The availability of this product is due to the financial support of the National Department of Agriculture and the AgriSETA. Terms and conditions apply.
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>ID Number</th>
<th>NQF Level</th>
<th>Credits</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Certificate in Animal Production</td>
<td>49048</td>
<td>3</td>
<td>120</td>
<td>☐</td>
</tr>
<tr>
<td>National Certificate in Plant Production</td>
<td>49052</td>
<td>3</td>
<td>120</td>
<td>☐</td>
</tr>
</tbody>
</table>

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:

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.

- **What am I doing?** 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.

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

- **How are we going to do this?** 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.

- **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.
# What are we going to learn?

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<tr>
<td>SAQA Unit standard</td>
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</tbody>
</table>
What will I be able to do?

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

- Supervise application of soil nutrient preparations in a safe, effective and responsible manner for the benefit of plant/crop growth with consideration to the environment.
- Gain specific knowledge and skills in soil and plant nutrition.
- 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:

- Sampling procedures.
- Chemical, properties of soil - pH, Nutrient status.
- Physical properties of soil - Texture, structure, soil profiles.
- Biological properties of soil.
- Soil ecology e.g. soil organisms, food webs, role of water and oxygen in soil.
- Soil health and conservation.
- Role of living organisms.
- Conservation practices - Runoff control, contours.
- Tillage operations - mechanical, non mechanical, organic, Minimum and zero Tillage and application of nutrients (liquid and solid).
- Primary and secondary soil preparation methods.
- Soil preparation and Fertilizer application equipment.
- Nutrients - Mixtures, limes, calcite and dolomite lime, single nutrients and compost, liquids, etc.
- Calibration of equipment.

What do I need to know?

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

- NQF2, Literacy and Numeracy
- NQF2, 116053, Understand basic soil fertility and plant nutrition
- NQF 3, 116269, Supervise the collection of agricultural data
- NQF 3 (F), 116269
Introduction

Preparing and Measuring Soil Nutrient Applications

♦ Plants need sunlight, water, air (oxygen and carbon dioxide) and nutrients in varying quantities to grow well and produce food. Nutrients are also called essential nutrient elements.

♦ To grow crop successfully, we need to know which nutrients are required, the quantities of nutrients required, the right time to apply them, and the best way to apply them.

♦ Essential nutrient elements are divided into macro and micro nutrient element groups.

♦ Essential nutrient elements play various roles in the physiological processes in plants, some of which are still not understood.

♦ Nutrients, or fertilizers, are applied through soil applications (manual or mechanical), foliar applications, and fertigation.

♦ Fertilizers can be from organic (natural or synthetic) or inorganic (chemical) sources. In commercial citrus production inorganic, commercial fertilizers are mostly used.

♦ Compost and manure are forms of organic fertilizers that are produced by allowing organic material to decompose.

♦ Commercial fertilizers are available in granular, powdered and liquid form.

♦ A fertilization program is developed to provide for the application of fertilizers that need to be applied during a specific period, usually a year.

♦ Soil and leaf analyses are used to guide the development of the fertilization program and to detect nutrient deficiencies and excesses.

♦ When the fertilization program has been developed, preparations are made for the fertilizer applications by calculating the total amount of fertilizer required, collecting the fertilizer from storage and measuring the fertilizer to determine the volume relative to the weight prescribed on the fertilization program.

♦ The total amount of fertilizer required is calculated by determining the number of trees in the orchard, and multiplying that with the amount prescribed per tree.

♦ When fertilizer is collected from the storeroom, the active ingredient and the weight of the bags must be checked.

♦ The volume of fertilizer that must be applied to each tree is determined by weighing the required amount. Scoops of the exact volume are made to be used during the application.
Fertilizers are applied manually by irrigating the orchard first to demarcate the area where the feeder roots are concentrated, and then scooping the correct amount of fertiliser and applying it to the wetted area.

Sampling for Nutrient Analysis

- A nutrient deficiency means that there is not enough of a specific nutrient for the plant to complete a physiological process.
- Nutrient deficiencies of each nutrient cause very specific symptoms.
- Nutrient deficiencies are confirmed by doing leaf and soil analysis.
- Fertilization programs cannot be developed in response to a detected nutrient deficiency as the deficiency would already have had a negative influence on the growth and production of the plant.
- Sampling and analyses are used as a diagnostic tool.
- Soil analyses are used to determine the chemical composition and nutrient content of the soil, and certain physical and chemical properties.
- Leaf analyses are used to determine the nutrient status of the plant.
- Fruit sampling is not used to determine the nutrient status of the plant in citrus production, but is only used for maturity indexing.
- Fertilizer samples are taken and analysed if there is uncertainty about the content of the container or the chemical composition.
- A sample must be representative of a unit.
- Sampling equipment must be washed thoroughly with clean water before being used.
- Leaf and soil samples must be taken at the same trees every time.
- Leaf samples are taken in South Africa between February and May before harvesting.
- Between 50 and 100 leaves must be taken for a leaf sample from fruit-bearing twigs.
- Soil samples are taken by combining a number of smaller samples, or sub-samples, and taking a sample from the mixture.
- Sub-samples are also taken from fertilizers and mixed. The final sample is taken from the mixture.
- Sample labels must contain all the necessary information, with at least one label containing all the contact information of the farm or producer.
Properties and Composition of Soil

- Plants need soil to stay upright and to get nutrients, water and air (oxygen and carbon dioxide).
- It is important to understand chemical and physical soil properties to understand their influence on the ability of plants to grow.
- Soil with optimal properties is not always available for cultivation, and steps can be taken during soil preparation to correct or at least improve the conditions.
- Physical soil properties include texture, structure, depth, layering (stratification) and aeration.
- Texture is a fixed soil property and ranges from clay to sand.
- Soil with a clay content of between 7% and 30% is optimal for citrus production.
- Soil ranges from having no structure to being granular. Soil structure determines the aeration, water penetration and drainage of the soil.
- Soil with a depth of at least 500mm is required for citrus production.
- Soil layers are formed over many years, and the differences in the properties of soil in various layers determines the ability of water and roots to move from one layer into the next.
- Aeration refers to ability of the soil profile to supply air to the roots. Poorly drained soil becomes water-logged and anaerobic, which can cause roots to die.
- Chemical soil properties include pH, resistance and electrical conductivity, salinity, fertility level, cation exchange capacity, and organic matter.
- pH indicates the acidity of soil. The optimal water pH of soil for citrus production is between 6.5 and 7.5.
- Electrical conductivity and resistance indicate the salinity of the soil.
- Soil salinity affects soil fertility and physical soil properties.
- Soil fertility indicates the ability of soil to sustain plant growth.
- The cation exchange capacity of soil determines the ability of soil particles to bind with nutrients and keep them available to plants.
- Organic matter in soil consists of dead plant and animal material, organic and microbial debris, and humus. Humus contributes to the activity in soil.
Basic Symptoms of Nutritional Deficiencies

- The plant’s ability to complete its physiological process, grow and produce food depends on the concentration of the most limiting element.

- Each nutrient element has a very specific role and function in the metabolism or life of a plant.

- The most limiting element is the nutrient element present at the lowest percentage of its optimum concentration. Even if only one nutrient element is not at optimum concentration, the plant will be limited in its ability to grow.

- Nutrient deficiency symptoms are specific to the nutrient that is not at the optimum level, but can be blurred by a combination of deficiency symptoms or symptoms of other factors.

- The fertilization program should provide for keeping nutrient elements at optimum levels. Mild deficiencies can be tolerated during certain times of the year.

- The cause of the deficiency has to be identified in order to deal with it effectively.
Session 1

Prepare for soil and foliar nutrient applications using specialized equipment

After completing this session, you should be able to:
SO 1: Prepare for soil nutrient applications using specialized equipment.

In this session we explore the following concepts:

♦ The ability to use specialized equipment is demonstrated.
♦ The ability to calibrate specialized equipment is demonstrated.
♦ The ability to select the appropriate nutrients for application from storage facilities is demonstrated.

1.1 Introduction

Fertilizers and other compounds used in soil management, such as potassium sulphate, can be applied either to the soil or to the leaves of crops. Leaf applications tend to be prevalent in longer term crops such as orchard crops and hydroponics grown tomato. Soil application of fertilizers can be done manually or through the use of mechanical application equipment, or via the irrigation systems (fertigation).

The following steps are followed in for fertiliser application:

♦ **Determine the fertilization need.** Collect a sample for fertilizer requirements analyses, have the sample analysed, and obtain a fertilizer recommendation.

♦ **Calculate the volume of fertilizer required, either per field or orchard** – The total amount of fertilizer required is calculated by using the information supplied in a fertilization program.

♦ **Decide on the type of fertiliser that is to be used.** – Most fertilizer recommendations will suggest the use of a specific type.

♦ **Collect the fertilizer form storage or purchase fertilizer.** – The correct fertilizer is identified and collected from storage. In most cases there will be control systems in place on the farm that control the collection and use of the compounds. In such instances farms may have their own procedures for fertilizer use that should be followed.
Manage Soil Fertility and Plant Nutrition

Primary Agriculture
NQF Level 3
Unit Standard No: 116267

Version: 01                 Version Date: July 2006

− **Measurement** – The correct amount of fertilizer is carefully measured. Over-application of a fertiliser harmful to crops. In the case where under-application occurs, the crop will not produce, as it should.

− **Preparation** – Some fertilizers may require preparation, such as mixing and making up solutions to be applied using application equipment. Where fertigation is applied, a stock solution is made up to certain strength, and then diluted in the irrigation system using specialised dosing equipment.

− **Calibration** – Certain application methods require the calibration of equipment to ensure that the fertilizer is applied at the correct rate.

− **Application** – Fertilizer is applied to the crop following predetermined methods and procedures.

Please complete Activity 1 – Group Activity:
1. Develop and draw a flow diagram of the steps that you would follow when you need to apply a granular fertiliser.
2. Discuss these steps in your group according to the principles below, and make notes for yourself:
3. Possible risk areas for the personal safety of the staff who is involved in the process.
4. Possible mistakes that can be made in the process and what the financial consequences of those mistakes might be.
5. Possible impacts that the process or mistakes in the process might have on the ecological environment.

Activity 1.2
Supervise a fellow learner whilst he/she demonstrate the calibration of the fertilizer application equipment used commonly at your place of work.

**Fertilisation activities**

− **Fertilization requirements**

The table below is an example of a typical fertilization program. The programme provided is for a citrus farm. Because there may be differences in soil type and chemical composition between different orchards, and even fields on a single farm, fertiliser requirements are best determined for individual fields or units. In the example below the orchard has been planted to Valencia Oranges with 316 trees per ha. The specific orchard is 3 ha in size.
FERTILISATION PROGRAM – CITRUS

<table>
<thead>
<tr>
<th>Orchard:</th>
<th>Size: 3.0ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivar/Variety: Delta Valencias</td>
<td>Trees per ha: 316</td>
</tr>
</tbody>
</table>

### Soil Applications

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>Quantity</th>
<th>Time of Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone Ammonium Nitrate (LAN)</td>
<td>500g</td>
<td>July</td>
</tr>
<tr>
<td>LAN</td>
<td>250g</td>
<td>August</td>
</tr>
<tr>
<td>LAN</td>
<td>250g</td>
<td>September</td>
</tr>
<tr>
<td>Potassium Chloride (KCL)</td>
<td>500g</td>
<td>September</td>
</tr>
<tr>
<td>Dolomitic Lime</td>
<td>4000g</td>
<td>October</td>
</tr>
</tbody>
</table>

### Foliar Sprays

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>Quantity</th>
<th>Time of Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Biuret Urea</td>
<td>1000g</td>
<td>July</td>
</tr>
<tr>
<td>Manganese Sulphate</td>
<td>200g</td>
<td>October</td>
</tr>
<tr>
<td>Solubor®</td>
<td>150g</td>
<td>October</td>
</tr>
</tbody>
</table>

Remarks:

The programme is split into 2 sections, the firsts is for soil applications and the second for foliar applications. For soil applications the fertilizer rates provided are per tree. The recommendation is for the application of LAN at three different occasions during the season, in July, August and September. This type of application is known as a split application with the initial (July) application is the highest. The programme further recommends the use of KCl and dolomite lime. The inclusion of lime in such programme could indicate a soil acidity problem.

In the case of foliar applications, the rates are provided as g per 100 l of water of hectoliters (HL) water. For these applications there are recommendations for Urea, Manganese Sulphate and Boron as Solubor. Foliar applications are normally applied as a full cover spray. This means that the application will be such that the tree as a whole will be treated and that the applicator should penetrate the inner canopy of the tree.

### 1.2 Manual soil applications

Manual application refers to the application of the fertilizer by hand. In other words, directly to the soil. During a manual application, the amount of granular or powdered fertilizer is applied to each tree by hand.
Calculation of the Total Fertilizer Requirement

- The total fertilizer requirement is calculated by multiplying the number of trees in the orchard by the recommended amount of fertiliser per tree. If we use the example of a fertilization program provided earlier the calculations are done as follows:

- The total amount of LAN required for the September application:

  - Number of Trees in Orchard = Orchard Size in Hectare (ha) x Number of Trees per Ha
  - = 3.0ha x 316
  - = 948 trees in the orchard
  - Total Amount of LAN Required = LAN required per Tree (g) x Number of Trees in Orchard
  - = 250g x 948 trees
  - = 237,000g (/1,000 to convert to kg)
  - = 237kg

So the calculations show that we require 237 kg of LAN the September application to Orchard 10.

Similarly the LAN required for July and August can be calculated as well as The KCl requirements.

Collection from Storage

Granular and powdered fertilizers are most commonly supplied in 25kg or 50kg bags. The number of bags that have to be collected from storage is calculated by rounding the total amount required up to the nearest 25- or 50-kg. This number is then divided by 25 or 50 (depending on the bags used on the farm) to give the number of bags required.

If we assume that the LAN is available in 50kg bags on our farm, we can calculate the number of bags as:

- If 237 kg is rounded up to the nearest 50 kg it is 250 kg
- We will therefore need to collect 250 Kg of LAN.
- Number 50kg of bags required = total rounded up amount ÷ 50
  - = 259 Kg ÷ 50
  - = 5 bags of LAN must be collected from storage
Note that there should be 13kg (250-237) of fertilizer left in the last bag if the application is done correctly. This bag should be returned to the storeroom and sealed to be used at a later stage.

When collecting fertilizer from storage, check for the following:

- The names and descriptions on the bags. Even though good agricultural practices (GAP) prescribe that fertilizer of the same type should be stored together, do not assume that this is the case. Make sure that all the bags required have the same labeling.

- The concentration of the fertilizer specified on the bag or container is the same as that which is prescribed in the programme. Some fertilizers are made in more than one concentration. Zinc nitrate, for instance, is supplied in formulations with an active ingredient (Zn) concentration ranging from 5.5% to 16%.

- The mass of each bag.

- That used bags are sealed properly before use.

- Make sure that where an opened bag is to be used that the bag contains fertilizer and that nothing else had been added to it. Some granular herbicides look similar to fertilizer granules, make sure that these are not mixed up or confused as you could cause serious damage to the crops.

### Measurement

Even though the fertilization program usually states the amount of fertilizer to be applied in grams per tree, it is impractical and unproductive to weigh it off in the field.

To solve this problem the fertilizer is weighed off accurately once and the volume that corresponds with the weight is determined. Scoops are then manufactured by cutting used tin cans or plastics containers to the determined volume. **It is important that empty pesticides containers are not used for this purpose.** If the scoop is filled with fertilizer, the scoop will contain the correct, prescribed mass of fertilizer.

Each fieldworker is supplied with a scoop of the correct volume, and the fertilizer is scooped out of the bag and applied.

### Application

Fertilizer is applied in the area around the tree trunk where irrigation water is applied, and where the feeder-roots are present. The majority of the feeder-roots in citrus are concentrated in a strip of 50cm inside to 50cm outside the drip-line of the tree, provided this area is irrigated. It is useful to irrigate the orchard for about 30 minutes before applying fertilizer to demarcate the area where the feeder-roots are. Fieldworkers scoop the fertilizer from a bag and spread it below the canopy of the tree on the wetted zone with avoiding contact of the fertilizer on the trunk.
1.3 Mechanical Applications

Mechanical application is another soil application method. Lime and other fertilizers are often applied using mechanical spreaders. For tree crops the spreaders are adapted to apply the fertilizer from either one or both of the sides, but not from behind. This means the application will be made to the soil around the tree but not in the paths between the trees.

Often contractors used for these types of applications. The operators and supervisors of the contractor will then take responsibility for equipment calibration and the correct application of the fertilizer. Fertilizer suppliers may also offer such a service.

Where fertilizers are specially prepared as suspensions or slurries to be applied to the soil, special equipment will be required. This is a specialised service and will normally be requested from the supplier. Mixing the fertilizers and calibrating the equipment are part of the service.

**Calculation of the Total Requirement and Collection from Storage**

The amount of fertilizer required for a mechanical application is calculated in the same way as for manual application, and the same procedures are followed for when fertilizer is collected from storage.

**Measurement**

The total amount of fertilizer required for a mechanical application is weighed carefully and loaded into the spreading equipment.

**Calibration**

The spreader is calibrated to deliver a certain mass of fertilizers onto a specific area. This can be affected by the delivery volume as well as the application speed. The equipment should be calibrated before use. Tractor speed and settings on the fertilizer spreader are interrelated and must be kept constant for a specific calibration.

In field crops the spreaders are set to apply a band of fertilizer behind the applicator. In the case of tree crops, the applicators are set to apply the fertilizers in a strip of about one meter wide, on each side of the applicator, under the trees. In orchards spreaders are set so that fertilizers are not applied paths between rows.

**Application**

The mechanical spreader is attached to the tractor and drawn through the orchard, spreading fertiliser from one or both sides. The driver must ensure that the application speed to which the calibration was done is adhered to.
1.4 Fertigation

Fertigation is a method of soil application of a nutrient solution. In this case liquid fertilizer are added into to the irrigation stream and applied through the irrigation system during normal irrigation. Fertigation is one of the more recent developments in the application of nutrient solutions or single-element solutions.

■ Application

Fertigation systems can apply any number of essential nutrient elements at the same time. It is important that workers, who work with this type of system and the associated equipment, receive clear instructions on operations and must be trained in the use of fertigation equipment. The operating instructions and training will usually be provided by fertigation equipment suppliers.

Fertigation systems are normally made up of a reservoir containing the fertilizer stock solutions, and a dosing system that introduces the mixture into the irrigation system. It is thus critical that the irrigation system operates effectively.

■ Measurement and Calibration

The fertilization instruction will specify the mass or volume of fertiliser to be added to the fertilizer reservoir / tank. It is made up tank with irrigation water and the applied into the irrigation lines a pre determined rate and ratio.

Note that one should be careful if liquid fertilizers are used and the recommendation is specified as a mass. The density of liquids is seldom 1.00, meaning that one litre is not the same as one kilogram. Be careful to make sure that the correct amount of active ingredient is used.

■ Guidelines and Principles of Fertigation

♦ The principle of applying a fertilizer only to the wetted zone is easy to adhere to with fertigation systems as water carries the fertiliser. The fertilizers are applied in small dosages during 90% to 100% of the duration of the irrigation cycle.

♦ When fertigation is used on drip irrigation systems, the depth to which the fertilizers are applied must be controlled. The system must be calibrated to apply the mixture to the top 60% to 70% of the root-zone.

♦ Phosphate fertilizer fertigation through micro-jets systems is not always successful.

♦ Fertigation systems vary widely in the way fertilizers are measured, prepared, diluted and introduced into the system. It is important that the operating instructions for each unit are followed carefully.
1.5 **Foliar Applications**

Foliar applications imply that the nutrients are applied to the leaves of the crop.

The applications are made using a variety of mist blowers and other spraying equipment in orchards and back-pack type applicators for other crops including tunnels. The spraying equipment is normally not dedicated for use in foliar nutrient applications, but also used for pesticide application. The requirements for foliar application of nutrients and pesticides vary and the same calibration should not be used for both types of sprays.

Plant leaves can only absorb nutrients that are dissolved in water. The leaves must therefore stay wet with the nutrient solution for as long as possible. The mass of nutrient and therefore the volume of nutrient solution that stays on the leaves are therefore important. To create an effective period of absorption, the following calibration requirements are important:

- The concentration of the nutrient element in the spray solution must be as high as possible, while avoiding the potential for scorching the leaves or fruit.

- The droplets applied to the leaves must be larger than 500 micron in diameter. This will prevent excessive runoff and quick drying.

- The leaves must be kept wet for as long as possible, preferably exceeding 15 minutes. These applications are typically not done during windy or very hot periods. Spraying after sundown night is the most effective.

- Foliar applications are normally applied to the leaves in the outer 50cm layer of the canopy (medium cover spray).
Please complete Activity 2 – Case Study:

Joe is a citrus farmer in the Limpopo province of South Africa. Two years ago he upgraded his irrigation system to a micro-jet system. Last year he changed from manual fertiliser to a fertigation system. He has found that the system works very well in some areas of his farm, but in a small area there are some problems.

He decided to resolve the plan step-by-step. He went out and beaconed off the exact area where the problems are experienced. Then he checked exactly what kinds of problems were occurring. He identified the following:

**Indicator:** Two-year old and older leaves on the trees

**Symptoms:** A large number of the old leaves have a light yellow colour. These leaves started yellowing just before or during a new leaf flush with some immediate leaf drop after that.

**Deficiency Identified:** Nitrogen (N)

He then decided to consult an expert and increase the application of nitrogen (N) and potassium (K) in his fertigation program. Unfortunately the problem still did not improve. Then he decided to take some soil samples to see whether there might be any clues to be found in the soil. The laboratory results showed that the pH of the soil was high and that the clay content of the soil was also quite high. He then decided to include a super phosphate in his fertigation program, which helped to alleviate the problem.

Now answer the questions below:

1. What was the first indication that Joe had that there is a problem?
2. Explain in your own words what steps Joe followed to try and identify the reasons for the problem.
3. What would you have done differently?
4. Do you think that Joe came to the correct conclusion and applied the correct solution to the problem? Motivate your answer.

Please complete Activity 3 – Questions:

Complete the following questions on worksheets that will be handed to you by your facilitator.

1. Name three important considerations when calibrating for manual soil applications of granular fertilisers.
2. Name three major considerations when calibrating equipment to apply foliar nutrient sprays.
3. Name the most important issue when applying fertilisers (nutrient solutions) by means of fertigation through micro-jets.
Concept (SO 1) | I understand this concept | Questions that I still would like to ask
--- | --- | ---
The ability to use specialized equipment is demonstrated. |

The ability to calibrate specialized equipment is demonstrated. |

The ability to select the appropriate nutrients for application from storage facilities is demonstrated.
Session 2

Collection, storage and dispatch of samples for nutrient analyses

After completing this session, you should be able to:
SO 2: Supervise the collection of samples, and the storage and dispatch of samples to appropriate service providers

In this session we explore the following concepts:
♦ Sampling orchards.
♦ Sampling pitfalls.
♦ Handling samples.
♦ Dispatching samples.
♦ Recording sample information.

2.1 Introduction

During any sampling procedure, the actual sample taking is usually the part where errors occur. Taking samples according to prescribed procedures requires much effort. It may be tempting to take shortcuts to speed-up the process. The quality of the samples will be jeopardized by what may seem like insignificant deviations from a prescribed procedure. Deviations usually occur when the person taking the sample is not fully aware of the details of the procedure or does not appreciate the importance of following the procedure.

Being aware of the pitfalls of sampling is important when supervising these activities. There are also certain preparations to be made.

In most tree fruit crops, the fruit is not sampled for nutrient analyses and fertilizer recommendations. Fruit is usually sampled to determine whether the fruit are mature and ready for harvest.
Please complete Activity 4 – Group Activity:

To constantly achieve the same high quality result in sampling, it is a good idea to divide your sampling process into clear and effective steps. What do you think the steps for each stage of sampling should be?

- List the steps that you believe should be taken when taking leaf and soil samples.
- Next to each step, write down who would normally do it on a citrus farm.
- Write down the safety instructions that you would have to give to your team for each specific step.
- Write down any cautionary information that you would have to tell your team to ensure that the integrity of the sample is not compromised, meaning that the samples would not become confused or contaminated.

After finalising the group discussion and deciding on the best options, write them down on the worksheets provided by your facilitator and make keynotes for yourself.

### 2.2 Sampling Orchards

In a permanent crop such as most tree crops, it is important that sampling preparation is done. Some of the activities include:

- Identify and mark the index rows in each orchard where samples will be taken for the first time.
- Ensure that the demarcation of the index rows is still in place and visible in orchards where samples had previously been taken.
- Prepare a list of the orchards to be sampled and indicate whether leaf- or soil samples or both should be collected.
- Ensure that the containers (specialised boxes or plastics bags) are marked according to the requirements of the laboratory and the site procedures. Some laboratories provide sample containers for orchards, which are registered with them at the beginning of each season.
- Allocate specific sampling tasks to specific people who have been trained and briefed in the application of specific procedures.
- Provide cautionary advice and health and safety instructions to the sampling team.
- Accompany the team to the orchards / fields where the sampling is to take place.
2.3 Sampling Pitfalls

### Leaf Sampling
- The leaves that are to be sampled and analysed are referred to as the diagnostic leaves.
- In tree crops the diagnostic leaf is one that is located on a new shoot formed during the spring of the year of sampling. In citrus the leaves on older twigs will be older than nine months and will have a different nutrient composition than the diagnostic leaf.
- The sampler must be aware of the difference between the diagnostic leaf and older leaves.
- The diagnostic leaf is taken from a fruit-bearing twig, meaning that the shoot should carry fruit.
- Usually only one or two leaves are taken from a single tree.
- The final sample may be made up of leaves from a number of sample trees or indicator trees.

### Soil Sampling – Orchards
- The major pitfall with soil-sampling is taking the total mass of soil required at one single tree.
- A soil sample is made up of a number of sub-samples each collected from a different spot in the orchard or field.
- Soil samples are taken to a depth of 20-30cm.
- The entire sub sampled are placed into one sample container (new plastics bag or clean suitable container), making up a composite sample. The sub-samples are then mixed thoroughly. This will leave you with a larger sample volume that will be required by the laboratory. The actual sample for analyses is taken as a sub sample from the bulk or composite sample. For this reason it is essential that the composite sample is well mixed (homogenous).
- It may be difficult to reach the wetted and fertilized area below the canopy, but samples must not be taken outside this specific area.

### Soil Sampling – Field crops
- Soil samples for field crops are usually taken before the crop is established.
- To collect a sample for a field crop, divide the field into 10 different sections each approximately the same size. You now take a spade and collect from
each of these areas a spade full of soil. Take a spade full from the top 30 cm layer (top soil) of soil and place it on a plastics sheet.

♦ Collect a second spade full from the same area from the 30 – 50 cm soil layer (sub-soil) and place it on a separate plastics sheet. Repeat the procedure for each of the 10 areas identified.

♦ Now mix the combined spade full’s of the top soil. Do the same for the soil from the next layer.

♦ Collect approximately 1 kg of soil form the top soil heap and place it in a plastics bag and seal. Repeat the procedure for the sub-soil.

♦ For every field you require a soil analysis for you should have two samples.

♦ Label each sample properly with a sample number a field number indicating the field it comes from and a sampling date. Indicate whether it is a top soil or sub-soil sample.

2.4 Handling Samples

After the samples have been taken, they must be handled as follows:

♦ Label the sample

♦ Mark the sample list to indicate that the sample has been collected.

♦ Seal the sample containers properly.

♦ Keep samples in the shade until they can be transported to the office.

♦ Laboratories may have special requirements or procedures for sample handling and storage. These must be followed at all times, if they differ from the on farm procedures.

2.5 Dispatching Samples

At the office, separate the leaf and soil samples, and place them in order according to orchard or field number.

Check the numbers on the labels of the leaf and soil samples for each orchard / field sampled, and record it on a list that will serve as a consignment note.

Make a copy of the list and include that with the consignment of samples in the container that is to be dispatched to the laboratory. The list serves as a consignment note. Ensure that all the details that the laboratory may require are included on the list.
2.6 Recording Sample Information

Keeping record of the samples is important for the communication between the farm, laboratory and the expert developing the fertilization program. It is important to streamline this process and to ensure that one keeps track of the samples.

Keep record by means of a consignment note. Samples in a consignment are listed on a consignment note, so that the laboratory can crosscheck that they have received all the samples when they arrive. If a sample is missing, it is easy to communicate that immediately to the farm, and allow time to re-sample if required.

The table below contains an example of a consignment note.

<table>
<thead>
<tr>
<th>AA Farming</th>
<th>Telephone: (019) 222-9988</th>
</tr>
</thead>
<tbody>
<tr>
<td>P O Box 21</td>
<td>Fax: (019) 222-9989</td>
</tr>
<tr>
<td>Sand River</td>
<td></td>
</tr>
<tr>
<td>0111</td>
<td></td>
</tr>
<tr>
<td>Contact Person: J Ralepele</td>
<td></td>
</tr>
<tr>
<td>To:</td>
<td></td>
</tr>
<tr>
<td>Date: 25/03/05</td>
<td></td>
</tr>
<tr>
<td>Carrier: Sun Couriers</td>
<td></td>
</tr>
<tr>
<td>Waybill No: SC 2118/05</td>
<td></td>
</tr>
<tr>
<td>Number of Parcels: One</td>
<td></td>
</tr>
<tr>
<td>Special Instructions: CAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Please do the standard analyses on leaf and soil samples for fertilisation recommendations. For soil samples also please determine organic content.</td>
</tr>
</tbody>
</table>

**SAMPLES DISPATCHED**

<table>
<thead>
<tr>
<th>Sample type: Citrus leaf Samples</th>
<th>Sample type: Soil samples Top 30 cm soil layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample number</td>
<td>Sample description</td>
</tr>
<tr>
<td>1</td>
<td>Orange Cv Delta Orchard 10</td>
</tr>
<tr>
<td>2</td>
<td>Orange Cv Midknight Orchard 11</td>
</tr>
<tr>
<td>3</td>
<td>Mandarins Cv clemintine Orchard 12</td>
</tr>
<tr>
<td>Total of 3 leaf samples</td>
<td></td>
</tr>
</tbody>
</table>
Please complete Activity 5:

Activity 5.1 – Questions:
Discuss the questions below with a partner and write down the conclusions that you reach.

1. Why is it important to keep records of samples? What do you think these records could be used for?
2. What could happen if no records were kept of samples?

Activity 5.2 – Groups of two:
Supervise one of your fellow learners whilst they implement the soil sampling procedures (including labelling and dispatch), for fertilisation recommendation analyses, that are practiced at your place of work.

- Sampling procedures must be followed carefully to ensure that the results of analyses are accurate and meaningful.
- In preparation for sampling, demarcate the orchards and trees, prepare a list of samples, ensure that the sampling containers are clean and properly marked, allocate specific tasks to specific team members and ensure that they are aware of proper procedure, and health and safety instructions.
- With leaf sampling, ensure that the leaves that are taken is on young shoots, that the leaf is taken from a fruit-bearing shoot, and that not more than two leaves are taken from a tree.
- With soil samples, ensure that the correct number of sub-samples are taken, that samples are taken at a depth of 20-30cm, that the sub-samples are mixed thoroughly, and that samples are taken from the wetted area under the canopy of the tree.
- After samples have been taken, mark it off on the list, seal the containers properly and keep it in the shade.
- Before dispatching samples, separate the leaf and soil samples, check and order the samples, and record them on a consignment note.
- Samples must be recorded to facilitate communication between the farm and laboratory. The most important record is the consignment note.
<table>
<thead>
<tr>
<th>Concept (SO 2)</th>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ability to take and handle leaf, soil and fruit samples according to prescribed procedures are demonstrated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The process of recording and dispatching the samples to the appropriate service provider is explained.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Nutritional deficiencies in crops

After completing this session, you should be able to:
SO 4: Identify and interpret symptoms of nutritional deficiencies in various crops and make basic recommendations.

In this session we explore the following concepts:
♦ Plant nutrition.
♦ Plant nutrition elements.
♦ Plant nutrient macro-elements.
♦ Plant nutrient trace elements.
♦ The relationship between fruit quality and tree nutrient status in orchard crops.

3.1 Plant Nutrition

This section deals with the identification of deficits of nutrients in plants, and will allow you to identify such deficits by inspecting the plant. The section also provides a short explanation of what the nutrients are and why they are needed, so that you can understand the deficit symptom better.

3.2 Plant Nutrition elements

There are 16 main nutrients or elements that plants require for normal growth and development. These nutrients are divided into two main groups, the macro-elements that are required in relatively large quantities and the micro-elements or trace elements, which are required in very small quantities.

The macro-elements are carbon (C), hydrogen (H), oxygen (O), Nitrogen (N), potassium (K), phosphorous (P), calcium (Ca), magnesium (Mg) and sulphur (S).

The trace elements are iron (Fe), copper (Cu), boron (B), molybdenum (Mo), chlorine (Cl), manganese (Mn) and zinc (Zn).

The three elements carbon, hydrogen and oxygen, make up about 95% of the fresh mass of plant tissue. These three nutrients however occur naturally in large quantities and do not require addition.
The remaining elements are generally present in soils/growth media, but are not always present in the correct ratios or the correct amounts. These nutrients are taken up primarily through roots from the soil, but some can be taken up through leaves.

The next three most important elements that can be added to soil for plant growth is nitrogen (N), phosphorous (P) and potassium (K). In fertilizer terms these are the most well known nutrients. The number that appears on fertilizer packaging such as 3:1:3, indicates the N: P: K ratio that the specific fertilizer in the bag contains. In a 3:1:3 fertilizer for example, there are 3 parts N for every 1 Part of P and every 3 parts of K.

Fertilizers that are high in nitrogen (those with a high N ratio) are suitable for leafy vegetables such as lettuce and spinach and also for grass and lawns because it will stimulate growth of leaf tissue (vegetative growth). An example is a lawn fertilizer with a NPK ratio of 7:3:2.

A more balanced NPK ratio such as a 3:2:3 ratio such as found in fertilizers made for roses, will tend to encourage the production of flowers.

Although N, P and K are the most well known elements that plants require, the remaining macro elements (phosphorous (P), calcium (Ca), magnesium (Mg) and sulphur (S)) are also important.

What follows is a short discussion of the main reasons why each nutrient is important. There is also a discussion on how to identify their deficit.

### 3.3 Plant Nutrient macro-elements

#### Nitrogen (N)

**Why does a plant need N?**

- Nitrogen is essential for the synthesis of proteins in plants.
- Nitrogen is necessary as a building block for genetic material.
- Nitrogen is an essential part of the green pigment chlorophyll.
- Nitrogen is good for leafy vegetables or as a general tonic to boost plant growth.

**Where do we find N?**

- Plants use nitrogen in two forms, these are ammonium and nitrate
- These are both available as inorganic fertilizers.
- Ammonium will stimulate leafy growth.
Manage Soil Fertility and Plant Nutrition

Primary Agriculture  NQF Level 3  Unit Standard No: 116267

- Applying nitrate or urea as an inorganic fertilizer as a foliar spray very quickly stimulates crop growth.
- Take care when applying these as crops are easily scorched when overdosing.
- Nitrogen is also found in organic matter, such as lawn clippings, compost, manure as well as blood or bone meal.

What does a plant that is deficient in N look like?
- Plants are stunted
- Leaves become pale green or yellow (chlorosis)
- Yellowing is normally seen on older leaves first
- On closer inspection yellowing starts at the tip of the leaf progressing down the middle of the leaf to the leaf base, spreading across the leaf blade as a whole.

Phosphorus (P)

Why does a plant need P?
- Plants require phosphorous all the time.
- There is a strong relationship between phosphorous and nitrogen requirements.
- If there is no N, the plant cannot take up P from the growth medium
- P is essential for growth and development of stems, roots, seeds, flowers and seedlings.
- In crops P improves crop quality, increases root growth and leads to earlier crop maturity.

Where do we find P?
- Phosphorous deficiency can be corrected by adding phosphorus to irrigation water in the form of e.g. potassium phosphate, or a foliar application of ammonium phosphate.
- As with nitrogen scorching of leaves could occur.
- A more long-term source of phosphorous is super-phosphate which is applied to the soil

What does a plant that is deficient in P look like?
- Plants are stunted
- Leaves take on a purplish colour.
The undersides of the leaves become characteristically purple especially on the veins.

Fruits mature late and seeds do not develop properly

The change in colour usually develops on older leaves first.

### Potassium (K)

**Why does a plant need K?**

- Potassium is not an important structural component of a plant.
- K is important in a range of plant growth processes.
- K is important for photosynthesis and aids in the plants overall vigor, strength, water uptake and disease resistance.
- K plays a role in maintaining plant water balance, controls transpiration, and activates enzymes.
- K improves the plants’ flower, fruit and seed quality.

**Where do we find K?**

- Potassium deficiency can be overcome by foliar application of potassium Sulphate or potassium nitrate. A more long-term source of potassium is potash worked into the soil.

**What does a plant that is deficient in K look like?**

- The first sign of potassium deficiency is that the leaves turn dark green
- In time leaves become a purple brown colour.
- This discoloration is followed by yellowing of leaf edges leading to a browning dying off (necrosis) of the tissue.
- Weak stems, with yellowing or browning around the edges and tips of older leaves are a tell-tail sign of K deficiency.

### Calcium (Ca)

**Why does a plant need Ca?**

- Calcium is a major constituent of cell walls.
- Ca is involved in nitrogen metabolism and activates enzymes.
- Ca helps to build strong stems.

**Where do we find Ca?**

- The effects of can generally be reversed.
- This is done by a foliar application of compounds such as calcium nitrate. Calcium is also found in agricultural lime, super-phosphate and gypsum.
What does a plant that is deficient in Ca look like?

- Common symptoms of calcium deficits are stunting, wilting and dark green discoloration.
- Leaf margins become scorched
- Roots are poorly developed and the root tips die off.
- In fruit crops like tomatoes, cucumbers and peppers calcium deficiency causes blossom end rot. This condition is irreversible.

Magnesium (Mg)

Why does a plant need Mg?

- Magnesium is essential a part of the green pigment chlorophyll and is thus an extremely important element.

Where do we find Mg?

- Magnesium deficiency is common and can be corrected by foliar application of Epson salts. Magnesium is found in a number of commercial fertilizers.

What does a plant that is deficient in Mg look like?

- A plant is deficient in magnesium develops yellow leaves
- Usually the older leaves of the plant, rather than the new young leaves develop this symptom.
- The margins of leaves turn yellow, spreading to the leaf blade as a whole.

Sulphur (S)

Why does a plant need S?

- Sulphur is important for the production of chlorophyll
- S is also important as a protein constituent.

Where do we find S?

- Mg is found in super phosphate and gypsum.

What does a plant that is deficient in S look like?

- A sulphur deficiency affects the quality and flavour of fruit and vegetables.
- It is seen as a light purple discoloration of petioles, stems and veins, with the leaves turning pale yellow.
- Dead spots and patches may develop on leaves.
3.4 Plant Nutrient Trace Elements

Trace elements have to be present in the plant in order for other nutrients to be available to the plant. They are required in very small amounts.

Intensively cropped soils such as vegetable gardens, heavy clay soils or light sandy soils often are deficient in trace elements.

■ Iron (Fe)

Why does a plant need Fe?

♦ Iron plays a vital role in the formation of chlorophyll during photosynthesis.

Where do we find Fe?

♦ Iron can be applied as iron chelates and iron salts.
♦ Deficiency develops if the growth medium pH is too high or if anaerobic conditions develop in soil or to much magnesium is found in the in the rooting medium.

What does a plant that is deficient in Fe look like?

♦ Iron deficiency symptoms are similar to those of magnesium.
♦ The major symptoms are yellowing of young developing leaves.
♦ The veins remain green but the rest of the tissue becomes yellow, causing a mottled leaf.

■ Manganese (Mn)

Why does a plant need Mn?

♦ Mn is Essential for the manufacturing of “sugars”
♦ Mn is required for nitrogen metabolism.

Where do we find Mn?

♦ Manganese can be applied as manganese sulphate.
♦ Care must be taken however as this element is toxic at high concentrations.

What does a plant that is deficient in Mn look like?

♦ Develops first on young tissues and can easily be confused with iron deficiency.
♦ The distinguishing factor is that Mn deficits cause more overall leaf discoloration and may also cause necrotic spots and lesions.
♦ In severe cases leaves become distorted.
Zinc (Zn)

Why does a plant need Zn?
- Plays a role in enzymes
- Involved in synthesis of plant hormone indole-acetic-acid

Copper (Cu)

Why does a plant need Cu?
- Plays a role in the activation of several enzymes, effects cell wall formation.
- Plants require very little Cu to be present.

Where do we find Mn?
- Copper deficits can be remedied by the application of copper sulphate.

What does a plant that is deficient in Mn look like?
- Cu deficiency causes stunting of the plants leading to shortened inter-nodes and small leaves.
- Chlorite blotches develop on older leaves, gradually spreading to younger leaves.
- Affected leaves turn dull green to bronze with the edges curling upwards.

Boron (B)

Why does a plant need B?
- Required for healthy plant growth.
- A plant that lacks boron cannot take up calcium from the soil.
- Boron easily becomes toxic to the plant, and thus boron toxicity is more common than boron deficiency.
- Beetroot plants are highly susceptible to boron toxicity.

Where do we find B?
- Boron deficiency can be readily corrected using sodium borate added to the nutrient solution, or as a foliar spray.

What does a plant that is deficient in B look like?
- Boron deficiency is first seen as yellowing of leaf tips on older leaves.
- The growth tip or stem apex dies off and the veins supplying the young leaflets become clogged.
- The tops of plants assume a bushy appearance, the stems and petioles become brittle causing them to break easily.
The leaves may develop orange to yellow discoloration.

- Roots become blackened.

### Molybdenum (Mo)

**Why does a plant need Mo?**

- Molybdenum is involved in the activity of enzymes and is essential for the conversion of nitrogen from the air into a soluble form that the plant can use.
- Mo becomes more available to the plant as the root medium pH is increased.

**Where do we find Mo?**

- Mo deficiency can be corrected by applying a foliar application of sodium molybdate or ammonium molybdate.

**What does a plant that is deficient in Mo look like?**

- Mo deficiency in scarce, but can be found on acid soils.
- Older leaves become mottled spreading slowly to the younger leaves; later leaves become scorched and curled.

### Chlorine (Cl)

Chlorine is essential for plant growth, but chlorine toxicity is more common than deficiency. An analysis of water for chlorine is especially important for hydroponics growers.

- Dead spots and patches may develop on leaves.

### 3.5 The relationship between Fruit Quality and Tree Nutrient Status in orchard crops

The nutritional status of the trees at specific periods during the development of the fruit has a definite influence on the quality of the fruit produced, and its exportability. The influence of specific nutrient elements on fruit quality is discussed in detail in this section.
Nitrogen (N) • A too high nitrogen status of the citrus trees during could influence fruit ripening and could affect the quality of the fruit. Too low concentration of nitrogen during bud-break and flowering will reduce the number of fruit.

Phosphorus (P) • Too high concentrations seldom have an influence on the fruit quality, but a too low phosphorus status will affect fruit quality.

Potassium (K) • When the potassium status of a tree is too low, the fruit tend to be stunted and the acid content low.

Calcium (Ca) • The detrimental effect of excess calcium on fruit quality, apart from lemons, is unknown.

Combined effects of the status of nutrient elements also occur.

### 3.6 Basic Recommendations for improving Nutritional Status – Tree crops

Improving the nutritional status of the trees means that the status of all fourteen essential nutrient elements must be brought within the normal range for the specific crop and cultivar.

Methods to improve the status of a nutrient element are the application of additional amounts of a specific nutrient element or combinations of elements either as soil application or through foliar sprays. Both methods have advantages and disadvantages relating to the soil type, condition of the tree and the specific nutrient element.

The most common method to increase the nutritional status of the trees is to apply more of the nutrient to the soil. This rates and timing of applications should be based on soil analyses. Additional application of a fertilizer to the soil must only be done if the concentration of the available form of the nutrient content in the soil is low. A further consideration is whether the applied nutrient will stay in the available form long enough to satisfy the demand. Apart from applying more nutrients to the root-zone, other methods used to improve the nutritional status should be considered. In the table below, possible causes and the corresponding remedies are listed.
Decreasing the nutritional status is not always possible. However, sometimes the effect of too high concentrations of a nutrient element can be counteracted.

<table>
<thead>
<tr>
<th>Nutrient Element</th>
<th>Possible Cause</th>
<th>Possible Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Too much fertilizers applied at a time</td>
<td>Split the mass / volume of fertilizers applied at any one time</td>
</tr>
<tr>
<td></td>
<td>Excess leaching</td>
<td>Reduce the application of water to wet the root-zone only</td>
</tr>
<tr>
<td></td>
<td>Phytophthora infection of the roots</td>
<td>Test the roots for Phytophthora and act accordingly</td>
</tr>
<tr>
<td></td>
<td>Low efficiency of applied fertilizers</td>
<td>Foliar sprays with low biuret urea or potassium nitrate</td>
</tr>
<tr>
<td>P</td>
<td>Too high soil pH</td>
<td>Apply single or double super phosphate in a narrow strip on the soil</td>
</tr>
<tr>
<td></td>
<td>Too low soil pH</td>
<td>Apply lime to increase the pH to 6.50</td>
</tr>
<tr>
<td></td>
<td>Foliar sprays with phosphates are not effective.</td>
<td>Foliar sprays with phosphates are not effective.</td>
</tr>
<tr>
<td>K</td>
<td>Too high concentration of magnesium in the soil or water</td>
<td>Use potassium nitrate to apply some of the nitrogen required</td>
</tr>
<tr>
<td></td>
<td>Nematodes</td>
<td>Test the roots for nematodes and act accordingly</td>
</tr>
<tr>
<td></td>
<td>Salinity</td>
<td>Locate the source and act accordingly</td>
</tr>
<tr>
<td></td>
<td>Low efficiency of applied fertilizers</td>
<td>Foliar sprays with low potassium nitrate</td>
</tr>
<tr>
<td></td>
<td>Poor root health</td>
<td>Take remedial actions</td>
</tr>
<tr>
<td></td>
<td>Old trees</td>
<td>Rejuvenate the root system</td>
</tr>
<tr>
<td></td>
<td>Compaction</td>
<td>Corrective actions with mechanical implements may be used, but are not always successful</td>
</tr>
<tr>
<td>Ca</td>
<td>Climatic conditions</td>
<td>Ensure that enough available calcium is present in the root zone during the critical period from budding to petal drop</td>
</tr>
<tr>
<td></td>
<td>Low pH</td>
<td>Apply lime</td>
</tr>
<tr>
<td></td>
<td>Salinity</td>
<td>Locate the source and act accordingly</td>
</tr>
<tr>
<td></td>
<td>Low calcium saturation</td>
<td>Apply lime, gypsum or calcium nitrate</td>
</tr>
<tr>
<td></td>
<td>Foliar sprays with calcium have limited success</td>
<td>Foliar sprays with calcium have limited success</td>
</tr>
<tr>
<td>Mg</td>
<td>Too high concentration of potassium in the soil</td>
<td>Apply magnesium nitrate foliar sprays</td>
</tr>
<tr>
<td></td>
<td>Low pH</td>
<td>Apply dolomitic lime</td>
</tr>
<tr>
<td></td>
<td>Foliar sprays with potassium nitrate</td>
<td>Apply magnesium nitrate foliar sprays</td>
</tr>
<tr>
<td>S</td>
<td>Too low concentration of S in the soil</td>
<td>Apply sulphates to the soil. The efficacy of</td>
</tr>
</tbody>
</table>
### Nutrient Element

<table>
<thead>
<tr>
<th>Nutrient Element</th>
<th>Possible Cause</th>
<th>Possible Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>Too low concentration of Cu in the soil</td>
<td>Apply foliar sprays. The efficacy of soil application depends on many soil factors.</td>
</tr>
<tr>
<td>Fe</td>
<td>Too high pH in the soil</td>
<td>Apply Fe-EDDHA in August</td>
</tr>
<tr>
<td></td>
<td>Water logging</td>
<td>Improve scheduling and drainage</td>
</tr>
<tr>
<td>Mn</td>
<td>Too high pH in the soil</td>
<td>Apply foliar sprays</td>
</tr>
<tr>
<td></td>
<td>Recent liming</td>
<td>Apply foliar sprays</td>
</tr>
<tr>
<td>Zn</td>
<td>Too high pH in the soil</td>
<td>Apply foliar sprays</td>
</tr>
<tr>
<td></td>
<td>Recent liming</td>
<td>Apply foliar sprays</td>
</tr>
<tr>
<td></td>
<td>High P status</td>
<td>Soil applications to mature trees are not effective</td>
</tr>
<tr>
<td>B</td>
<td>Too low pH in the soil</td>
<td>Apply foliar sprays</td>
</tr>
<tr>
<td></td>
<td>Recent liming</td>
<td>Apply foliar sprays</td>
</tr>
<tr>
<td>Mo</td>
<td>Too low soil pH</td>
<td>Apply lime. Apply foliar sprays.</td>
</tr>
</tbody>
</table>

- The status of various nutrients in the tree has a marked effect on fruit quality. Nitrogen, phosphorous, potassium and calcium play the most important role.

- To correct the nutrient status of the tree, the cause of the over- or under-supply must be known. Applying more fertilizer may not be an effective remedy.

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### Please complete Activity 6 - Questions:

Complete the following questions below on worksheets that will be handed to you by your facilitator.

1. What will the result be of too high concentrations of the following elements on the quality of citrus fruit?
   - Nitrogen, Phosphorus, Potassium.
2. Apart from increasing the application rate of fertilizers, how can a too low status of the following nutrient elements be corrected?
   - Nitrogen, Potassium, Iron
<table>
<thead>
<tr>
<th>Concept (SO 4)</th>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
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</thead>
<tbody>
<tr>
<td>The relationship between plant abnormalities and deficiencies of specific macro- and micro-nutrients is explained.</td>
<td></td>
<td></td>
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<tr>
<td>Basic recommendations for improving soil fertility are made.</td>
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</table>
After completing this session, you should be able to:

**SO 3: Demonstrate an understanding of the properties of soil and how these impact on plant nutrition and soil preparation.**

In this session we explore the following concepts:

- The impact of soil properties on plant nutrition.
- The impact of physical soil properties on plant nutrition.
- The impact of chemical soil properties on plant nutrition.
- The impact of soil properties on soil preparation.

Please complete Activity 7 – Group Brainstorm:

Brainstorm as a group and find answers to the questions below. You may refer to your level 2 learner guide if necessary.

1. What are the physical soil properties?
2. What are the chemical soil properties?
3. What kinds of impact might these properties have on plants and plant nutrition?
4. The impact that we have discussed above may be direct or indirect. The impact of physical properties is mostly indirect, while the impact of chemical properties is mostly direct. Give a practical example of a direct impact that the chemical properties of soil might have on the nutrition of a plant?
5. Give a practical example of an indirect impact that the physical properties of soil might have on the nutrition of a plant?

### 4.1 The impact of Soil Properties on Plant Nutrition

Both the physical and chemical properties of soil will impact on plant nutrition. The impact of the physical properties is mostly indirect and that of the chemical properties mostly direct.
4.2 The impact of Physical Soil Properties on Plant Nutrition

- **Soil Texture**
  - The higher the clay content of the soil, the more water is absorbed and the less air is present at field water capacity (FWC). It is critical to have enough air around the roots at FWC.
  - Citrus trees grown in soils containing more than 30% clay often produce too many small fruit. This could be associated with less air, not enough available potassium or too much competition for the cations that are present.

- **Structure**
  - When the structure of soil is destroyed or degraded, adverse affects are found on root development and root health, weaker water penetration, aeration and internal drainage.
  - These will all lead to reduce crop productivity.

- **Soil Depth**
  - Shallow soils need better management and more inputs to optimise irrigation and fertilization. A shallow soil depth also poses many problems with internal drainage.
  - Various crops and crop types have different soil depth requirements. In citrus a minimum of 30cm effective rooting depth is required, in a profile with at least 75cm total depth is. When using micro-jet irrigation, a rooting depth of 40cm to 50cm will be optimal, whereas 60cm to 70cm is optimal for drip irrigation. This example shows clearly that it is essential that the soil depth be matched with the crop requirements.

- **Layering or Stratification**
  - Layering is caused by the differences in the clay content of consecutive layers in the soil profile. This can be easily observed in alluvial soils, which are soils deposited by water such as on river banks, where many thin layers of different textures are present in the profile. The layers can also be quite thick and are the result of various soil forming factors.
  - A well-documented property of roots is that they do not cross easily from one textural type of soil into another if the soil texture differs too much between layers. The guideline for too great a difference is more than 1.5 times the clay content. The factor of 1.5 is influenced by other soil properties, such as the type of clay and the silt content.
The factor of 1.5 can be explained as follows:

- If the top layer of soil contains 15% clay and the next layer 25%, the increase in clay content from the top to the next layer is $25/15 = 1.67$. The factor in this case is more than 1.5 and the difference between layers is therefore too large too allow for successful cultivation.

- Water movement in the soil profile is also restricted by layering. This is the result of the difference in hydraulic forces in a clayey versus a sandy soil. When a sandy soil is overlaying a clay layer, the water will move quickly through the sandy soil until it reaches the clay layer. Water moves slower through clay than sandy soil and, in this example, will accumulate on top of the clayey layer. This accumulated water is called free water and causes anaerobic (containing no oxygen) conditions in the rooting zone.

### Aeration

- Roots perform respiration during their normal activity.

### Respiration

- Respiration is an energy-producing oxidation process in cells, the complete chemical and physical process in which oxygen is delivered to plant cells and carbon dioxide and water are given off.

- The decomposition of organic material also produces carbon dioxide. The concentration of carbon dioxide in the air in the soil increases because of these two factors. Soil must be aerated to supplement the oxygen and remove the carbon dioxide.

- The macro pores in soil form a chain of canals to exchange the air in the soil with that in the atmosphere. If these pores are filled with water or reduced in size by compaction, the exchange rate is reduced and the rooting zone becomes more anaerobic and less suitable for root activity.

- At FWC the soil contains the lowest volume of air. For optimal root development and activity, the spaces filled with air at FWC should be about 10% of the total soil volume.

### 4.3 The impact of Chemical Soil Properties on Plant Nutrition

#### pH

- The pH of the soil defines the environment in which the roots must absorb water and nutrients, with the availability of the nutrients being affected by the pH. Optimum soil water pH, where all the nutrients are available, is said
to be between 5.5 and 6.5. The solubility of aluminium, which is phytotoxic, however increases rapidly below a soil water pH of 5.3.

Soil with a pH value higher than 7.5 are alkaline and the metal ions Fe, Cu, Mn and Zn are less soluble and hence less available. At a pH of less than 5.3, aluminium becomes more soluble and reaches toxic levels. Manganese also reaches toxic levels in acid soils.

### Resistance

- Resistance to conductance of electrical current measures the concentration of total soluble salts in a soil. The lower the salt concentration is in soil, the higher the resistance, and conversely, the higher the concentration of soluble salts, the lower the resistance.

- The soluble salt content includes the plant nutrients. At the same concentration, different salts or fertilisers will contribute differently to the resistance. Sulphates contribute less to the resistance than chlorides. The contribution of fertilisers to the resistance is called the salt index of fertilisers.

- In the table below, the salt index of potassium chloride is 114, but that of potassium Sulphate is only 46 at the same concentration. The higher the salt index of the solution, the lower the resistance, and the higher the electrical conductivity of the solution. When the resistance is too low, meaning when the salt index is too high, the plants need energy to overcome the osmotic pressure in order to absorb water and nutrients. When the resistance is too low, the mass of nutrients available for absorption might be too low if not supplemented in time.

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Salt Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium chloride</td>
<td>114</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>105</td>
</tr>
<tr>
<td>Sodium nitrate</td>
<td>100</td>
</tr>
<tr>
<td>Limestone ammonium nitrate</td>
<td>98</td>
</tr>
<tr>
<td>Urea (after hydrolyses)</td>
<td>75</td>
</tr>
<tr>
<td>Ammonium Sulphate</td>
<td>69</td>
</tr>
<tr>
<td>Potassium Sulphate</td>
<td>46</td>
</tr>
<tr>
<td>Double super phosphate (20,5%P)</td>
<td>10</td>
</tr>
<tr>
<td>Single super phosphate (10,5%P)</td>
<td>8</td>
</tr>
</tbody>
</table>

### Fertility

- Fertility is the collective name to describe the level of all the nutrients in the soil. The higher the fertility, up to a certain point, the better the yields, provided all other production factors such as irrigation are optimal.
Organic Material

- Organic matter in soil consists of various components including plant and animal debris, partly decomposed material of various origin, and humus. Humus is the stable form of organic material in the soil and consists of very large molecules.

- Organic material adds another dimension to the soil and plant growth. Organic material influences almost all the physical and chemical factors mentioned above. Furthermore, it influences the biological activity of the soil.

Please complete Activity 8 – Questions:
Complete the following question below on worksheets that will be handed to you by your facilitator.

1. Give reasons why the following physical and chemical properties of soils will impact on plant nutrition.
   - **Physical Properties:** Texture, Structure, Soil Layering, Soil Depth, Aeration
   - **Chemical Properties:** PH, Resistance, Salinity, Organic Material, Fertility

4.4 The impact of Soil Properties on Soil Preparation

The purpose of soil preparation is to create a homogeneous rooting zone with no physical and chemical barriers that will restrict root development, root health and root activity. An active and healthy root system has a better chance of maintaining profitable production. Both physical and chemical properties have an impact on soil preparation.

**Homogenous**

Homogenous means having a uniform composition and structure. In terms of soil, it means creating a consistent rooting zone with no layering or chemical barriers, such as radical changes in soil pH.

Soil preparation must always be preceded by a soil survey and soil analyses, and the manner in which the preparation is done should be guided by the results of these tests.
Soil Survey

- The purpose of a soil survey is the evaluation of the profile(s) of the soil. The soil profile is the visible face on the side of a hole dug into the soil, referred to as a profile pit. This profile pit is evaluated in terms of depth, the condition, type and sequence of the layers, called horizons, soil structure and indicators of aeration and internal drainage.

Positioning Profile Pits

- The number of profile pits per hectare depends on the variation in soil type. Typically, profile pits are dug on a grid of 50m or 100m, but the frequency depends on soil conditions and topography.
- The pit must always be positioned in such a way to ensure that one of the long sides will receive sunlight to make the survey easy.
- The position of the profile pit must be recorded geographically. This can be done by using beacons inside or outside the orchard or site. Nowadays Global Positioning System (GPS) coordinates are used. The position of the pit is important when planning the layout, soil preparation and irrigation system for the orchard.

Digging Profile Pits

- A profile pit is usually 60cm to 75cm wide and 100cm to 150cm long. It is dug to a depth of at least 100cm, or to where the parent material or rock is encountered.

Surveying Profile Pits

- Before surveying the profile, use a garden fork or geological hammer and loosen a strip of about 20cm wide from the surface down to the bottom on one of the sides. This will help to observe the profile in a natural state.
- Look for signs that indicate the different horizons, such as changes in colour, structure and / or texture.
- Mark the different layers, or horizons, and measure their position in the profile. The position is marked by the depth from the surface to the top and the bottom of the layer, for instance the first layer 0cm to 25cm, the second layer 25cm to 45cm, and the third layer 45cm to 90cm, and so on.
- Note the transition between layers. It can be gradually over more than 20cm, or abruptly in less than 5cm.
Sampling Profile Pits

- Mark the position of each layer on all four sides of the profile pit. Take a slice of the layer from its top to its bottom on all four sides of the pit. Mix the soil from the four sides and collect about 500g for analyses. Mark the samples stating the farm, the location or orchard, and the profile number.

Comparing Profiles

- The next step in soil survey is to group areas with the same profile properties together. This is the first step to demarcating soil types. Comparison between soil profiles is done on a horizon bases. The same horizons must be present on soils that are grouped together. The horizons that are grouped together must also have the same position, thickness and other properties. Soil samples from the same horizon from different profile pits in the same group can be mixed to give one composite sample.

- As an alternative, a modal profile pit which represents all similar profiles can be chosen, recorded and sampled to represent the group or area.

Demarcation of Soil Types

- Based on the grouped profiles, the area can be demarcated into soil types. The preliminary soil map of the area can, after refinement, be used to design the irrigation and plan the soil preparation action. The refinement of the soil map can be done as soon as the results from the laboratory are available.
Preliminary Recommendations on Soil Preparation

♦ The recommendations should include directions as to the cultivation depth, what type of loosening action is required and whether ridges are needed. All these decisions are based on the profile survey and laboratory analyses.

4.5 Chemical and Physical Analysis of Profile Pit Soil Samples

The purpose of the analyses is to confirm certain observations of the profile survey and to determine the necessity for ameliorants, which are chemicals or fertilizers that will improve the physical and chemical condition of the soil, that are applied during soil preparation, as well as a fertilization program for the newly planted trees during their non-bearing stage.

The minimum analytical requirements on the profile samples are as follows:

- Top soil layer pH, resistance, P, K, Ca, Mg, Na, texture
- Second layer pH, resistance, texture
- Third layer pH, resistance, texture

♦ Physical and chemical soil properties play a role in plant nutrition. The impact of the physical properties is mostly indirect and that of the chemical properties mostly direct.

♦ In as far as soil texture is concerned; the higher the clay content of the soil, the less air is available for the roots.

♦ If the soil structure is destroyed, it has an adverse effect on root development and root health, and leads to weaker water penetration, aeration and internal drainage.

♦ A minimum soil depth of 30cm for rooting is required for citrus production, with a rooting depth of 40cm to 50cm for micro-jets and 60cm to 70cm for drip irrigation considered as optimal.

♦ For the development of a healthy root zone, a soil strength of less than 1,800 to 2,000 mega Pascal per cm² (MPa cm⁻²) is required.

♦ In terms of soil stratification, the guideline for too great a difference is more than 1.5 times the clay content from one layer to the next.

♦ In terms of soil aeration, for optimal root development and activity, the spaces filled with air at FWC should be about 10% of the total soil volume.

♦ Optimum soil water pH, where all the nutrients are available, is said to be between 5.5 and 6.5.
When the **soil resistance** is too low, meaning when the salt index is too high, the plants need energy to overcome the osmotic pressure in order to absorb water and nutrients. When the resistance is too low, the mass of nutrients available for absorption might be too low if not supplemented in time.

The higher the **soil fertility**, up to a certain point, the better the yields, provided all other production factors such as irrigation are optimal.

**Organic material** influences almost all the physical and chemical factors.

The purpose of soil preparation is to create a homogeneous rooting zone with no physical and chemical barriers that will restrict root development, root health and root activity.

The purpose of a soil survey is the evaluation of the profile(s) of the soil, and it is done by evaluating the inside of a profile pit.

Profile pits are surveyed by marking the positions of the various layers and by taking samples from the layers.

Profile pits with the same horizons are grouped together. The area is demarcated into soil types based on the grouped profiles and a soil map is developed.

Please complete Activity 9 - Questions:

Complete the following questions below.

1. Describe the positioning of a profile pit.
2. Describe the major components of a soil profile.
3. Describe the use of profile pits to initiate a soil map.

Physical and chemical soil properties play a role in plant nutrition. The impact of the physical properties is mostly indirect and that of the chemical properties mostly direct.

In as far as **soil texture** is concerned, the higher the clay content of the soil, the less air is available for the roots.

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♦ In terms of soil aeration, for optimal root development and activity, the spaces filled with air at FWC should be about 10% of the total soil volume.

♦ Optimum soil pH (water), where all the nutrients are available, is said to be between 5.5 and 6.5.

♦ When the soil resistance is too low, meaning when the salt index is too high, the plants need energy to overcome the osmotic pressure in order to absorb water and nutrients. When the resistance is too low, the mass of nutrients available for absorption might be too low if not supplemented in time.

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<th>Concept (SO 3)</th>
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Supervise and implement soil preparation and remediation

After completing this session, you should be able to:

SO 5: Supervise and implement soil preparation and remediation.

In this session we explore the following concepts:

- Soil remediation.
- The purpose of soil preparation.
- Cultivation needs of various soils.
- Soil preparation methods and implements.

Please complete Activity 10 — Group Activity:

In your group, revise what you have already learnt about soil preparation by drawing a mind map. Refer to your level 2 learner guide is necessary. Discuss the questions below in your group and complete.

1. What are the different methods of soil preparation?
2. What do you know about mechanical soil preparation?
3. What do you know about non-mechanical soil preparation?

5.1 Soil Remediation

Soil aggregation

- Soil that drains well does not crust, takes in water rapidly, does not clod and have good tilth. Tilth refers to the physical condition of the soil and has to do with ease of tillage, seedbed quality, ease of seedling emergence, and root penetration. Good tilth is dependent on soil aggregation.
Aggregated soils allow water to penetrate the soil with ease and eases airflow through the soil. At the same time the water-holding capacity of the soil is increased. This allows the plant roots to occupy a larger volume of the soil as compared to crusted or compacted soils. Aggregated soils allow for easier movement of earthworms and soil arthropods. Well-aggregated soils are less likely to erode because the aggregates are heavier than the single particle components. Addition of organic matter improves soil aggregation.

Non-aggregated soils are dispersed soils. In such a soil the individual soil particles are free to blow away in the wind or wash away with overland water flow. Thus the erosion potential of such a soil is high.

Dispersed soils with high clay content tend to be sticky when wet, and clod when dried. To solve these soils should be treated so that the clay particles can be aggregated together resulting in better aeration and water infiltration. Sandy soils benefit from aggregation by having a small amount of dispersed clay that tends to stick between the sand particles and slow the excess downward movement of water.

Poorly aggregated soils tend to crust. Crusting occurs because of the impact of falling raindrops. The rain causes the clay particles on the soil surface to disperse, clogging the pores immediately beneath the surface. Once dried the surface is sealed and most of the pore space are reduced due to clogging from dispersed clay particles. A consequence of this is that subsequent rainwater is more likely to run off than to flow into the soil.

Aggregates are formed because of physical forces that bind the particles together. However they can also be held together by plant roots, earthworm activity, and by products produced by soil micro-organisms. An aggregate formed by physical forces can be bound together by fine root hairs or threads produced by fungi. Aggregates can also stabilize, remaining intact when wet, when fungi and bacteria decompose organic matter, forming gums, waxes,
and other glue-like substances that bind soil particles. The by-products cement the soil particles together, forming water-stable aggregates.

- Soil aggregates are destroyed if:
  - bare soil surface is exposed to the impact of raindrops
  - the organic matter is removed when crops are produced and harvested without returning organic matter to the soil
  - the soil is excessively exposed to tillage
  - the soil is worked when it is too wet or too dry
  - when anhydrous ammonia is applied because it speeds up decomposition of organic matter
  - excess nitrogen fertilizer is applied
  - sodium build up in soil from irrigation or sodium-containing fertilizers

**Key Principles of Sustainable Soil Management**

- Soil organisms cycle nutrients and add many other benefits to the soil
- Organic matter is the food for the soil organisms
- Soil should be covered to protect it from erosion and temperature extremes
- Tillage can speed up the decomposition of organic matter
- Excess nitrogen speeds up the decomposition of organic matter and insufficient nitrogen slows down organic matter decomposition but starves plants
- Mouldboard ploughing speeds up the decomposition of organic matter, destroys earthworm habitat, and increases erosion
- To build soil organic matter, the production or addition of organic matter must exceed the decomposition of organic matter
- Soil fertility levels need to be within acceptable ranges before a soil-building program is initiated

**Cultivation and tillage**

- Tillage and cultivation are used in a farming system to control weeds, manage crop residues, aerate soil, conserve manure and fertilizers, reduce hardpan, and as a sanitation measure to destroy insect and disease habitat.

- Conventional farming tends to rely on chemicals to accomplish many of these objectives, whereas organic growers have focused more on improving tillage and gaining the maximum benefits. Primary tillage should be intent on conserving crop residues and added manures in the upper zones of the soil, rather than burying them deeply where decomposition is anaerobic and thus
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Version: 01                 Version Date: July 2006

slow. Mouldboard ploughing tends to turn the soil placing the biologically active soil into the deeper soil layer, mostly killing the predominantly aerobic organisms.

♦ In an organic system of row crops tillage is often limited to blind tillage, where the soils undergoes shallow tillage, but the crops rows are mainly ignored. Equipment such as a rotary hoe is ideally suited for this purpose.

♦ Excessive tillage could increase costs of production aerates the soil and speeds the decomposition of the organic fraction. This generally provides a boost to the current crop but it can be overdone and in so doing destroy the soil humus reserves. Excessive tillage also destroys earthworms and their tunnels, reducing their benefits to the land. There is also the danger of compaction, even when field operations are well timed.

♦ However soils should not be left completely bare as they become vulnerable to erosion.

### Intercropping & Companion Planting

♦ Intercropping is a strategy used when Inter-planting two or more mutually beneficial crops in close proximity helps to increase the biodiversity within the agricultural system. The process involves alternating rows of compatible field crops such as soybeans and maize on a single field. Intercropping on a smaller scale is often referred to as companion planting. An example of companion planting is the planting of maize with beans and creeping pumpkins such as squash. In this system, the beans provide nitrogen; the maize provides support for the beans and a screen against squash borer. Creeping squash on the other hand acts as a weed suppressive.

### Soil ameliorants

♦ There are a number of different soil composition improvement agents available. All these agents have a slightly different effect on the soil.

♦ Manure is generally widely available. Manure usually causes a decrease in soil pH it decomposes. Manure should be well rotted before it is used. Manure contains a small amount of a large number of plant nutrients. Manure can however also contain weed seeds. Although rate carry over of herbicide residues into manure has been recorded.

♦ Peat usually makes the soil acid. It is usually expensive costly and is becoming a scarce natural commodity. Pest mining also has a negative environmental impact. Peat is usually rich in nitrogen and other plant nutrients, but not usually in phosphate. It does not contain many weed seeds, and the coarse grades are best for soil composition improvement.

♦ Compost if well made is a very useful material, but is generally weaker at soil improvement than peat or manure. It does not supply much plant food and usually contain weeds and some diseases if not properly made. Regular use is needed for and effect.
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- **Spent Mushroom Compost** is one of the few types of organic matter to have a slightly alkaline effect on the soil. It is therefore good for soils that need both composition improvement and increased in pH, or soils at the right pH level that would become too acid if peat or manure were used. It is a waste product of the mushroom growing industry but expensive. It is generally widely used and in great demand in the gardening sector.

- **Straw** is very good for improving soil composition, but reduces the available nitrogen for a period when first added. This is because the addition of straw stimulates microbial activity, which uses high levels of nitrogen. It is better if straw is used once it has been rotted somewhat.

- **Gypsum** is an excellent soil improver for heavy soils. It should be ploughed in well and mixed intimately with soil particles. The tiny soil particles are chemically attracted to each gypsum particle and then stick together around it so that the whole clay “lump” behaves just as though it were a sand sized multi-particle. Gypsum is not usually expensive. Gypsum works in the same way as lime, but without raising the soil pH.

- **Lime** is available in different forms. Lime works in the same way as gypsum but lime causes the soil pH to increase.

- Bacterial products are usually freeze dried bacterial cultures which are useful on soils which do not have any bacteria present such as in desert sands, or subsoil. These products are also used for specific purposes such as metabolism of pollutants.

- **Aquifiers and Aqueupulses** were developed recently. These are compounds that act like a wetting agent breaking down the surface tension of water, thereby improving drainage. These compounds can be leached out of the soil with rain. The other types turn to a gel when wetted, and release the water more slowly as the soil dries out. The use of these type of compounds have not yet been widely demonstrated in agriculture but some success has been shown in gardens and glass-houses.

### 5.2 The purpose of Soil Preparation

The main aim of soil preparation for citrus orchards is to create the homogenous layer of soil with no major changes in the physical and chemical properties laterally, but most importantly no major changes with depth. This homogenous layer is the future rooting zone.

The optimum depth of the rooting zone is 50cm to 60cm, but the depth depends on what is available, the soil type and method of irrigation. Thinner rooting zones of 20cm to 30cm require better management of the irrigation, drainage and fertilization. For drip irrigation the optimum rooting zone has a depth of 60cm to 70cm and with micro-jets the optimum depth is 40 to 50cm.
5.3 Cultivation needs of various soils

The cultivation needs of a soil are prescribed by the soil profile and the requirement of the roots of citrus trees. Tree roots require a homogeneous volume of soil with no drastic changes in physical and chemical properties.

When evaluating the profile, it is important to record the properties of the different horizons and to sample each horizon separately. Analyzing samples of different horizons will identify variation with depth, which is important in deciding on an appropriate cultivation method.

■ Profile Properties and Soil Preparation

The aim of soil preparation is to create a homogenous, well aerated, well drained rooting zone, with a depth of at least 40cm. The profile properties that are very important in meeting this requirement are texture, layering, strength (compaction), aeration, drainage and depth.

■ Soil Probe

- One easy way to test these factors is to press a probe into the soil. Use any type of steel rod with a diameter of 8mm to 10mm. This probe will go into wet soil fairly easily, and without effort into soil where no compaction is present. Compaction, cultivation depth, and even wetting depth and spreading can be detected with such a probe.

- To construct a soil probe, take a 1.5m length of mild steel with a diameter of 8mm to 10mm. Sharpen the tip and weld a handle to the other end, as indicated in the sketch below.

A soil probe can be used to test the actual depth to which the implement loosened the soil after soil preparation as well. The homogeneity of the loosened profile can also be detected by probing in a fixed pattern.

■ Chemical Properties and Soil Preparation

- The two most important chemical properties of soil that have an influence on the methods used in soil preparation are pH and salt content. The salt content is measured by the resistance or electrical conductivity. Remember that profile sampling will be done during the evaluation of the profile and that samples need to be taken of the various horizons or at increasing depths.
In neutral to acid soils the pH of the subsoil tends to be lower than that of the topsoil. However, this must be determined in the laboratory. Liming of soils with a pH (water) of less than 6.5 must be done during soil preparation. The depth to where the lime has to be mixed will dictate the method of to be used in preparing the soil.

The opposite can also be true, namely that the pH of the subsoil is higher than that of the topsoil. In this case, the high pH is usually associated with saline or salty conditions and this saline soil must not be brought to the surface.

**Salt Content**

Under most conditions, the salt content of the soil increases with depth. If the subsoil contains more salts than the topsoil, the subsoil must not be mixed with the topsoil or brought to the surface and put on top of the topsoil. The right implements must be chosen to loosen the profile without turning the subsoil to the top.

### 5.4 Soil Preparation Methods and Implements

Based on the discussions above, two major methods of soil preparation are identified. The first method is used where the horizons in the soil profile need to be mixed due to inherent differences exceeding the set limits. This mixing action can also be used to incorporate required chemicals, such as lime or phosphates. The second method is where the profile needs to be loosened only and no mixing is required.

**Mixing**

When the soil survey indicates that a mixing action is required to render a homogeneous rooting zone, the selection of the right implement will depend on what needs to be mixed with what. If the second layer has to be mixed with the top layer, the right implement will have the mould board that fit this action. Soil preparation professionals adjust the implement to suit the profile. The plough with the correct mould board to create the correct mixing must be selected very carefully.

The other reason to mix the profile is to incorporate the required chemicals and fertilisers to optimise the chemical composition of the soil. This can be done by any implement with a mixing action, because specific layers in the soil are in this case not being mixed, but the whole profile.
Loosening

♦ When the properties of the profile indicate that the soil needs only to be loosened, almost any ripper-type plough will be adequate. However, a standard ripper tine will loosen the top half of the penetration depth but compact the lower half. The ripper tine is therefore fitted with wings at its tip to avoid compaction through the lifting action of the wings. The wings must run at an angle of 30° with the horizontal. These wings can extend up to 15cm on each side, depending on the capacity of the tractor.

♦ Loosening is sometimes also referred to as ripping because of the use of a ripping tine.

♦ Soil preparation must be done correctly before planting, because corrective cultivation is very seldom successful.

♦ Proper soil preparation involves a soil survey, the selection of appropriate implements, and the proper execution of the decided actions.

♦ The objective of soil preparation is to provide tree roots with a homogeneous volume of soil with no drastic changes in physical and chemical properties.

♦ The profile properties that are important in meeting the objective of soil preparation are texture, layering, strength (compaction), aeration, drainage and depth.

♦ The two most important chemical properties of soil that have an influence on the methods used in soil preparation are pH and salt content.

♦ The two methods used during soil preparation are mixing and loosening.

♦ Mixing is used when soil layers must be mixed to create a homogenous region and where chemicals must be incorporated into the soil during preparation.

♦ Loosening is used where mixing is not required.

Please complete Activity 11 – Questions:

Complete the following questions below.

1. What is the basic requirement of the soil in the root zone?

2. How will layering restrict root development?
<table>
<thead>
<tr>
<th>Concept (SO 5)</th>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>An understanding of the special cultivation needs of various soils is demonstrated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appropriate implements and/or methods for soil preparation is selected.</td>
<td></td>
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</tbody>
</table>
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrient Deficiency</td>
<td>A nutrient deficiency is when there is not a sufficient quantity of a specific nutrient element and the plant cannot complete a certain physiological process as a result.</td>
</tr>
<tr>
<td>Soil Penetrometer</td>
<td>A soil penetrometer is an instrument that measures soil strength. Soil strength is the resistance of soil against penetration of roots, or against the probe when using the instrument. Soil strength is expressed in mega-Pascal per square centimetre, written as MPa/cm² or MPa cm⁻².</td>
</tr>
<tr>
<td>Field Water Capacity (FWC)</td>
<td>Field Water Capacity (FWC) is reached when a soil is allowed to drain freely after it was saturated with water. This is the point where no free water is present in the soil. All the water present is bound to the soil particles.</td>
</tr>
<tr>
<td>pH</td>
<td>pH indicates the acidity or alkalinity of any substance, in this case soil, on a scale of 1 to 14. pH can range from 1 (extremely acidic) to 14 (extremely alkaline). A pH value of 7 is neutral. Plant sap has a pH of 5.8 and the pH of human blood is almost 7. Soil with a low pH is referred to as acidic. Soil with a high pH is referred to as alkaline.</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>Electrical conductivity refers to the ability of soil paste to conduct an electrical current and can be expressed in various units. The international standard unit is Siemen.</td>
</tr>
<tr>
<td>Resistance</td>
<td>Resistance is the opposite of electrical conductivity, and refers to the resistance of a soil paste to conducting an electrical current. Resistance is expressed in ohms.</td>
</tr>
<tr>
<td>Lime</td>
<td>Lime is added to soil that is too acid. Lime applications can be done as part of soil preparation before the trees are planted or as part of the fertilization program after the trees have been planted.</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>
</tr>
</thead>
<tbody>
<tr>
<td>1. Explain how you would mix fertilizer to apply through: A dripper system (fertigation), Foliar application</td>
<td></td>
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<tr>
<td>2. Explain in your own words what calibration means</td>
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<tr>
<td>3. Make a list of equipment that would need to be calibrated during the fertilization process.</td>
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<tr>
<td>4. What does the zeroing of a scale have to do with calibration?</td>
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<tr>
<td>5. Do you think that a general farm worker is involved in the calibration of fertilisation equipment? Explain your answer.</td>
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<tr>
<td>6. Write a job card in order to explain the following to another member of your team: “Collect 100 kilograms of Manganese Sulphate for application as a foliar spray in a dose of 200 grams per 100 litres of water.”</td>
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<tr>
<td>7. In your own words, describe why you think it would be important to take samples of each of the following: Leaves, Soil.</td>
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<tr>
<td>8. Explain whose duty the taking of the following samples would be on a citrus farm: Leaves, Soil.</td>
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<tr>
<td>9. Describe briefly in your own words how to take a leaf sample.</td>
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<tr>
<td>Question</td>
<td>Answer</td>
<td></td>
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<tr>
<td>-------------------------------------------------------------------------</td>
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<tr>
<td>10. Describe briefly in your own words how to take a soil sample.</td>
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<tr>
<td>11. Give an example of one service provider who can help you with the analysis of leaf and soil samples.</td>
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<tr>
<td>12. Explain the physical properties of soil in your own words.</td>
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</tr>
<tr>
<td>13. Explain the chemical properties of soil in your own words.</td>
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<td></td>
</tr>
<tr>
<td>14. What would happen if: You applied a foliar spray with a mist blower on a windy day? ; You applied a too strong fertilizer mix to your orchard? ; You forgot to fertilize as per recommendations?</td>
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</tr>
<tr>
<td>15. What would be your recommendation for soil preparation if: There is a very hard rock layer approximately 30cm under the topsoil.; There is a distinct colour difference between soil horizons at a depth of 60cm.</td>
<td></td>
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</tr>
<tr>
<td>16. What would be the visible defect in a citrus tree if there was too little of the following macro nutrient element available: Nitrogen, Phosphorous, Potassium, Calcium</td>
<td></td>
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<tr>
<td>17. What would be the visible defect in a citrus tree if there were too little of the following micro nutrient element available: Boron, Zinc, Iron, Manganese,</td>
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<tr>
<td>18. What is the purpose of mulching?</td>
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<tr>
<td>19. Why would we add compost to soil in a citrus orchard?</td>
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<tr>
<td>20. Do you think that adding fertilizer to soil can improve the soil? Explain your answer in detail.</td>
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<tr>
<td>21. Explain in your own words what does it mean to rip soil?</td>
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<tr>
<td>22. Do you think that all soil should be ripped? Explain your answer.</td>
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<tr>
<td>23. Do you think that you should till all soil? Explain your answer.</td>
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<tr>
<td>24. Explain in your own words what you understand by the term soil ecology?</td>
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<tr>
<td>Question</td>
<td>Answer</td>
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<td>------------------------------------------------------------------------</td>
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<tr>
<td>25. Give a practical example on a citrus farm of how soil health and soil conservation can be promoted.</td>
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<tr>
<td>26. Explain in your own words what you understand by the term run-off control.</td>
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<tr>
<td>27. Explain what role contours can play in soil conservation practices on a citrus farm.</td>
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<tr>
<td>28. Do you think that soil preparation that stops as soon as you have completed the primary preparation of the soil, in other words, when you are ready to plant you Citrus trees for the first time? Motivate your answer.</td>
<td></td>
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</tr>
</tbody>
</table>

My Notes ...
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 (Give examples, reasons, etc.)</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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</tbody>
</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>
<thead>
<tr>
<th>Learner Information Form</th>
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<tbody>
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Bibliography

Books:


World Wide Web:

♦ Department of Agriculture Web Site: [www.nda.agric.za](http://www.nda.agric.za)

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  Mr R H Meinhardt

■ **Language Editing:**
  Mr D Erasmus

■ **OBE Formatting:**
  Ms P Prinsloo

■ **Design:**
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■ **Layout:**
  Ms A du Plessis
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SOUTH AFRICAN QUALIFICATIONS AUTHORITY
REGISTERED UNIT STANDARD:

Manage soil fertility and plant nutrition

<table>
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<th>SAQA US ID</th>
<th>UNIT STANDARD TITLE</th>
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<th>REGISTRATION END DATE</th>
<th>SAQA DECISION NUMBER</th>
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<td>2004-10-13</td>
<td>2007-10-13</td>
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PURPOSE OF THE UNIT STANDARD

A learner achieving this unit standard will be able to supervise application of soil nutrient preparations in a safe, effective and responsible manner for the benefit of plant/crop growth with consideration to the environment.

Learners will gain specific knowledge and skills in soil and plant nutrition 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 demonstrate competence against unit standard

- NQF 3: Supervise the collection of agricultural data.
- NQF 3: Understand the planning and scheduling of tasks in a production environment.
- NQF 3: Interpret and maintain factors influencing agricultural enterprises and plan accordingly.

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
UNIT STANDARD OUTCOME HEADER
N/A

Specific Outcomes and Assessment Criteria:

Specific Outcome 1
Prepare for soil nutrient applications using specialized equipment.
Outcome Range
Nutrient application refers to but is not limited to fertiliser or compost spreaders and planters.

Assessment Criteria

Assessment Criterion 1
The ability to use specialized equipment is demonstrated.

Assessment Criterion 2
The ability to calibrate specialized equipment is demonstrated.

Assessment Criterion 3
The ability to select the appropriate nutrients for application from storage facilities is demonstrated.

Specific Outcome 2
Supervise the collection of samples, storage and dispatch of samples to appropriate service provider.
Outcome Range
Samples for leaf, soil and fruit analysis.

Assessment Criteria

Assessment Criterion 1
The ability to take and handle leaf, soil and fruit samples according to prescribed procedures are demonstrated.

Assessment Criterion 2
The process of recording and dispatching the samples to the appropriate service provider is explained.

Specific Outcome 3
Demonstrate an understanding of the properties of soil and how these impact on plant nutrition and soil preparation.
Outcome Range
Soil properties may include chemical, physical and biological properties.

Assessment Criteria

Assessment Criterion 1
The impact of soil properties on plant nutrition is explained.
ASSESSMENT CRITERION 2
The impact of soil properties on soil preparation is explained.

SPECIFIC OUTCOME 4
Identify and interpret symptoms of nutritional deficiencies in different crops and make basic recommendations.

OUTCOME RANGE
Macronutrients may include (among others) Nitrogen, Phosphorous, Potassium and Calcium. Micronutrients may include (among others) Boron, Zinc, Iron and Manganese.

Simple recommendations on steps to correct nutrient deficiencies.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
The relationship between plant abnormalities and deficiencies of specific macro- and micro- nutrients is explained.

ASSESSMENT CRITERION 2
Basic recommendations for improving soil fertility are made.

SPECIFIC OUTCOME 5
Supervise and implement soil preparation and remediation.

OUTCOME RANGE
Soil preparation methods refer to mechanical and non-mechanical approaches, minimum tillage, no tillage, and both primary and secondary soil preparation. Remediation includes methods of dealing with acidity and Aluminium or Iron toxicity, water logging, compost making, etc.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
An understanding of the special cultivation needs of various soils is demonstrated.

ASSESSMENT CRITERION 2
Appropriate implements and/or methods for soil preparation is selected.

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:

- Sampling procedures.
- Chemical, properties of soil - pH, Nutrient status.
- Physical properties of soil - Texture, structure, soil profiles.
- Biological properties of soil.
- Soil ecology e.g. soil organisms, food webs, role of water and oxygen in soil.
- Soil health and conservation.
- Role of living organisms.
- Conservation practices - Runoff control, contours.
- Tillage operations - mechanical, non mechanical, organic, Minimum and zero Tillage and application of nutrients (liquid and solid).
- Primary and secondary soil preparation methods.
- Soil preparation and Fertiliser application equipment.
- Nutrients - Mixtures, limes, calcite and dolomite lime, single nutrients and compost, liquids, etc.
- Calibration of equipment.

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 specific outcomes.

UNIT STANDARD CCFO WORKING

Teamwork: Relates to all specific outcomes.
UNIT STANDARD CCFO ORGANIZING
Self-management: Relates to all specific outcomes.

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

UNIT STANDARD CCFO COMMUNICATING
Communication: Relates to all specific outcomes.

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

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

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

UNIT STANDARD ASSESSOR CRITERIA
N/A

UNIT STANDARD NOTES
N/A

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