Learner Guide
Primary Agriculture

Explain the propagation of plants

My name: ..............................................
Company: ...........................................
Commodity: ....................... Date: ............

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Dear Learner - This Learner Guide contains all the information to acquire all the knowledge and skills leading to the unit standard:

<table>
<thead>
<tr>
<th>Title</th>
<th>US No</th>
<th>NQF Level</th>
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<td>Explain the Propagation of Plants</td>
<td>116220</td>
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The full unit standard will be handed to you by your facilitator. Please read the unit standard at your own time. Whilst reading the unit standard, make a note of your questions and aspects that you do not understand, and discuss it with your facilitator.

This unit standard is one of the building blocks in the qualifications listed below. Please mark the qualification you are currently doing:

<table>
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<th>Title</th>
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<tr>
<td>National Certificate in Animal Production</td>
<td>49048</td>
<td>3</td>
<td>120</td>
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<tr>
<td>National Certificate in Plant Production</td>
<td>49052</td>
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<td>120</td>
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Please mark the learning program you are enrolled in:

- **Learnership?**
- **Skills Program?**
- **Short Course?**

Your facilitator should explain the above concepts to you.

This Learner Guide contains all the information, and more, as well as the activities that you will be expected to do during the course of your study. Please keep the activities that you have completed and include it in your **Portfolio of Evidence**. Your PoE will be required during your final assessment.

**What is assessment all about?**

You will be assessed during the course of your study. This is called *formative assessment*. You will also be assessed on completion of this unit standard. This is called *summative assessment*. Before your assessment, your assessor will discuss the unit standard with you.

Assessment takes place at different intervals of the learning process and includes various activities. Some activities will be done before the commencement of the program whilst others will be done during programme delivery and other after completion of the program.

The assessment experience should be user friendly, transparent and fair. Should you feel that you have been treated unfairly, you have the right to appeal. Please ask your facilitator about the appeals process and make your own notes.
Your activities must be handed in from time to time on request of the facilitator for the following purposes:

- The activities that follow are designed to help you gain the skills, knowledge and attitudes that you need in order to become competent in this learning module.

- It is important that you complete all the activities, as directed in the learner guide and at the time indicated by the facilitator.

- It is important that you ask questions and participate as much as possible in order to play an active role in reaching competence.

- When you have completed all the activities hand this in to the assessor who will mark it and guide you in areas where additional learning might be required.

- You should not move on to the next step in the assessment process until this step is completed, marked and you have received feedback from the assessor.

- Sources of information to complete these activities should be identified by your facilitator.

- Please note that all completed activities, tasks and other items on which you were assessed must be kept in good order as it becomes part of your Portfolio of Evidence for final assessment.

Enjoy this learning experience!
How to use this guide …

Throughout this guide, you will come across certain re-occurring “boxes”. These boxes each represent a certain aspect of the learning process, containing information, which would help you with the identification and understanding of these aspects. The following is a list of these boxes and what they represent:

**What does it mean?** Each learning field is characterized by unique terms and definitions – it is important to know and use these terms and definitions correctly. These terms and definitions are highlighted throughout the guide in this manner.

You will be requested to complete activities, which could be group activities, or individual activities. Please remember to complete the activities, as the facilitator will assess it and these will become part of your portfolio of evidence. Activities, whether group or individual activities, will be described in this box.

Examples of certain concepts or principles to help you contextualise them easier, will be shown in this box.

The following box indicates a summary of concepts that we have covered, and offers you an opportunity to ask questions to your facilitator if you are still feeling unsure of the concepts listed.

**My Notes …**

You can use this box to jot down questions you might have, words that you do not understand, instructions given by the facilitator or explanations given by the facilitator or any other remarks that will help you to understand the work better.

.................................................................................................................................................................................................................................................................................................................................................................................................................
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SAQA Unit Standard
What will I be able to do?

When you have achieved this unit standard, you will be able to:

- Propagate plants.
- Gain specific knowledge and skills in plant propagation.
- Operate in a plant production environment implementing sustainable and economically viable production principles.

Learning Outcomes

At the end of this learning module, you must is able to demonstrate a basic knowledge and understanding of:

- Basic safety requirements related to the propagation environment, tools and procedures.
- Basic hygiene requirements for the propagation environments.
- Growing media - wet and dry.
- Weeds, pest and diseases.
- The safe handling of hormone and Chemicals preparations (rooting powders and plant protection substances).

What do I need to know?

It is assumed that the learner has successfully completed the unit standards listed below:

- *NQF Level 2; Literacy and Numeracy.*
- *NQF Level 2; 116119; Demonstrate an understanding of plant propagation.*
- *NQF Level 2; 116077; Monitor water quality.*
- *NQF Level 3; 116272; Demonstrate a basic understanding of the physiological functioning of the anatomical structures of the plant.*
Glossary of concepts and terms

**Environmental Requirements for successful plant propagation**

- **Propagation** means the multiplication of plants of a specific type.
- **Environmental conditions** that must be controlled during plant propagation include humidity, aeration, light quality and quantity, temperature and moisture.
- **Humidity** is important for a plant to carry on metabolic processes at desired rates.
- Plants require an environment with sufficient **oxygen and carbon dioxide** for respiration and photosynthesis to take place. Tunnels in which plants are propagated are ventilated.
- All green plants require **light** for photosynthesis. Red light is used to stimulate seed germination of some species.
- The temperature during germination must be maintained at the temperature suitable to the specific crop species to optimise growth and prevent heat or cold injury.
- A uniform and constant supply of good quality water is required for the propagation of healthy plants. Over-irrigating seedlings is as dangerous as under-irrigating.

**Propagation Methods and Tools**

- Plants can propagate through sexual (seeds) and asexual (vegetative using plant parts) means.
- Planting the seeds directly into the crop field or by making seedlings first and then transplanting these to the crop field. [Most vegetable crops.]
- Seedlings are produced by sowing the seeds into seedling beds or seedling trays, where the seeds and seedlings are then pampered by giving the right amount of water and nutrients at the right temperature.
- Before planting seedlings into the field, they have to be **hardened off** first. Hardening off is done by gradually reducing the application of water and nutrients.
- **Vegetative propagation**
  - Vegetative propagation material includes the use of tubers (potatoes), shoots (sugar cane) and bulbs (onions). Only disease free material should be used.
  - Budding is a form of grafting, which is a form of vegetative propagation.
  - Budding is done when the bark of the rootstock seedling is slipping by making an inverted T-cut on the stem of the tree seedling. After about 2 weeks the wrapping is removed, and if the union is successful, growth energy is directed to the bud by lopping or topping the rootstock seedling. Plants are staked for support and directed growth.
  - Propagating plants through cuttings involves planting a cutting (stem, leaf or root) treated with growth hormones in a growth medium and allowing it to form roots and/or buds.
  - Tissue culture propagation involves growing plants from small plant parts in vitro in a laboratory under very strictly sterile conditions.
- **Propagation tools commonly used** include budding knives, budding tape, pruning shears, a sharpening stone and sterilisation liquid. In tissue culture
special equipment like laminar flow cabinet, autoclave and sterilised containers are used
♦ Propagation tools must be sterilised to prevent the development and distribution of pathogens.

**Successful and Unsuccessful Propagation**

♦ Indicators of successful propagation are strong rooted plants, trueness-to-type and lack of pathogens.
♦ Indicators of unsuccessful propagation are deviations from type, diseased plants, mixed cultivars and inferior plant quality.
♦ Environmental conditions must be maintained to ensure successful propagation.

| **Propagative** | Propagation refers to the multiplication of plant material that is of a specific cultivar and variety, and that possesses desirable characteristics, such as grain quality (wheat and maize), fibre quality (cotton), fruit shape and colour and internal quality (fruit crops). |
| **Dormancy** | Dormancy refers to the ability of certain plant-parts, such as seeds, to suspend metabolic processes until ideal environmental conditions occur or seed with mechanical or physiological barriers that need to be removed before the seed can germinate. |
| **Metabolic Processes** | Metabolic processes refer to organic chemical processes inside a cell that enable life. |
| **Humidity** | Humidity, also referred to as relative humidity, is the amount of water vapour in the air at a given temperature, and is expressed as a percentage. This means that at 20% relative humidity, 20% of any given volume of air will consist of suspended water molecules. |
| **Respiration** | Respiration refers to the process during which the plant takes up oxygen (O₂) for the “burning” of carbohydrates to release energy, water and carbon dioxide (CO₂). |
| **Photosynthesis** | Photosynthesis refers to the chemical reaction that takes place when the plant takes up CO₂, and uses the sunlight energy trapped by the chlorophyll to combine it with water molecules in the plant to produce carbohydrates, which is food. O₂ is released during this process. |
| **Rootstock** | Rootstock means the root-bearing part of a stem used for grafting or budding in plant propagation. |
| **Grafting** | Grafting refers to any process of inserting a part of one plant into or onto another plant in such a way that they will unite and grow as a single unit. |
| **Apical Dominance** | It is the phenomenon whereby the main central growing point or apical bud of a shoot suppresses the lateral buds by producing hormones (axons’) that move down the stem. |
Session 1

Influences of environmental conditions on plant propagation

After completing this session, you should be able to:
SO 1: Demonstrate an understanding of the function of environmental requirements for propagation within a specific agricultural production context.

In this session we explore the following concepts:
- Metabolic plant processes.
- Environmental factors for propagation.
- The roles of environmental factors.
- Problem solving within the propagation environment.

1.1 Introduction

It is beneficial to the successful propagation of certain crop plants to manage their environmental conditions to imitate natural conditions. Plant propagation aims to emulate natural process and enhancing these. In order to achieve this it is important to understand the natural environment in which a specific crop plant develops.

1.2 Metabolic Plant Processes

Plant growth is a result of a series of biochemical reactions that take place in the plant. It is essential to understand the principles of the processes, photosynthesis, transpiration and respiration, to better understand the influence of environmental conditions on propagation.

- Photosynthesis

Photosynthesis takes place in the green parts of plants. The green pigment (chlorophyll) in the chloroplast absorbs the energy from the red and blue spectrum of sunlight and converts it to chemical energy that is used to drive the process of photosynthesis. The end product is the energy-containing carbohydrates (sugar), water and oxygen. The latter two exit the leaf through the stomata, while the carbohydrates are 'loaded' into the phloem and transported to other parts of the plant where it is either used as energy source, converted into more complicated substances or stored for later use.
Explain the Propagation of Plants

Primary Agriculture
NQF Level 3
Unit Standard No: 116220

The formula below summarises the process of photosynthesis:

\[
6\text{CO}_2 + 12\text{H}_2\text{O} \xrightarrow{\text{Light Energy}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}
\]

- **Respiration and Transpiration**

The opposite process to photosynthesis is respiration. During respiration \(\text{O}_2\) from the air is used and carbohydrates in the plant are metabolised forming energy, water and \(\text{CO}_2\), which is released in the air. The evaporation of water molecules (water vapour) from the leaf surface is the core process that drives transpiration.

Transpiration is driven by temperature, light intensity, water vapour in the air, and the moisture level in the growth medium or soil. In the plant, transpiration is expressed through turgid cells, opened stomata, which are small openings on the surface of the leaf. The rate of transpiration is closely related to the amount of water vapour in the surrounding air.

When the moisture in the surrounding air increases, plant transpiration decreases. On the other hand, when the moisture in the surrounding air decreases, the transpiration rate increases. This increase can lead to irreversible damage to the plant as plant roots cannot take up water fast enough. An excessive water loss will lead to irreversible damage to the plant. Stomatal pores will close preventing damage to the plant. When the stomata are closed, \(\text{CO}_2\) cannot enter the plant for photosynthesis to occur.

Thus when the air becomes too dry, photosynthetic rates are low or photosynthesis ceases, which could result in yield and crop quality losses.

The quantity of moisture in the surrounding air is influenced by the ambient air temperature.

Light intensity influences transpiration by affecting the leaf surface temperature. Higher leaf surface temperatures result in an increased transpiration rate. At temperatures above 30°C however, stomata close and the photosynthesis rate decreases.

The water available to the roots of the plant also influences the rate of transpiration. Low soil water results in stunted growth with short internodes and small leaves, i.e. a reduced surface area for photosynthesis and transpiration. As the rate of water absorption decreases, the plant struggles to find the necessary moisture to support metabolic processes. Transpiration then uses available water, which could result in the wilting. At the extreme wilting point, no food is manufactured as there is virtually no photosynthesis taking place, and the plant is forced to use its reserves to survive.

At the other extreme, excess water results in increased cell-size and a normal transpiration rate initially. However under anaerobic conditions (low or no oxygen), where the roots are water drenched, roots starve as a result of lack of oxygen. Such
conditions are conducive to the development and spread of pathogens like \textit{Rhizotocnia} (dumping off) and \textit{Phytophthora} (root rot).

1.3 Environmental Factors for Propagation

The environmental conditions that require management in order to ensure plant growth are: \textbf{Atmospheric and climatic requirements}, including light, water, and humidity, temperature, and gas exchange

\begin{itemize}
    \item \textbf{Biotic requirements}, including rhizosphere, bacteria, fungi, insects and pests, and weeds
    \item \textbf{Edaphic requirements}, including physical soil properties (texture, porosity, temperature) and chemical soil properties (pH, mineral nutrients, gas exchange), and container properties
\end{itemize}

Crop plants respond to the environmental conditions through growth rate. Where these factors are well managed, better growth is achieved, while retarded growth and even loss of plants may result from an environment that is not well managed.

1.4 The Roles of Environmental Factors

Every environmental factor plays a specific role, both on its own as well as in interaction with other factors. In this section, each factor is discussed with the assumption that all other factors are favourable.

\textbf{Atmospheric and climatic Requirements}

Each crop has its own set of climatic conditions at which it will produce optimally. It is therefore important to know these requirements and to ensure your environment is suited to the proposed crop. If one does not adhere to the climatic requirements of the crop, it can increase the input costs and often lead to establishment failure.

\begin{itemize}
    \item \textbf{Light}
        Light manipulation is an important factor in propagation. Some seeds like those of most field crops germinate better if not exposed to light. Others seeds like those from grasses and some lettuce cultivars will not germinate in the absence of light.

        Some cuttings root better after being kept in the dark (etiolating), while green leaves on cuttings produce hormones that stimulate rooting. The bud-take rate after budding is influenced by the sap flow, and rates of transpiration and photosynthesis in the plant, which is influenced by light intensity.

        There are two sources of light solar radiation (the sun) and artificial lighting. Understanding solar radiation is important before planning any propagation. Light intensity refers to the strength of the light leaving a light source. The
strength of light falling on a plant is referred to as light irradiance or light flux rate. However this should be considered in conjunction with the quality of the light.

The three important aspects of light to be considered for plant growth are the amount of light per unit of time and per unit area (irradiation), light quality (colour or wavelength composition) and the duration (time) of exposure.

In energy terms, the sun radiates up to 1.36 kJ.m\(^{-2}\).sec\(^{-1}\) on a clear, sunny day but only 50% of the energy can be utilised by plants. And which can be reduced to more than half on an overcast day. A fluorescent light discharges 1,400 lux. In nature, light irradiance intensity decreases with the presence of clouds or dust in the atmosphere. Propagation structures that draw light primarily from the sun experience large fluctuations in irradiance intensity daily.

Most plant species can only synthesize chlorophyll if they receive light. Although normal sunlight will be saturating for the photosynthesis of single leaves, full sunlight is not sufficient to satisfy the photosynthetic capacity of whole [intact] plants under ideal conditions. Fluctuations in light intensity trigger different plant responses in terms of growth rate. High light intensity causes more chlorophyll to be synthesised and a greater gross rate of photosynthesis.

Photosynthesis is most effective under blue light conditions (wavelengths 430 to 500nm) and red light region (wavelengths from 620-690nm), although other wavelengths of visible light can also be utilized to some extent. Ultraviolet light (<280 nm wavelength) has high energy and is detrimental to plants. Far-red light (710-780 nm wavelength regions) is especially important in determining the photomorphogenic growth of plants like phototropism. Light quality refers to wavelength, measured in nanometres (nm), and is associated with the colour of the light as perceived by the human eye. Light is classified in eight bands, ranging from ultraviolet (<280 nanometres) to near infrared (>1,000 nanometres) and includes the visible range, i.e. violet, blue, green, yellow, orange, and red light.

Light from Fluorescent tubes lacks the longer wavelengths (650-780nm) but is rich in light of shorter (blue) wavelengths. Plants grown under Fluorescent Cool White (FCW) light grow slowly and branch easily. Fluorescent Grow-lux (FGL) tubes are often employed in growth chambers. If plants are to be grown under artificial lighting, it is best to combine fluorescent tubes with incandescent light bulbs which produce light rich in longer wave lengths although poor in the shorter wavelengths. The ratio of red/far-red light has considerable importance for the germination of light sensitive seeds and the normal growth of plants. Fluorescent plant lights used in germination rooms are rich in red light (610-700 nanometres) but lack in the far red (700-730 nm).
The loss of water from plants (transpiration) depends on the capacity of air to absorb water as well as the water potential of the plant.

Factors such as high soil water content, high rates of water uptake, low solute concentration, absorption of radiant sun energy increase the plant’s water potential. Increased plant water potential in turn will enhance water loss from plants. Factors such as low humidity and high temperature will lead to an increase in the capacity of the air to absorb moisture and in turn increase the plant transpiration rate.

An additional factor is the plant’s capacity to retain moisture by closing of stomata (stomatal resistance). Although stomatal closure will retard water loss, photosynthesis will then not take place because the entry of carbon dioxide is prevented. The accumulation of starch in the leaf cells which absorbs less water than sugar, results in stomata closing and a reduced transpiration and photosynthesis rates.

Lower light absorption rates adversely influences the transpiration rate. In this case, sugars are not transformed to starch, but maintain turgid leaves for a longer time leading to a reduced starch level in the plant. With starch being the form of carbohydrate that is used in respiration, this results in a reduced photosynthesis rate.

**Humidity**

Relative humidity is a measure of the percentage saturation of water vapour in ambient air. The relative humidity regulates the transpiration rate of plants. Relative humidity (RH) is generally below 80% in the sub-tropics. For the propagation of plants in general, a high RH, between 80% and 95%, occasionally reaching 100% is ideal.

In an environment where the humidity is high, it takes longer for the water molecules inside the leaf to escape through the stomata, and so the water vapour factor is lower. Where relative humidity is low, the transpiration rate increases.

These fundamentals are important for the manipulation of RH in a propagation environment. Seed germination requires a high humidity around the seed allowing the seed to absorb more water molecules during respiration. Respiration will in turn hydrolyse insoluble stored food stuffs to soluble forms. As respiration increases the radicle emerges and elongates. If the respiration rate decreases the storage life of a seed is longer. If hydrolysis of stored foods does not take place at all no germination will occur and the seed storage can be prolonged.

Seedling growth and development depends on the transpiration rate as this directly relates to photosynthesis. Plants require an environment where the processes of transpiration, respiration and photosynthesis can take place at normal rates. In such an environment, CO₂ is rapidly diffused into leaves and transformed to carbohydrates that are used for growth.
In the case of cuttings, high humidity ensures that leaves do not lose turgidity, and that they continue with photosynthesis and respire while roots are developing.

The figure below shows the variations in humidity relative to the time of day and temperature for Letsitele during the week of 28/11/2004 (Courtesy of QMS)

**Temperature**

Temperature has a major effect on seed germination, root development in cuttings as well as bud union in grafting. Germination of summer crops and tropical crops requires relatively high temperatures ranging between 20°C and 30°C (average of 25°C). Most summer field and vegetable crops will germinate well in soils at a temperature of 18 to 20°C. An ideal germination temperature for winter crops is at a soil temperature of between 8 and 15°C.

Within a selected temperature range the optimal temperature needs to be identified for photosynthesis and respiration.

Each crop has a lower temperature limit at which growth is slowed down or halted. A scientist called Shelford described the relationship between temperature and plant growth. This relationship is shown in the figure below.

A crop can tolerate a relatively wide range of temperatures. Within this range the plant can function and grow. Within the tolerance range the plant will achieve optimal growth at a set maximum temperature. Should the temperature exceed the tolerance range the plant becomes stressed. If a certain maximum limit is reached the plant will be damaged, this is the zone of intolerance. The plant will reach in a similar fashion where temperatures are reduced below the tolerance range.
Water

The management of the available water is critical to plant growth. Water is involved in cell turgidity, is involved as a catalyst in biochemical reactions, and is the medium for translocation of compounds.

Water is the major regulator of growth. It is taken up through the roots and is used in the metabolic processes, including transpiration and photosynthesis. During transpiration the plant loses water and cells lose their turgidity, and the lost water has to be replenished.

If a crop is propagated with seed, enough water should be available to ensure complete imbibitions of the seed. If there is a shortage of water, the seed will take longer to germinate and it can even cause damage to the seed tissue, resulting in poor seedlings.

Mineral nutrients are commonly supplied to plants through water, either a medium (fertigation) or by dissolving the fertilisers progressively when manual soil applications are used. Nutrient movements are governed by the principles of osmosis and mass diffusion. Salts move from areas with higher concentrations to areas with low concentrations (osmosis) or are simply taken up as part of the water compounds that get absorbed (mass diffusion).

Ultimately, the quality and quantity of water applied to plants being propagated is crucial. Too little or too much water impacts on growth.

Water quality refers to the pH and salt content (electrical conductivity) of the water. The influence of pH is considered in relation to nutrient availability.
and uptake, while the salt concentration relates to the abundance of nutrients in solution ready for absorption.

A pH (H₂O) range between 5.8 and 6.2 is recommended for optimum interaction in the root-zone of most crops. Salts have a corrosive effect on root growth, and exposure to higher concentrations of above 2.00 mS/cm for more than seven days can burn roots of sensitive plants.

<table>
<thead>
<tr>
<th>Osmosis</th>
<th>The movement of a substance dissolved in a solution with a lower concentration through a membrane to a solution with a higher concentration.</th>
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<tbody>
<tr>
<td>Diffusion</td>
<td>Diffusion is the spontaneous spreading of something such as particles, heat, or momentum. The phenomenon is readily observed when a drop of coloured water is added to clear water, or when smoke from a chimney dissipates into the air. In these cases, diffusion is the result of turbulent fluid motion rather than chemical reactions or the application of external force. In cell biology, diffusion is described as a form of “passive transport”, by which substances cross membranes.</td>
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- **Aeration and Ventilation**

  Gaseous exchange, in both leaves and roots, ensures that growth and development take place normally. Oxygen availability in the root zone and its subsequent uptake rate essentially governs root development and the ability of roots to perform their roles, (being structural stability, feeding, and respiration). Healthier roots develop in a medium where the air-water balance is optimal.

  Surface air movement directly influences the quantity of CO₂ available for uptake by the leaf. Plants require CO₂ diffusion through leaves for growth. Air movement, if not controlled, has a draining effect on the available CO₂. This leads to a deficit, resulting in poor growth and development.

- **Biotic Requirements**

  - **Rhizosphere**

    The rhizosphere is defined as the narrow region of soil that is directly influenced by roots and associated soil microorganisms. It is teeming with bacteria that feed on sloughed-off plant cells, termed *rhizodeposition* and the proteins and sugars released by roots. The protozoa and nematodes that graze on bacteria are also concentrated near roots. Thus, much of the nutrient cycling and disease suppression needed by plants occurs immediately adjacent to roots.

    It is therefore important to keep the rhizosphere in a good condition, as destroying the organisms living there can have negative effects on the normal functioning of the roots. To improve rhizosphere conditions, one can make sure not to compact the soil (poor soil aeration), not to add chemicals which can harm the good soil living organisms (*Rhizobium* bacteria needed for N fixing in legumes) and to make use of conservation tillage (less soil
disturbance and increase the amount of organic material in the soil) to mention a few.

♦ **Bacteria and fungi**

Not all bacteria and fungi in the environment are bad for a crop plant. Some of these organisms can play an important role in increasing growth, yield and quality. One such an example is that of *Rhizobium* bacteria.

These bacteria live in close association with plant roots of leguminous crops. The bacteria make Nitrogen available to the plant, while the plant supplies the bacteria with food (carbohydrates etc.). In such a case, a farmer does not necessarily need to apply Nitrogen out of the bag. It is more economical and environmental friendly.

There are also other organisms involved in breaking down plant residue. The nutrients released in this way can also improve the growing conditions of the crop, helping it to establish quicker and produce better.

In the case of harmful bacteria and fungi, one should have management strategies in place to prevent the crop from being attacked by these and thus resulting in poor growth or even death of the plant.

♦ **Insects**

Insects are also a natural part of the environment in which a crop is propagated. During the propagation of a crop, insects tend to be more problematic than helpful. They can damage the propagation material while still in storage or attack the newly germinated seedling etc. during the early stages of propagation. A good insect control strategy should therefore also be in place.

♦ **Weeds**

Weeds are a big problem when sowing/planting propagation material in the open field. The weed plants are strong competitors and cause stunted growth or even death of crop seedlings if left unchecked. In open field conditions one should thus have good weed management strategies set in place to prevent the weed plants from using up the water and nutrients, intended for the crop plant.

Weeds can also shade the crop seedlings. The seedlings then receive less energy for photosynthesis and it can cause poor growth with lower yields and quality in the end.

### Edaphic Requirements

♦ **Physical soil properties (texture, porosity, temperature)**
  ♦ Clay and loam soils

Clay and loam soils are seldom if ever used as propagation media for propagation material other than seed. When sowing seeds in clay and loam soils, it is important that the soil contains sufficient water to allow speedy
germination. The seedbed should be fine and no big clods should be present, as it interferes with accurate planting and germination.

It is important to make sure that the soil temperature fulfil in the requirements of the specific crop. So for example a summer growing crop should not be planted in soils colder than 18°C. At low temperatures the seeds take a long time to germinate, which make the seeds and seedlings more susceptible to damage by insects and diseases.

Due to the small size of the clay and loam particles, pore space is also small and extra management inputs will be needed to ensure the soil drainage is good. Water logging reduces the availability of air supply to the roots, resulting in poor plant growth.

♦ Sandy soils

Sandy soil on its own or in a mixture is most often used as propagation media for all types of propagation material. It can be used with ease to fill containers in which the propagation material is going to be planted. It also has good drainage preventing water logging and thus decreasing the incidence of diseases associated with water logged conditions.

Sandy soils tend to become warm and even hot very quickly. Care should thus be taken not to let the soil become so warm that it leads to damage of the propagation material.

♦ Chemical soil properties (pH, mineral nutrients, gas exchange)

Most of the information given in: [Temperature 1.4.1.3; Water 1.4.1.4; and Aeration/Ventilation1.4.1.5] is applicable here. In summy the following:

- Soil should be well aerated to sustain the normal functioning of the roots. Roots need energy for uptake of water and certain nutrients and also for growth. This energy is released during respiration, but for that oxygen is needed. If soil is not well aerated (water logged or compacted), low or no respiration can take place.
- At low pH levels (pH (H₂O) < 4.5) most elements needed for good growth becomes restricted, with the exception of Iron and Aluminium, which becomes toxic. Liming it therefore important to prevent such conditions. At this pH level, Molybdenum (Mo) is one of the micro-elements which availability becomes severely restricted and Mo deficiencies are often experienced.
- At pH (H₂O) = 5.5 to 7.5 most elements are readily available for plant uptake, but best results are obtained with a pH range of 6 to 7.
- In soils with pH (H₂O) levels above 7.5, plants often experience Boron and Copper deficiencies. It is very difficult to alleviated too high pH; therefore the selection of fertilizer will play an important role. At these pH levels, acidifying fertilizers are often recommended; however, always consult with a fertilizer expert on the best strategy.
Container properties

- Containers should not be made of material, which releases harmful chemicals into the growing media. It is therefore often made of plastic, polystyrene or even concrete.
- Containers should be big enough to encourage root development and growth. A well-developed root system before transplanting increases the success rate in the field.
- Containers should fit the propagators budget and need.
- Make sure that the containers have good drainage. As explained previously, poor aeration can cause a lot of problems during the propagation process.

1.5 Problem solving within the Propagation Environment

As discussed before, all the environmental factors have to be manipulated in concert to produce quality results. The key challenge in all propagation endeavours is to produce plants with the desired properties at reasonably low cost in the shortest possible time.

Problems likely to occur relate to manipulating environmental factors to mimic nature as closely as possible and to induce natural responses from the plant in a shorter period of time. It is important to remember that in nature these factors combine and biochemical processes take place at a slower pace.

Temperature rising beyond of range in tunnels and greenhouses is a common problem if either the extractor fans or the wet-wall pads, or both, are not working properly. If the problem cannot be fixed easily, doors are kept open and the back of the tunnel or greenhouse is opened to allow air movement. Propagation material produced during the winter months might also have problems with too low temperatures. In this case it may be a faulty boiler, heater, fan etc., which will have to be checked.

In germination rooms, temperatures may also rise out of range. Lights are in this case the most probable cause, and the propagator must carefully select certain lights to be switched off temporarily. Where citrus is propagated through cuttings, bottom heating might be required if basal temperatures are not within the required range. Bottom heating can be avoided by timing the propagation period. In the germination room the temperature can also go down too low. This is often associated with faulty thermostats. If the cooling system is linked to a faulty thermostat, the cooling system will keep on running and thus keep on lowering the temperature.

The humidity level often drops below the required level in the germination room or in tunnels or greenhouses. Wetting the floor assists in building up the relative humidity and plants, if already transplanted as single units, are mist-sprayed with a knapsack sprayer at least every 10 minutes, depending on the temperature.
Ventilation, though the suggested solution for too high temperatures, can also bring in fresh air with adequate levels of CO₂, while removing old are where the CO₂ levels have been depleted. As plants need CO₂ for photosynthesis, a lack in this gas reduces photosynthesis and there is thus less energy available for the propagation material to function normally and give rise to the plants we require.

- The specific environmental requirements for the propagation of plants within a specific agricultural production context are explained.
- The role of the different environmental requirements for the propagation of plants within a specific agricultural production context is described.
- An understanding of how problems within the propagation environment of the specific agricultural production context, confined to routine tasks, are solved is demonstrated.

Please complete Activity 1: Group Work

- As a group explain briefly what is required for the crop that you are involved with to be propagated successfully.
- Also explain the problems you might encounter.

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Session 2 Environmental conditions in a propagation area

After completing this session, you should be able to:
SO 3: Monitor environmental conditions in the propagation area within a specific agricultural production context.

In this session we explore the following concepts:
- Monitoring atmospheric conditions.
- Record keeping.
- Unforeseen changes in environmental conditions.
- Adjusting conditions.

2.1 Introduction

The understanding of environmental factors affecting propagation is essential. The environmental conditions within propagation areas need to be monitored and manipulated to maximise the propagation success rate. The starting point is the implementation of monitoring systems of the environmental conditions.

2.2 Monitoring Atmospheric Conditions

There is a wide range of electronic and manual control systems that are used to monitor environmental factors.

- Measurement of Light

The measurement of light in relation to a plant’s physiological systems and its response is measured using a radiometric system. A radiometric system is used where a unit of radiant energy is measured in joule (J). The amount of energy intercepted by a unit surface area is measured as joule per square metre (Jm⁻²). The flow of energy is measured as joule per second (J sec⁻¹).

So the amount of radiant flux intercepted per unit area is measured as joule per square meter per second (J m⁻² sec⁻¹) (Joule per square meter = watt).

The instrument used to measure irradiance is known as radiometers. Radiant energy interacts with matter as photons and it is a useful measure of the number of photons (photon density) intercepted by a surface or object such as a plant leaf. Photon density is measured as the number of photons in mol per m⁻². This is measured using a sensors that at specific wavelengths.
The relevant wavelengths for plants are photosynthetically active radiation (PAR). This is measured as the photon flux density at the wavelengths between 400 to 700 nm. The measurement is in \( \text{umol m}^{-2} \text{ sec}^{-1} \) (PAR).

### Humidity & Temperature

Humidity can be measured using a Hydro-Thermograph, which measures and records both relative humidity (hydro-) and temperature (thermo-), such as a Thiess CLIMA. The meter has a rotating drum onto which graph paper is placed. The graph paper is replaced at the end of a specified period, such as 1 day, 7 days, 31 days, etc.

Other more sophisticated meters are available as well. In addition to supplying the user with the accurate data of relative humidity (RH) and temperature at the touch of a button, these instruments provides an option of storing information, which can then be transferred to a computer for analyses.

These systems may also provide for the connection to electronic control systems that control heating and humidifying systems. These generally come with additional options such as light intensity sensor, heating or cooling commands, and ventilation and dehumidification commands. As such, they provide the ultimate control mechanism to ensure optimum conditions for plant growth and development.

### Water

Moisture levels are measured using soil moisture sensors, which convert pressure, or water tension, in the soil to centibars of suction. Tensiometers are the most commonly used sensors to continuously register available soil moisture in the root-zone. They are placed in the soil at different depths for better representation of the moisture found in the soil. Lengths of tensiometers range from 15 cm to 180 cm for different rooting depths.

If seedlings are grown in containers in a nursery, the containers do not provide enough depth for long and thick devices such as Irrometers. Although 15 cm tensiometers could be used, it is more appropriate to use hand-held probes or install water sensors in the growth media, which log the fluctuation of water on a continuous basis.

Irrigation water represents a high-risk area for a nursery with regard to the presence of harmful pathogens, such as fungi and nematodes. To ensure that the water is not contaminated and is free of harmful pathogens, the water must be treated. Treatments begin with the flocculation, being the precipitation of silts and organic material, of the water stored in a reservoir. Flocculation makes use of aluminium sulphate based products, such as AluFloc. The amount of AluFloc to be used depends on the amount of mud and other organic material in the water. The flocculated, or clear, water is then filtered using a sand filter to remove any silt or organic material that was not precipitated successfully.
Any remaining pathogen spores, such as *Phytophtora* and *Pythium*, are eradicated through chlorination at 2-3 ppm preferably using chlorine gas, or otherwise sodium hypochlorite (Jik) or granular chlorine (HTH).

| Prop gules | The shoot, seed, or other method that plants use to spread or propagate (reproduce). Any part of the plant that may be used to propagate it, either sexually or through vegetative means. |

Monitoring water quality requires a constant monitoring of the level of free chlorine available in the irrigation water. This can be done by using a swimming pool kit, or more sophisticated methods, such as Hanna Instruments HI9011. The presence of pathogen spores can only be detected through laboratory tests.

Chemical water quality factors are monitored by using pH and EC (electrical Conductivity) meters, which are combined in some devices. For improved nutrient uptake, the pH of the solution has to be between 5.8 and 6.2 with a maximum of 6.5. pH levels outside this range impair nutrient uptake. Critical levels are below 4.5 and above 7.5.

Electrical conductivity (EC) is used to monitor the salinity in the irrigation water, which may cause build-up in the root-zone. Salinity may have severe consequences, such as death of seedlings. Levels above 2.5 mS/cm are considered unacceptably high and such water has to be avoided. Initial water EC of less than 0.3 mS/cm is the ideal for fertigation.

**Ventilation and CO₂ levels**

CO₂ levels are seldom measured outside the nursery/growth chamber, as air movement (ventilation) is not restricted in an open field situation. In a closed environment, air movement is restricted which can cause a depletion of CO₂. The level of CO₂ can be measured with CO₂ gas sensors and if the levels increase or decrease above the required levels, one should act on it promptly as both too high and too low levels retard photosynthesis. If CO₂ levels are too high or too low, levels can be normalized by ventilation. If levels are too low, CO₂ can be pumped or released into the tunnel from gas cylinders containing CO₂. If the CO₂ levels become too high in the closed structure, it can be an indication that the plants are not active in photosynthesis, but that a lot of respiration is going on. In closed tunnels the CO₂ concentration in the morning are usually higher than later during the day as a result of respiration and no photosynthesis.

Wind, especially strong winds can do a lot of damage to crops and protective structures, to alleviate the problem, windbreakers can be planted on the side from which current winds are coming. Windbreaks must not stop the wind, but rather filter the wind.
2.3 Record keeping

Record keeping is a managerial function that ensures that operations are monitored properly. If this function is neglected, inaccurate records can lead to poor decision-making.

Records must always be verified before they are stored for future use. It is common practice to have a dual record keeping system, being manual and computerised, to provide a cross-check of records.

Based on previous records, the propagator can project future operational needs with a greater degree of accuracy. Although conditions may change, there is a greater probability that the same trend will be repeated.

Records should not only reflect what went wrong or what mistakes was made, but also what good things happened (success rate of propagation material), routine measurements and inputs into making the propagation process a success.

Routine measurements can include temperature, EC, pH, water, humidity and CO2 levels in a closed structure, while in open fields mainly temperature and water (precipitation and soil water content) measurements will be taken.

2.4 Unforeseen Changes in Environmental Conditions

The nature of agriculture itself is such that natural environments can change without warning, and this constitutes the major uncertainty linked to agriculture.

Though there are several services that provide weather forecasts with high level of accuracy, there is still a shaded area of about 10% that makes predictions a useful management tool, but not something to be relied on solely. The unpredictability of the weather remains a risk.

Where natural conditions are controlled to some extent, such as in shade-houses, the propagator has to balance the conditions taking into account the level of other factors required. Under extreme unexpected heat conditions, irrigation can for instance be timed to coincide with periods of the day when the stomata are still open and transpiration is taking place, which is generally before 10h00 and after 15h30.

If water supply is a problem, moisture becomes the affected factor. In this case, humidity, light and temperature become the factors that can be balanced to ensure that growth still takes place normally.
2.5 Adjusting Conditions

In tunnels, the use of electronic sensors ensures a better control of the propagation environment. The propagator can set and alter parameters accordingly by the push of a button.

Under shade-cloth, adjustments are less drastic. Ventilation is passive and relies on wind movement. The major adjustments the propagator can make relate to the use of the shade-cloth to reduce light intensity and temperature. Shade-cloth, also referred to as thermal sheets, come in different colours and percentage shading, the most commonly used for propagation are black and white, with green also becoming more and more popular.

In open field conditions not much can be done. One of the options a farmer has is to plant or construct a windbreak in areas where wind is a problem. Excessive wind dries out the soil much quicker and it can also cause physical damage to the plants. In the case of vegetables like tomatoes, farmers often put up hail nets if they are in areas where that is a problem or even bird nets to prevent damage by birds.

- The propagation procedure for a specific agricultural production context is demonstrated.
- The parts of the plant used in a specific propagation procedure are described.
- The requirements for the specific propagation procedure are explained.
- The necessary hygiene and safety requirements for the appropriate procedure are described.
- The tools used in the specific propagation procedure are described.

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<td>The keeping of accurate records of environmental conditions are explained.</td>
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<td>An understanding of how significant unplanned changes in environmental conditions are recognised, reported and appropriately amended under general supervision is demonstrated.</td>
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<td>An understanding of how the environmental conditions of a controlled growing environment are changed according to specified criterion, in order to meet the needs of a specific crop is demonstrated.</td>
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In this session we explore the following concepts:

- Propagation of a tree crop - Citrus
- Propagation of open field or tunnel crops - Tomato

The propagation techniques used in different crops may differ. The examples used in this session are for tomatoes and citrus trees. Although the techniques discussed may be applicable to other crops, they may not cover all aspects related to all crops.

### 3.1 Propagation of a tree crop - Citrus

#### Budding

Budding is a form of grafting in which a vegetative scion from a tree of the desired cultivar and variety and with desirable traits is inserted in a rootstock seedling to produce a tree.

The term budding refers to bud grafting, a technique of grafting using a single bud as the graft scion where each part, the scion and the rootstock, have distinct roles to play.
• Rootstock Selection

Healthy rootstock seedlings are produced and raised through germination. The choice of the rootstock depends on the following factors:

- Predictable performance in environmental conditions in the orchard, which include the water quality, and the physical and chemical properties of the soil, such as soil pH and salinity;
- The market entrance timing in relation to time to maturity
- Internal fruit quality
- Resistance to root diseases

Rootstocks are produced through seed propagation. Rootstock seeds are purchased from certified sources or collected from the fruit of rootstock variety trees that are grown specifically for this purpose. The seeds are sown either outside in sand seedbeds, or, more commonly in South Africa, in seed-trays that are kept in a controlled environment in germination rooms. All seed trays are clearly marked with water-proof identification labels stating the variety, date sown and source code.

A loss of approximately 50% of seeds can be expected due to various conditions. Such unforeseen conditions include:

- Death of seedlings due to diseases, which result from excess water in the growing medium, such as damping-off and phytophthora.
- Albinism, which is a condition that expresses itself at the seedling stage if not treated properly.
- Seeds that have been sown to deep take longer to germinate, which lead to the considerable risk of seedlings emerging with defects associated with reduced levels of chlorophyll.
- The medium used is also a potential cause for losses. Compacted media make radicle development more difficult in that there is less space for the primary root to navigate freely.

The best seedlings are transplanted into trays with individual cells filled with bark mixed with a slow release fertiliser. These seedlings are raised to become rootstocks for budding.
Figure 3.1: Citrus Rootstock in Cavities

Four months after transplanting from the germination tray, seedlings are planted into bigger containers, such as four litre polyethylene bags, to grow and develop for budding. At this stage, losses may occur through selection, as more seedlings may display unwanted traits that have been hidden previously. These seedlings are referred to as off-types. Management at this stage is concerned with creating an environment conducive to transpiration and photosynthesis taking place at a good rate. Each batch of seedlings retains its identity label.

Figure 3.2: Example of the Labelling of rootstocks

Budding takes place about four months after transplanting.

**Parts of the Plant Used**

On the rootstock, the mid-section of the stem is used to accommodate the bud. The cut is made between nodes at a height of not less than 20 cm above the growth-medium.

The bud itself is cut from a twig collected from the selected cultivar with desired traits. The twig constitutes the bud-wood and is referred to as the scion. The bud-wood must have enough food reserves for the bud to survive before it is taken over by the rootstock cambium.
The shape of the bud-wood is not clearly prescribed. Some propagators use buds from well rounded bud-wood sticks, while others prefer using those from slightly angular shaped sticks.

**Budding Procedure**

The ultimate goal of the propagator is to produce a successful union between the scion and the rootstock that will last for a long period of time. The lifespan of a citrus orchard depend, amongst other factors, on the initial plant quality and it is therefore essential to ensure that the budding process is done correctly.

To ensure a successful union, the propagator must aim at maximum contact between cambiums of the rootstock and scion. To this end, tissues must be matched correctly, and care must be taken to ensure that they are bound and remain in contact.

The budding process in nurseries is carried out at a time of the year which promotes the success of the operation and subsequent union. The most ideal time is in the summer when the sap flow is optimal in the rootstock. There must be clear signs of growth on the rootstock, such as new shoots.

The selection of the bud-wood plays an important role in achieving success. The selection has to be done at the right growth stage. Scion material is collected from healthy and young twigs in active growth.

An inverted T-cut is made on the stem of the rootstock at a height of about 20 cm above the growth medium. For the sake of uniformity, the propagator ensures that the height of budding is the same throughout.

The depth of the cut is shallow, i.e. just deep enough to lift the bark. The thickness of the stem is important because it has to lend itself to manipulation. The thinner the stem, the more difficult it is to bud on.
Figure 3.4: The Inverted T-Cut: Vertical Cut (left) and Lateral Cut (right)

The scion is inserted into the T-cut and pressed down firmly to ensure that the tissue contact. The joint is wrapped and sealed to allow the wounds to heal.

Figure 3.5: Inserting a Bud-piece Into the T-Cut
Sanitation has to be monitored very closely during plant propagation to prevent contamination. Cultivated citrus species, including rootstocks and scions, are susceptible to a range of pathogens ranging from bacteria to viruses and fungi.

Most of these pathogens are transmissible through cutting tools. Pathogens infest the vascular cambium, and any cut that reaches the vascular cambium therefore has the potential to contaminate the tool used and to transmit the infection to other plants with disastrous consequences for the future of the industry.

The use of cutting tools requires safety measures to be put in place and those handling these tools must be aware of the dangers.

Once the bud-wood is cut off, it is placed in a clean crate for fungicide treatment, which involves dipping it in a fungicide solution for about a minute. It must be ensured that the fungicide mixture is made up according to label specifications.

Tools Used for Budding

During budding, cutting tools are used. Budding knives are used to remove the bud-piece from the bud-wood and to make the inverted T-cut, and pruning shears that are used to collect bud-wood. These tools are sterilised using bleach in a 30% solution after every 100 plants have been budded, or every time the propagator moves from one tree to the next while cutting plant material.
After inserting the bud into the rootstock, it has to be wrapped using a polyethylene plastic strip to maximise the contact between the rootstock and the bud, and keep water out as it might infect and rot the bud.

**Pruning shears** are used to cut the bud-wood from the trees.

**Growth medium** and **seedling trays** are required for seed germination and growing of rootstocks.

Most tree crops are propagated by grafting scions onto seedling rootstocks, either by budding as described for citrus, or by grafting a scion. The scion consists of a piece of a shoot containing two or three lateral buds or a terminal bud, onto a rootstock.

In the case of grapes the rootstocks are produced from rooted cuttings.

Ornamental shrubs and plants are propagated primarily through cuttings, but may also be grafted as described for citrus.

## 3.2 Propagation of open field or tunnel crops - Tomato

**Greenhouse tomatoes:**

In the case of greenhouse tomatoes, there are two options.

1. Tomato seeds are sown into the containers in which they will be growing. The seedlings are often grown in a nursery. Once as the seedlings are strong enough, they are moved to the greenhouses (Figure 3.8) where they are correctly spaced.

2. The more widely applied system is one where tomato seedlings are first produced in a nursery and these are then transplanted into the containers in the greenhouses. The containers are generally pre-filled and spaced, and irrigation systems installed.
**Open field tomatoes - Direct sowing**

Before one can sow the seed, the seedbed has to be prepared. Soil preparation includes not only cultivation of the soil, but also incorporation of the necessary nutrients and chemicals to control insects, weeds, diseases and nematodes. The seedbed should be free from plant rests and the soil moist to facilitate good germination.

In the mean time, the seed has to be bought and stored under controlled conditions and only removed from the store on the day it has to be sown. Seed from trusty seed companies will be free from diseases, have a high germination percentage and will often be treated with fungicides. It is therefore ready for planting without additional preparation. This is true for most non-leguminous crops. For legumes like alfalfa, soybean, peanut etc., one first has to apply the spores of nitrogen fixing bacteria (*Rhizobium* spp) to the seed before plant.

Now that the seedbed is prepared and the soil conditions ideal for planting (soil temperature > 18°C and the soil moist), the seed can be sown. The seeds are sown with specialized planters which can handle such small seeds. The planter is also calibrated before entering the field to ensure the in-row and between row spacing is correct.

If a mechanical or semi-mechanical planter is not available, seeds can be sown by hand. In this case it is important to have a planter line to ensure the seeds are spaced correctly and planted in a straight line. The workers should further be equipped with a bag in which the seeds can be carried. Old fertilizer bags can be cut to the right size and strapped around the body for easy access. Because the seeds are relatively small, it is not necessary to first make a hole in the soil. The workers can simply put the seed on the soil and with the one foot scrape some soil over the seed to cover it and then step on it with the other foot to firmly get it in contact with the soil.
If everything went well, the seedlings should appear within five to seven days after planting. It is thus important to monitor the process. By doing so, problems can be picked up early. Sometimes a few seedlings are also made in addition to the seeds directly sown into the field. These can be used to fill in any gaps (missing plants due to seed which did not germinate or which were damaged) in the field. If the plants are too close to each other, one should thin out to the correct spacing within three to four weeks after sowing, but no later than six weeks after sowing. If the plants are too close to each other, the individual plants cannot produce optimally and are often weaker than plants spaced at the right spacing.

### Sowing Seeds

There is a saying that says healthy seedlings make healthy plants. This applies especially to vegetables. It is essential that a good quality seed is purchased for planting and production. The choice of cultivar is also important. At the early stages of planning the producer should select the type of crops he wants to produce and he has to select the traits of the specific crop he is interested in, as well as know the environmental conditions he experiences. Once all this information is available the producer selects the cultivar that suits his needs.

Vegetables can be planted either as seed directly into the soil, or as seedlings planted directly into the soil. The seedlings can either be bought or the producer can produce the seedlings from seed. Seeds can be sown in one of three ways, depending on the size of the seed.

**Large seeds** such as those of pumpkins can be planted one by one. These seeds are planted about 20 cm apart and each seed is placed into a separate hole made for each seed.

**As a rule of thumb the seeds are placed at a** depth of about 5 times the length of the seed into the ground. The more clay in the soil the more shallow the seeds should be placed into the soil. The holes can be made using a wooden stake or specialized bulb planter.
Seeds of medium size, such as for spinach and beetroot are sown into furrows made in the ground. The seeds are sown closer together in the soil about 10 to 15 cm apart. The planting depth rule of thumb applies here as well. The seeds can also be adhered to self-adhesive paper tape (masking tape) at set intervals, and the tape simply placed into the furrows and covered. Do not use plastic tape however.

**PLANTING MEDIUM SEEDS**

Very small seeds such as those of carrot and cabbage are broadcast sown onto a prepared seedbed. The seed is scattered over the soil and then covered in soil. Use a thin soil layer to cover the seeds and water the seeds immediately after sowing. It is important that seeds be sown into moist soil and that the soil is kept at constant moisture up to emergence.

**PLANTING SMALL SEEDS**

**Open field tomatoes - seedling beds**

Seedlings can be produced in seedling beds in the open or sometimes it will be covered with mini plastic tunnels (30 to 50 cm in height) for extra protection.

In producing seedlings in seedling beds, the seedbed has first to be prepared. In this case it is a much smaller area and the seed is not spaced individually, but broadcasted. The same principles of seedbed preparation, however, holds true and the seedbed should be well aerated (often raised seedbeds), free from undecomposed plant material, diseases etc.
A seedbed is an area in your garden where soil is prepared and seedlings are produced from seed. The seedbed should be located in an area where it receives sufficient sunlight. It is also a good idea to fence off the area to keep out animals. The area selected to preferably contain a sandy loam soil.

### Preparing a seedbed

1. The first step is to select an appropriate site. This is usually done during planning of the layout of the vegetable garden as a whole.

2. Pace off an area of approximately 2m by 2m.

3. Wet the soil so that it is moist.

4. Turn the soil with a fork or similar tool.

5. Break up large soil lumps into fine pieces.

6. Remove all stones from the area.

7. Add fertilised, manure or compost to the area and dig it in. When using kraal manure 2 spade fulls should be added for each 1 m X 1m area. Thus on a 2m X 2m area you would add 8 spade fulls of manure or compost. If adding chemical fertiliser, add 2 cups of fertiliser per 1m X 1m area.

8. The fertiliser (chemical or organic) is scattered evenly over the area and dug in lightly.

9. Rake the soil to form a level, slightly raised area approximately 20 cm higher than surrounding soil, with a slight ridge on the edges to keep water from running off.

10. Wet the seedbed to moisten the soil, but do not flood the soil.

11. The seeds can now be sown using one of the techniques described above.

12. The seeds should be kept moist from this moment on. It is a good idea to protect the seeds and seedlings from the elements during the first few weeks using mulches or shade cloth.
13. Once all the plants have germinated, the plants will have to be thinned. This is done when the plants are about 5 cm high.

14. The plants are removed to reach a pre-determined distance between plants (about 5 cm).

15. When the plants reach about 15 cm in height they can be removed from the soil for transplanting.

16. Seedlings can be removed by inserting a knife into the soil about 5 cm from the stem all around the plant and extracting the plant from the soil.

The seed should be of good quality and stored properly before use. The seeds can be sown by a specialized seedbed planter or broadcasted by hand. If planted by hand, use a rake to cover the seed with soil after sowing and lightly tap the soil afterwards with the broadside of the rake to get the seeds in good contact with the soil.

After the seedlings have germinated, proper care has to be taken of the seedlings till it is pulled for transplanting. This include regular watering, removing diseased seedlings, removing weeds, applying nutrients etc., all to keep the seedlings happy and growing actively.

**Seed Storage and Treatment**

Although good quality seed is expensive, they normally render healthy seedlings and healthy plants that give good yields. If you do not use all the seed that you have purchased at once, ensure that you store the unused seed for later use. Place the seeds into envelopes or small paper bags and label them with the seed type and cultivar as well as date of storage. Now take a glass bottle with screw type lid. Place a few pieces of charcoal in the bottom and a cardboard circle on top. The seeds in bags are now placed on top of the cardboard disc and the bottle closed tightly. The charcoal in the bottom of the bottle will absorb excess moisture.
Seeds can be treated with fungicides to ensure that they do not develop diseases. Fungicide seed dressings can be bought and seed treated. To treat the seed always follow the label instructions exactly. Place a known mass of seeds in a plastic bag, add the correct volume of fungicide to the seed, close the bag and shake it well for at least 5 to 10 minutes. Check to see if all the seeds have come into contact with the fungicide.

Seeds can also be heat treated to kill diseases. To do this water is boiled over a fire or on a stove. Let the water cool to a temperature where it just does not burn your hand (52 to 54°C). Place the seeds into a cloth bag and place the bag into the water (hot) for 30 minutes, ensuring that the temperature stays constant during this period. Now remove the seed from the bag and place onto newspaper in the shade to dry. The seed can now be planted or stored. It is a good idea to always treat seeds either with hot water of fungicide prior to storage or planting, this will ensure that seed-borne diseases do not trouble you.

Open field tomatoes - seedling trays

Seedling trays are also called plug/cell trays can be made from plastic or polystyrene (Fig 3.10) and can have as few as 6 cells (cavities – Fig 3.11) to as much as 500 cells per single tray. Trays containing 100 to 300 cells are available. Small seedlings can be planted in seedling trays with high number of cells per tray, while big seedlings need more space and is trays with less cells per tray is better suited. The best is to talk to your seedling tray supplier on the best for your situation.

Seedling trays can be re-used if taken care of properly. This includes cleaning it after usage and stacking them neatly out of the way in a store when not in used. Each time before you use the trays, it is best to sterilize it to prevent the spread of diseases.
Figure 3.10 Plastic (left) and polystyrene (right) seedling trays, which can be used in seedling production. Also note the differences in number and size of single cells (cavities).

Figure 3.11 Close up of a single cell. Also note the drainage holes.

After deciding on the seedling trays that best suits the crop, the next step is to decide on the growth medium. The growth media can be soil or non-soil based. Soil is the cheapest, but not always the easiest to use and non-soil based media are more often used.

The growth media used include:

- Pine bark

  Two key disadvantages of pine bark are the effect of its toxins on plant growth and in its hydrophobic (or difficult to wet) nature. There have also been problems at times with purity of samples, and in uniformity of particle size following milling. When used in seedling mixes the bark is milled to a maximum particle size of 5 mm. The toxins are leached out by ageing wetted bark in open air stacks.

  Newly stripped bark is harder to wet following drying than stockpiled, weathered bark. Pine bark can be composted with the addition of small
amounts for slow-release fertilizers, to help in the process. This process provides some control of selected diseases.

♦ Wood shavings

There are similar problems with wood shavings to those of pine bark, and some timber contain toxin. Clean pine shavings are preferred. Treatment is the same. Sawdust composted in the recommended manner can be combined with pine bark and with peat moss. It is desirable to keep the percentage by volume of sawdust to around 40 percent or less.

♦ Sand

The value of adding sand, as an inert mineral, to any seedling mix is to obtain a balance between the other components and to give some bulk to the final product. A common belief is that sand helps with drainage in fact the reverse can occur. If sand is added to peat moss it may fill the spaces between peat particles, thereby reducing drainage. Conversely re-wetting a dried-out mix is improved if there is a small amount of sand present. However, over mixing of peat and sand in a rotary mixer can lead to pulverization of the peat, thus changing its structural qualities. On the other hand large amounts of sand added to a seedling mix is likely to produce dense mixtures. Likewise there needs to be a balance between the extremes of fine and coarse sands. Sand 2 mm or larger is classed as coarse material.

♦ Perlite

Perlite is an inert light material, and is used to reduce the bulk density of growth media. It does not retain moisture or hold any plant nutrients. There is no real value of having perlite as part of the growing media.

♦ Vermiculite

Horticultural vermiculite has long been valued by the nursery industry. It has most value in short-term mixes such as those used for seedlings. As a material with a high base exchange capacity, it is able to reduce the loss of nutrients through leaching. It also contains small amounts of magnesium and potassium and stores water.

♦ Polystyrene pellets or beads

This material is sometimes used to add bulk. It has no nutrient value or water holding capacity. Polystyrene is difficult to handle outside when there is a wind

♦ Peat moss

Peat is a natural deposit of degraded organic matter that develops over a period of thousands of years. The use of peat moss in horticulture is increasing world wide. Most peat is relatively stable against rapid decay.
They are valued for their high water-holding capacity. The sphagnum peat has a better balance between water and air, than most sedge peat. Even though peat has a capacity to hold water, their loss of moisture is high through transpiration and evaporation. Because of this it is claimed that plants growing under optimum conditions would grow faster in this material.

The growth medium that is used depends on its availability and cost. The material mentioned above is often mixed to get better results. Fertilizers may be added to boost seedling growth. Before the growth media are placed in seedling trays, it is best to sterilize it against diseases and insects and wet it to such an extent that it is easy to handle. If it is too dry, it will fall through the drainage holes.

After the trays have been filled with the moist, sterilized media, the seeds are sown. One seed is sown per cavity. Sowing can be done mechanically or by hand. After sowing seeds are covered with media and gently pressed down.

After emergence, the seedlings are regularly irrigated and fertilised. Diseased seedlings are removed and discarded. This is done until the seedlings are ready for transplanting.

- **Using seedlings**
  - **In open field**
    - The seedlings in seedling trays or seedling beds are harvested within six weeks after sowing. They are first tested by removing from the trays. Seedlings are fit if they can be removed from the soil/tray without breaking a root. To encourage adoption, seedlings are first hardened off. This means that towards the last two weeks before pulling the seedlings, the amount of water and nutrients provided are gradually reduced. In this way the seedlings adapt quicker to conditions in the field.

- **Removing seedlings:**
  - Seedling beds – Seedlings grown in seedling beds can be pulled by first lifting them from the soil by means of a mechanical implement or by using a garden fork. The seedlings are then pulled from the soil by firmly gripping it at the base of the stem and slowly pulling it out. There are usually more seedlings available than what is needed and one can choose the strongest and healthiest seedlings for transplanting. Place the pulled seedlings on moist pieces of material/bags or in plastic bags and place in the shade to prevent the seedlings from wilting. Transplant the seedlings to the prepared seedbed in the field as soon as possible.
Seedling trays – Seedlings growing in seedling trays are pulled by turning the tray onto one of its sides and then with a blunt object (something that won’t bend or break and which fits through the drainage hole), poke the seedlings through the drainage hole (Fig 3.3). This loosens the seedling from the cavity and when you turn the seedling tray back to the original way, it is much easier to pull the seedlings from the cavity without breaking it. Again firmly grip the seedling at the base of the stem and pull it out, after which it is kept moist and cool till it is transplanted to the well prepared seedbed in the field.

Prepared seedbed in the field.

After the seedlings have been pulled it can be transplanted to the field with the aid of mechanical or semi-mechanical seedling planters or by hand. The mechanical or semi-mechanical planters are calibrated before entering the field to ensure the seedlings are spaced correctly in the field.
If transplanting is done by hand, the best way is to have two to three workers working in a team. Firstly mark out the spacing with planter lines and then start planting in straight rows. A method which work good is to have one worker making a hole in the soil with a hand spade or other appropriate tool, after which the next worker place the seedling in the whole and lastly another worker come behind and cover the seedling and hole with soil and pressing the soil around the seedling roots. The worker doing the actual planting can carry the seedlings in a plastic bag (similar to the one used for sowing) which makes handling easier and which also keeps the seedlings moist. If it is very hot, some irrigation should be applied soon after transplanting, but if the soil can provide in the water needs of the seedlings, and it is not too hot, irrigation can be withheld for up to two weeks. This will encourage good root development.

♦ **In a greenhouse**

The containers used in the greenhouse are usually black or white plastic bags with a capacity of 15 to 20 l. The bags can be filled with any or a combination of any of the previously mentioned growth media. Again sterilization of the bags (if re-used) and growth media is important before transplanting.

The seedlings are pulled as described earlier and single plants are then planted to each bag by hand. The growth media is firmly pressed against the transplant to ensure good contact between the roots and the media. The containers are small and the growth media cannot hold a lot of water and nutrients. Therefore the seedlings should be irrigated and fertilized regularly.

■ **Hygiene/Sanitation**

♦ **Open field**

In the open field it is often difficult to control or prevent the spread of diseases. There are, however, some principles, which can be followed.

- Don’t smoke while handling seedlings. The tobacco can be contaminated with the tobacco mosaic virus, which attacks a variety of crops including tomatoes.
- Clean implements/tools/equipment when moving from one field to the next. This can prevent spreading of diseases from a contaminated to non-infected field.
- Only sow certified seed and use healthy seedlings.
- Wash hands after eating and using the bathroom.

♦ **Nursery**

Planning is essential to maintain nursery hygiene and to ensure a high standard of plant health. A seedling nursery must be clearly separated from any other growing system and there must be strict control over entry to the nursery to limit the possibility of introducing pests and diseases. In other words, a nursery must be treated as a quarantine area, with restrictions on
entry and movement inside the boundary. This applies to people and to materials or equipment. All he principles mentioned above also holds true here.

• Safety

Just a few safety tips:

♦ No person should touch any tool/equipment/machine unless he/she is trained for the job
♦ When machinery is involved, it is best to wear overalls, protective gloves and closed end shoes (not barefoot or sandals).
♦ Remember no safety gear can protect you if you act irresponsible. Always take into consideration that you are working with dangerous equipment and be on constant alert.
♦ If pruning shears, knifes or other tools with blades are used, rather wear protective gloves.

• An understanding of how different environmental conditions are monitored for the specific propagation process is demonstrated.
• The keeping of accurate records of environmental conditions is explained.
• An understanding of how significant unplanned changes in environmental conditions are recognised, reported and appropriately amended under general supervision is demonstrated.
• An understanding of how the environmental conditions of a controlled growing environment are changed according to specified criterion, in order to meet the needs of a specific crop is demonstrated.
• The most appropriate tool for the specific propagation procedure is described.
• An understanding of why the specific tool is used for that specific propagation procedure is demonstrated.
• The necessary hygiene requirements associated with the procedure are demonstrated.
• The necessary safety requirements needed when using the specific tools is explained.

Please complete Activity 3.1 below:
Visit (or do online research about) the propagation of the crop that is grown at the site where you work.
1. Describe how the plant is propagated?
2. Explain what tools, equipment and materials are required for the propagation?
3. At what time of year is the propagation occurring?
4. What parts of the plant are being used? For what are the plant parts used?
5. What do they do to ensure that they have a high success rate?
6. What hygiene and sanitation rules are there in the propagation environment? Why?
Please complete Activity 3.2 below:

Do research about a propagation area for the crop that you work with and answer the following questions:

1. What are the requirements regarding?
   - Humidity
   - Ventilation
   - Temperature
   - Light Intensity
   - Moisture
   - Growth medium

2. How is the following monitored and maintained at the right levels:
   - Humidity
   - CO₂ levels vs. O₂ levels
   - Temperature
   - Light Intensity
   - Growth medium moisture?

3. What would a propagation nursery keep record of? Why?

4. What happens if the environmental measurements in the above questions are incorrect for the propagation environment? Who is informed? How is it corrected?

Please complete Activity 3.3 below:

For a specific type of propagation used in the crop that you work with:

1. What are the best tools for the job?
2. Why are these tools used?
3. Can the tools spread disease? Explain your answer.
4. Can the tools injure people working with it? Explain your answer.
5. How will you personally prevent that tools spread disease in the propagation environment?
6. How will you personally prevent damage to the plant material by the tool?
7. How will you personally prevent damage to yourself while using the tool?
### Concept (SO 2 & SO 4)

<table>
<thead>
<tr>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
</tr>
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<tr>
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<tr>
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<tr>
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</table>
# Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apical Dominance</td>
<td>It is the phenomenon whereby the main central growing point or apical bud of a shoot suppresses the lateral buds by producing hormones (axons’) that move down the stem.</td>
</tr>
<tr>
<td>Dormancy</td>
<td>Dormancy refers to the ability of certain plant-parts, such as seeds, to suspend metabolic processes until ideal environmental conditions occur or seed with mechanical or physiological barriers that need to be removed before the seed can germinate.</td>
</tr>
<tr>
<td>Grafting</td>
<td>Grafting refers to any process of inserting a part of one plant into or onto another plant in such a way that they will unite and grow as a single unit.</td>
</tr>
<tr>
<td>Humidity</td>
<td>Respiration refers to the process during which the plant takes up oxygen (O₂) for the “burning” of carbohydrates to release energy, water and carbon dioxide (CO₂).</td>
</tr>
<tr>
<td>Metabolic Processes</td>
<td>Metabolic processes refer to organic chemical processes inside a cell that enable life.</td>
</tr>
<tr>
<td>Photosynthesis</td>
<td>Photosynthesis refers to the chemical reaction that takes place when the plant takes up CO₂, and uses the sunlight energy trapped by the chlorophyll to combine it with water molecules in the plant to produce carbohydrates, which is food. O₂ is released during this process.</td>
</tr>
<tr>
<td>Propagation</td>
<td>Propagation refers to the multiplication of plant material that is of a specific cultivar and variety, and that possesses desirable characteristics, such as grain quality (wheat and maize), fibre quality (cotton), fruit shape and colour and internal quality (fruit crops).</td>
</tr>
<tr>
<td>Respiration</td>
<td>Respiration refers to the process during which the plant takes up oxygen (O₂) for the “burning” of carbohydrates to release energy, water and carbon dioxide (CO₂).</td>
</tr>
<tr>
<td>Rootstock</td>
<td>Rootstock means the root-bearing part of a stem used for grafting or budding in plant propagation.</td>
</tr>
</tbody>
</table>
Am I ready for my test?

♦ Check your plan carefully to make sure that you **prepare in good time**.
♦ You have to be found **competent** by a qualified **assessor** to be declared competent.
♦ Inform the assessor if you have any **special needs** or requirements **before** the agreed date for the test to be completed. You might, for example, require an interpreter to translate the questions to your mother tongue, or you might need to take this test orally.
♦ Use this worksheet to help you prepare for the test. These are **examples of possible questions** that might appear in the test. All the information you need was taught in the classroom and can be found in the learner guide that you received.

1. **I am sure** of this and understand it well
2. **I am unsure** of this and need to ask the Facilitator or Assessor to explain what it means

<table>
<thead>
<tr>
<th>Questions</th>
<th>1. I am sure</th>
<th>2. I am unsure</th>
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<tbody>
<tr>
<td>1. Explain the Environmental Requirements for successful plant propagation</td>
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<tr>
<td>2. What is photosynthesis</td>
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<tr>
<td>3. What are the requirements for successful plant propagation</td>
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<tr>
<td>4. Why are environmental conditions monitored during propagation</td>
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<td>5. Why is record keeping important</td>
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<tr>
<td>6. Why is it important to know and understand the propagation techniques used for the crops you grow</td>
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<td>7. What is meant by sanitation during propagation</td>
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</table>
Checklist for practical assessment …

Use the checklist below to help you prepare for the part of the practical assessment when you are observed on the **attitudes** and **attributes** that you need to have to be found competent for this learning module.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Answer Yes or No</th>
<th>Motivate your Answer <em>(Give examples, reasons, etc.)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Can you identify problems and deficiencies correctly?</td>
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<tr>
<td>Are you able to work well in a team?</td>
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<tr>
<td>Do you work in an organised and systematic way while performing all tasks and tests?</td>
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<tr>
<td>Are you able to collect the correct and appropriate information and / or samples as per the instructions and procedures that you were taught?</td>
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<tr>
<td>Are you able to communicate your knowledge orally and in writing, in such a way that you show what knowledge you have gained?</td>
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<tr>
<td>Can you base your tasks and answers on scientific knowledge that you have learnt?</td>
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<tr>
<td>Are you able to show and perform the tasks required correctly?</td>
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<tr>
<td>Are you able to link the knowledge, skills and attitudes that you have learnt in this module of learning to specific duties in your job or in the community where you live?</td>
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</table>

The assessor will complete a checklist that gives details of the points that are checked and assessed by the assessor.

The assessor will write commentary and feedback on that checklist. They will discuss all commentary and feedback with you.

You will be asked to give your own feedback and to sign this document.

**It will be placed together with this completed guide in a file as part of your portfolio of evidence.**

The assessor will give you feedback on the test and guide you if there are areas in which you still need further development.
**Paperwork to be done ...**

Please assist the assessor by filling in this form and then sign as instructed.

<table>
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<th>Learner Information Form</th>
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Bibliography

Books:

World Wide Web:

Terms & Conditions

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SOUTH AFRICAN QUALIFICATIONS AUTHORITY
REGISTERED UNIT STANDARD:

Explain the propagation of plants

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<td>2007-10-13</td>
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PURPOSE OF THE UNIT STANDARD
The learner achieving this unit standard will be able to propagate plants.

Learners will gain specific knowledge and skills in plant propagation and will be able to operate in a plant production environment implementing sustainable and economically viable production principles.

They will be capacitated to gain access to the mainstream agricultural sector, in plant production, impacting directly on the sustainability of the sub-sector. The improvement in production technology will also have a direct impact on the improvement of agricultural productivity of the sector.

LEARNING ASSUMED TO BE IN PLACE AND RECOGNITION OF PRIOR LEARNING
It is assumed that a learner attempting this unit standard will show competence against the following unit standards or equivalent:

- NQF 3: Demonstrate a basic understanding of the physiological functioning of the anatomical structures of the plant.
- NQF 2: Demonstrate an understanding of plant propagation.
- NQF 2: Monitor water quality.

UNIT STANDARD RANGE
Whilst range statements have been defined generically to include as wide a set of alternatives as possible, all range statements should be interpreted within the specific context of application.

Range statements are neither comprehensive nor necessarily appropriate to all contexts. Alternatives must however be comparable in scope and complexity. These are only as a general guide to scope and complexity of what is required.
Specific Outcomes and Assessment Criteria:

SPECIFIC OUTCOME 1
Demonstrate an understanding of the function of environmental requirements for propagation within a specific agricultural production context.

OUTCOME RANGE
The propagation environment includes, but is not limited to, open field and protective structures related to the environmental needs of humidity, ventilation, temperature, light intensity and moisture.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
The specific environmental requirements for the propagation of plants within a specific agricultural production context are explained.

ASSESSMENT CRITERION 2
The role of the different environmental requirements for the propagation of plants within a specific agricultural production context is described.

ASSESSMENT CRITERION 3
An understanding of how problems within the propagation environment of the specific agricultural production context, confined to routine tasks, are solved is demonstrated.

SPECIFIC OUTCOME 2
Demonstrate an understanding of the general propagation procedures and select appropriate procedures within a specific agricultural production context.

OUTCOME RANGE
Propagation procedures include, but are not limited to, direct sowing, seedling tray, seedbed, vegetative cuttings of rhizomes, corns, tubes, scaling of bulbs and tissue culture.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
The propagation procedure for a specific agricultural production context is demonstrated.

ASSESSMENT CRITERION 2
The parts of the plant used in a specific propagation procedure are described.

ASSESSMENT CRITERION 3
The requirements for the specific propagation procedure are explained.

ASSESSMENT CRITERION 4
The necessary hygiene and safety requirements for the appropriate procedure are described.

ASSESSMENT CRITERION 5
The tools used in the specific propagation procedure are described.
SPECIFIC OUTCOME 3
Monitor environmental conditions in the propagation area within a specific agricultural production context.

OUTCOME RANGE
The environmental conditions may include but are not limited to humidity, ventilation, temperature, light intensity, moisture, etc.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
An understanding of how different environmental conditions are monitored for the specific propagation process is demonstrated.

ASSESSMENT CRITERION 2
The keeping of accurate records of environmental conditions is explained.

ASSESSMENT CRITERION 3
An understanding of how significant unplanned changes in environmental conditions are recognised, reported and appropriately amended under general supervision is demonstrated.

ASSESSMENT CRITERION 4
An understanding of how the environmental conditions of a controlled growing environment are changed according to specified criterion, in order to meet the needs of a specific crop is demonstrated.

SPECIFIC OUTCOME 4
Choose and apply the necessary tools for the propagation within a specific agricultural production context.

OUTCOME RANGE
Tools include but are not limited to pruning shears, budding knives, scalpels, gas flames, laminar flow bench etc. Hygiene requirements include but are not limited to sterilization, radiation, alcohol washes etc. Safety requirements include but are not limited to using eye protection, hand protection, clothes etc.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
The most appropriate tool for the specific propagation procedure is described.

ASSESSMENT CRITERION 2
An understanding of why the specific tool is used for that specific propagation procedure is demonstrated.

ASSESSMENT CRITERION 3
The necessary hygiene requirements associated with the procedure are demonstrated.

ASSESSMENT CRITERION 4
The necessary safety requirements needed when using the specific tools is explained.

UNIT STANDARD ACCREDITATION AND MODERATION OPTIONS
The assessment of qualifying learners against this standard should meet the requirements of established assessment principles.
It will be necessary to develop assessment activities and tools, which are appropriate to the contexts in which the qualifying learners are working. These activities and tools may include an appropriate combination of self-assessment and peer assessment, formative and summative assessment, portfolios and observations etc.

The assessment should ensure that all the specific outcomes; critical cross-field outcomes and essential embedded knowledge are assessed.

The specific outcomes must be assessed through observation of performance. Supporting evidence should be used to prove competence of specific outcomes only when they are not clearly seen in the actual performance.

Essential embedded knowledge must be assessed in its own right, through oral or written evidence and cannot be assessed only by being observed.

The specific outcomes and essential embedded knowledge must be assessed in relation to each other. If a qualifying learner is able to explain the essential embedded knowledge but is unable to perform the specific outcomes, they should not be assessed as competent. Similarly, if a qualifying learner is able to perform the specific outcomes but is unable to explain or justify their performance in terms of the essential embedded knowledge, then they should not be assessed as competent.

Evidence of the specified critical cross-field outcomes should be found both in performance and in the essential embedded knowledge.

Performance of specific outcomes must actively affirm target groups of qualifying learners, not unfairly discriminate against them. Qualifying learners should be able to justify their performance in terms of these values.

- Anyone assessing a learner against this unit standard must be registered as an assessor with the relevant ETQA.
- Any institution offering learning that will enable achievement of this unit standard or assessing this unit standard must be accredited as a provider with the relevant ETQA.
- Moderation of assessment will be overseen by the relevant ETQA according to the moderation guidelines in the relevant qualification and the agreed ETQA procedures.

**UNIT STANDARD ESSENTIAL EMBEDDED KNOWLEDGE**

The person is able to demonstrate a basic knowledge of:

- Basic safety requirements related to the propagation environment, tools and procedures.
- Basic hygiene requirements for the propagation environments.
- Growing media - wet and dry.
- Weeds, pest and diseases.
- The safe handling of hormone and Chemicals preparations (rooting powders and plant protection substances)

**UNIT STANDARD DEVELOPMENTAL OUTCOME**

N/A

**UNIT STANDARD LINKAGES**

N/A

**Critical Cross-field Outcomes (CCFO):**

**UNIT STANDARD CCFO IDENTIFYING**

Problem Solving: Relates to all outcomes.

**UNIT STANDARD CCFO WORKING**
Teamwork: Relates to all outcomes.

UNIT STANDARD CCFO ORGANIZING
Self-Management: Relates to all outcomes.

UNIT STANDARD CCFO COLLECTING
Interpreting Information: Relates to all outcomes.

UNIT STANDARD CCFO COMMUNICATING
Communication: Relates to all outcomes.

UNIT STANDARD CCFO SCIENCE
Use Science and Technology: Relates to all outcomes.

UNIT STANDARD CCFO DEMONSTRATING
The world as a set of related systems: Relates to all outcomes.

UNIT STANDARD CCFO CONTRIBUTING
Self-development: Relates to all outcomes.

UNIT STANDARD ASSESSOR CRITERIA
N/A

UNIT STANDARD NOTES
This person should be able to function in a management position and should have the ability to make sound decisions regarding the operation as well as guide subordinates in the process of harvesting and related issues.

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