Facilitator Guide

Plant Propagation

Level 4

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Title:		**Propagate Plants in a Variety of Situations**					
Applied Title:		**Propagate Citrus Plants**					
Field:		Agriculture and Nature Conservation					
Sub-Field:		Primary Agriculture					
SETA (SGB):		AgriSETA					
Skills Area:		Propagation					
Context:		Citrus Production					
US No:	116316	**Level:**	4	**Credits:**	3	**Notional Hours:**	30
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Based on the Production Guidelines of:

Supported by:

Unit standard alignment and assessment tool development:
Cabeton Training and Development

Project coordinator:
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Directions

1. Learning Material

This guide has developed to assist the facilitator in presenting this unit standard. The guide contains all necessary material to ensure that the facilitator will be able to assist the learner to attain the competencies required by the unit standard.

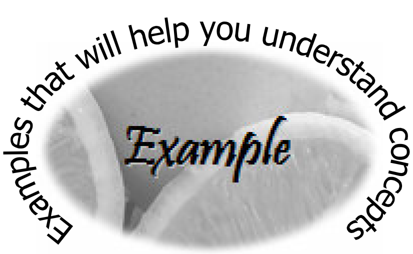
This set of learning material consists of the following guides:

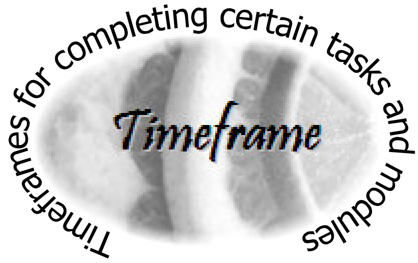
- ***Learner guide*** that contains all the information required by the learner to attain competency in this unit standard
- ***Facilitator guide*** that is a copy of the learner guide but contains additional instructions for the facilitator.
- ***Assessment Guide for Assessors and Facilitators*** that contains all the documentation needed by the assessor and facilitator to assess the competency of the learner against this unit standard.
- ***Assessment Guide for Learner and Learner Workbook*** that contains the documentation required by the learner to complete the assessment, along with the worksheets and practical exercises that the learner needs to complete as part of the formative assessment.

Please ensure that you are familiar with the contents of all of these guides before presenting this unit standard.

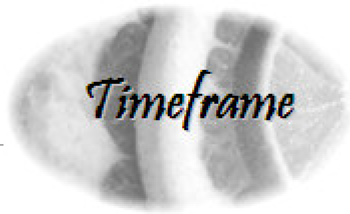
Although the learner and facilitator guide contains all the information required for attaining competency in this unit standard, references to additional resources (both printed and electronic) are provided for further study by the learner.

Information in boxes is indicated by tags that show:





2. Learning Program Timeframe



This is a summary of the timeframe for this learning program. You will be reminded of the time allowed for each module as you work through the guide.

Process	***Total Allocated Time***	***Theoretical Learning***	***Practical Learning***	***Activities***
Complete Program (Including summative assessment)	**30h**	**12h 15min**	**17h 45min**	**10**
Learner Orientation and Ice Breaker	30min	15min	15min	n/a
Purpose, Introduction and Learner Directions	30min	15min	15min	n/a
Revision of Level 3	45min	30min	15min	n/a
Session 1 (Chapter 1)	5h 30min	2h	3h 30min activities	2
Session 2 (Chapter 2)	7h	2h 30min	4h 30min activities	3
Session 3 (Chapter 3)	7h	2h	5h activities	3
Session 4 (Chapter 4)	6h 30min	2h 30min	4h activities	2
Preparation for Assessment and Revision	2h 15min	2h 15min		n/a

3. Technical Program Specifications

Format	Programmed instruction workshop, combined with structured internship format as prescribed for learnership, skills program or short course.
Target Learner Description	A typical level 4 learner should have been exposed to the working world for a reasonable period and should have a reasonable level of experience in the subject matter. **EE Ratios:** 1 Male:1 Female 8 PDI:2 W 1 Employed:1 Unemployed
Articulation Options	Nil formal in place
Delivery Mode	A combination of small group mode and individual mode

Training Method and Activities	**Program Instruction:** This program forms part of an apprenticeship where coaches provide practical training in the fields requiring functional competency. The theoretical study section of the training is conducted as a 4-day workshop in the Cohort group format. Additional training activities include buzz groups, rotating role-plays, simulations, games and brainstorming sessions, and group discussions.
Learner Support Strategies	Learners are inducted by "explore strategies to learn program". Learners are supplied with all resources and aids as required by the program, including: • Objects and devices such as equipment • Manuals and guides • Visual aids

Facilitator Tip

This unit standard is aimed at level 4 learners.

Typical level 4 learners:

- Have a broad knowledge base of the theoretical concepts related to the skills area.
- Have wide ranging scholastic and technical skills related to the industry and skills area targeted in this learning program.
- Are able to access, analyse, and evaluate information independently.
- Are able to operate in a range of contexts under broad guidance and evaluation.
- Are able to select from a considerable range of procedures in order to give quantity and quality output in terms of evidence required.
- Are able to give presentations to others.
- Take complete responsibility for the quality and quantity of their outputs and may possibly also be responsible for the output of others, meaning they are in a supervisory position, a member of junior management, or technical experts in their field.

The examples given in this resource guide might be for a different geographical area or commodity to what the learner is exposed to. Please adapt your examples according to the learning context.

4. Facilitator's Checklist

Facilitator Tip

This checklist has been designed to assist you in delivering the best possible facilitation to the learners. Please use it and supply whatever resources you might have in short supply at your venue of learning.

Preparation	***Yes***	***No***
Content Knowledge I have sufficient knowledge of the content to enable me to facilitate with ease.		

Preparation	***Yes***	***No***
Application Knowledge I understand the program matrix and have prepared for program delivery accordingly.		
Ability to Respond to Learners Background and Experience I have studied the learner demographics, age group, experience and circumstances, and prepared for program delivery accordingly.		
Enthusiasm and Commitment I am passionate about my subject and have prepared my program delivery to create a motivating environment with real commitment to success.		
Enterprise Knowledge I know and understand the values, ethics, vision and mission of the Citrus Academy and the service provider under whose auspices the program will be conducted, and have prepared my program delivery, reporting and administrative tasks accordingly.		
Equipment Checklist:		
Learner Guides: 1 per learner		
Learner Assessment Guides: 1 per learner		
Writing material and stationery for facilitator and learner		
White board and pens		
Flip chart paper		
Proxima projector and screen		
Notebook computer and program disk		
Documentation Checklist:		
Attendance register		
Course evaluation		
Learner course evaluation		
Portfolios of evidence		

5. Proposed Floor Plan

No floor plan is prescribed for this training module.

Introduction

1. Purpose

A learner achieving this 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.

2. Learning Assumed to Be in Place

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

NQF Level	***Unit Standard Number***	***Unit Standard Description***
NQF3	Literacy and Numeracy	
3	116220	Explain the propagation of plants
3	116218	Explain the planning and scheduling of tasks in a production environment
3	116214	Interpret factors influencing agricultural enterprises and plan accordingly
4	116295	Demonstrate a basic understanding of the physiological processes in plant growth and development

Facilitator Tip

It is important to ensure that the learners who are undertaking this learning program has already completed the correct prior learning modules, to ensure that they are not unfairly disadvantaged by the learning process, and can be supported accordingly.

Do not forget to complete the Diagnostic Assessment (Step 3 in the Assessment Guide).

Revision of Level 3

Timeframe

You have to complete this section as follows:

Total time	***Theory***	***Practical***
45min	30min	15min

Facilitator Tip

Utilise this opportunity to determine the knowledge levels of the learners and to identify learners who might not have the required level of knowledge. This will assist you in identifying areas in the learning program where additional time will have to be spent. Encourage participation from learners and remind them to share their knowledge and experience with the rest of the group.

1. Function of Environmental Conditions

- Environmental conditions impact on the growth rate of plants, by mostly impacting on two metabolic processes, being photosynthesis and respiration, or transpiration.
- During photosynthesis, the plant absorbs CO_2 and water, and uses heat to manufacture sugars (carbohydrates), oxygen, and water molecules.
- During respiration O_2 from the air is used to break down carbohydrates in the plant into energy that is used by the plant, CO_2 that is released into the air, and water molecules that are dispersed from the surface of the leaf.
- When the moisture in the surrounding air increases, plant transpiration decreases and light intensity influences transpiration through leaf surface temperature.
- Three classes of environmental conditions impact on plant growth, being atmospheric conditions, biotic conditions and edaphic conditions.
- Atmospheric conditions refer to light, humidity, temperature, water and aeration.
- Seed germination is activated by increased light intensity and light impacts on the rate of photosynthesis and respiration. Fluorescent lights are used in germination rooms to promote seed germination, and natural light is used in tunnels and shade houses.
- Relative humidity impacts on the transpiration rate of plants.
- Temperature impacts on photosynthesis and respiration rates. Germination requires relatively high temperatures, with a range of between 27°C and 32°C, with an average of 29°C being considered optimal.

- Water plays a role in keeping the plant cells turgid, as a catalyst in biochemical reactions in the plant, and in the translocation of manufactured compounds.

- Aeration in the leaf and root areas allows gaseous exchange that ensures that growth and development take place normally.

- Biotic conditions refer to bacteria, fungi and viruses in the rhizosphere, insects and weeds.

- Certain types of bacteria, fungi and viruses in the root-zone are beneficial and have a positive impact on the growth of the plant, while others are non-beneficial and have a negative impact.

- Insects are also classified as beneficial and non-beneficial. Examples of beneficial insects are *Aphytis lingnanensis*, *Chilocorus nigritus*, and *Cryptolaemas montrouzieri*, while non-beneficial insects include red mites, red scale, mealybugs, aphids, leafminer, and thrips.

- Weeds negatively impact on the growth of seedlings because they compete for water and nutrients.

- Edaphic conditions refer to physical and chemical properties of the growth medium in the root-zone, and the properties of the container in which the plant is grown.

- Soilless media that are also used in nurseries include pine-bark, sawdust, peanut shell, river sand, composted organic material, and ash.

- In terms of propagation, physical growth medium properties refer to the texture, structure and aeration of the soil. Soil depth and stratification are controlled in the nursery environment.

- Chemical growth medium properties are those characteristics that cannot be seen or felt, but influence reactions that take place in it and include the pH, salinity, and potential gas exchange reactions.

- Container properties are determined by the material used for the containers in which plants are grown.

2. Monitoring Environmental Conditions

- Biotic and edaphic conditions are not likely to change quickly, but atmospheric conditions can change in a short space of time and must therefore be monitored.

- Light is not generally monitored in citrus nurseries, but can be measured by a light-meter.

- Humidity and temperature is monitored using a battery operated Hygro-Thermograph meter.

- Tensiometers and irrometers are used to measure soil moisture content, while laboratory analyses are used to monitor water quality.

- Unforeseen changes in atmospheric conditions are mostly due to changes in weather conditions.

- Records are kept of atmospheric conditions and of all actions that are taken in the nursery.

3. Propagation Procedures

- Budding is a form of grafting, where a bud from a selected tree is inserted into a rootstock seedling to produce a tree.

- The choice of the rootstock depends on predictable performance in environmental conditions in the orchard, resistance or tolerance to diseases, compatibility with the scion, market entrance timing in relation to time to maturity, and internal fruit quality.

- Rootstocks are produced through seed propagation and because losses of seedlings occur due to a variety of reasons, double the amount of seed is sown.

- Rootstock seedlings are planted in seedlings trays and then transferred to larger containers three to four months later.

- Rootstocks are always labelled carefully with the cultivar, planting date and transfer dates.

- Budding takes place about four to six months after the seedlings are transplanted.

- All bud-wood that is used in certified citrus nurseries in South Africa is provided by the Citrus Foundation Block.

- To promote a successful union between the scion and the rootstock, maximum contact between the cambiums of the rootstock and the scion is required.

- Their must be signs of active growth in the rootstock and the bud-piece from which the scion is taken.

- An inverted T-cut is made on the stem of the rootstock and the bud is inserted and secured with a polyethylene plastic strip.

- Sanitation and hygiene is essential for preventing contamination, and especially cutting tools must be sterilised properly.

- Budding knives and pruning shears are the main tools that are used during budding.

- Shoot tip grafting is another propagation method that is used to eliminate viruses in the plant material.

4. <u>Tools and Equipment</u>

- The tools and equipment used commonly in South African citrus nurseries are seed trays, seedling trays, watering cans, knapsacks, soil augers, jugs, spades, planting containers, mesh panels, hose pipes, stakes, collection bags, wheelbarrows, tying machines (tapeners), rakes, and leather gloves.

- Health and safety is addressed by the Occupational Health and Safety Act (OHSA), which prescribes that conditions that may threaten the health and safety of workers must be anticipated, recognised, evaluated, and controlled.

- Tools and equipment must be stored in clean and dry facility that is kept safe and secure.

Definition

<u>Propagation</u>

Propagation in citrus production refers to the multiplication of plant material that is of a specific cultivar and variety, and that possesses more desirable characteristics, such as yield, fruit size and shape and internal quality.

<u>Dormancy</u>

Dormancy refers to the ability of certain plant-parts, such as seeds, to suspend metabolic processes until ideal environmental conditions occur.

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 (O_2) and releases carbon dioxide (CO_2).
Photosynthesis Photosynthesis refers to the chemical reaction that takes place when the plant takes up CO_2, which combines with water molecules in the plant to produce carbohydrates, which is food for the plant. O_2 is released during this process.
Ovule The ovule is a small structure inside the ovary of a seed plant that contains the female reproductive cells inside the embryo sac, and which develops into a seed after fertilisation.
Embryo The embryo is a plant in its earliest stage of development before an organism becomes self-supporting. Once the embryo begins to grow out from the seed, or germinate, it is called a seedling.
Meiosis Meiosis is a type of cell division in organisms that reproduce sexually and results in cells with half the number of chromosomes of the original cell.
Rootstock Rootstock means the root or part of a root used for plant propagation. In reference to grafting, the rootstock is that part of a grafted plant that supplies the aboveground plant parts.
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 Apical dominance refers to powerful tip growth that suppresses the growth of lateral buds.
Osmosis Osmosis is the flow of water and other liquids through a semi-permeable membrane, such as the thin membrane underneath the shell of an egg, from an area with a low concentration of dissolved matter, such as salts, to an area with a high concentration of dissolved matter, so that the concentration imbalance is gradually evened out.

Diffusion 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.
Rhizosphere The rhizosphere, also referred to as the root-zone, is the soil zone that surrounds the roots of the plant. This zone influences the roots and is in turn influenced by the roots.
Edaphic The term edaphic means the effect of soil characteristics, especially chemical and physical properties, on plants and animals. For the purpose of this section, edaphic conditions refer to the properties of the growth medium, whether it is soil or another substance.
Propagules Propagules are the shoots, seeds, or other parts that plants use to spread or propagate, either sexually or vegetatively.

Chapter 1

After completing this chapter, the learner will be able to:

Propagate a variety of plant types using different asexual methods or processes

Timeframe

You have to complete this section as follows:

Total time	*Theory*	*Practical*
5h 30min	2h	3h 30min activities

Facilitator Tip

As preparation to this chapter it is important that learners have a good background of propagation methods used in the citrus industry. If possible arrange a visit or a demonstration where the different techniques are shown to learners. You can contact your local CRI extension officer for more information regarding propagation facilities in your area.

1. Introduction

Asexual propagation implies the use of vegetative plant parts to generate another plant which is true-to-type to the mother plant. Pure lines are produced using this method of propagation. The choice of method depends on the ease with which one can perform the operation and the associated cost.

2. Methods of Asexual Propagation

The choice of propagation method depends on the expected final product. The propagator has to work towards achieving what the grower desires. If desirable traits are lost or changed by a propagation technique, the method is unsatisfactory. Successful methods transmit all the desirable traits of the mother plant. Plants can be propagated asexually by:

- Grafting
- Cuttings
- Layering
- Tissue culture

2.1. Grafting

The most commonly used grafting method is the inverted T-cut budding method. Since this method has been discussed extensively in the previous modules, this section will describe other grafting methods.

Chip budding is another grafting method used in citrus propagation. It differs from the inverted T-cut budding method in that a larger portion of 'hard wood' is used when removing the bud from the bud stick. It is also done when the bark is not slipping, and requires slightly more skill than the inverted T-cut budding method.

The chip bud is cut while holding the bud-wood with the apical end toward the propagator. A thin slice of wood with a selected scion bud is removed by making a smooth upward cut just into the wood. A second cut is made at the top of the first cut, forming a notch.

A chip is removed from the stem of the rootstock to receive the cultivar. Only two thin lines of cambial tissue are available for healing on both the scion bud and rootstock, it is therefore important to match both sides whenever possible.

The scion is wrapped as described for inverted T-cut budding method. After the wrapping has been removed and the healing of the union has occurred, the bud must be forced to grow, again as described for inverted T-cut budding.

Grafting using a twig with two buds or more is another method that is used. This method is not commonly used in South African nurseries, but it is still used in other parts of the world, such as Morocco.

Top-working refers to changing the top of an established tree from one cultivar to another. The original scion is removed from the original rootstock part of the plant, leaving a stump. The stump is allowed to form new growth (shoots). A few of these shoots are selected and the new cultivar is budded onto these. Other forms of grafting, such as cleft grafting, are also used for top working.

2.2. Cuttings

Cuttings refers to when plant material in the form of a stem with at least two leaves is selected from a plant with desirable traits and propagated to become a separate pure-line individual. Cuttings are propagated in greenhouses under conditions of high humidity levels and high light intensity during the day.

Propagation through cuttings provides a faster way to obtain rootstock material when there is a shortage of seeds. It is also used to propagate certain rootstock varieties, such as Yuma citrange, that have a low percentage of nucellar seedlings and a high percentage of off-types.

Propagating a commercial cultivar by means of cuttings has a number of disadvantages, such as vulnerability to soil borne fungi, less adaptability to different soil types, and excessive tree vigour.

The following procedure is used:

- The selection and cut are made when active growth has slowed down, and the plant has accumulated a high level of stored carbohydrates.
- For best results, the cut is made at bud (node) level where the cambium is more active than at the internodes level. In the case of rootstock cuttings, the whole upper part of the budding point is simply taken and sectioned as desired.
- The cutting must be planted within 30 minutes from the first cut. Since the area of selection is generally not the greenhouse where cuttings are to be rooted, the cuttings have to be stored in a cool environment such as a cooler-bag to reduce the transpiration rate and moisture-loss while in transit and during subsequent handling stages.
- Once in the rooting area, the leaves are trimmed to less than half their surface area.
- The whole cutting is soaked in a fungicide mix (Benlate and Captab) for about one minute.

- The cutting is allowed to dry slightly and the moist lower end is then dipped in a growth hormone such as IBA (Indolebutyric Acid or Seradix B). The propagator must ensure that the cutting is not overly wet when it is dipped in IBA.

- The cutting is planted in wetted medium. The medium must be sterilised, able to drain excess water easily, and must be porous to allow gas exchange in the soil. Ordinary composted pine bark (12mm) can be used as a medium.

After planting into the cavities or plugs, the wounded surfaces have to heal, or callus, quickly to avoid losing moisture. Callusing takes place when suberin, tannin and other compounds are manufactured. These in turn produce an elastic substance that prevents water from escaping and pathogens from entering. The cambium callus develops into a growth point for adventitious roots.

The rooting rate is influenced by the stem to leaf ratio as this affects the rate of transpiration. Transpiration rate should preferably be low, and the leaves therefore have to be trimmed and kept cool to attain turgid cells.

Maintaining high humidity and high light intensity is essential for rooting the cuttings. A fogging or misting unit is required for this purpose, and the structure must be able to provide additional heat units if required. Soil or rooting medium temperatures in the region of 25°C are ideal. During the rooting period, the fogging or misting frequency is gradually reduced.

The water holding capacity of the medium must be taken into account. Excessive water supply, or a water-saturated medium, leads to reduced levels of O_2 and reduced root formation. The medium must freely drain excess water. Draining water will take with it most nutrients found in solution.

The condition of the plants must be monitored and corrected with foliar feeds if need be.

With developed roots and active shoots, the cutting grows to a plant that can be transplanted after five to six weeks. The hardening off process consist of gradual reduction of humidity and fog or mist until the plants no longer require moisture on the leaves to prevent wilting.

2.3. Layering

Layering is another method that can be used to propagate citrus. Roots are induced to develop from stems while these are still attached to the tree. The rooted stems are then cut and placed in containers or directly into the ground as trees. This method is used mainly on bigger branches. Commercially, this method is not used in the citrus industry.

2.4. Tissue Culture

Tissue culture concerns reproducing plants in a sterile and aseptic environment by using portions from a mother plant that has the desired characteristics. Laboratories are the best environments for such operations. The plant part that is to be used for the multiplication is selected and extracted. The reproduction process is initiated by placing the plant part in a prepared medium.

In citrus, this method is used for virus indexing and / or cleaning a plant stock of any known and unknown pathogens, such as the Tristeza virus and the Exocortis bacteria.

A budstick from a candidate plant is disinfected and placed in a medium under sterile conditions with adequate light and temperature to induce bud emergence. The apex containing the meristem is extracted and grafted onto a rootstock grown in dark conditions two weeks before.

Troyer rootstock is for example the most sensitive to Exocortis and will be therefore used for screening the pathogen in the budstick. The same procedure is used for Tristeza virus indexing.

In some citrus producing areas in the world, rootstocks that have a low rate of polyembryony are propagated using this method. One such case is the reported in vitro multiplication of the Chinese mandarin as a rootstock in France. Using this process, the rootstock is propagated commercially on a large scale and sold to producers.

Definition

Polyembryony

Polyembryony means the formation of more than one embryo in a plant seed.

Despite such reports, the use of this technique for mass propagation of citrus plants is limited to regeneration and proliferation of cultivars that have high economic potential, but are in danger of being lost due to disease or ecological factors.

3. Asexual Propagation for Other Plants

Facilitator Tip

By teaching the learners propagation methods used when cultivating other plants, we aim to broaden the scope of their knowledge. Initiate a group discussion where learners are allowed to share their own knowledge and experience on other propagation methods. As the question: what can citrus propagation learn from these methods?

Different types of plants are propagated using different methods and different plant sections. Here are a few examples:

- **Strawberry** plants are propagated using its aerial stem, referred to as runner. A section of the runner is cut and rooted to produce another plant.
- Plants of the **lily** family, which includes onions, are propagated using the bulb, which is a shortened stem with thick and fleshy leaves. Bulbs are allowed to generate roots and develop into plants.
- **Bananas** can be propagated by means of offshoots, which are lateral shoots developing from the stem, also referred to as suckers. In commercial banana propagation, tissue culture is used because it provides a much higher yield and better plant uniformity, as well as freedom from diseases.
- **Litchis** are propagated through air layering, which is the regeneration of a vegetative part while still attached to the plant.
- **Grape-vines** are propagated through cuttings, which is a method that differs from layering by the fact that the vegetative part being regenerated is detached from the plant.

Plants in all these categories are also commercially reproduced through tissue culture.

4. Use of Hormones for Asexual Propagation

Hormones in plants are referred to as **plant growth substances**. These substances are produced by the plant in low concentrations and transported to locations within the plant where they are used. Plant growth substances include auxin, cytokinin, gibberellin, abscisic acid and ethylene, and all play an important role in the physiology of the plant.

Artificial hormones are synthetically produced chemicals that induce similar reactions to the naturally occurring hormones in the plant. Hormone treatments are used in citrus propagation only for the rooting of cuttings. The composition of naturally-occurring auxins responsible for adventitious root initiation was determined, with Indole-3-acetic acid (IAA) identified as the main compound promoting this process.

Two major shortcomings are associated with naturally-occurring IAA. Firstly, the low concentration produced at a time makes it insufficient for rooting cuttings in time. Secondly, because the site of hormone production is not the site of action, it is likely that a cutting might not have sufficient hormones at the right site to induce rooting.

Parallel to the identification of IAA, it was established that synthetic products IBA and Naphthalene acetic acid (NAA) were much more effective in adventitious root initiation and development. In propagation through cuttings, IBA is commonly used, and initiates through a series of bio-chemical reactions the transformation of the callus into the root primordial which will develop into roots.

Other hormones such as cytokinin and gibberellin are used for cell growth and differentiation, and stem elongation respectively. These hormones are produced naturally by the plant in sufficient quantities to carry out these physiological processes.

5. Sanitary Measures in Propagation Procedures

Sanitation in the propagation of citrus is highly important for the survival of the industry. Any person embarking on this activity has to follow the strict regulations set in place by the Citrus Improvement Programme (CIP).

The first line of defence against contamination is to isolate or strictly control access to the propagation area. Those that have access to this area have to be given clear guidance on how to remain 'clean' and free from any contaminants.

Tools used for propagation purposes should be dedicated to specific areas and operations, and not interchanged. Propagation tools must be disinfected on a regular basis, and stored in a clean, dry area.

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Chapter 1

- Asexual propagation implies the use of vegetative plant parts to generate another plant which is true-to-type to the mother plant.
- Citrus is propagated asexually by grafting, cuttings, layering, and tissue culture. The choice of propagation method depends on the expected final product.
- The most commonly used grafting method is the inverted T-cut budding method. Chip budding, using a twig with two buds or more and top-working are other grafting methods that are used for citrus.
- Cuttings refers to when plant material with desirable traits is selected and propagated to become a separate pure-line individual.
- Layering is when roots are induced to develop from stems while these are still attached to the tree.

- Tissue culture concerns reproducing plants in a sterile and aseptic environment (laboratory) by using portions from a mother plant that has the desired characteristics.
- Different types of plants are propagated using different methods and different plant sections.
- Hormones in plants are referred to as plant growth substances and are produced within the plant in low concentrations and transported to other locations within the plant where they are used.
- Citrus propagators have to follow the strict regulations set in place by the Citrus Improvement Programme (CIP).

Practical

Complete activities 1 and 2 in the **Learner Workbook**.

Facilitator Tip

<u>Activity 1 – Research Project</u> Remind learners about the resources that they can consult during their research. Explain to that they are expected to reflect their own understanding, and not to simply rewrite the research information. **Timeframe:** 2h
<u>Activity 2 – Research and Discover</u> Assist learners with contact details of a local nursery, or assist them to arrange a group visit. **Timeframe:** 1h 30min

Chapter 2

After completing this chapter, the learner will be able to:

Recognise and use propagation structures, facilities and materials under supervision and do independent problem solving in relation to processes

Timeframe

You have to complete this section as follows:

Total time	***Theory***	***Practical***
7h	2h 30min	4h 30min activities

Facilitator Tip

As preparation for this chapter ask learners to identify propagation structures in their workplace or in a workplace that they are familiar with. Hold a group discussion around these structures and their suitability for citrus propagation. Continue this discussion as you facilitate the chapter, asking learners to highlight areas where structures can be improved.

1. Introduction

The propagation of citrus can be seen as a natural process that is undertaken in modified, controlled environments in order to enhance the natural process. These modified environments take into account the immediate surroundings and the requirements for citrus propagation. Structures are established to create environments that can be modified and controlled.

2. Propagation Structures

For citrus propagation in South Africa, the Citrus Improvement Programme (CIP) guidelines promote propagation in containers. Container propagation makes use of various structures before the tree is finally planted in the land, including:

- Germination rooms
- Greenhouses
- Shade-houses

2.1. Germination Rooms

Seed trays that have been sown with citrus seeds for the production of rootstocks are placed in germination rooms, where they stay until the seedlings have developed and are ready to be transplanted into individual cavities.

Germination rooms are permanent buildings, simply built with raised walls that are plastered and painted. The standard size for a germination room is 3m x 2m with a ceiling height of 2.5m. A germination room is laid out to retain heat, to allow very little air circulation, and to easily build up and maintain humidity.

Germination rooms are equipped with fluorescent lights as a source of red light, which promote germination.

2.2. Greenhouses

Greenhouses, also referred to as tunnels, are the next structure which the citrus seedlings are taken to in the propagation line. Greenhouses are built in such a way that plant growth and development are promoted and accelerated.

Materials used to build the greenhouse should take into account the environment in which the structure will be built, and the environmental requirements of the plants. If the greenhouse is to be built in a location that is known to be windy, provision must be made to strengthen the structure to withstand wind. If the structure is to be built in conditions that are generally humid, special corrosion-resistant material must be used. At the same time, the design and material used in the greenhouse must contribute to creating the ideal environmental conditions that promote plant growth.

A greenhouse has a metal framework that is built from steel or aluminium that is rust and corrosion resistant. The framework is covered with ultraviolet (UV) resistant polyethylene sheeting. Initially glass was used for covering the metal framework. Now several different plastic materials can be used, but the best results, in terms of lifespan and light penetration, have been obtained with 100 micron UV resistant cross-woven polyethylene.

Greenhouses provide a more favourable environment than the outdoors. The propagator is not at the mercy of nature's extremes in as far as temperature is concerned, and propagation and plant production can take place year-round. With the use of control systems, temperature is controlled to allow normal respiration, even when photosynthesis is reduced, commonly in cloudy weather.

Plants are grown closer together in greenhouses resulting in an increased density per surface area. If water-supply is not a limiting factor, light becomes the most important factor as it relates to photosynthesis. With increased light intensity, coupled with increased relative humidity (rh), comes a reduction in the rate of transpiration as CO_2 diffuses rapidly into the leaves increasing the rate of photosynthesis.

Cooled air ensures that the environment is cooled off and increases light intensity. This reduces the respiration rate resulting in less carbohydrates being used up for respiration and more being available for plant growth. Greenhouses can be equipped to humidify the air when required. Air movement also helps to avoid high temperatures and high levels of CO_2. The propagator must constantly check the balance between heat build-up and the availability of CO_2 for plant growth.

The following equipment is used for this purpose:

- A wet-wall on one side of the greenhouse, or tunnel, made up of a honeycombed cellulose pad, perforated PVC pipes that run water through the wall, a pump, and a shallow tank.
- A set of extractor or exhaust fans on the other end of the tunnel, that pull air from outside the greenhouse through the wet wall which cools and humidifies the incoming air and at the same time removes the 'old' warm air out of the tunnel.
- An irrigation system and tables or beds where plants are to be placed.
- An automated control system that regulates the temperature, aeration, and light intensity by using ceiling curtains.

Figure 2.1 shows a greenhouse where the wet-wall is at the far end. The extractor fans will therefore be behind the photographer.

Figure 2.1: Seedlings in a Greenhouse

2.3. Shade-Houses

Shade-houses are where young citrus trees are kept before being sent to the farmer to be planted in the orchard.

Shade-houses have frameworks built from wooden or metal poles and are covered with shade-cloth on the top and the sides. They generally have flat tops.

Shade cloth is available in different colours and shading percentages. The most commonly used in the South African citrus industry are black and white nets. Depending on the area, the percentage of shading varies between 30% and 50%.

Plants under shade cloth are reasonably protected from harsh environmental conditions. Aeration is passive as the wind speed is reduced. The main concern is the transpiration rate. At high light-intensity, the temperature in the shade-house increases and the relative humidity decreases. Keeping the cells of the plant turgid becomes the main goal. The choice of shading percentage is influenced by this goal. The ideal environment is where light-intensity is reduced, which in turn reduces the temperature and increases humidity.

All shade-houses are equipped for irrigation and fertiliser application, and have access points for pest and diseases control systems.

Figure 2.2: Young Trees in a Shade-House

3. Potential Problems with Structures

Structures are used to provide an environment that is and remains easily controllable. Should any structure lose this property, it becomes less useful to the propagator and economic losses may occur. Potential faults may occur with the control devices, such as probe malfunction, or as a result of the wrong interpretation of information that has been relayed by a machine, or with the structure frame itself.

Propagation structures are generally held together with links and joints, and these can come loose. The links and joints and the generally stability of the structure must be checked regularly.

Tears or cuts in the covering material, whether it is the polyethylene sheeting of greenhouses or the shade-cloth of shade-houses, results in unwanted changes of the environmental conditions in the structure. Plants are exposed to harsher conditions with increased probability of damage to the plant.

Greenhouses are at greater risk. Fans and wet-wall malfunctions spell disasters of bigger proportions. Temperatures can quickly reach levels where plants cannot continue normal metabolic processes, resulting in severely wilted plants which are the result of low photosynthesis rate. Poor aeration can also lead to a drop in the CO_2 level, limiting photosynthesis. High respiration rates are required, with a constant supply of O_2 and CO_2.

The selection of the wrong covering material for a shade-house can result in poor light intensity during a specific time of the year. Light is filtered before reaching the plants. The location and season are important factors that determine the quantity of light received. From October to March the light intensity is high, with the peak reached in January. From April to September, the intensity is classified as moderate with the lowest intensity recorded in June.

Higher shading percentage might be good for the high intensity months, but may result in insufficient light during the low intensity period. In areas such as Letsitele, the propagator has to ensure that there is sufficient light during the month of August for growth as the plants come out of the winter.

4. Propagation Media

Different media are available for citrus propagation, ranging from natural coarse river sand to exfoliated vermiculite, which are available in fine, medium and coarse grade. The choice of the medium is determined by the propagation method and the economics of the particular media.

The success or failure of a propagation activity can be influenced by the medium used and how this medium is handled. The quality of the materials used to formulate propagation media is very important. The materials must be consistent in quality, free from all pathogens and must provide an appropriate balance between air and water in the medium.

In any growing medium, the space not occupied by solids constitutes pore space which is utilised partially for holding water, and partially to provide air for the plant roots to function normally. An absence of either is injurious to the plant.

Oxygen is essential to healthy root activity, and it is important that it is available in sufficient volumes. After saturating a growing medium with water and after drainage has ceased, there will be a portion of the pore-space occupied by air. In field soils and sand seedbeds, values of 5% or more are usually considered favourable. In container media, values of 15% to 25% are desirable, while citrus is propagated best in media with porosity ranging from 14% to 20%.

The smaller the pores of the growing medium are, the greater the water retention and the lower the air supply will be. Conversely, the larger the pores, the less water retained and the greater the amount of air space in the mixture.

The quantity of water held in a growing medium is best measured on a volume percentage basis and expressed as water holding capacity (WHC). Different media have different WHC. Sand has larger pores and lower WHC, vermiculite generally has a higher WHC, but the coarser the particle size, which depends on the grade, the less water is retained.

The most commonly used media in the South African citrus industry is composted pine bark, followed by coarse river sand. While seeds are germinated in medium grade vermiculite, most of the roots are developed in pine bark. Shredded coconut fibre can also be considered as an option. Sterilising pine bark before it is used for the first transplanting is recommended.

The best and most economic way of sterilising growth media is through steam sterilisation. The bark is treated with hot steam, produced by boiling water. The temperature in the medium while being treated must be raised to a minimum of 90°C. Steam sterilisation is harmless, effective, and inexpensive compared to chemical treatments, such as Methyl bromide applications.

Figure 2.3: Facility Used for Sterilising Pine Bark by Using Steam

Other media include peat moss, sedge peat, composted sawdust, perlite, and rockwool.

5. Growing Media Mixes

Propagators of citrus trees in different parts of the world make use of mixtures to form the final growing medium for the plants to be raised in.

In Australia, for instance, propagators frequently use mixtures of peat and sand constituents for raising trees, for instance 3 parts peat and 1 part sand or 1 part peat and 1 part sand. In other places, such as Egypt, mixes of 1 part sand, 1 part sawdust, 1 part peat, have been used successfully.

Sand is too heavy for use in small cells and other propagation containers. This promotes the use of lightweight materials, such as perlite and vermiculite. The extraction of root systems from cell and plug trays can be difficult where sand is used as a constituent of the mix. This leads to the medium separating from the root system and may cause excessive transplant shock.

For propagation through cuttings, because of the high mist frequency, the ideal mixture or medium is the one that has maximum porosity and minimum WHC.

Facilitator Tip

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Summary

Chapter 2

- The propagation of citrus can be seen as a natural process that is undertaken in modified, controlled environments in order to enhance the natural process.
- Container propagation makes use of various structures before the tree is finally planted in the

land, including germination rooms, greenhouses, and shade-houses.

- Seed trays that have been sown with citrus seeds for the production of rootstocks are placed in germination rooms.
- Greenhouses are built in such a way that plant growth and development are promoted and accelerated.
- Shade-houses are where young trees are kept before being sent to the farmer to be planted in the orchard.
- Structures are used to provide an environment that is and remains easily controllable.
- Potential faults may occur with the control devices or as a result of the wrong interpretation of information that has been relayed by a machine, or with the structure frame itself.
- Different media are available for citrus propagation, ranging from natural coarse river sand to exfoliated vermiculite.
- The most commonly used media in the South African citrus industry is composted pine bark, followed by coarse river sand.
- Propagators of citrus trees in different parts of the world make use of mixtures to form the final growing medium for the plants to be raised in.

Complete activities 3, 4 and 5 in the **Learner Workbook**.

Activity 3 – Worksheet

Remind learners to base their answers on their own workplace and experience, and to reflect their own understanding.

Timeframe: 30min

Activity 4 – Site Visit and Report

Assist learners in arranging the site visit, if necessary. Give an opportunity in class to discuss their experiences after returning from the visit, before they complete the written assignment.

Timeframe: 3h

Activity 5 – Report Writing

Allow time for a discussion on these conclusions, before the learners complete the written assignments. Remind them to reflect their own understanding and conclusions.

Timeframe: 1h

Chapter 3

After completing this chapter, the learner will be able to:

Experiment with different types of propagation media and environments

Timeframe

You have to complete this section as follows:

Total time	***Theory***	***Practical***
7h	2h	5h activities

Facilitator Tip

As preparation for this chapter ask learners to bring samples of different propagation media used in their workplace. Use these samples throughout the facilitation of this chapter and discuss each sample's strengths and weaknesses.

1. Introduction

'Propagation media' is a term that means more than just one standard growing medium. There are several combinations of material used to host plants in containers or seedbeds. Depending on the needs, the propagator identifies the product best suited to his or her environment to produce the best trees possible.

2. Role of Artificial Propagation Media

Propagation media are a major component of the whole operation as they host the roots that feed and stabilise the plant. Most media are made-up to meet specific requirements, and can therefore be considered to a certain extent as artificial, as opposed to natural.

For a plant to feed easily, the medium must retain and make available enough water. The medium must also have the capacity to retain nutrients and make those readily available to plant roots when required. Technically this is referred to as the cation exchange capacity (CEC) of the medium. Mediums that are dense, with small pores, inhibit water movement and make it more difficult for the plant to take up nutrients.

The other extreme is an excessively porous medium, which is a medium closer to natural coarse sand. Water leaches most nutrients from such a medium, making the nutrients unavailable to plants. Slow release fertiliser can be used with such a medium, together with closely monitored water application.

Seedlings have to be able to develop a root system that will later sustain the plant throughout its entire lifespan. The medium has to provide as little resistance as possible to the developing roots. However, the medium must be firm enough to hold seedlings and cuttings in place.

The range of media used includes:

- Composted pine bark
- Sand
- Vermiculite
- Perlite
- Peat moss
- Coconut fibre

Besides the considerations mentioned earlier, the propagator must take the following into account:

- Does the medium require any additional sterilisation? Can it be sterilised? At what cost?
- Is the salinity level of the medium acceptable?
- Is the medium free of contaminants such as weeds, nematodes and pathogens?

Sawdust is not recommended in the South African context, because of its property to compact quickly and reduce pore-space.

3. Problems with Propagation Media

Poor irrigation scheduling can lead to the alteration of the physical properties of the medium. Media that have a high WHC are less stable, can cake easily and form a crust preventing water from penetrating, resulting in roots being starved of water and nutrients.

Pine bark is particularly susceptible to poor irrigation scheduling. If kept dry for too long, compounds such as cellulose and tannins found in the medium coat the bark particles and prevent it from retaining water.

The medium must be suitable to the environment where propagation is taking place and to the method that is used. Cuttings require a medium that allows roots to penetrate easily. In some cases, roots fail to penetrate in the medium and lift the cutting from its initial position. Plants produced under such conditions require special attention when transplanted in the container during the following stage.

If cuttings are propagated under mist, they require a medium that has a higher air-filled porosity to prevent moisture saturation in the root-zone.

4. Effectiveness of Different Processes

Different processes are used to obtain propagation media. Some processes use organic material and transform it into growing medium through composting, while others combine different materials to make up a medium that suits the needs of the propagator.

In South Africa, the cost of materials used in different mixes is high. Imported materials, such as peat, make combinations an expensive option.

Composting requires knowledge of the decomposition processes of the materials used. Most important is the final ratio of carbon to nitrogen to avoid nitrogen immobilisation, which translates to nutritional problems for the plant. A ratio of between 25 and 40 is preferred.

If done correctly, composting is the best economic option. Bark is available at a reasonable price and the supplier constantly looks for ways to improve the product. Planted containers with bark also weigh less than those with sand, and plants develop a good root system.

5. Successful Versus Non-Successful Propagation Media and Environments

Propagation is considered successful if the medium remains clean and free from contaminants up to the end of the process when the tree is planted in the field. Successful propagation with regards to medium also means producing strong and healthy trees with good healthy roots that are evenly spread in the medium.

Unsuccessful propagation relates to the plant not developing to its potential due to contaminants preventing the roots to develop properly. Infected medium will in turn infect the roots of the plant and weaken it. The final product will be of inferior quality.

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Chapter 3

- Propagation media are a major component of the whole operation as they host the roots that feed and stabilise the plant.
- The range of media used includes composted pine bark, sand, vermiculite, perlite, peat moss, and coconut fibre.
- The medium must retain and make available enough water, and have the capacity to retain nutrients and make those readily available to plant roots when required.
- Other considerations when choosing a medium is sterilisation, salinity, and freedom from weeds nematodes and pathogens.
- Poor irrigation scheduling can lead to the alteration of the physical properties of the medium.
- The medium must be suitable to the environment where propagation is taking place and to the method that is used.
- Different processes are used to obtain propagation media, such as using organic material and transforming it into growing medium through composting or combining different materials. If done correctly, composting is the best economic option.
- Propagation is considered successful if the medium remains clean and free from contaminants up to the end of the process when the tree is planted in the field.

Complete activities 6, 7 and 8 in the **Learner Workbook**.

Facilitator Tip

Activity 6 – Worksheet Remind learners to reflect their own understanding. **Timeframe:** 30min
Activity 7 – Research and Discover If necessary, assist learners to gain access to resources to conduct this research. Remind them not to merely rewrite the information that they find, but to reflect their understanding of the subject. **Timeframe:** 1h 30min
Activity 8 – Site Visit If necessary, assist learners in arranging the site visit. Remind them to take the questions along to ensure that they gather all the information they require. **Timeframe:** 3h

Chapter 4

After completing this chapter, the learner will be able to:

Establish a process for the post-propagation activities

Timeframe

You have to complete this section as follows:

Total time	*Theory*	*Practical*
6h 30min	2h 30min	4h activities

Facilitator Tip

As preparation for this chapter, ask learners to research post-propagation activities, especially the conditions under which a plant should be removed from the nursery or propagation structure and planted in the orchard. Use this information to guide you while facilitating, building on the information that the learners obtained.

1. Introduction

Propagating plants requires the understanding of different physiological stages that the plant faces before it goes into production. The propagator must have a good sense of timing to match the growth stage to the appropriate environment to achieve the best results.

2. Readiness for Transference to Next Phase

There are three different stages of transferring or transplanting citrus seedlings. The population density per surface area decreases from the seed germination stage in the germination room, to seedling trays in the greenhouse, to polyethylene bags in shade-houses.

For citrus, being a woody perennial plant, transplanting readiness is determined by the growth stage of the seedling and climatic conditions. In most citrus producing areas in South Africa, propagators wait until warmer weather after the winter to transplant seedlings to shade-houses.

For the first transplanting from the germination room to the greenhouse only the growth stage and size of the seedling is considered and climatic conditions can be overlooked because the greenhouse will provide the required environment. In the germination trays the propagator generally looks for seedlings that have developed at least three differentiated leaves to be transplanted. This stage is reached between three to five weeks after sowing the seeds and when the seedling is about 5cm tall.

Once transplanted into seedling trays, each seedling occupies a cavity, or plug, filled with growing medium. The seedling generally remains in the seedling tray for three to four months, but no longer than six months, depending on the season, the cultivar, and the space available in the shade-house. Under normal conditions temperatures of between 27°C and 32°C are maintained in the greenhouse, and, given high light intensity and high relative humidity of about 90%, the seedling will have developed to a height of about 15cm to 20cm.

Seedlings and cutting plantlets are transferred to a hardening off area before they are planted out to bigger containers in the next stage.

3. Pests and Diseases

Facilitator Tip

Ask learners to gather physical samples of pests and diseases that occur in their workplace. By hand of the information below, initiate group discussion where learners are ask to identify the pests and disease samples and discuss their impact in a propagation environment.

For the citrus propagator, pests and diseases are of major concern, especially pests and diseases that damage the foliage, wood and roots.

3.1. Foliar Damaging Pests

Foliage damaging pests are pests that cause encrustations on leaves, shoots and stems. They can be further classified into fast (1 to 30 days) damaging and slow (1 to 3 months) damaging pests as follow:

Fast Damaging Pests

- Orange Dog
- Thrips
- Aphids
- Citrus Psylla
- Looper
- Mites

Slow Damaging Pests

- Red scale
- Mealybug
- Slugs

3.1.1. Orange Dog

Orange dog is the larva of the citrus swallowtail butterfly. Well-developed larvae have a smooth, green appearance with a brown to black stripe on each side. The larvae feed on new flush and severe damage can be caused as the plant becomes exfoliated.

3.1.2. Thrips

Thrips are translucent orange-yellow in colour. The insects are wingless at the immature nymphal stages, with adults having two pairs of narrow wings. The damage caused by thrips is found on young tender shoots and leaves that are malformed, resulting in stunted growth. Thrips extract chlorophyll from the infested plant parts, which then become pale.

3.1.3. Aphids

Winged and wingless black and brown aphids secrete honeydew, which causes leaves to become covered with sooty mould. This in turn reduces the rate of transpiration and photosynthesis of the plant. Leaves malformation has also been associated with aphid damage.

The most worrying damage associated with aphids is its ability to transmit the tristeza virus that causes the tristeza disease in citrus. Trees infected with the disease die in the orchard even as soon as ten years after being planted.

3.1.4. Citrus Psylla

Citrus psylla nymphs are wingless and yellowish in colour. Adults have large and clear wings, and lay eggs on the edges of young, actively growing leaves. Symptoms of the presence of the pest are white deposits on leaves and deformation of young leaves, caused by the nymphs feeding on them. This damage affects tree vitality to a certain extent.

Citrus psylla however also transmits the bacteria that cause greening disease in citrus. Infected trees grow poorly, produce misshapen, small and sour fruit, and have leaves that are chlorotic.

3.1.5. Loopers

The citrus looper worm feeds on young and mature leaves of citrus plants, starting from the margins. Immature larvae have a different feeding pattern, first feeding on the upper and lower epidermis and then making holes in the leaves.

3.1.6. Mites

Red mites are oval-shaped, and feed on leaves and green bark of citrus plants. They prefer the upper surface of leaves, turning them grey, silver or yellow. This affects photosynthesis and transpiration rates.

Silver mites also have an oval-shape, but are flat, straw coloured and translucent. They damage the leaves, which become crinkled and may present with corky brown patches on the under-surface.

3.1.7. Red Scale

Red scale feeds off the sap of leaves, twigs and stem of the plant, reducing the vitality of the plant. The surface area for photosynthesis is affected and little chlorophyll is synthesised. Severe infestations lead to leaf drop and twig die-back.

3.1.8. Mealybug

Citrus mealybug is an oval, pale yellow insect covered by powdery white wax. Adults are slow moving and secrete honeydew and black sooty mould. Heavy infestations cause leaf drop and reduced photosynthesis rate.

3.1.9. Slugs

Slugs occasionally infest citrus seedlings. They mainly eat the leaves of orange and grapefruit trees. Rootstock seedlings occasionally get infested.

3.2. Wood Damaging Pests

Rodents feed on the bark of young citrus trees in the nursery. Severe infestations may lead to the trees drying up. When feeding on smaller seedlings, rodents can cut the stem off.

3.3. Root Damaging Pests and Diseases

The pest that causes root damage is nematodes, which feed on roots causing them to appear darker in colour. Rootlets become stunted, swollen and irregular in shape and appearance. Infested trees cannot tolerate stress and drought conditions.

Diseases of concern are root and collar rot caused by Phytophthora, damping off caused by amongst others Rhizoctonia, CBS (citrus black spot), greening diseases which is a bacterial disease transmitted by Psylla, and Tristeza which is a viral disease transmitted by citrus aphids.

Root and stem rot, as well as damping off, start in the nursery and generally express itself in the nursery before trees are planted in the fields. If the plant is infected at the end of the nursery cycle, the disease might not be detected in the nursery but rather express itself in the field.

Damping off is a seedling disease. It only occurs in the seedling stage of propagation, from germination until after the first transplanting.

Tristeza, black spot, and greening are generally field diseases, meaning that the symptoms appear long after the trees have left the nursery. Even if the disease was contracted in the nursery, there is a great probability that these will only be noticed in the field, unless specific analyses are done before the trees leave the nursery.

4. Phases of Propagation

Citrus is propagated in controlled environments form seed germination to taking out the budded tree for planting in the field. Factors such as light intensity, temperature, humidity and aeration are manipulated to create the most conducive environment for citrus propagation.

Each propagation phase has different environmental requirements and some factors are more important than others during different phases. In the germination phase, light intensity and quality, moisture levels, aeration, and temperature are the most crucial factors. Once the seed has germinated, the seedling requires enough humidity to support optimum transpiration.

Respiration and transpiration rates of the seedling determine the level of carbohydrates in the plant that can be used for growth. The more carbohydrates are used in the transpiration process, the less there is available to the plant for growth. Roots develop to ensure that the plant can sustain itself, absorbing water and nutrients, and anchoring the seedling in the medium.

The seedling development phase is therefore mainly characterised by humidity and light intensity control. Humidity levels, coupled with light intensity, influence the temperature in the structure and around the leaf surface area. High humidity reduces the temperature. The preferred temperature is between 20 and 27°C. Higher temperatures negatively affect the seedling.

During the shade-house phase, the plant is subjected to lower humidity and light intensity levels. The use of thermal sheets in the form of shade cloth to protect the plant from harsher environmental conditions of the immediate outdoor is the most important factor.

Ranging from 20% light reduction to near blackout condition (80%), the propagator selects the level that best suits the prevailing conditions of the area. The plant at this stage is acclimatised to fluctuations of environmental conditions.

From one phase to the next the propagator has to ensure that the transfer is done under optimum environmental conditions to avoid transplant shock.

5. Hardening-Off Process

Before the seedlings are transplanted in the shade-houses, and because of the differences in environmental conditions between the greenhouse and the shade-houses, seedlings are subjected to an acclimatisation process to soften transplant shock.

The seedlings stay for a minimum of a week in a facility where the humidity level is lower and the light intensity brought closer to the ambient surroundings. This leads to an accumulation of carbohydrates, increasing the ability of the plant to withstand its new environment and prevailing conditions.

For cuttings, hardening off begins in the structure where propagation takes place. The humidity level is gradually reduced. The rooted cuttings then become more self-sufficient in carrying out physiological activities such as water and nutrient absorption, photosynthesis and leaf development.

6. Possible Problems with Hardening-Off Process

Disease infested plants will display symptoms of the disease and, because of their reduced ability to survive on their own under harsher conditions, will most probably die. Should they survive, they will grow to become inferior trees. Plants with poorly developed root systems will display their inability to survive under harsher conditions during the hardening off process.

Reducing light intensity might lead to spindly and elongated plants. To correct this, an aluminium coated shade cloth (Aluminet) can be used to diffuse light.

With reduced humidity the plants might be losing too much water and carbohydrates through transpiration. If the situation is not corrected plants start to wilt, the extreme being the death of severely wilted plants.

Facilitator Tip

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Summary

Chapter 4

- The propagator must have a good sense of timing to match the growth stage to the appropriate environment to achieve the best results.
- For citrus, being a woody perennial plant, transplanting readiness is determined by the growth stage of the seedling and climatic conditions.
- Foliar damaging pests include fast damaging pests such as orange dog, thrips, aphids, citrus psylla, looper and mites, and slow damaging pests such as red scale, mealybug, and slugs.
- Rodents feed on the bark of young citrus trees in the nursery.
- The pest that causes root damage is nematodes, which feed on roots causing them to appear darker in colour. Diseases of concern are root and collar rot caused by Phytophthora, damping off caused by amongst others Rhizoctonia, CBS (citrus black spot), greening diseases which is a bacterial disease transmitted by Psylla, and tristeza which is a viral disease transmitted by citrus aphids.
- Each propagation phase has different environmental requirements and some factors are more

important than others during different phases.
- In the germination phase, light intensity and quality, moisture levels, aeration, and temperature are the most crucial factors. Once the seed has germinated, the seedling requires enough humidity to support optimum transpiration.
- Before the seedlings are transplanted in the shade-houses, seedlings are subjected to an acclimatisation process to soften transplant shock.
- Plants with poorly developed root systems will display their inability to survive under harsher conditions during the hardening off process.

Practical

Complete activities 9 and 10 in the **Learner Workbook**.

Facilitator Tip

Activity 9 – Flow Diagram

Remind learners to base their flow diagram on an actual nursery and not to view it as a theoretical exercise. Also remind them to include all the relevant steps in the propagation process.

Timeframe: 1h

Activity 10 –Research and Present

If necessary, assist learners to gain access to resources and facilities to conduct their research. Remind them of the literacy level of the target group for their presentation. Allow time for learners to do their presentations for the rest of the class.

Timeframe: 3h

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