peat consists of the remains of aquatic, marsh, bog, or swamp vegetation that has been preserved under water in a partially decomposed state. Composition of different peat deposits varies widely, depending upon the vegetation from which it originated, state of decomposition, mineral content, and degree of acidity.

Sphagnum Moss Peat

Commercial sphagnum moss peat or sphagnum peat is the dehydrated young residue or living portions of acid-bog plants in the genus *Sphagnum*, such as *S. papillosum*, *S. capillaceum*, and *S. palustre*. It is the most desirable peat for horticultural purposes, but its high cost limits its commercial use. It is relatively pathogen-free, light in weight, and has a very high water-holding capacity, able to absorb 10 to 20 times its weight in water. Sphagnum moss has a pH of about 3.5 to 4.0.

Vermiculite

Vermiculite is a micaceous mineral that expands markedly when heated. When expanded, vermiculite is very light in weight 90 to 150 kg per cubic meter, neutral in reaction with good buffering properties, and insoluble in water. Vermiculite has a relatively high cation-exchange capacity and, thus, can hold nutrients in reserve for later release. It contains magnesium and potassium, but supplementary amounts are needed from other fertilizer sources.

Perlite

Perlite, a gray-white siliceous material, is of volcanic origin, mined from lava flows. Usually, a particle size of 1.6 to 3.0 mm in diameter is used in horticultural applications. It is essentially neutral with a pH of 6.0 to 8.0 but with no buffering capacity. Unlike vermiculite, it has no cation exchange capacity and contains no mineral nutrients. It is most useful in increasing

aeration in a mix. Perlite, in combination with peat moss, is a very popular rooting medium for cuttings.

Pumice Chemically, pumice is mostly silicon dioxide and aluminum oxide, with small amounts of iron, calcium, magnesium, and sodium in the oxide form. Pumice is screened to different size grades, but is not heat-treated. It increases aeration and drainage in a propagation mix and can be used alone or mixed with peat moss.

Rockwool (Mineral Wool) This material is prepared from various rock sources, such as basalt rock, melted at a temperature of about 1600°C. Horticultural rock wool is available in several forms shredded, prills (pellets), slabs, blocks, cubes, or combined with peat moss as a mixture. Rockwool will hold a considerable amount of water, yet retains good oxygen levels.

Shredded Bark Shredded or pulverized softwood bark from redwood, cedar, fir, pine, hemlock, or various hardwood bark species, such as oaks and maples, can be used as an organic component in propagation and growing mixes and are frequently substituted for peat moss at a lower cost. Before it is used as a growing medium, pine bark is hammer-milled into smaller component pieces, stockpiled in the open, and often composted by turning the piles and watering as needed.

Coconut Fiber/Coir **Coconut fiber** (coir) is an economical peat substitute that can be mixed with a mineral component as propagation media. It is derived from coconut husks.

Compost: In some countries, compost is synonymous with container media for propagation and plant growth; however, we define *compost* (composting) as the product of biological decomposition of bulk organic wastes under controlled conditions, which takes place in piles or bins.

3.4. Selecting Storage requirements for the unused propagation media

Appropriate storage of planting materials. The viability of materials can be maintained by :

Page 75 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- Appropriate storage
- Shade regulation
- Showering
- Wrapping
- Deeping in the solution

For best results, harvest only as much scion wood as can be used for grafting during the same day. Select only healthy scion wood that is free from insect, disease or physical damage. Be sure the stock plants are of good quality, healthy, and true to type. If large quantities of scion wood must be harvested at one time. If freezing temperatures are likely to damage plant tissues, collect scion wood for grafting in the fall after normal leaf drop but before severe winter temperatures. Otherwise, wait to collect until late winter. Store the wood in a plastic bag. Enclose a moist cloth, but leave no free water in the bag. Store the wood in a refrigerator between 35°F (1.7°C) and 40°F (4°C). Make sure that fruits or plant materials capable of generating ethylene gas (plant hormone that induces ripening/senescence) are stored in a different cooler than the scions or rootstocks. If refrigeration is unavailable, store the wood outdoors in moist sand in a well-drained, protected location where the soil will not freeze. Scions and stock plant are selected from the previous season's growth. Collect “bud sticks” of the cultivar to be propagated from vigorous current season growth. The middle buds generally are the best to use since the tip buds are too immature, and those near the base may be a cluster of buds or weak buds. The bud sticks are prepared by removing the leaves but leaving 0.25 to 0.5cm of leaf petiole on the stem. The scions should be tied securely, carefully labeled and placed in moist (not wet) sawdust or moss or wrapped in plastic material. They should be kept in a cool, moist place where they will remain fresh and dormant until spring. The buds should be used as soon as practical but may be stored for three to four days. To store bud sticks:

- Wrap them in damp paper toweling,
- Attach a label for positive identification,
- Place in a polyethylene bag,

Page 76 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

- Seal tightly, and
- Place in a refrigerator (32° to 45°F).

Shortly after harvesting or receiving scion material, I recommend sealing the cut ends of the scion with water-based sealant such as liquid shade or tree seal. If you have a long bag leave the terminal bud on - then you have only one wound to seal. The sealed ends retard scion dehydration. Apply sealant to any area where the cambium has been broken, Pushing, packing and labelling, and controlling environmental parameters such as moisture, air, humidity and temperature Stick immediately or mist and hold overnight in a refrigerator



Figure 3.7 collected scion

Stored graft wood is required for several grafting methods. Unless the wood is collected and stored properly, the grafting effort is designed for failure. A variety of problems may occur in the collection and storage process, including drying out or freezing the wood, immature buds, old shoots, and insect and/or disease damage.

Microbes in the growing media can potentially consume the fertilizer charge, especially nitrogen and iron. This may explain why crops planted in aged growing media get off to a slower start. These processes occur more rapidly with hot storage temperatures than with cold. The unused growing media was manufactured this way or it was caused by excessive fluffing with a bale breaker or soil mixer.

3.5. Selecting conditioning and storage requirements for maximum viability of propagating material

Propagation material should be selected or collected according to propagation method and species. The conditioning and storage requirements should be selected based on the type of propagating material used. For example, hardwood cuttings require different storage conditions than softwood cuttings. The storage conditions should be maintained at optimal levels of temperature and humidity to ensure maximum viability of the propagating material. It is also important to monitor the storage conditions regularly to ensure that they remain within the optimal range

3.6. Preparation of growing site and propagation method must be suit to the target crop species

The preparation of the growing site and propagation method must be suitable for the target crop species and propagation method because it ensures that the plants are grown in an environment that is conducive to their growth and development. The growing site should have the right soil type, pH level, and drainage system to support the growth of the target crop species. The propagation method should also be suitable for the target crop species to ensure that the plants are propagated in a way that preserves their essential characteristics. For example, some plants may require vegetative propagation methods such as cuttings or grafting, while others may require seed propagation methods¹. By using the appropriate propagation method, horticulturists can ensure that the plants are propagated in a way that is consistent with their genetic makeup and that they will grow into healthy plants.

Page 78 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

Self-Check 3	Written Test
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Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Test I: True/False

1. Propagation medium is a substance in which plant parts are placed for propagation.
2. Pasteurization of propagation media at higher temperatures with aerated steam is generally preferable to fumigation with chemicals.
3. Facilities-disinfection refers to the reduction of pathogens and algae, while sanitation refers to the level of cleanliness.

Test I: Short Answer Questions

1. List characteristics of the medium that are required for plant propagation
2. Describe the Examples of propagation media?
3. Discuss the purpose of testing propagating media.
4. What is the relationship between media and Propagation techniques?
5. What mean pasteurization of propagation media?
6. List and discuss the media components that can be used in propagation systems
7. Describe use of selecting storage requirements for the unused propagation media.

Operation Sheet 3

2.2. Techniques of collecting and storage propagation material

Objective: To know how to select, collect and store propagation material

Material required: Budding knife, Grafting knife, A fine-tooth saw, Pruning shears, Dormant scion, Tying material such as grafting tape, adhesive tape and electrician's tape.

Procedures

1. Select suitable PPE and wear
2. Then, collect planting material from selected mother plant
3. Cut all scions to a uniform length, keep their basal ends together, and tie them in bundles of known quantity.
4. Label them, recording the cultivar, date of harvest, and location of the stock plant.
5. Wrap the base of the bundles in moistened burlap or sphagnum moss. Place them in polyethylene or waterproof paper bags, and seal the bags.
6. Store the bundles for short periods, if necessary, either iced down in insulated coolers or in a commercial storage unit at 0° to 1.1°C .
7. Never store scions in refrigerated units where fruits or vegetables are currently kept or have been stored recently.
8. Stored fruits and vegetables release ethylene gas, which can cause woody plant buds to abort, making the scions useless.
9. The scions should not be frozen during storage.

LAP Test 3

Name.....ID.....Date.....

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **60** minutes. The project is expected from each student or in a group to do it.

Task 1: Perform how to collect and storage propagation material

LG #4

LO #4 Prepare Parent Material

Instruction Sheet

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

- Interpreting workplace information and organizing tasks.
- Selecting tools, equipment and machinery.
- Identifying and selecting parent plant.
- Preparing parent plant and employing suitable method of propagation.
- Collecting propagation material.
- Maintaining viability of materials by appropriate storage.
- Implementing hygiene practices.
- Identifying OHS hazards, assessed, controls implemented and reported risks

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:

- Interpret workplace information and organizing tasks.
- Select tools, equipment and machinery.
- Identify and select parent plant.
- Prepare parent plant and employ suitable method of propagation.
- Collect propagation material.
- Maintain viability of materials by appropriate storage.
- Implement hygiene practices.
- Identify OHS hazards, assessed, controls implemented and reported risks

Learning Instructions:

Page 82 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

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

Information Sheet 4

4.1. Interpreting and organizing Workplace information and tasks

Plant propagation involves the formation and development of new individuals, which are used in establishment of new plantings. It simply refers to the reproduction or multiplication of plant material of a specific cultivar, variety, breeding line or strain that possesses desirable characteristics, (such as fruit shape and internal quality) in such a way that more daughter plants are obtained from the mother plant. The production of true to type progeny from the mother plant is the prime objective of propagation. Plant propagation has been a useful tool since centuries, which has made possible the generations to pass through and sustain production especially for fruit plants since time immemorial. Plant propagation depends on the plant species, variety, method of propagation, climatic and growth conditions. Man has propagated plant material almost as long as he has cultivated the land to produce food. For a long time, plant material was propagated mainly by using the seeds of existing plants. Better methods were discovered over time, methods that allowed the farmer to retain the desirable qualities of the plant material, while eliminating some of the less desirable qualities. Through these methods, the farmer was also able to eliminate the variations between plants of the same cultivar and produce more consistently. Today, farmers buy their plant material consisting of seed and seedlings from commercial seed companies or nurseries. The farmer is able to obtain plant material of a wide variety of cultivars, and that has qualities most suited to his specific environment.

Plant Propagation is important because:

- It multiplies the different species in large number.
- It protects the plant species which are endangered
- It improves the characteristics and quality of the plants.
- It produces quality and healthy plants on commercial base.

Organizing tasks and Interpreting work place information

Page 84 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

Work procedure will be based on sound horticultural principles and practices and may include supervisors, oral and written instructions, propagation program, enterprise standard operating procedures, specifications, production schedules, routine maintenance schedules, work notes, product labels, material safety data sheet, Integrated pest management (IPM) programs; manufacturers service specifications and operators manuals; waste disposal, recycling and re-use guidelines and OHS procedures must be interpreted and organized.

Principles of Workplace information

The trainees need to collect necessary information before preparing the plan. The information needed may include: agro-ecological data, socio-economic data, market information, propagation material availability, assessing services and site modifications required propagation techniques, sequence of operational activities in the propagation of horticultural crops and production guidelines for different horticultural crops (spacing, seeding rate, fertilizer requirement, types of chemicals used for control of insect pest and diseases of fruits, yield per hectare, etc.) and monitoring the activities. This can be done by visiting nearby metrological center, farmers' field, market, etc.

Plant propagation is the process of creating new plant. There are two types of propagation (sexual and asexual) .sexual reproduction is the union of the pollen. Sexual propagation involves the floral parts of a plant. Work procedure will be based on sound horticultural principles and practices and may include supervisors oral and written instructions, propagation program, enterprise standard operating procedures(SOPs), specifications, production schedules, routine maintenance schedules, work notes, product labels, material safety data sheet(MSDSs);Integrated pest management(IPM) programs; manufacturers service specifications and operators manuals; waste disposal, recycling and re-use guidelines and OHS procedures must be interpreted and organized.

4.2. Selecting tools, equipment and machinery

Page 85 of 157	Ministry of Labor and Skills	Crops Production Level -III	Version 1
			May 2023

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.

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.

Pruning Shears: Bud-wood is cut using pruning shears. Pruning shears are also used where cuttings are used for propagation.

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

Sterilization Liquid-Knives and shears must be periodically cleaned and sterilized properly with a solution of 10% bleach.

- Plastic containers and trays, scalpel,
- laminar flow cabinet,
- Autoclave, alcohol,
- Wheelbarrow,
- Trolley, mechanical trolley,
- Shovel, water spray container, dibblers and rubbish bins.

Materials used for propagation includes:

- Plant material
- Container (Tray, pots, sleeves, etc.)
- Rooting hormone
- Measuring tape
- Media

- ✓ Sterile
- ✓ Low fertility
- ✓ Well-drained
- ✓ Retains moisture
- ✓ Peat/perlite (1:1 mix)
- ✓ Vermiculite/perlite(1:1mix)

Equipments and machinery for propagation

Different types of sprayers and dusters are available from manually to power operated such as knapsack sprayers, foot operated sprayers, power operated mist blowers and dusters for plant protection. Fogging machines and mist blowers are available which can be used in the green houses and for covered crop cultivation. Different types of pumps which includes centrifugal, turbine, submersible, axial flow, mixed flow pumps etc. are available for lifting of the water for irrigation. Including sprinkler and drip irrigation systems.



Figure 4.1. Plant propagation tools

1. Budding knife
2. Grafting knife
3. A fine-tooth saw for cleft grafting
4. Pruning shears
5. Dormant scions (cultivar labeled)
6. Tying material such as grafting tape, adhesive tape, electrician's ber tape or rubber strips

7. Asphalt water emulsion compound for covering grafts
8. A light hammer for bridge grafting

A cleft-grafting chisel and mallet, or a heavy knife or hatchet can be used for a small job.

Preparing growing environment

In propagating and growing young nursery plants, facilities and procedures are designed to optimize the response of plants to environmental factors influencing their growth and development, such as light, water, temperature, gases, and mineral nutrition. In addition, young nursery plants require protection from pathogens and other pests, as well as control of salinity levels in the growing media. The propagation structures, equipment, and procedures maximize the plants' growth and development by controlling their environment.

Light

Light is important for photosynthesis as a source of radiant energy. Light also generates a heat load that needs to be controlled (i.e., too high a temperature can quickly desiccate and kill cuttings). The management of light can be critical for rooting cuttings, germinating seeds, growing seedlings, or shoot multiplication of explants during tissue culture propagation.

Water: Water management and humidity control are critical in propagation. Water management is one of the most effective tools for regulating plant growth. Evaporative cooling of an intermittent mist system can help control the propagation house microenvironment and reduce the heat load on cuttings, thereby permitting utilization of high light conditions to increase photosynthesis and encourage subsequent root development. Tissue culture explants are often grown in a liquid phase rather than on a solid agar media. While leaf water potential is an important parameter for measuring water status of seedlings and cuttings, and influences rooting of cuttings, turgor is physiologically more important for growth processes. The water status of seedlings and cuttings is a balance between transpiration losses and uptake of water.

Temperature: Temperature affects plant propagation in many ways. Seed dormancy is broken in some woody species by cool moist stratification conditions that allow the germination process to

proceed. Temperature of the propagation medium can be suboptimal for seed germination or rooting due to seasonally related ambient air temperature or the cooling effect of mist. In grafting, heating devices are sometimes placed in the graft union area to speed up graft union formation, while the rest of the rootstock is kept dormant under cooler conditions. It is often more satisfactory and cost-effective to manipulate temperature by bottom heating at the propagation bench level, rather than heating the entire propagation house .

Gases and Gas Exchange

High respiration rates occur with seed germination and plug development, and during adventitious root formation at the base of a cutting. During propagation in enclosed greenhouses, ambient CO₂ levels can drop to suboptimal levels, limiting photosynthesis and propagules development. The buildup of ethylene gas can be deleterious to propagules during storage, shipping, and propagation conditions. Ethylene also plays a role in plant respiration, rooting of cuttings, and seed propagation.

Mineral Nutrition: To avoid stress and poor development during propagation, it is important that the stock plants be maintained under optimal nutrition prior to harvesting propagules. During propagation, nutrients are generally applied to seedlings and plugs by fertigation (soluble fertilizers added to irrigation water) or with controlled-release fertilizers that are either.

4.3. Identifying and selecting parent plant.

According to the Royal Horticultural Society, vegetative propagation is useful for increasing stock of named cultivars which don't come true from seed. Use these methods to produce cloned copies of the parent stock. Hardwood cuttings are suitable for many deciduous climbers, trees and shrubs as well as evergreens¹. You can also use softwood cuttings for plants that have non-woody stems². Another method is layering which involves bending a low-growing stem down to the soil surface and covering it with soil or compost. The stem will then produce roots at the point where it is covered with soil. Once the roots have formed, the stem can be cut away from the parent plant and potted up. When it comes to propagating plants, selecting the right parent plant is crucial for ensuring successful propagation. The parent plant is the source of the plant

material that will be used to produce new plants, so it is important to choose a healthy and vigorous specimen.

There are several factors to consider when identifying and selecting a parent plant for propagation. First and foremost, the plant should be free from disease and pest infestations. Propagating from a diseased or infested plant can result in offspring with the same issues, which can lead to poor crop yields and loss of profits. In addition to disease and pest resistance, the parent plant should also exhibit desirable traits such as high yield, good flavor, or strong growth habits. This can be achieved through careful observation and data-driven insights. By tracking the performance of different plants over time, growers can identify those that exhibit the most favorable traits and use them as parent plants for future generations.

Other factors to consider when selecting a parent plant for propagation include environmental conditions and genetic diversity. Plants that are well-adapted to local climate conditions are more likely to produce strong, healthy offspring, while those that are genetically diverse are better able to adapt to changing environmental conditions over time.

Once a suitable parent plant has been identified and selected, it is important to take proper care during the propagation process to ensure maximum viability of the propagating material. This includes selecting appropriate conditioning and storage requirements based on the specific type of plant being propagated and carefully monitoring irrigation levels and other external factors that can affect growth and development.

i. Identifying parent plant

- Prior to seed/scion collection, you will need to select and mark good mother trees. These are the trees you will use as sources of high quality seed/fruit. Here are the major criteria that determine a good mother tree/plant:

ii. Criteria for selection of mother Plants

- The mother plants of the variety should be genetically true to type and superior in quality.
- The mother plants should be healthy, vigorous, high yielding ability and free from any diseases, pest infestations and physiological disorder.

- The mother plants should have known pedigree records regarding bearing potential, fruit quality and problems, if any.
- The mother plants should be a productive and regular fruit bearer.
- Dwarfing and semi-dwarfing in nature
- Compatibility with the known commercial cultivars.
- Resistance/tolerance to biotic (diseases and pests) and abiotic stresses.
- Rootstock should have well developed and profuse root system.
- The rootstock should be easy to propagate vegetatively or from seeds.
- Early mature
- Good producers of the desired product
- Growing in the midst of a healthy stand of the same species.
- The purchase receipt of mother plant should be preserved to prove the origin and authenticity of the mother plants

For good mother trees (mother trees for scion and root stocks)

- Collect seed from trees of local varieties producing good quantities of tasty, healthy fruit of marketable size.
- Low branching trees may be preferable as mother trees. It is easy to pick fruits from low branches.

iii. Mother plant selection and maintenance

- Mother plant is the most important factor of plant nursery. Care should be taken that the mother plants attain optimum vegetative growth. Mother plant plantation must be well classified according to the types and varieties. The success of any nursery depends greatly on the health and vigor of its mother plants. It is therefore necessary to obtain genetically sound mother plants to produce healthy and vigorous off springs. Not only selection of mother plants necessary but also proper care and maintenance of these plants is also essential to obtain vigorous and healthy growth. This can be achieved by taking appropriate care. Mother plants are irrigated regularly. Trees that are used for propagation material are called mother trees. Of course it is important to select outstanding mother trees. Mark the outstanding mother trees so that you can recognize them in years to come.

Selection makes sense because the young trees will be expected to inherit the favorable characteristics from the mother tree, such as fast growth, upright or spreading shape of the tree crown, good flowering and fruiting and tolerance of diseases or pests.

Collecting Scion Wood

The success of any form of propagation depends on the quality of the scion wood to be grafted. Collect scion or bud wood early in the day while temperatures are cool and the plants are still fully turgid. The best vegetative buds usually come from the current season's growth or dormant wood that grew the previous year. Mature buds are most desirable; discard terminal and younger buds.

Separated living portion of a plant (such as a bud or shoot) joined to a stock in grafting and usually supplying solely aerial parts to a graft. Quality plants are produced only from quality seeds obtained from a reliable dealer. Select varieties to provide the size, color, and growth of plant. Many new vegetable and Flower varieties are hybrids, which cost a little more than open pollinated types. However, hybrid plants usually have more strength, more uniformity, and better production than non-hybrids and sometimes have specific disease resistance or other unique cultural Characteristics

Parameters of scion selection

- Behavior fruit
- One year old wood
- Pencil size
- At list it have 3 bud

To keep buds from drying out, getting hot, or freezing (depending on the season), place the bud wood into plastic bags or wrap it in moist towels or burlap as you collect it. Place bud wood of only one variety in a labeled bag. Bud sticks that will not be used immediately should be bundled, labeled, and stored in moisture-retaining containers such as plastic bags or waxed cardboard boxes, which should be kept cool (32 to 45°F). The longer bud wood is stored, the less likely it is to “take.”

Generally, bud wood stored for more than a few days should be discarded. In budding, the situation is somewhat different in that the “June bud” technique involves the use of previous

season's terminal growth, whereas the dormant budding is made from non-growing buds on the current season's growth.

The scions should be wrapped in non-perforated plastic (a plastic bread wrapper is excellent) and placed in cold storage (30 to 40°F) or buried in moist sand or sawdust until ready for use. When making the graft, remove an inch or two of the tip and basal portions of the scions to eliminate wood that may have dried out. Another reason for discarding the tip and basal portions is that the tip portion is too small and the base too large for proper handling. Furthermore, neither portion will have properly matured buds.

4.4. Preparing parent plant and employing suitable method of propagation.

There are two methods of plant propagation: sexual and asexual

(A) Sexual Plant Propagation

Sexual plant propagation involves the union of the pollen (male organ) with the egg (female organ) in plants 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 mature seed is exposed to favorable environment, it germinates and begins its active growth.

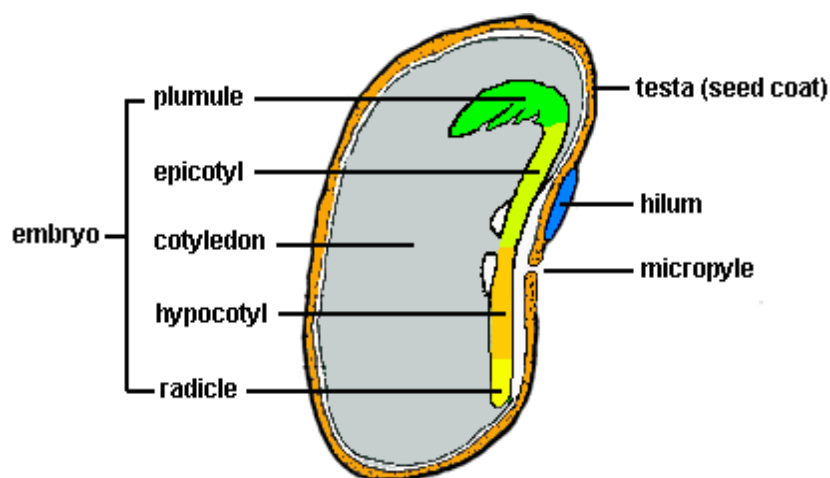


Figure 4.2 Structure of a Seed

Advantages of Sexual Plant Propagation

- ✓ It is the easiest and least expensive method of plant propagation.
- ✓ Seedling trees are hardier and have longer life span.

- ✓ Plants which are difficult to propagate by vegetative method e.g. papaya, phalsa, coconut etc. can only be propagated by seed.
- ✓ The rootstocks on which the fruit varieties are budded or grafted are usually obtained by means of sexual propagation.
- ✓ Sexually propagated plants are more resistant to pests and disease.
- ✓ Large number of plants can be produced at a time by this method.
- ✓ Poly embryonic varieties (give rise to more than one seedling from one seed) can be propagated by seed eg. Nucellar Embryo in Nucellar Mosambi (Sweet Orange)

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 manuring, pruning and spraying increases.
- ✓ In case of sexually propagated plants, there is no assurance about genetic purity of the offspring or seedling.

(B) Asexual Plant Propagation

In this method the 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. It is also called as vegetative method of plant propagation.

Advantages of Asexual Plant Propagation

- 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.
- Vegetatively 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.
- Better rootstock can be conveniently combined with the method to suit the climatic requirement of the area.

- 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 grafting 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

- 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.
- Plants propagated by this method are not hardy and fall easy prey to adverse conditions of soil, climate, diseases, pests, etc.

A seed must have a mature embryo , contain a large enough endosperm to sustain the embryo during germination , and contain sufficient hormones to initiate the process.

In general do not expect more than 65% to 80 % of new seed to germinate.

1. Seed germination process: Germination in plants is the process by which a dormant seed begins to sprout and grow into a seedling under the right growing conditions. In bacteria or fungi, germination is the process in which a spore begins to grow vegetative cells, and sporeling hyphae

Steps involved germination

- The seed absorbs water and seed coat bursts. It is the first sign of germination. There is an activation of enzymes, increase in respiration, and plant cells get duplicated. A chain of chemical changes starts which leads to the development of the plant embryo.

- Chemical energy stored in the form of starch is converted to sugar, which serves as food for the embryo during the germination process. Soon, the embryo gets nourished and enlarged, and the seed coat bursts open.
- The growing plant emerges out. Tip of the root first emerges, growing downwards, and helps to anchor the seed in place. It also allows the embryo to absorb minerals and water from soil.
- Some seeds require special treatment of temperature, light or moisture to start germination.

2. Stages involved in Germination process:

Seed germination means the growth of embryo into seedling and plant. The steps of germination of seeds are based on the time period and physiological changes.

- Imbibition phase
- Latent phase
- Exponential growth phase

Imbibition phase:

This is a phase where seeds imbibe water from surroundings. When a seed falls onto soil, it receives sufficient water and moisture. Then the actual process of germination starts. The water permeates through the seed coat and the seed material inside is drenched. The internal seed content imbibes (absorbs) water and the seed swells. This puts pressure on seed coat to provide eruption for germination. All the parts of a germinating seed become soft and smooth in this phase.

The food material inside the seed, now in presence of water provide sufficient energy. This helps the embryo to sprout out of the seed as a seedling. There is an internal active metabolism for the seed. This is a bit long time consuming process so it remain latent. The metabolic reaction is active and there is release of heat. This stage makes the seed ready to sprout out.

Exponential growth phase:

Page 96 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

All the biochemical reaction get activated and plant growth hormones then guide the process of germination. By regulation of auxin a growth hormone, the root tends to grow into the soil while the stem forms and grows towards light. This process continues till the germination of seed into small plant is complete. Until the level of formation of leaves, the growth of plant is sustained by reserve food material, water and oxygen from air. Once leaves form, food is synthesized from light using carbon-dioxide and water. Thus the seed germination process ends with formation of seedling which grows into big plant.

3. Factors affecting germination of seeds: Seed germination is affected by many factors like: Environmental and internal factors

Water: Seeds are most driest forms and they require water for germination. It helps seed in activation of enzymes to digest reserve food to rupture seed coat and to mediate all the physiological processes of seed.

Temperature: Soil temperature for seed germination is critical. Both low temperatures and high temperatures are not suitable for seed growth. Because enzymes are not active at low temperatures and physiology of growth is slow while at high temperatures they get denatured.

Oxygen: is vital to oxidize reserve food and provide energy for seed germination. Without oxygen seed do not germinate as seen in seeds sown very deep in the soil.

Sunlight: Seed germination varies in plants due to light. Some require light for germination while in other germination is inhibited by light. But light seems to guide direction of roots and stem from the seed.

1. Methods of Breaking Dormancy

One of the functions of dormancy is to prevent a seed from germinating before it is surrounded by a favorable environment. In some trees and shrubs, seed dormancy is difficult to break, even when the environment is ideal. Various treatments are performed on the seed to break dormancy and begin germination.

Scarification: Seed scarification involves breaking, scratching, or softening the seed coat so that water can enter and begin the germination process. There are several methods of scarifying seeds. In acid scarification, seeds are put in a glass container and covered with concentrated sulfuric acid. The seeds are gently stirred and allowed to soak from 10 minutes to several hours, depending on the hardness of the seed coat. When the seed coat has become thin, the seeds can be removed, washed, and planted. Another scarification method is mechanical. Seeds are filed with a metal file, rubbed with sandpaper, or cracked with a hammer to weaken the seed coat. Hot water scarification involves putting the seed into hot water (170 to 212 degrees F). The seeds are allowed to soak in the water, as it cools, for 12 to 24 hours and then

planted. A fourth method is one of warm, moist scarification. In this case, seeds are stored in non sterile, warm, damp containers where the seed coat will be broken down by decay over several months.

Stratification: Seeds of some fall-ripening trees and shrubs of the temperate zone will not germinate unless chilled underground as they over winter. This so called “after ripening” may be accomplished artificially by a practice called stratification. The following procedure is usually successful. Put sand or vermiculite in a clay pot to about 2.5cm from the top. Place the seeds on top of the medium and cover with 1.2cm of sand or vermiculite. Wet the medium thoroughly and allow excess water to drain through the hole in the pot. Place the pot containing the moist medium and seeds in a plastic bag and seal. Place the bag in a refrigerator. Periodically check to see that the medium is moist, but not wet. Additional water will probably not be necessary. After 10 to 12 weeks, remove the bag from the refrigerator. Take the pot out and set it in a warm place in the house. Water often enough to keep the medium moist. Soon the seedlings should emerge. When the young plants are about 7.5cm tall, transplant them into pots to grow until time for setting outside.

Viability: Seeds ability to germinate varies on the method of storage, health of the parent, age of seed, maturity of seed, infections etc. So the seeds with good viability germinate faster.

Seed treatment

Objectives of seed treatment

- To prevent the seed against pest and diseases infestation.
- To break seed dormancy and to induce higher germination percentage.
- To inoculate the seed with Rhizobium bio fertilizer.
- To induce tolerance to salinity, drought frost etc..
- To promote nitrogen fixation by treating it with Rhizobium

Important of seed treatment: Seed treatment is the process of applying physical, chemical or biological treatment to the seed to keep it viable and health.

Types of seed treatment

1. Physical treatment
2. Biological treatment
3. Chemical treatment

1. Physical seed treatment

It includes subjecting seeds to solar exposure, immersion in conditioned water etc.

- To induce higher germination, the seeds may be soaked in water before sowing or may be exposed to warm temperature. Early rooting may be induced by treating seeds with IBA or GA solutions.
- To induce or facilitates sowing and better germination in cotton seed treated with
- Sulphuric acid (H_2SO_4).

2. Biological Seed treatment

It includes the treatment of seeds with microbial cultivars such as that of Rhizobium to inoculate the seeds with microbial cultivars, to fix atmospheric nitrogen and release to the soil.

3. Chemical seed treatment

It includes treating seeds with fungicides, insecticides, nematocides etc.

Types of chemical used for seed treatment

1. Insecticides:- Parathion, phorate, chlorphosphos, furadan, dimethoate etc
2. Fungicides:- Thiram, thiophante (topsin), carbendazim, vitavax, dexton etc

Dressing seeds with chemicals

• Insecticides for stored seeds

Only use them with clean dry grain in good place. The seeds must be clean and dry in order to keep the high percentage of live seeds that will germinate.

Selection of insecticides: - The kinds of insecticides for fumigation may be used for stored seeds. Fumigants may kill many kinds of pests in store house by releasing toxic gas. Commonly used are:-

- A. **Phostoxin** (AIP):- used for 1-4 pieces/ m^3 in store, and 4-12 pieces/ m^3 in open bam.

Every pieces of space should be more than 2cm, avoid contact with water and keep the fire off.

- B. **Methyl bromine** (CH_3Br):- suitable for condition of low temperature, spray for 0.5 Kg/37/ m^3 . The store house must be strictly sealed in.

• Seed disinfectant

Fungicides: - for seed dressing, fungicides to seeds ratio is 0.3-1.0:100 for 10 to 48 hours.

For seed soaking, fungicides to seeds ratio is 1:500-1000 for 10 to 48 hours.

Insecticides: - quantity of usage is based on the insecticides but every seed should be coated with distributed insecticides used for seed coating. Insecticides, water and seed ratio is 1:50:50 suffocating for 4 to 6 hours

Fumigants: - look at insecticides used for stored seeds. Ways of application

A. Seed dressing: - is mixing of seeds with the pesticides powder or liquid evenly, like high concentration of powder or WP, EC etc.

Usage

Powder: - dry dressing by man or in the mixer (Drum)

Wettable powder or emulsion: - Prepare chemicals before seed dressing from 0.3% to 1.0% of the weight of the seeds.

B. Seed soaking

It is soaking of the seeds into the solution for certain time. Prepare the solution usually 500- 1000 times solution. Soak the seeds into the solution for certain time, from 10 minutes to 48 hours. Spray out the seeds and dry the moisture of the surface of the seeds.

C. Rinsing: - is just like the soaking, only the time of seed in the solutions is much shorter than that of soaking, aims to kill the pest on the seeds.

D. Seed suffocating: - compounds the seeds with pesticides and suffocate for several hours.

Usage:-

- Chemical, water to seed ratio is 1:50:50
- Mix the seed with the solution evenly
- Pile with a cover of cloth, plastic film or sacks for several hours
- Sow the seeds after drying the moisture on the surface of seeds

2. Asexual (Vegetative) Propagation

Budding is similar to grafting except that the scion is reduced to a single bud with a small portion of bark or wood attached.

- The single bud scion is joined with the rootstock to form a new plant.
- It is done in the spring or fall when the bark separates easily from the wood
- It is faster, easier and more economical than grafting

- No wax is needed & cambium does not need to be aligned; less scion is needed

Examples: Roses, fruit trees

- ✓ Cutting: rooting a severed piece from a parent plant
- ✓ Layering
- ✓ Rooting a stem while attached to the parent plant
- ✓ Division
- ✓ Separation of multi-crown plants
- ✓ Grafting & Budding
- ✓ Joining of 2 plant parts
- ✓ Tissue Culture
- ✓ Aseptic culture of meristematic tissue

Micro propagation is *in vitro* propagation and many genetically identical plants are produced from **one plant**

- Rapid (compared to outdoors)
- Asexual
- In vitro propagation (in tubes/petri plates etc.)
- A single node will produce a shoot within 4-6 weeks that has 4-6 nodes.
- Each plantlet can be "sub cultured" to produce another 4-6 plants each.
- Hundreds of thousands of plants could be developed from one node. Since these are produced from auxiliary buds, the plantlets will be clones of the mother plant.

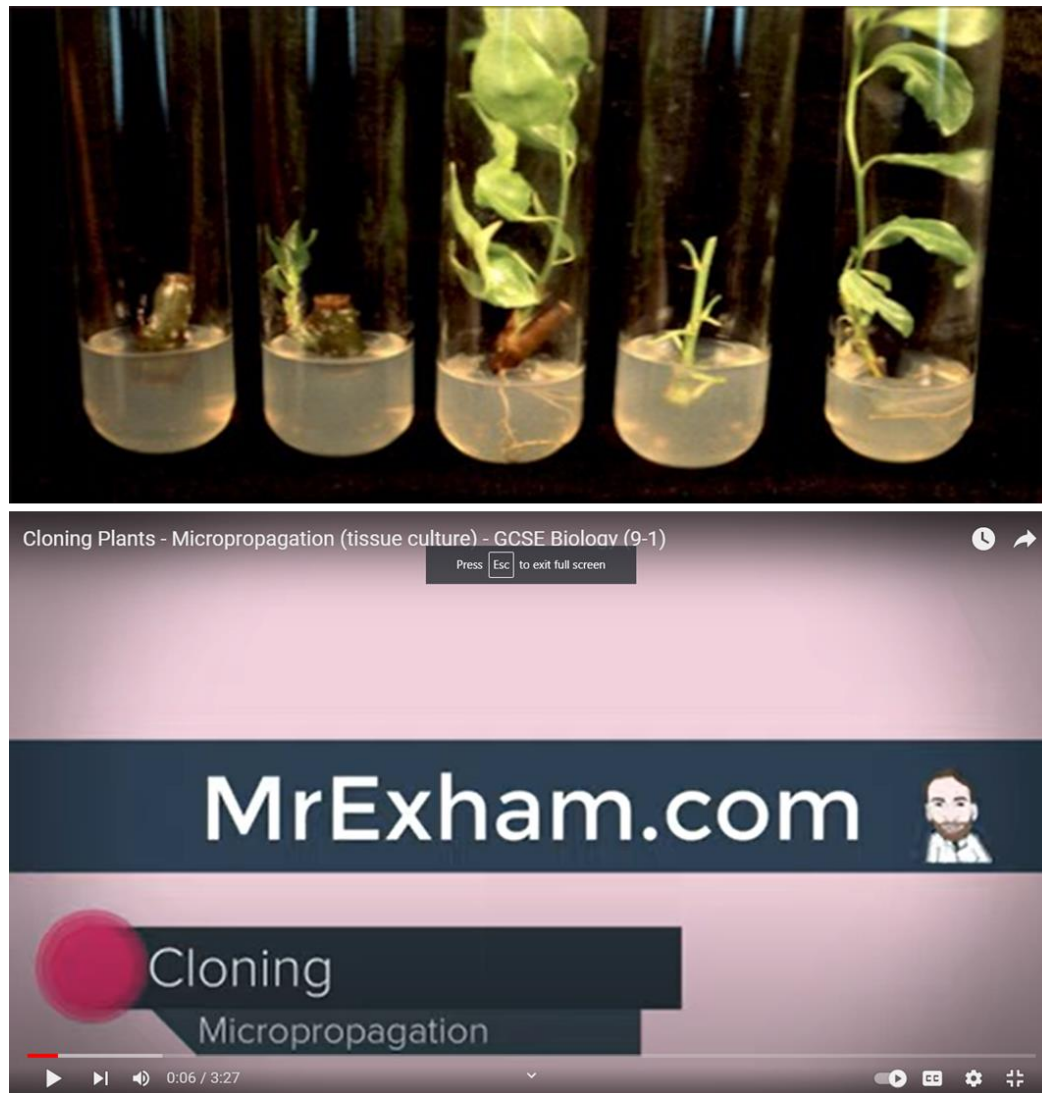


Figure 4.3. Micro propagation

(<https://www.youtube.com/watch?v=uSY6m1gqtYc>;

<https://www.youtube.com/watch?v=uSY6m1gqtYc> Accessed date: May 23, 2023)

Advantages of micro propagation

- Economical in time and space
- Greater output -can produce millions of uniformly flowering and yielding plants
 - African biotechnologies - fruit crops banana and indoor pot flowers 6 million pieces per year
- Disease free
- Elite plants with exceptional characteristics

- facilitates safer movements of germplasm across nations. *In vitro* germplasm assures the exchange of pest and disease free material
- Great for vegetatively reproduced crops which produce few seeds or highly heterozygous seeds.

Regeneration is possible because plant cells can be made *totipotent* using hormones.

- Differentiated tissue: stems, leaves, roots, etc.
- Undifferentiated (embryonic) cells are totipotent: can become a whole new plant by differentiating into a whole new plant.

Plant Hormones are naturally occurring chemicals that influence plant growth. **Growth Regulators** are synthetic versions of hormones

Cytokinins induce the production of shoots

Auxins induce the production of roots

How does a plant grow?

Plant growth is the process by which the plant growth in size .

A matured plant has a strong stem and healthy leaves.

Plant cell parts; plant cell have always spurred curiosity amongst biology students besides others .

The cell in a plant are the most basic units of life that come together to form its different parts such as the leaves stems

The action of the different hormones / regulators is not consistent:

- Different plants will respond to the same chemical differently.
- Different plant parts from the same plant can respond differently
- ✓ **Tissue must be sterile** - completely free of any microorganisms; done using aseptic technique
- ✓ **Starting tissue is called an explants:** differentiated cells (these cells have developed to be part of specialized tissue (root, leaf, stem, ovary, cotyledon, etc.).
- ✓ Explants are plated on a sterile petri dish containing hormones and nutrients that promote the explants cells to develop into Callus - a mass of *undifferentiated* cells. Callus cells are totipotent.

4.5. Collecting propagation material

Page 103 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

According to the Royal Horticultural Society, before collecting any plant material for cuttings, it is important to use clean tools and equipment during propagation (including surfaces). High standards of hygiene are important for success. Collect material early in the day when full of water (turgid) to avoid wilting. After propagating plants, it is important to carefully collect the propagation material to ensure maximum viability and promote healthy growth in the propagated plants. Proper collection and handling techniques can help prevent damage or disease to the plant material and minimize the risk of failed propagation. The key to successful collection of propagation material is to create a sterile environment while minimizing the amount of time between cutting or harvesting and storage or planting. This helps to preserve the healthy cells and tissues that are necessary for successful growth and development in the propagated plants.

One important consideration when collecting propagation material is timing. Different plant species have different optimal times for harvesting plant material, so it is important to research the specific requirements for each plant being propagated. As a general rule, most propagation materials should be harvested during the middle part of the growing season, when the plant's tissues are more pliable and able to regenerate.

Once collected, propagation material should be stored in a cool, dry place until it can be either planted or processed for long-term storage. This might involve storing the propagation material in peat moss, sand or some other type of sterilized growth medium. In summary, proper collection and handling of propagation material is essential for successful propagation. By focusing on timing, sterility, and storage conditions, growers can ensure that their propagation efforts produce healthy offspring that exhibit desirable traits like resistance to pests and diseases, improved yield, and strong growth habits. Ultimately, this can help boost crop yields, reduce costs, and increase profits for growers and farmers of all types.

4.6. Maintaining viability of materials by appropriate storage

Appropriate storage is crucial for maintaining the viability of materials such as seeds, bulbs, and cuttings. The storage conditions should be optimal for the specific material to ensure that it remains viable for as long as possible. For example, seeds should be stored in a cool and dry place to prevent them from germinating or becoming moldy. Bulbs should be stored in a cool and dry place as well but with good air circulation to prevent rotting. Cuttings should be stored in

a moist environment to prevent them from drying out. Proper storage can help extend the shelf life of materials and ensure that they remain viable for future use.

Proper storage is crucial for maintaining the viability of materials. Whether it is seeds, plant cuttings, or other horticultural materials, the right conditions can help ensure that they remain viable and usable for as long as possible.

One key factor to consider when storing materials is temperature. Depending on the specific type of material, certain temperatures may be more effective for maintaining viability. For example, some types of seeds may require cooler temperatures to remain viable, while others may do better in warmer conditions. Humidity is another important factor to consider. Excessive moisture can lead to mold or other forms of decay, which can quickly render materials unusable. On the other hand, particularly dry conditions can also be damaging, causing materials to become overly brittle and prone to breakage. Light exposure is also important to consider when storing horticultural materials. While some types of seeds may benefit from exposure to light, others may require darkness to maintain their viability.

Overall, careful attention to the storage needs of different types of horticultural materials can help maximize their viability and usefulness over the long term. By considering factors like temperature, humidity, light exposure, and container selection, growers and horticultural enthusiasts can ensure that they are able to maintain their materials effectively and achieve the best possible outcomes from their efforts.

4.7. Implementing hygiene practice

One of the most rewarding processes in nursery production is plant propagation. However, the opportunity for pest and diseases to severely impact on propagation success should not be underestimated. Poor hygiene in plant propagation can lead to complete propagation failure or retardation in plant growth, both of which have significant cost implications. This highlights hygiene protocols that should be implemented during the four stages of propagation:

- Cutting material and seed collection
- Cutting preparation

- Propagating
- Hardening off.

Although seed treatment reduces the possibility of infections, infected fruits should be avoided when collecting seeds. Only healthy fruit still hanging on the tree are to be used, as rotten fruit and fruit lying on the ground might carry brown rot (*Phytophthora*) and contaminate the medium.

Sanitation treatment is extended to the media used, the containers, floors and benches. Propagation media, such as perlite and vermiculite, are sterile and classified as very low-risk by virtue of the temperatures they are subjected to during their processing. For budding and cuttings, sterilization of pruning shears and budding knives ensures that the propagation material remains virus-free. Sterilization is accomplished by cleaning tools thoroughly with clean water and wiping the blades with a solution of 10% chlorine bleach. The solution should not be kept for more than five hours.

The importance of sanitation during propagation and growing has become widely recognized as an essential part of nursery operations. During propagation, losses of young seedlings, rooted cuttings, tissue-cultured rooted plants, and grafted nursery plants to various pathogens and insect pests can sometimes be devastating, especially under the warm, humid conditions found in propagation houses. Ideally, sanitation strategies should be considered even in the construction phase of propagation structures. Harmful pathogens and other pests are best managed by dealing with the three situations where they can enter and become a problem during propagation procedures:

- The propagation facilities: propagating room, containers, pots, flats, knives, shears, working surfaces, hoses, greenhouse benches, and the like
- The propagation media: rooting and growing mixes for cuttings, seedlings, and tissue culture plantlets
- The stock plant material: seeds, cutting material, scion, stock material for grafting, and tissue culture. Sanitation practices in nursery include,
 - i. Prevention of insects, pests and diseases
 - ii. Inspection for insect, pest and disease incidences

- iii. Environmental control leading to protection from harmful environment factors like hot sun, freezing temperatures, storms, etc.
- iv. Eradication of pests, diseases and weeds.

Sanitation Treatments

- Sterilization of the propagation media, tools, and implements used is necessary in nursery plant production. Propagating media and tools can be easily sterilized by heat or by chemicals. A temperature of about 71 °C for 30 minutes is considered sufficient to kill almost all disease producing pathogens.
- Chemicals used for sterilizations are Chloropicrin, Formaldehyde, Methyl Bromide.
- Fumigation with chemicals is useful for destroying harmful bacteria, fungi and nematodes in a relatively small quantity of soil that is used for propagation of plants.
- Drenching the medium with certain fungicides is also useful in eliminating pathogens from the soil, coco peat and other media.
- General cleanliness of nursery area (inside and outside) and all the implements are necessary.

4.8. Identifying OHS hazards, assessed, controls implemented and reported risks

Identifying OHS hazards

Workers have a duty to take reasonable care for their own health and safety and must not adversely affect the health and safety of other persons. Workers must comply with any reasonable instruction and cooperate with any reasonable policy or procedure relating to the use, handling and storage of hazardous chemicals at the workplace. Identifying hazards involves finding all of the foreseeable hazards in the workplace and understanding the possible harm that the hazards may cause. *OHS hazards* may include: disturbance or interruption of services, solar radiation, dust, noise, soil-, air- and water-borne micro-organisms, chemicals and hazardous substances, sharp hand tools and equipment, manual handling, moving vehicles, machinery and machinery parts, flying objects and uneven surfaces.

OHS is a crucial aspect of working in the horticulture industry. Horticulture jobs often involve working with potentially hazardous machinery, chemicals, and environments, such as working

with pesticides or operating tractors and other heavy equipment. Employers are responsible for ensuring the safety of their workers by providing adequate training, proper safety equipment and implementing safety measures in the workplace. Accidents in the horticulture industry can have serious consequences for workers, their families, their employers, their clients, and the environment. It is important for all parties to understand the importance of OHS in horticulture. According to Safe Work Australia, "all workers and employers have a shared responsibility to work together to address and improve OHS outcomes

Assessing risk and reporting risks

Risk assessment is a process for developing knowledge and understanding about hazards and risks so that sound decisions can be taken about control. A risk assessment will provide knowledge to make informed decisions about controlling hazards and risks. The risk assessment needs to be tailored to the situation and to the organization in which it is conducted; it can be as simple as structured discussion during consultation or it can be more elaborate and formal.

Risk assessment assists in determining:

- What levels of harm can occur
- How harm can occur
- The likelihood that harm will occur.

A risk assessment should be done when:

- There is only limited knowledge about a hazard or risk, or about how the risk may result in injury or illness
- There is uncertainty about whether all of the things that can go wrong have been found
- The situation involves a number of different hazards that are part of the same work process or piece of plant and there is a lack of understanding about how the hazards may impact upon each other to produce new or greater risks.

Controlling hazards and risks

Workplaces can be dangerous; there are many hazards that have the potential to kill, injure or cause ill health or disease. Protecting the health and safety of people in the workplace is a community expectation that makes good business sense. Workplace incidents can have a

dramatic impact on people’s lives (people in the workplace, families and friends), and they can have significant financial impacts on organizations through loss of skilled staff and lost production of goods or services.

However, in many circumstances it will be the best way to determine the measures that should be implemented to control risks. It will help to:

- Identify which workers are at risk of exposure
- Determine what sources and processes are causing that risk
- Identify if and what kind of control measures should be implemented
- Check the effectiveness of existing control measures.

Self-Check 4	Written Test
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Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Test I: Short Answer Questions

1. List the materials used for propagation includes?
2. What is the use of sterilization liquid?
3. Discuss the purpose of preparing growing environment
4. List important factors that may considered during preparing growing environment
5. Define micro propagation?
6. What is the difference between sexual and asexual?
7. List methods of asexual propagation
8. Explain the advantages of and disadvantages of sexual and asexual propagation.
9. List down hygiene protocols that should be implemented during the four stages of propagation
10. What is the cause of poor hygiene in plant propagation?
11. List criteria for selection of mother plants?
12. Why you identify parent plant

LG #5

LO #5 Undertake Propagation

Instruction Sheet

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

- Selecting propagation method
- Preparing propagation material
- Performing propagation techniques (Types of propagation technique)
- Handling of plants to minimize damage
- Completing records accurately and at the required time
- Identifying and reporting out-of-specification process and equipment performance

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:

- Select propagation method
- Prepare propagation material
- Perform propagation techniques (Types of propagation technique)
- Handle of plants to minimize damage
- Complete records accurately and at the required time
- Identify and report out-of-specification process and equipment performance

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 5

5.1. Selecting propagation method

There are many different methods of plant propagation, and the best method for a particular plant will depend on the type of plant, the time of year, and the resources available. Some of the most common methods of plant propagation include:

- **Seeds:** This is the most common method of plant propagation, and it is the way that most plants are naturally reproduced. Seeds can be collected from the plant itself or purchased from a nursery.
- **Cuttings:** This method involves taking a piece of the plant and rooting it in water or a growing medium. Cuttings can be taken from the stems, leaves, or roots of the plant.
- **Layering:** This method involves bending a stem of the plant down and covering it with soil. The stem will eventually root and form a new plant.
- **Division:** This method involves dividing the root system of the plant into two or more sections. Each section can then be planted as a new plant.
- **Grafting:** This method involves joining two different plants together so that they grow as one. Grafting is often used to combine the desirable traits of two different plants.

The best way to select a propagation method is to consult with a local nursery or garden center. They can help you choose the method that is best for the type of plant you are propagating and the conditions in your area.

Here are some additional factors to consider when selecting a propagation method:

- **The type of plant:** Some plants are easier to propagate than others. For example, succulents and cacti are relatively easy to propagate from cuttings, while woody plants are more difficult.
- **The time of year:** Some plants are best propagated in the spring or fall, while others can be propagated year-round.
- **The resources available:** Some propagation methods require more resources than others. For example, grafting requires special tools and skills, while seed propagation can be done with very little equipment.

5.2. Preparing propagation material.

Preparing Root Stocks and scions/bud sticks

The budding operation begins when one year old whips of the appropriate rootstock are planted in early spring. Roots should be pruned to 15 to 20cm to facilitate planting. Any side shoots on the lower 10 to 12.5cm of the trunk should be cleanly pruned off. In mid-September, before starting the actual budding operation, check the bark on the stocks to see if it peels easily. (Irrigate if dry; bark will then slip in a few days.) If it does not slip and the cambium layer appears dry, the budding will not be successful. At budding time, remove all side shoots up to 10 to 15 cm above the ground to give a clear trunk area for inserting the bud. Place the bud about 5 to 7.5cm above the ground on the shade side of the stem. If a dwarfing rootstock is being budded, place the bud higher on the stem, usually 10 to 15cm above the ground.

- **Preparing the stock**

- ✓ Seedling rootstocks should be healthy, vigorous, adaptive and resistant to any diseases and pests.
- ✓ Seedling rootstocks should be actively growing.
- ✓ Carefully clip off leaves (leave few at the top for photosynthesis), thorns and side twigs.

- **Bud stick preparation**

- ✓ Bud sticks should be at dormant stage
- ✓ Bud sticks should be collected one/two days before start to budding
- ✓ Clip off /remove the leaves as soon as the bud sticks are cut.
- ✓ Discard the soft tips of the bud sticks
- ✓ Bud stick should be placed in closeable plastic bags and kept cool until use.



Figures 5.1. Show scion stick preparation

Select straight, smooth graft wood from 1-year-old wood 1/4- to 1/2-inch diameter. Cut shoots for grafts into 6-, 12-, or 18-inch lengths to give one, two, or three graft sticks. Each graft stick should contain at least three buds or nodes. Seal the end of the graft sticks with melted wax, grafting paint, or orange shellac. Only 1/4-inch of the end of each stick needs to be treated. When the seal is dry, tie the graft sticks in bundles no more than six each. Label each bundle with permanent ink on a wood or metal write-on label. The variety and year should be recorded on the label. Figure 2 is a graft wood bundle labeled and ready for packing material and storage.



Figure 5.2. Collecting and preparing propagation plant materials



Figure 5.3. Preparing and handling of scion for grafting

5.1.2. Prepare and establish propagation material

Page 115 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

Propagation material:

- ✓ Seedlings
- ✓ Rooted cuttings
- ✓ Unrooted cuttings
- ✓ Divisions

• **Preparation methods:**

- ✓ Trimming of cuttings
- ✓ Trimming of divisions
- ✓ Preparation of stocks
- ✓ Trimming of scions

• **Aftercare:**

- ✓ Provision of water
- ✓ Provision of nutrients
- ✓ Temperature control
- ✓ Humidity control
- ✓ Removal of diseased material
- ✓ Training or trimming to promote appropriate growth formation
- ✓ Sub culturing

5.3. Performing propagation techniques/methods

Sexual propagation involves the union of the pollen (male) with the egg (female) to produce a seed.

Vegetative Propagation: The propagation of plants by the method other than sexual propagation is referred as vegetative or asexual propagation. It involves no change in genetic makeup of the new plant. All the characteristics of the parent plant are reproduced in the daughter plant due to exact duplication of chromosomes during cell division. Thus, the plants are true-to type in growth, ripening, yield and fruit quality. The major methods of asexual propagation are cuttings, layering, division, budding and grafting, sucker, bulb, runner. layering involves rooting a part of the parent and then severing it; and budding and grafting is joining two plant parts from different varieties.

- **Cuttings : involve rooting a severed piece of the parent plant**
 - ✓ Many new plants from few stock plants and in a limited space
 - ✓ Need structure and water
 - ✓ can be simple
 - ✓ some plant material are difficult to root wounding and rooting hormone
- **Types of Stem Cuttings**

The four main types of stem cuttings are herbaceous, softwood, semi-hardwood, and hardwood. These terms reflect the growth stage of the stock plant, which is one of the most important factors influencing whether or not cuttings will root.



Figures 5.4. Show cutting planting material

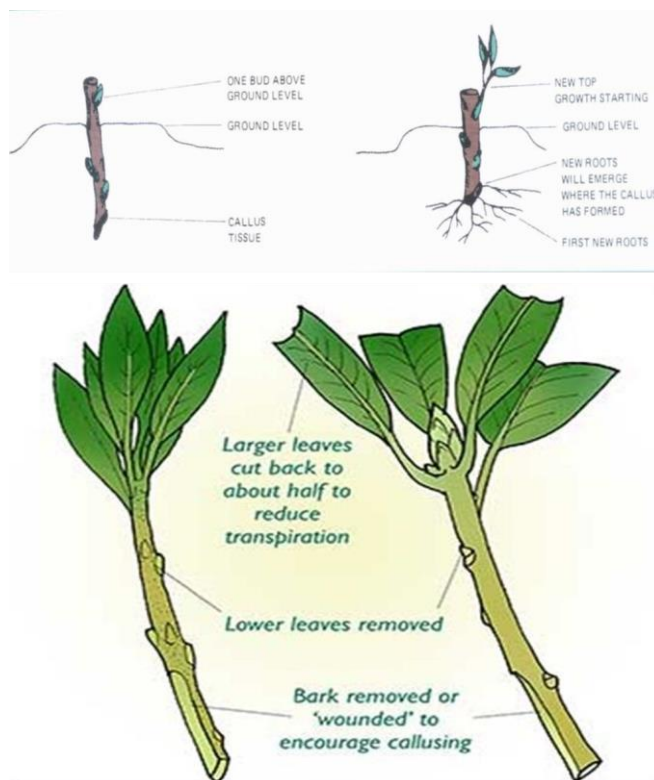


Figure 5.4. Cutting planting material

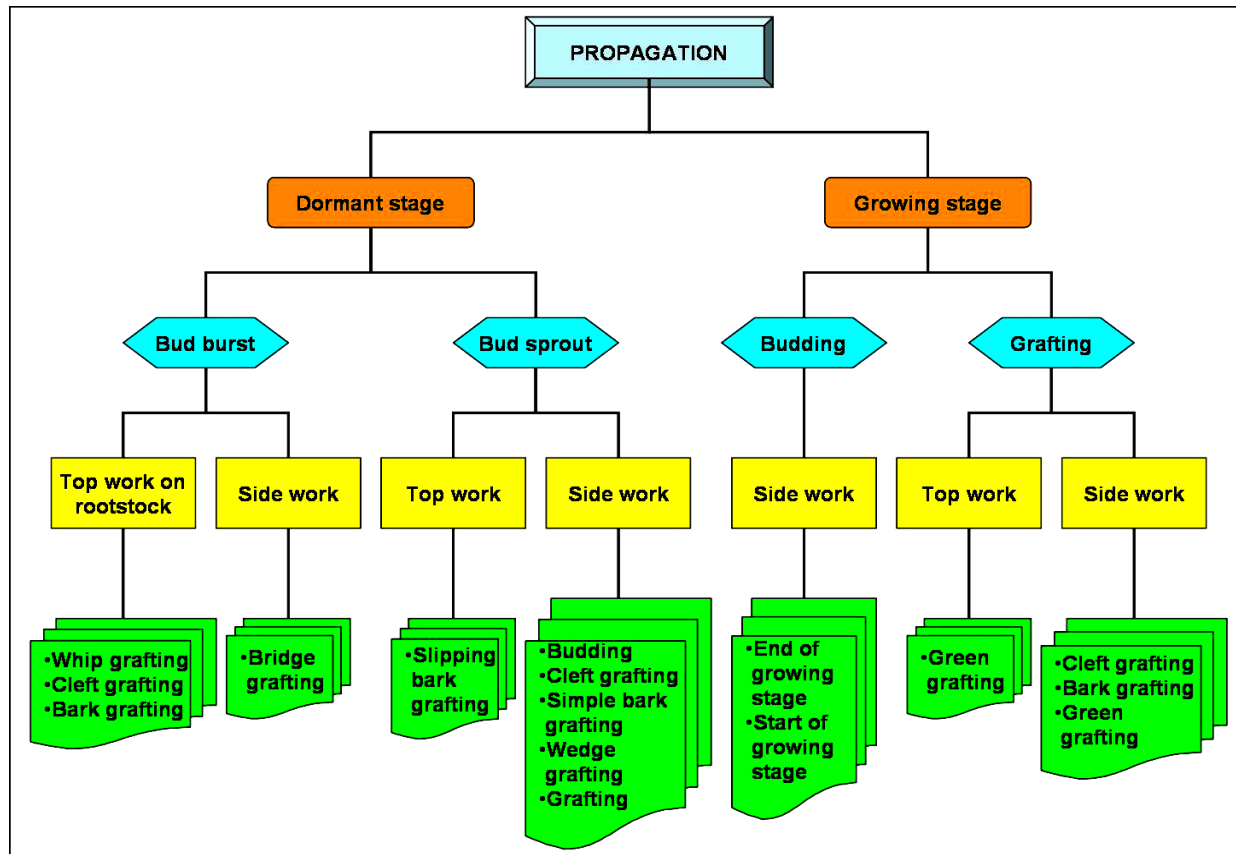


Figure 5.5. Show propagation by budding and grafting

2. Grafting: Grafting is another method of vegetative propagation, where two plant parts are joined together in such a manner that they unite and continue their growth as one plant. In this method, the scion twig has more than two buds on it. grafting is done when the plants are dormant while, in mango it is done when the trees are in active growth. The different methods of grafting are tongue grafting, cleft grafting, approach grafting, side grafting and veneer grafting.

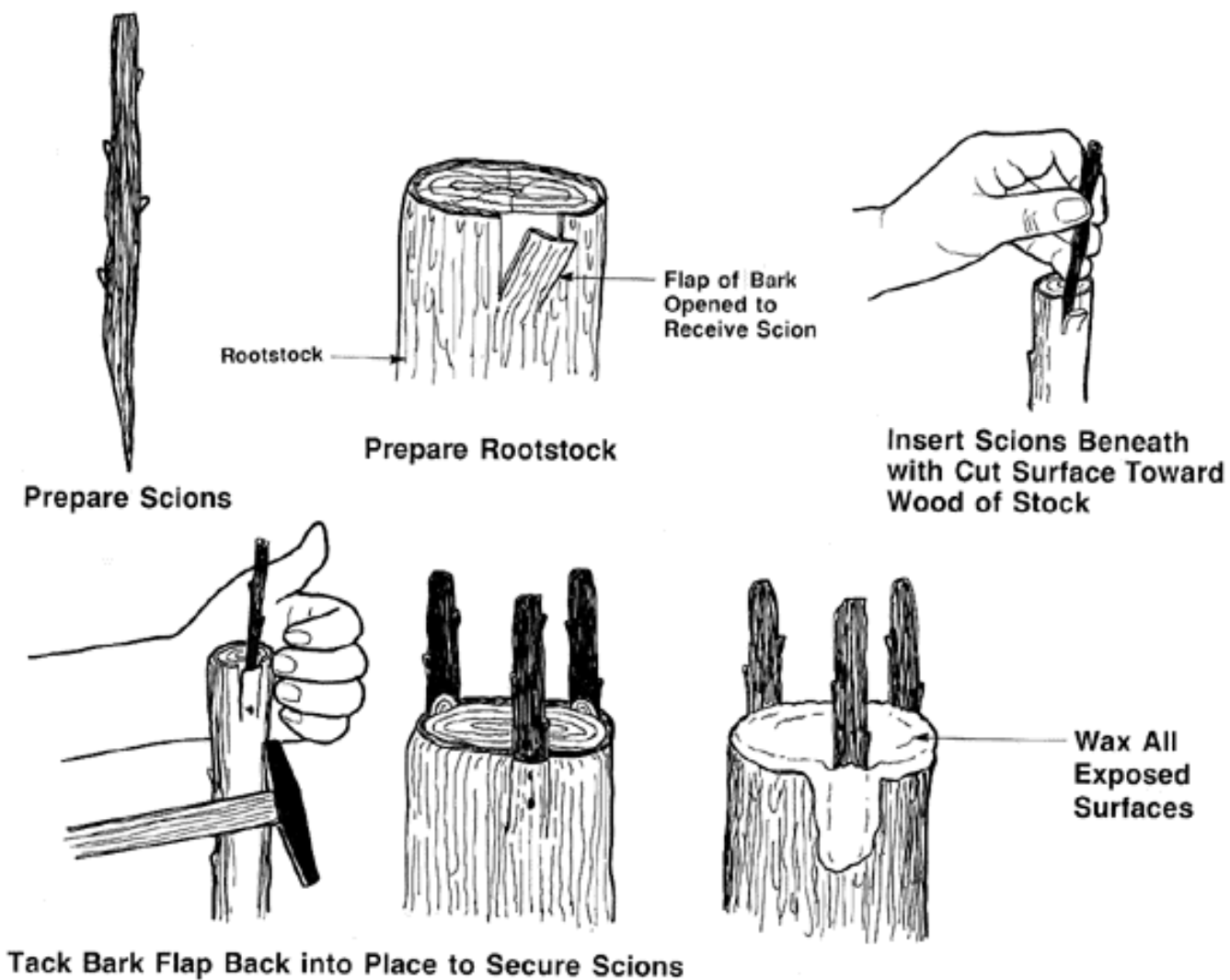


Figure 5.6. Bark graft.

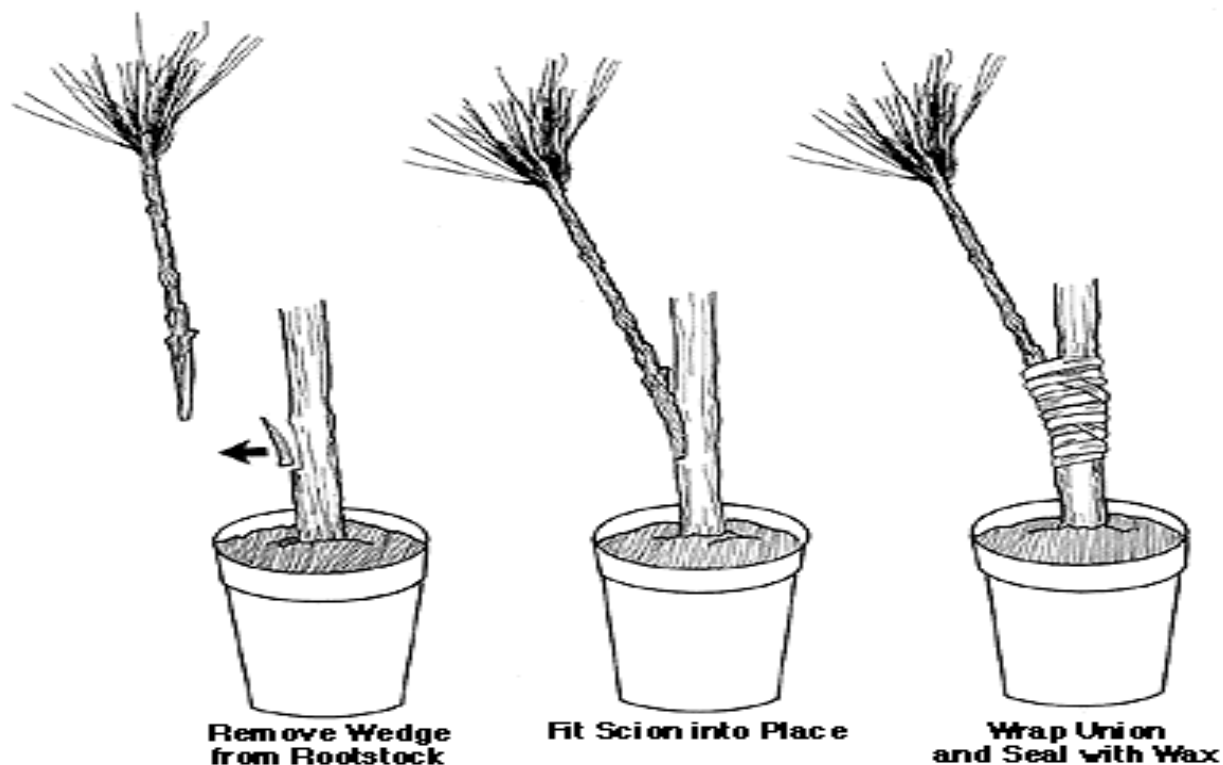


Figure 5.7. Side graft

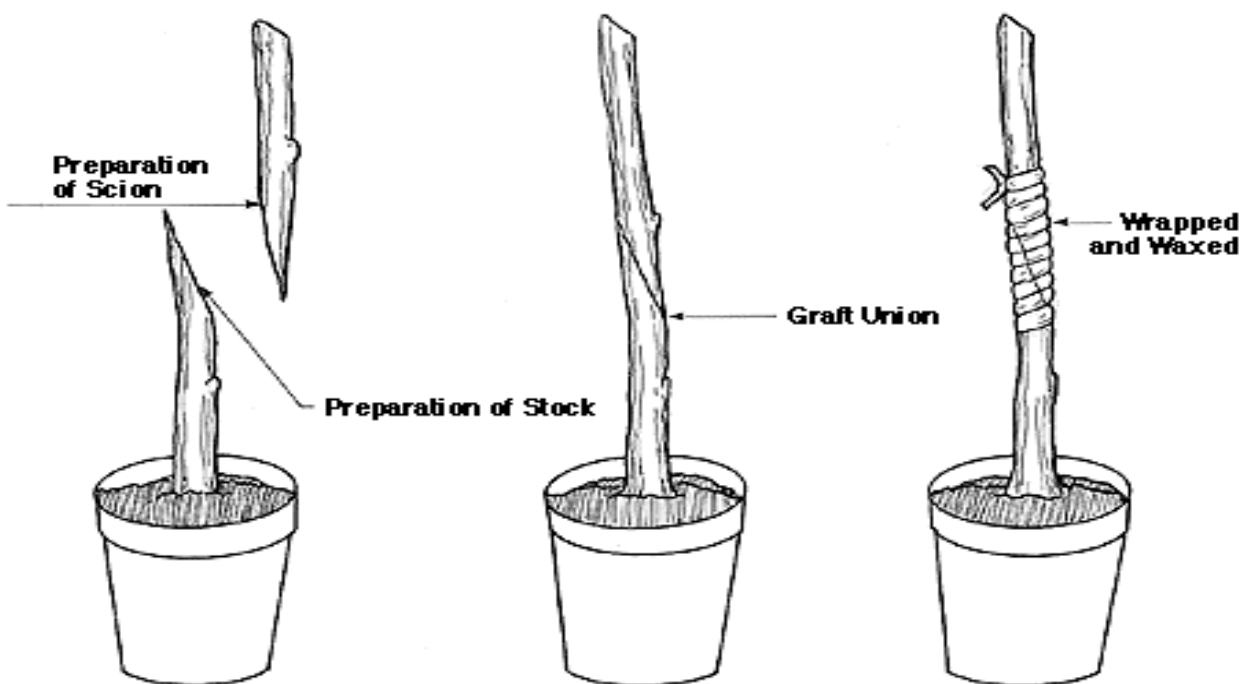


Figure 5.8. Splice graft

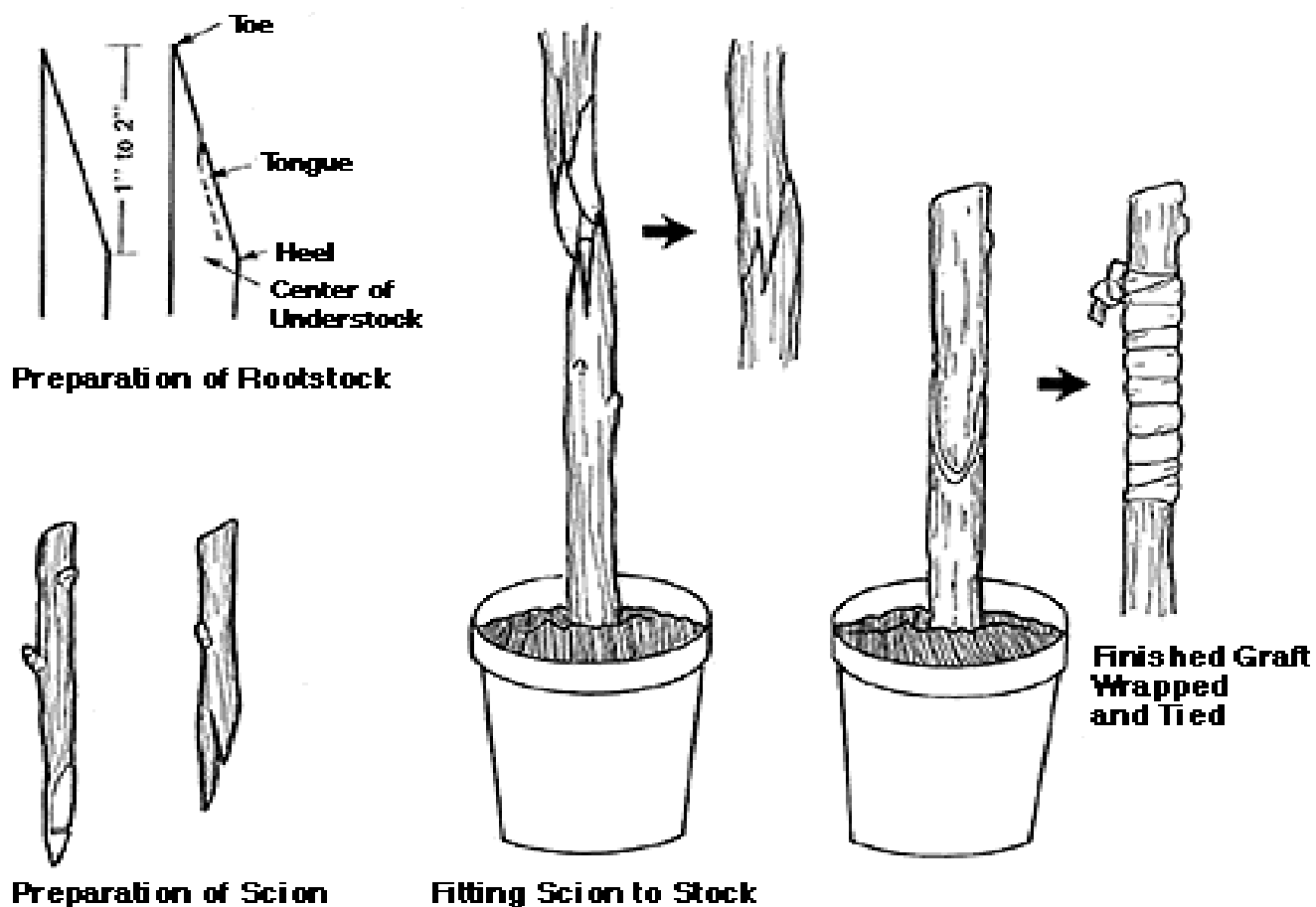


Figure 5.9. Whip and tongue graft

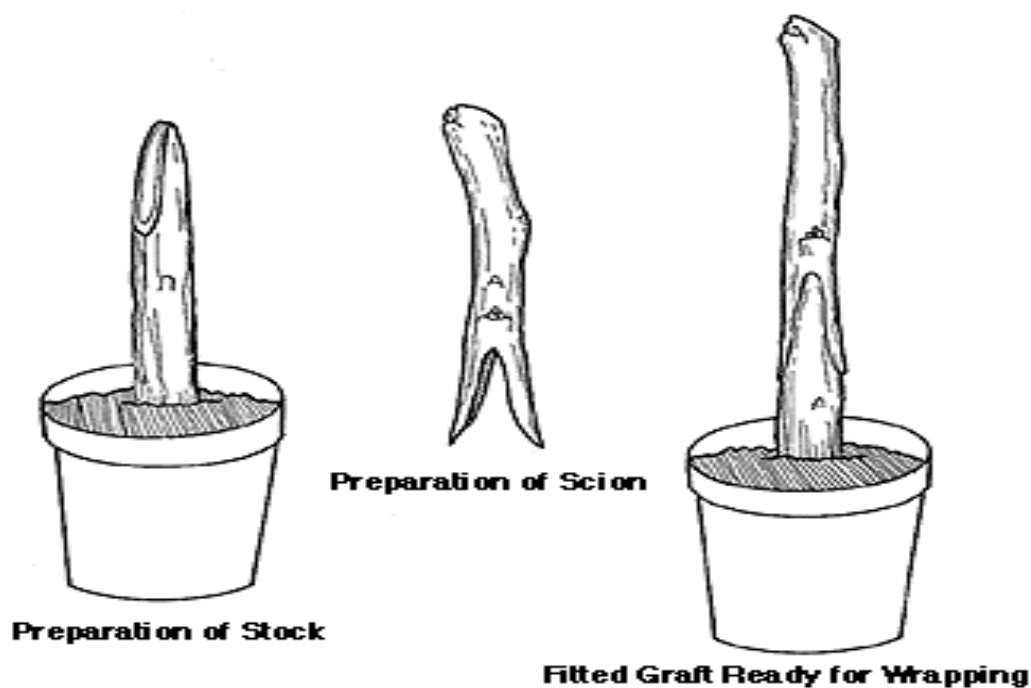


Figure 5.10. Saddle graft

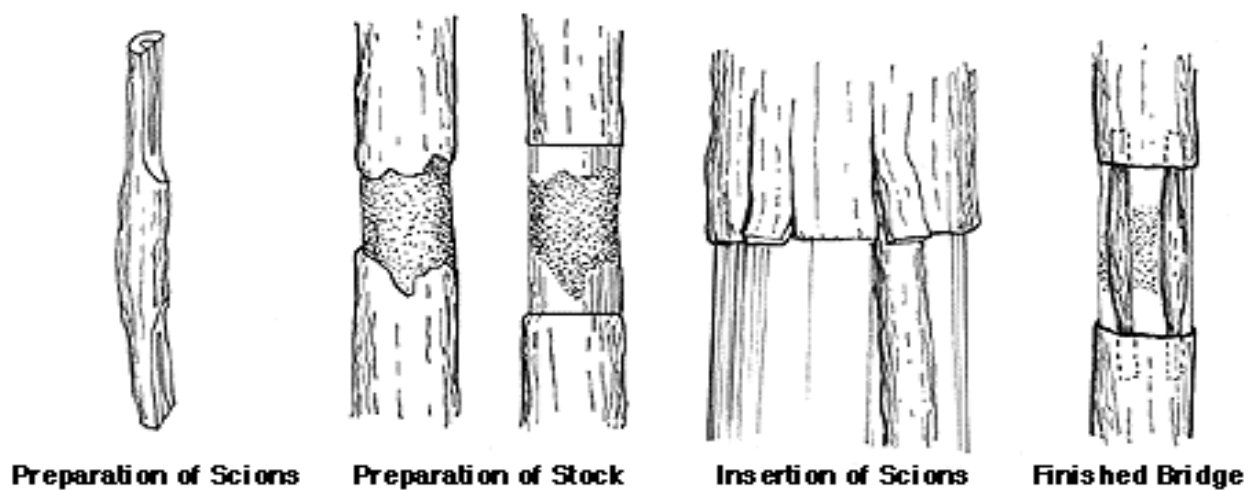


Figure 5.11. Bridge graft

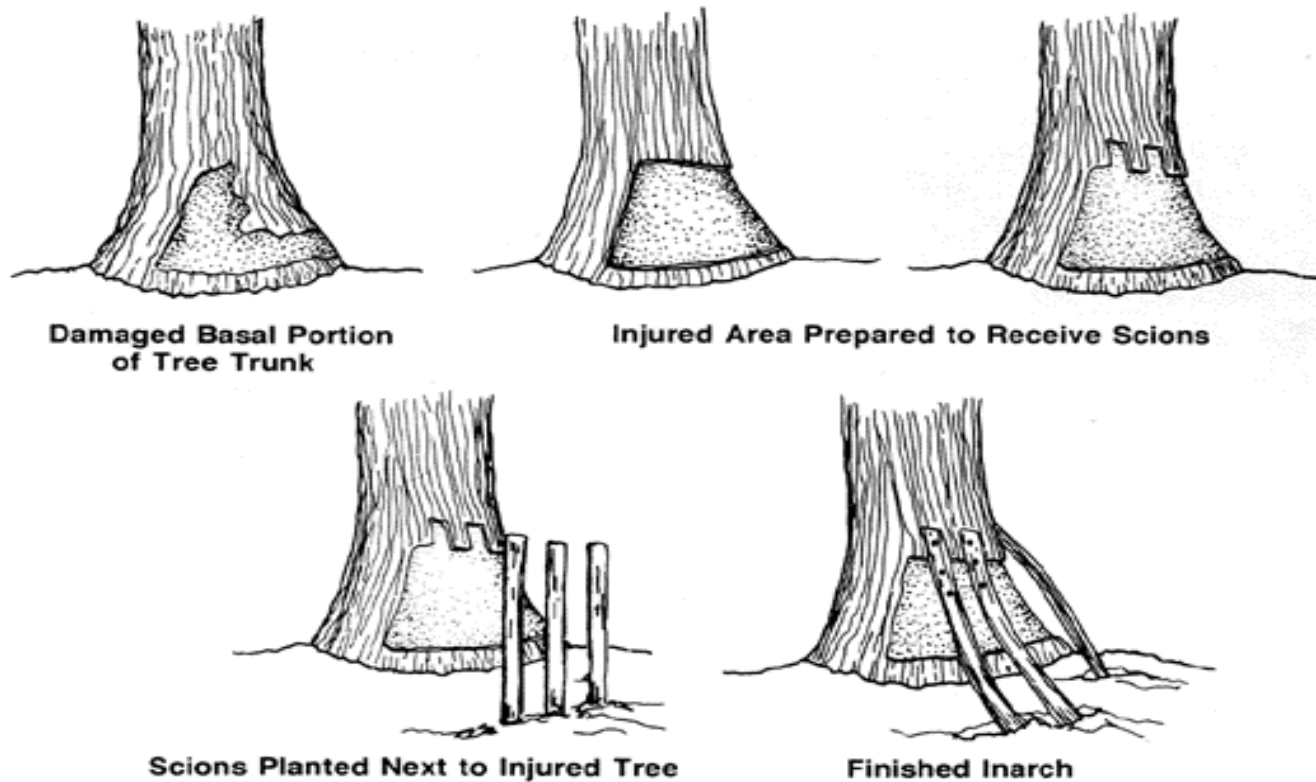


Figure 5.12. Inarch graft.

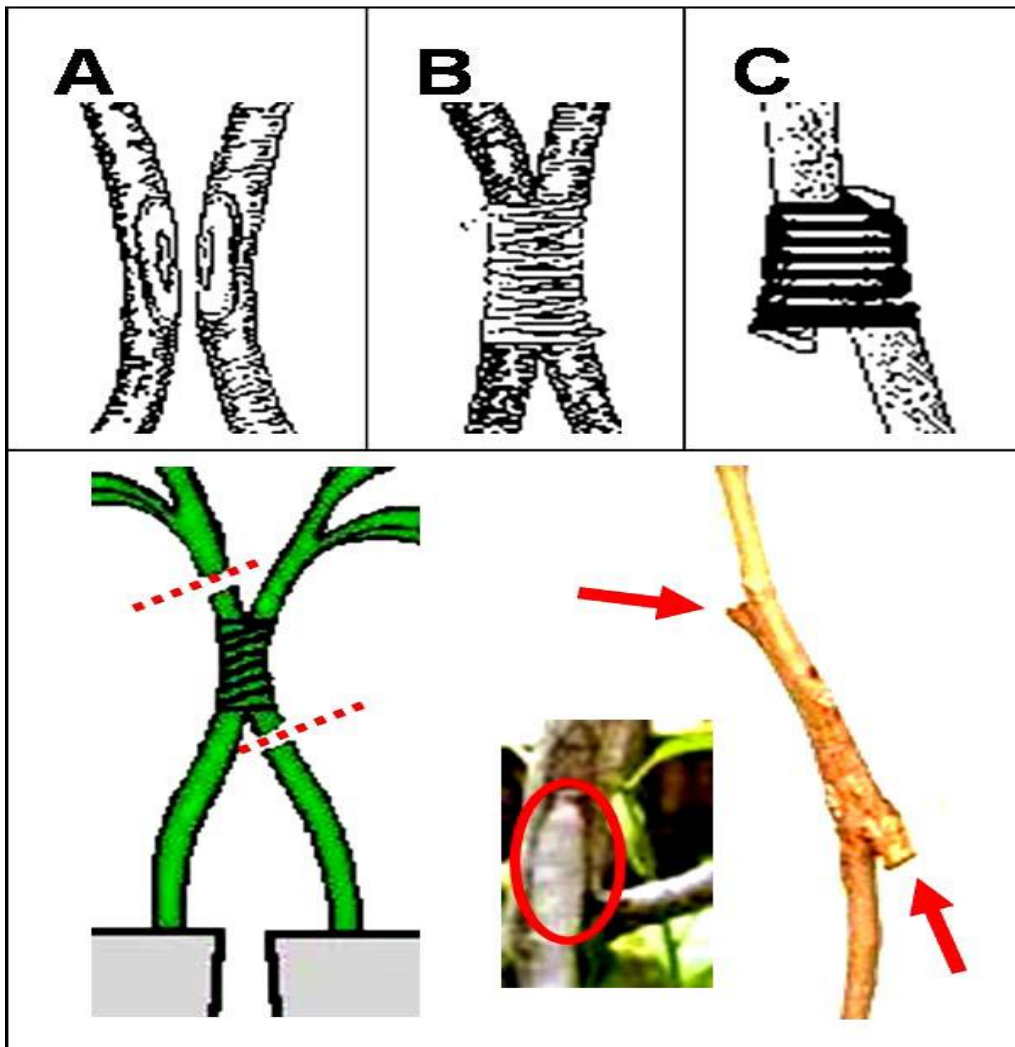


Figure 5.13. Approach grafting

3. Budding is a grafting technique in which a single bud from the desired scion is used rather than an entire scion containing many buds. Most budding is done just before or during the growing season. However some species may be budded during the winter while they are dormant.

Types of budding

1. T-budding involves taking buds from one plant and inserting them under the bark of the rootstock

Preparing the stock

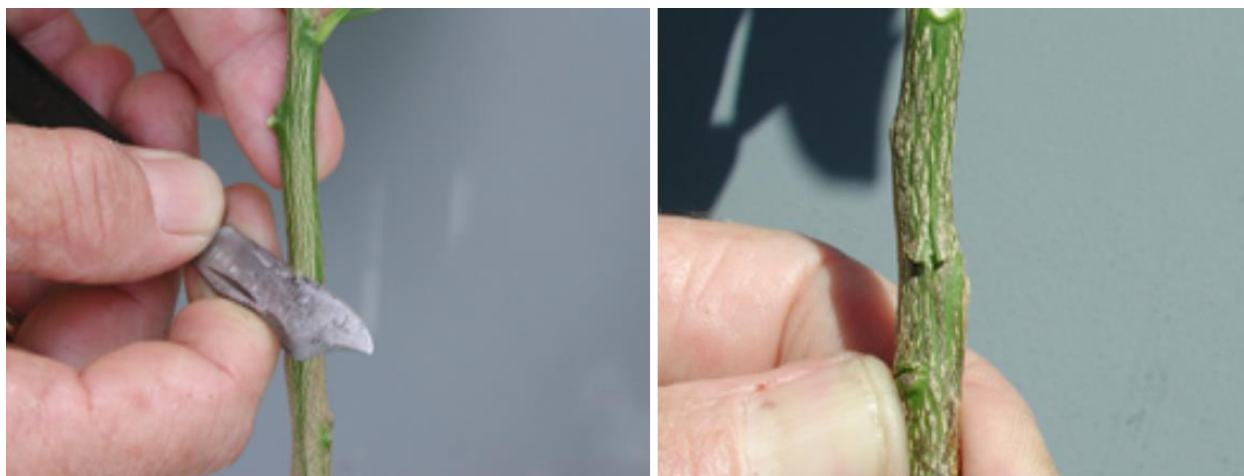


Figure 5.14. Horizontal and middle cut RS with completed Inverted-T incision

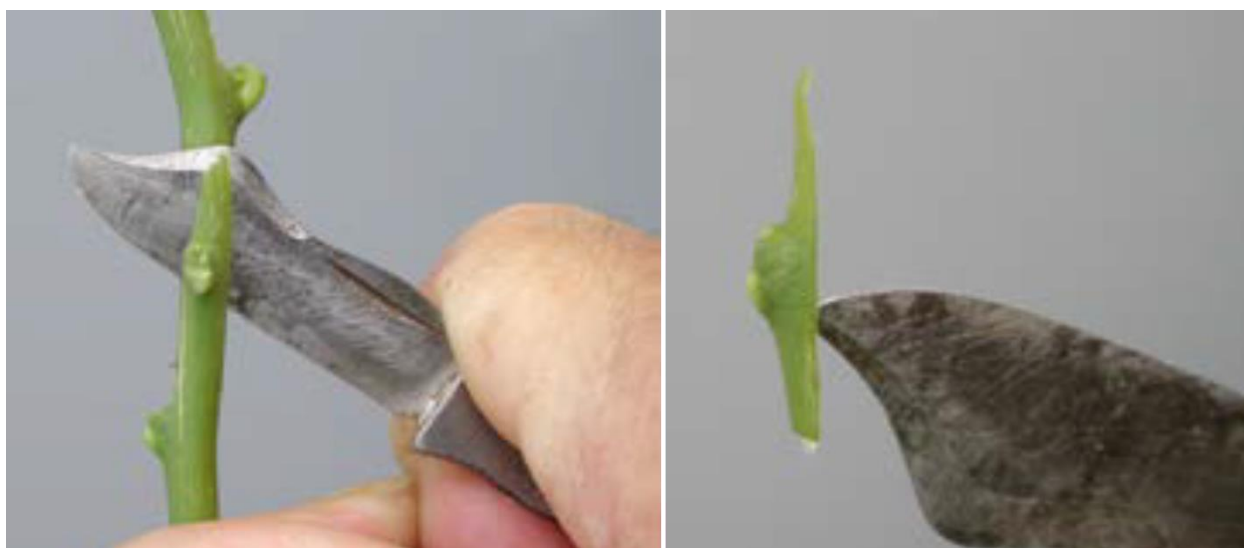


Figure 5.13. Bud preparation for inserting



Figure 5.14 Bud insertion and wrapping with polyethylene tape

2. Patch budding is used when the plant's bark is thick

- It done before growth starts in the spring
- The bud patch must be precisely matched with the patch opening in the bark on the rootstock



Figure 5.15. Healthy seedling ready for budding



Figure 5.16. Preparing rootstock and removing bud patch from scion shoot

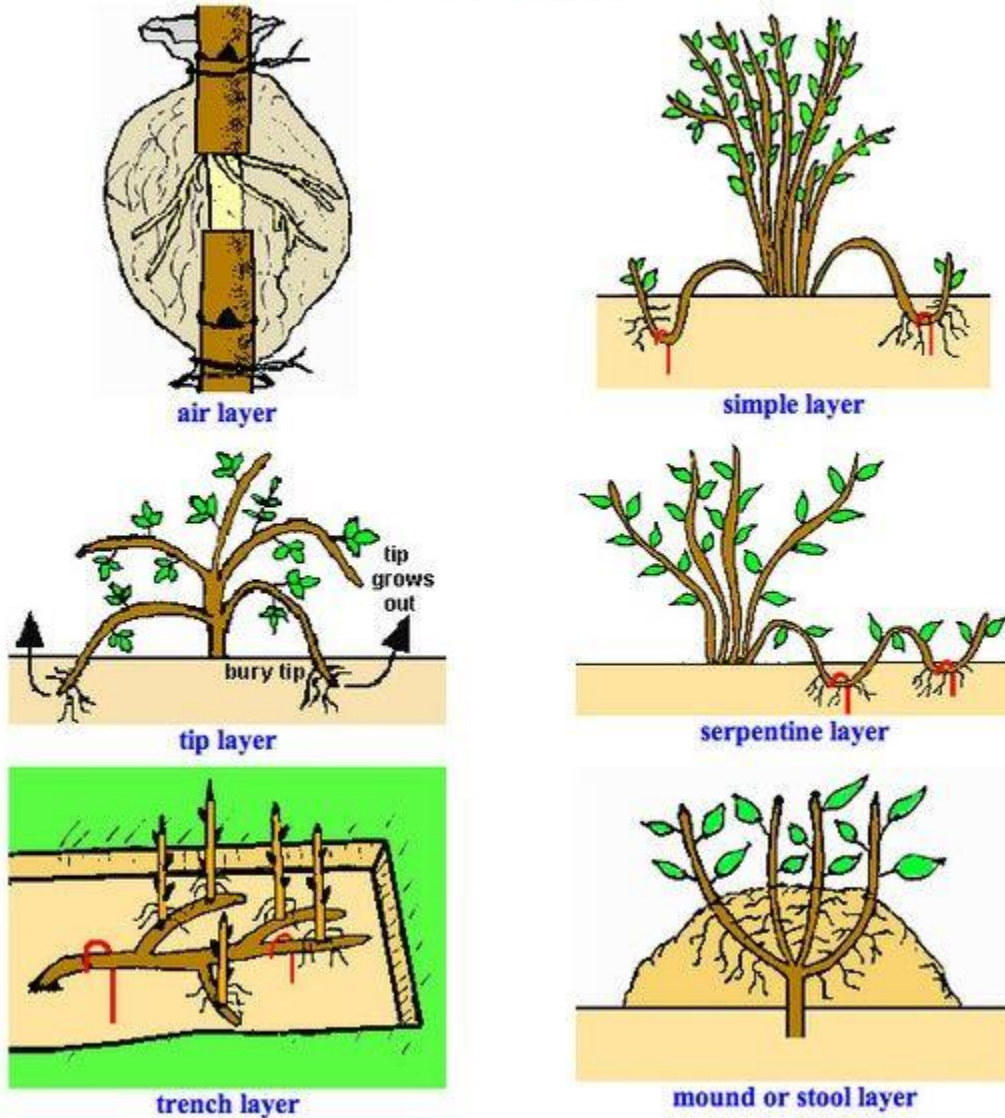


Figure 5.17. Tying budded portion after inserting the patch and Budding tape removed 21 days after budding

4. Layering: stems still attached to their parent plants may form roots where they touch a rooting medium. Severed from the parent plant, the rooted stem becomes a new plant. This method of vegetative propagation, called layering, promotes a high success rate because it prevents the water stress and carbohydrate shortage that plague cuttings. Some plants layer themselves naturally, but sometimes plant propagators assist the process. Layering may be enhanced by wounding one side of the stem or by bending it very sharply. The rooting medium should always provide aeration and a constant supply of moisture. There are six types of layering, Tip, compound, simple, air, mound and trench layering.



Types of Layering



Figures 5.18 shows types of layering and how activities takes place

Other specialized organ vegetative propagation includes:

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

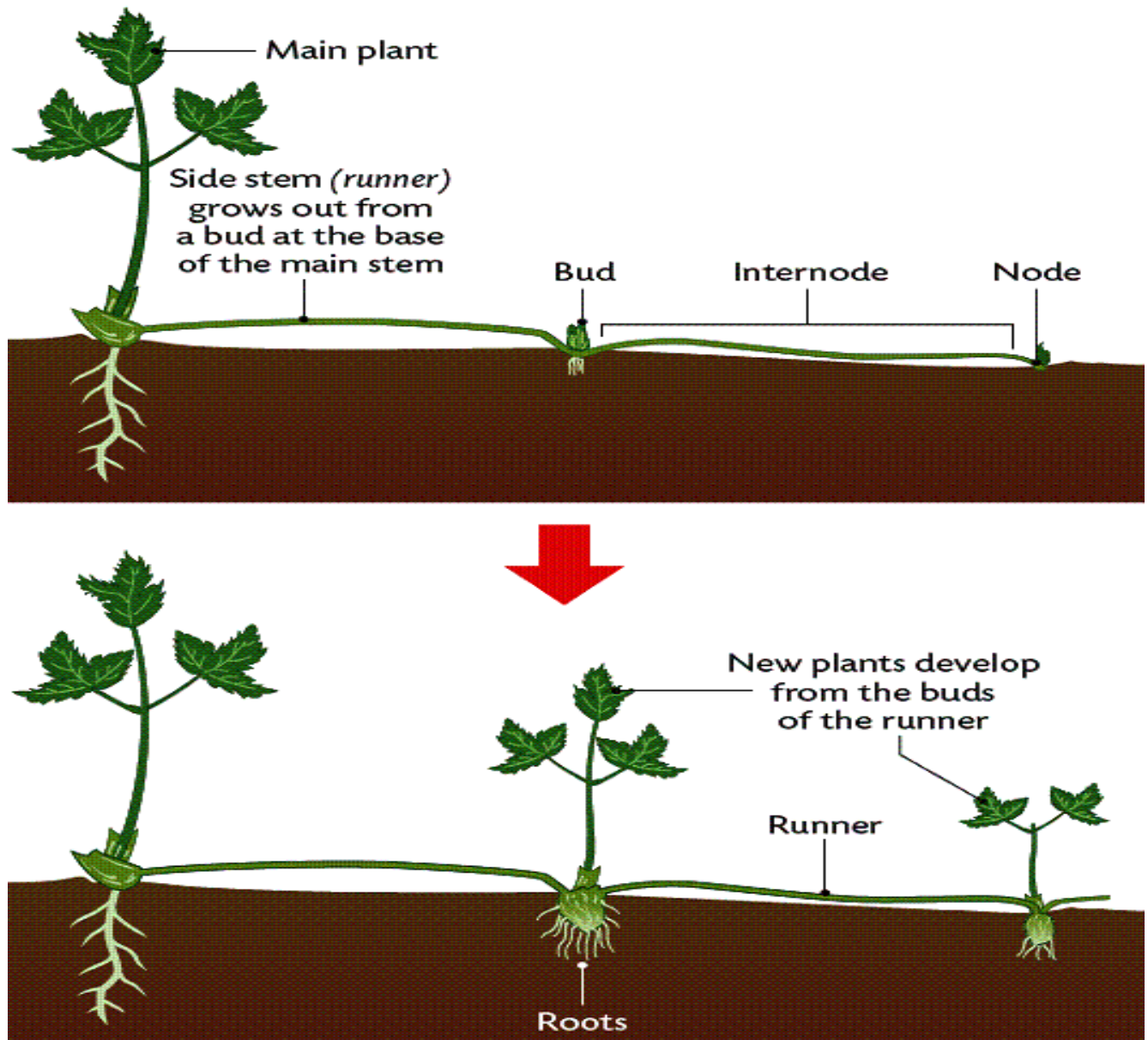


Figure 5.19 shows plant propagate by runners

6. Runners/stolons: Some plants produce long side shoots that develop roots, eventually forming a new plant. Example Strawberry, Spider plant.



7. Rhizomes: these are underground stems that can develop into new plants. They grow sideways in the soil and have a shoot with leaves. Example: Ginger.

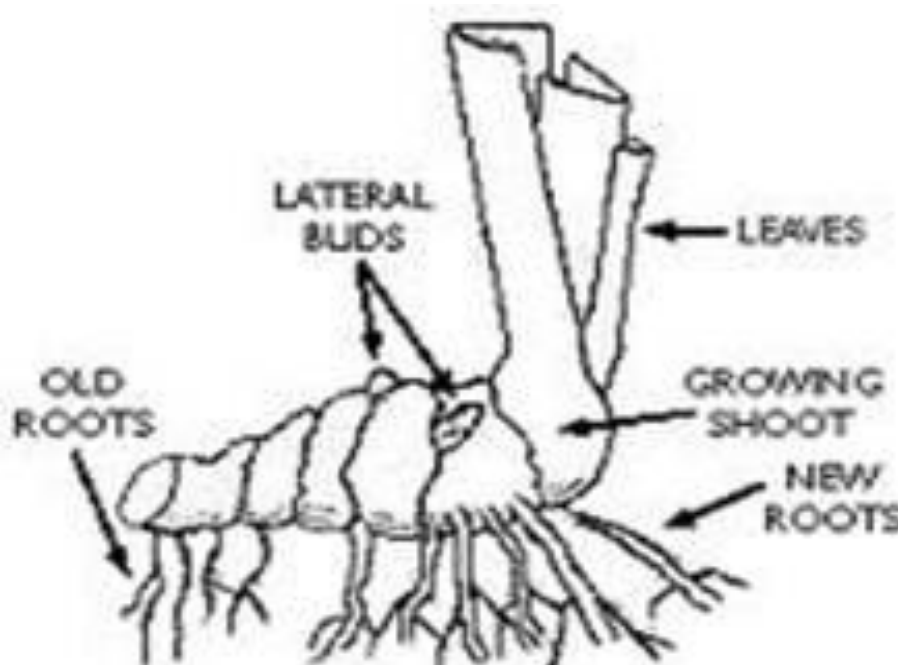


Figure 5.20. Ginger rhizome

A Rhizome is actually a stem of a plant, most commonly growing underground, that produces roots and stem shoots along its length from nodes. They are also known as rootstocks and creeping rootstalks. When cut into pieces, each piece of the Rhizome can potentially grow into a new plant through a process known as vegetative reproduction.

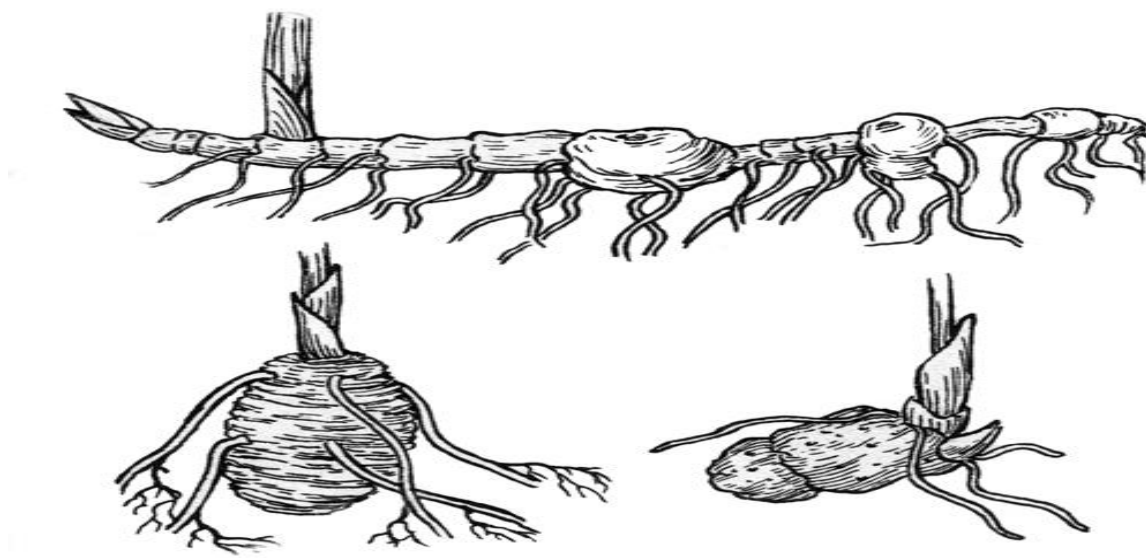


Figure: 2.21. Sample propagated plants by rhizome

7. Suckers: Banana is a good example of a plant that reproduces in this manner- a new stem grows from the base of an old one, forming a new plant.

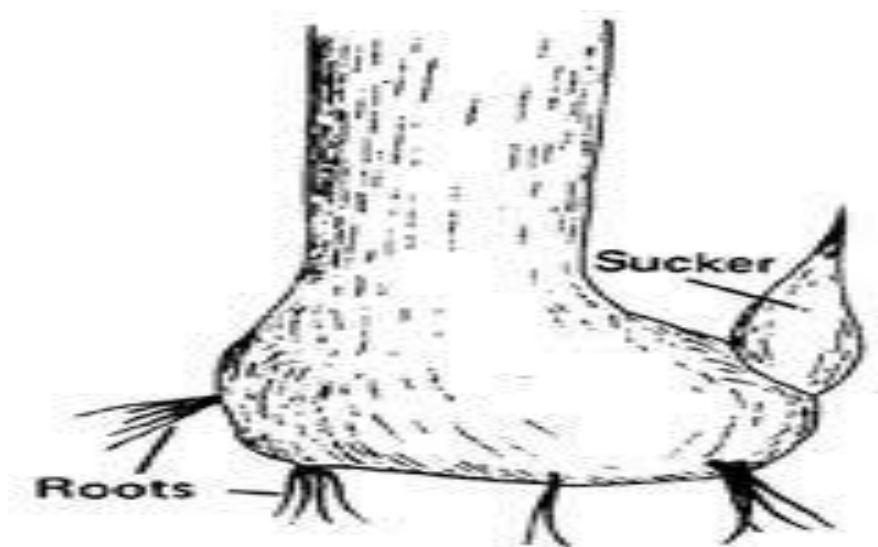


Figure 2.22. Propagation by sucker

9. Bulb: on plants such as the onion, there are lateral (side) buds which may grow to form new plants.

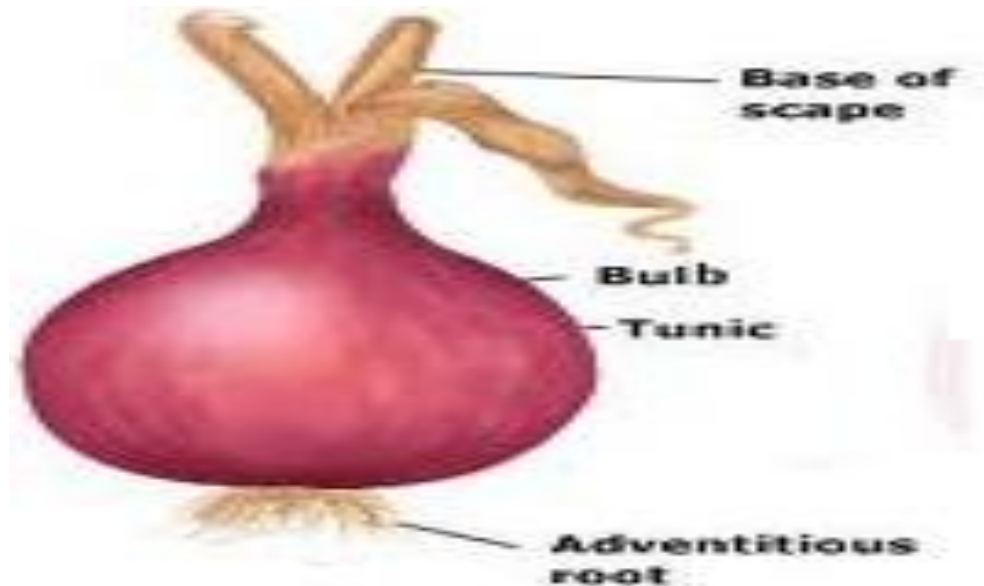


Figure 2.23. Propagation by bulb (Onion)

10. Tuber: swollen underground stems that can develop into new plants. Examples are Irish potato, carrots and turnips. Some tubers have swollen roots which are called **root tubers**. Examples of root tubers are sweet potato, cassava and yam.

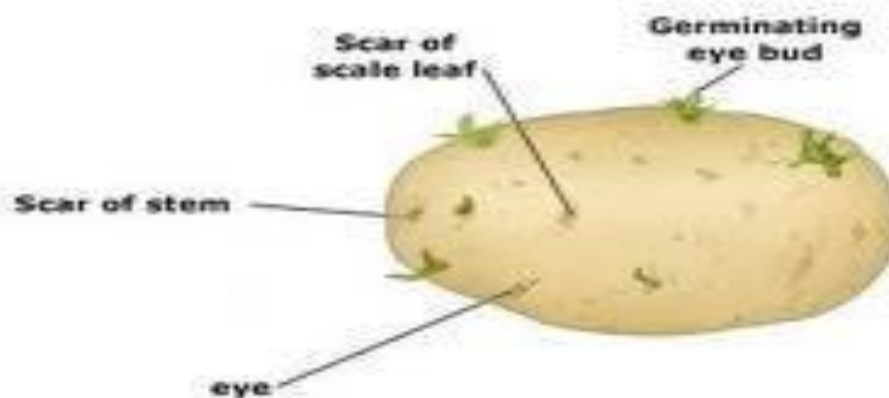


Figure 2.24. Propagation by tuber (Yam and Potato)

11. 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 2.24. Propagation by corm

5.4. Handling propagated plants

i. Collection and handling of scion material

If freezing temperatures are likely to damage plant tissues, collect scion wood for grafting in the fall after normal leaf drop but before severe winter temperatures. Otherwise, wait to collect until late winter. Store the wood in a plastic bag. Enclose a moist cloth, but leave no free water in the bag. Store the wood in a refrigerator between 1.7°C and 4°C. Make sure that fruits or plant materials capable of generating ethylene gas (plant hormone that induces ripening/senescence) are stored in a different cooler than the scions or rootstocks. If refrigeration is unavailable, store the wood outdoors in moist sand in a well-drained, protected location where the soil will not freeze growth with mature, plump buds. Remove the leaves by snipping through the petiole (the stalk of the leaf) and leaving a petiole stub of about 0.25 inch attached to the bud stick (the shoot with scion buds). You can store scion wood (bud sticks) in a refrigerator, but only for a few days. It is best to use the bud sticks immediately after collection. For either budding or grafting, select

only plants of known quality or performance free of insects, disease, and winter damage. For fruit trees, collect wood only from those in production to ensure that the kind and quality of fruit will be what you expect

ii. Applying care (post management)

After care may include application of preventative fungicides, fertilizers, water and nutrients

Hardening-Off

Hardening-off or acclimating rooted propagules, seedlings, and tissue culture plantlets is critical for plant survival and growth. In commercial production, it assures a smooth transition and efficient turnover of plant product from propagation to liner production to finished plants in protected culture (greenhouses, etc.) or containerization and field production. This smooth transition and turnover of plant production units is essential in the marketing, sales, and profitability of plant manufacturing companies. It is important to wean rooted cuttings from the mist system as quickly as possible. Reduction of irrigation and fertility in seedlings and plugs is done several weeks prior to shipping and/or transplanting to harden-off and ensure survival of the crop. Likewise, with acclimation of tissue culture-produced plantlets, light irradiance is increased and relative humidity is gradually reduced to stimulate the plantlet to increase photosynthetic rates and have better stomatal control. All of these ensure plant survival and a speedy transition when the acclimatized plant is shifted up and finished-off as a container or field crop.

Fertilizers

Fertilizers can be applied once the young plants begin to produce new growth. Fertilizer application is to be done very carefully. Vigorous growth of plant is always attractive to the buyer. Heavy manuring is not beneficial for storage of plants. Light manuring, watering is also important. Watering is done according to need of the plant. The nursery should have a water source of its own. Sprinkler system of irrigation is not advisable at the beginning. For sufficient vegetative and reproductive growth of plants, good drainage system must be developed in

between the beds and around the nursery. Adequately gentle slope in the pot bed surface is also desirable. It is extremely important to ensure that water logging does not occur in and around the pots and beds. Keen observation on attack of different pests and diseases is required. If the mother plants are infected, the propagated plants will also be infected therefore, necessary control measures in mother plants as well as in nursery plants should be taken immediately on observation.

5.5. Completing records accurately and at the required time

Completing records accurately and at the required time for propagation of plants is important for a number of reasons. First, it helps to ensure that the propagation process is successful. By keeping track of the details of each propagation attempt, growers can identify what is working and what is not, and make adjustments as needed. Second, accurate records can help growers to identify problems early on, before they have a chance to cause major damage. For example, if a grower notices that a particular type of cutting is not rooting well, they can take steps to improve the conditions or choose a different propagation method. Third, accurate records can help growers to track the progress of their propagation efforts over time. This information can be used to make decisions about future propagation projects, such as what plants to propagate, when to propagate them, and how to improve the success rate.

There are a number of different ways to keep track of propagation records. Some growers use simple spreadsheets, while others use more sophisticated software programs. The best way to choose a record-keeping system is to consider the specific needs of the grower and the type of plants they are propagating.

The following are some of the most important information to record when propagating plants:

- The date of propagation
- The type of plant
- The method of propagation
- The source of the plant material
- The conditions under which the plant was propagated

- The results of the propagation attempt

It is important to keep records as soon as possible after each propagation attempt. This will help to ensure that the information is accurate and complete. Records should be stored in a safe place where they can be easily accessed.

By following these simple steps, growers can ensure that they are completing records accurately and at the required time for propagation of plants. This will help to improve the success rate of their propagation efforts and make the process more efficient.

Here are some additional tips for keeping accurate propagation records:

- Use a consistent format for your records. This will make it easier to find the information you need when you need it.
- Use clear and concise language. Avoid jargon and technical terms that may not be understood by everyone who needs to access the records.
- Be as detailed as possible. The more information you record, the better equipped you will be to troubleshoot problems and make improvements.
- Review your records regularly. This will help you to identify trends and patterns that may not be immediately obvious.
- Keep your records up to date. As you propagate new plants and make changes to your propagation methods, be sure to update your records accordingly.

5.6. Identifying and reporting out-of-specification process and equipment performance.

Identifying and reporting out-of-specification process and equipment performance when propagating plants is important for a number of reasons. First, it can help to prevent problems from occurring in the first place. By identifying potential problems early on, growers can take steps to correct them before they cause damage. Second, reporting out-of-specification performance can help growers to improve their propagation methods. By understanding what is causing problems, growers can make changes to their procedures to improve the success rate of their propagation efforts. Third, reporting out-of-specification performance can help to protect

growers from liability. If a problem does occur, growers can show that they took steps to identify and correct it, which can help to reduce their legal liability.

There are a number of different ways to identify out-of-specification process and equipment performance when propagating plants. Some common methods include:

- **Monitoring the environment:** Growers should monitor the environment in which they are propagating plants. This includes factors such as temperature, humidity, and light levels. By monitoring the environment, growers can identify changes that may be causing problems.
- **Inspecting the plants:** Growers should inspect the plants regularly for signs of problems. This includes looking for signs of disease, pests, or damage. By inspecting the plants, growers can identify problems early on and take steps to correct them.
- **Testing the plants:** Growers may also need to test the plants to identify problems. This may involve testing the plants for nutrients, water content, or other factors. By testing the plants, growers can get a more accurate assessment of the problem and take steps to correct it.
- Once a problem has been identified, it is important to report it to the appropriate person or department. This may be the grower's supervisor, a quality control manager, or another employee. By reporting the problem, growers can help to ensure that it is addressed and that other plants are not affected.

Here are some additional tips for identifying and reporting out-of-specification process and equipment performance when propagating plants:

- **Be proactive:** Don't wait for problems to occur before taking action. By monitoring the environment and inspecting the plants regularly, growers can identify potential problems early on and take steps to correct them.
- **Be specific:** When reporting a problem, be as specific as possible. This will help the person or department that is receiving the report to understand the problem and take appropriate action.

- Be persistent: If a problem is not addressed promptly, follow up with the person or department that received the report. By being persistent, growers can help to ensure that problems are resolved quickly and effectively.

Self-Check 5	Written Test
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Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Test I: Short Answer Questions

1. How to preparing the stock?
2. How to preparing the scion?
3. List asexual propagation techniques and discuss each?
4. What is the difference between grafting and budding?
5. How to collect and handle the stock plant?
6. How to collect the scion?
7. How to applying care for propagated plant?
8. Describe care required for post planted?
9. What is the importance of hardening-off?

Operation Sheet 3

3.1. Techniques of performing propagation

Objective: To know how to apply different techniques of propagation

Materials required:

- Plastic containers and trays, scalpel,
- Autoclave and alcohol,
- Wheelbarrow, Shovel, water spray 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

i. Procedure cutting

1. Select suitable PPE and wear
2. To take your cuttings, select healthy and vigours growth that's 7.5 to 15cm long
3. Then, cut off a section of stem
4. Remove the lower leaves
5. Clip off the leaves on the lower half of the shoot so you have a bare stem to insert into your potting mix.
6. Pot up your cutting

ii. Procedure cleft Graft

1. Select suitable PPE and wear
2. Then, take scion from mother plant selected
3. Slice scion in both side by sharp knives
4. After that the root stock is cut off squarely and
5. Split vertically with a knife to a depth of about 5 to 7.5cm
6. Keep the knife in position or insert a chisel to keep the split open and insert the scions
7. Wax, Wrap and secure wound part or joining point

iii. Procedure inarch Grafts

1. Select suitable PPE and wear
2. Then, take scion from mother plant selected
3. Slice scion in side by sharp knives
4. Prepare rootstock by trimming the edges of the girdled section back to sound bark
5. Place the scion along the trunk so that the beveled edges rest on sound bark
6. Mark and remove the bark rectangles.
7. The stem piece to be inserted should be slightly longer than needed to ensure a homely fit.
8. Insert the scion and then secure with two number 16 or 18 wire nails at each end

Page 143 of 157	Ministry of Labor and Skills Author/Copyright	Crop Production Level -III	Version 1
			May 2023

iv. Procedure T-budding

1. Select suitable PPE and wear
2. Cut a T shape through the bark of the rootstock tree that selected
3. Open the flaps of the side of the T
4. 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
5. Make a horizontal cut just above the bud to sever it and the sliver of wood from the bud wood stick
6. Insert the bud, right side up, into the opening of the T cut
7. Slide it tightly into the cut and secure it with a rubber banding strip
8. Wrap the banding strip above and below the bud, stretching the banding strip to make a tight wrap that will prevent moisture loss

v. Procedure Tip layering

1. Select suitable PPE and wear
2. Dig a hole 7.5 to 10 cm deep
3. Insert the shoot tip and cover it with soil
4. Then, the tip grows downward first
5. Then bends sharply and grows upward
6. Roots form at the bend, and the recurved tip becomes a new plant.
7. Remove the tip layer and plant it in the early spring or late fall.

vi. Procedure air layering

1. Select suitable PPE and wear
2. Select stems of pencil size diameter or larger are best
3. 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.
4. The cut is held open with a toothpick or wooden match stick.
5. Surround the wound with moist, unmilled sphagnum moss (about a handful) that has been soaked in water and squeezed to remove excess moisture.
6. Wrap and cover with plastic and hold in place with twist ties or electrician's tape.
7. Fasten each end of the plastic securely, to retain moisture and to prevent water from entering

8. 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 5

Name.....ID.....Date.....

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following task within **60** minutes. The project is expected from each student or in a group to do it.

Task 1. Perform Cutting activities

Task 2. Perform Cleft grafting activities

Task 3. Perform Inarch grafting activities

Task 4. Perform T-budding activities

Task 5. Perform Tip layering activities

Task 6. Perform Air layering activities



LG #6

LO #6 Complete Propagation Activities

Instruction Sheet

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

- Cleaning equipment
- Disposing off/storing unused propagation materials
- Collecting, treating, disposing off or recycling waste
- Recording workplace information, the appropriate format

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:

- Clean equipment
- Dispose off/store unused propagation materials
- Collect, treat, dispose off or recycle waste
- Record workplace information, the appropriate format

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 6

6.1. Cleaning equipment

Cleaning work site

Having accomplished your task or propagation operation, every material, tool, equipment and machinery as well as work site should be inspected. The inspection can show us the broken, harmed and the healthy tools, equipments and machineries. Over take cleaning and maintenance operation so that the equipments/machineries which can be maintained should be stored with the healthy ones; and those which cannot be maintained should be avoided.

All equipment, tools and plant shall be maintained in a safe and useable condition, in particular, but not exclusively, all grafting and budding knives, pruning shears/scissors, hammers, hand saws, secateurs etc be regularly checked, and the checks recorded, replaced as necessary to ensure constant safety and effectiveness. Proper storage is also essential. Refrigerate the bags of graft stick bundles at a temperature of 30 to 45 °F. Do not allow graft wood to dry out during storage. Take the desired wood out of refrigeration only as needed. Wood should not be heated and re cooled during the grafting season.

After completion crop propagation, tools, equipments and machinery have to be:-

- Cleaned
- Maintained and
- Stored

Note: Disabling unused tools, equipment and machinery are stored neatly out of the way of crop propagation activities.

6.2. Disposing off/storing unused propagation materials

Currently there are several options for recycling some of the waste materials described above. Leaf and other vegetative debris can be made into compost for use at propagation site.

Disposing of waste materials

Page 148 of 157	Ministry of Labor and Skills Author/Copyright	Crops Production Level -III	Version 1
			May 2023

Waste materials are of different unwanted materials as a result of the grafting operation. These can be discarded planting materials (scions sticks, bud sticks and root stocks), pruned plant branches (small or large), broken equipments and used plastic materials. These all needed to be managed and disposed in an appropriate site and method. Some of the methods of disposing wastes are composting, re-using, recycling and incineration the waste materials from the grafting operation.

- Waste material generated during crop propagation may include:- Small to medium branches, foliage, leaves, sticks, buds, flowers, fruit, bark, plant debris and chipped material
Discard or compost pruned out shoots and branches.
- These plant parts will serve as dwelling sites for insects and diseases and should be removed from the area to reduce pest populations
- Unproductive, dead and broken branches, and those damaged by diseases and insects should be disposed. Otherwise, these might serve as source of pest and disease infection.
- Enhances a clean and safe work area

6.3. Collecting, treating, disposing off or recycling waste

Collecting, treating, disposing off or recycling wastes after propagating plants is important for a number of reasons. First, it helps to protect the environment. By properly disposing of waste, growers can help to prevent pollution and contamination. Second, it helps to protect public health. By properly disposing of waste, growers can help to prevent the spread of disease. Third, it helps to save money. By recycling waste, growers can reduce the amount of waste they send to landfills, which can save them money on disposal fees.

There are a number of different ways to collect, treat, dispose of or recycle wastes after propagating plants. Some common methods include:

- Composting: Composting is a great way to recycle plant waste. Compost can be used to improve soil quality and reduce the need for fertilizer.

- **Recycling:** Some plant waste, such as cardboard and plastic, can be recycled. Recycling helps to reduce the amount of waste sent to landfills and conserves resources.
- **Landfilling:** Landfilling is the most common method of disposing of plant waste. However, it is important to properly dispose of waste in landfills to prevent pollution and contamination.
- **Incineration:** Incineration is a method of disposing of waste by burning it. Incineration can be used to reduce the volume of waste and destroy hazardous materials.

The best way to collect, treat, dispose of or recycle wastes after propagating plants will depend on the specific type of waste and the local regulations. It is important to consult with a local waste management company to determine the best option for your situation.

Here are some additional tips for collecting, treating, disposing of or recycling wastes after propagating plants:

- **Reduce waste:** The best way to reduce waste is to avoid creating it in the first place. Growers can reduce waste by using sustainable practices, such as composting and recycling.
- **Minimize waste:** When waste is created, it is important to minimize it as much as possible. This can be done by using materials that can be reused or recycled.
- **Dispose of waste properly:** It is important to dispose of waste properly to protect the environment and public health. Growers should consult with a local waste management company to determine the best way to dispose of waste in their area.

6.4. Recording workplace information, the appropriate format

If you intend producing planting material in your nursery whether small or large for a number of years, you should consider keeping records. You may not like the idea. You may prefer handling the hoe to handling a pen, but as the years go by you will rely more and more on what you wrote down and wish you had recorded more rather than less.

Records are a powerful tool to make nursery work more rewarding. One forgets a lot within a year and as the years go by it becomes very difficult to remember what happened when and why. Even for a nursery of a single species. E.g. to raise planting material for improved fallows. Records do help. Moreover, for a single species you do not have to write down a lot. Other Information that should be recorded in the work place is like standard operating procedures (SOPs), specifications, production schedules /instructions, routine maintenance schedules, work notes, Material Safety Data Sheets (MSDS), manufacturer's instructions or verbal direction from the manager, supervisor or senior operator.

- Evaluating and reporting of evaluation results to concerned bodies is done at the work completion
- Report is an official document comprising of :-
 - ✓ Activities undertaken
 - ✓ Work progress/status and achievements of objectives and goals
 - ✓ Resource utilization
 - ✓ Risks and problems and corrective measures taken
 - ✓ Strengths and weakness
 - ✓ Summary and recommendations



Self-Check 6	Written Test
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Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Test I: Short Answer Questions

1. Define term cleaning
2. Why you clean worksite after propagation activities complete?
3. Mention waste material generated during crop propagation
4. How to recycle waste materials?
5. Mention information that should be recorded in the work place
6. What is the purpose of record workplace information?

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ACKNOWLEDGEMENT

Ministry of Labor and Skills 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).

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