Learner Guide
Primary Agriculture

Soil fertility and plant nutrition practices

My name: ________________________________
Company: ______________________________
Commodity: ________________ Date: ______________

The availability of this product is due to the financial support of the National Department of Agriculture and the AgriSETA. Terms and conditions apply.
Before we start...

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

<table>
<thead>
<tr>
<th>Title</th>
<th>US No: 116311</th>
<th>NQF Level: 4</th>
<th>Credits: 3</th>
</tr>
</thead>
</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:

<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>48979</td>
<td>4</td>
<td>120</td>
<td>☐</td>
</tr>
<tr>
<td>National Certificate in Plant Production</td>
<td>49009</td>
<td>4</td>
<td>120</td>
<td>☐</td>
</tr>
</tbody>
</table>

Please mark the learning program you are enrolled in:

Are you enrolled in a:   Y   N

- Learnership?         ☐   ☐   ☐
- Skills Program?      ☐   ☐   ☐
- Short Course?        ☐   ☐   ☐

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 roll in reaching competence.

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

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

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

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

   
   Enjoy this learning experience!
How to use this guide …

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

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

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

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

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

**My Notes …**

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

What will I be able to do? ......................................................................................... 6
Learning outcomes ........................................................................................................ 6
What do I need to know? ............................................................................................... 7
Session 1 Set up a Nutritional Program................................................................. 8
Session 2 Soil Utilization Plan.................................................................................. 25
Session 3 Symptoms of Nutritional Deficiencies................................................. 30
Session 4 Soil Improvement....................................................................................... 44
Am I ready for my test? ............................................................................................. 53
Checklist for Practical assessment............................................................................. 54
Paperwork to be done .................................................................................................. 55
Bibliography................................................................................................................... 56
Terms and conditions..................................................................................................... 56
Acknowledgements...................................................................................................... 57

SAQA Unit Standards
What will I be able to do?

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

♦ Set up and supervise the implementation of soil preparation and maintain and conserve soil in a safe, effective and responsible manner with consideration to the environment.

♦ 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.

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 and degradation.

♦ Physical properties of soil - Texture, structure, soil profiles, crust formation, erosion types, compaction, and degradation.

♦ Biological properties of soil and processes.

♦ 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/ compost application equipment.

♦ Nutrients - mixtures, limes, calcite and dolomite lime, single nutrients and compost, liquids, etc.

♦ Calibration of equipment.

♦ Chemical, physical and biological properties, degradation and rehabilitation.

♦ Characteristics of the nutrients.

♦ Role of nutrients in the plant.

♦ Rules and regulations for storage and handling of agro-chemicals transport.

♦ Crop requirements.

♦ Soil water relationships.

♦ Mulching and ploughing in of mulch layer.

♦ Pollution prevention.
Biological processes.
Mineral cycles e.g. Nitrogen.

What do I need to know?

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

- NQF3; Literacy and Numeracy
- Level 3; 116267; Manage soil fertility and plant nutrition
- Level 4; 116312; Implement a data collection plan
- Level 4; 116288; Execute sustainable resource use and quality control
- Level 4; 116320; Plan and maintain environmentally sound agricultural processes
In this session we explore the following concepts:

- Nutritional program for tree crops – Citrus.
- Stock levels.

1.1 Introduction

In the following sections, two nutrient programs are provided as examples. The examples provided are for citrus, representing tree crops and sunflower representing field crops. The programmes provided may be relevant to other, similar crops as the basic principles are the same. However the values provided in the examples are not definite as these may vary between crops as well as between different farms growing the same crop. This is because soil, climate, crop, cultivars etc. vary. It is for this reason that all good fertilizer programmes are based on recommendations from soil and / or leaf samples for the crop and site.

1.2 Nutritional program for Tree Crops - Citrus

Citrus production, as is the case of all other crops, has a specific schedule for the application of nutrients. Certain nutrients require application at critical times, while others may be applied over a longer and less specific period.

When the fertilizer applications schedule is planned all production practices must be considered. This is especially true for foliar sprays, where the application of crop protection products must be considered. Fertilizer application must be coordinated with other production practices to ensure that the right fertilizer is applied at the right time.

Various institutions will develop fertilization programs for a crop. These may vary from basic, general programs to highly specific programs. General programs may be of little value in a commercial citrus production unit. The ideal programs are formulated for a specific orchard, based on specific data from that orchard. Such
specific programs are developed based on leaf and soil analyses data for the current year, as well as historic data. The leaf and soil analytical data is usually supported by information on the previous fertilizer applications (what, how much and when) and information on the previous as well as current crop information such as yields and fruit quality.

All these factors are evaluated in conjunction in order to formulate the best fertilization program. The best fertilization program is one that will result in the best possible fruit volumes and quality, and therefore give the highest economic benefit, without sacrificing sustainability.

A good fertilization program will contain the following information for each orchard:

♦ Orchard number or reference
♦ Cultivar and variety
♦ Details for soil applications:
  ♦ Quantity in grams (g) to be applied per tree
  ♦ Name of fertiliser
  ♦ Time of application
  • Details for foliar applications:
    ♦ Quantity in grams (g) or millilitre (ml) to be mixed per 100l water
    ♦ Name of fertilizer
    ♦ Time of application
  • Additional information or special instructions

---

**Example**

**Fertilization Program - Citrus**

<table>
<thead>
<tr>
<th>Orchard:</th>
<th>Size:</th>
<th>Trees per ha:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchard 10</td>
<td>3.0ha</td>
<td>316</td>
</tr>
<tr>
<td>Delta Valencias</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fertiliser**

**Soil Applications**

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>Quantity per tree</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></th>
<th>g per 100l water</th>
<th></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: 1. Manganese and Solubor® are compatible. Spread the lime over the entire area allocated per tree.
Once a programme has been provided, the orchard manager needs to develop a schedule for the implementation of the programme provided. The schedule is developed for soil applications as well as foliar sprays so as to slot into the rest of the production programme. The programme may require adaptation to suit younger trees.

### Scheduling a Soil Application Program

The best practice for citrus is to schedule soil applications on a monthly basis. Most fertiliser programmes provide the fertiliser mass or volume per month. The fertilisation programs will recommend rates per tree or per ha.

In order to develop a soil program for the farm as a whole, the applications of all the orchards are summed and presented in one working document or schedule per month. Additional information is added, such as the size of each orchard and the number of trees per hectare. Using the fertilization program in the example above as a starting point, the following **Soil Application Schedule** can be developed.

<table>
<thead>
<tr>
<th>Orchard</th>
<th>Size (ha)</th>
<th>Trees per ha</th>
<th>Total Trees</th>
<th>Recommend (g per tree)</th>
<th><strong>Total Recommend per Orchard (kg)</strong></th>
<th>Applied (g per tree)</th>
<th>Total Applied per Orchard</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.5</td>
<td>316</td>
<td>1,106</td>
<td>650g</td>
<td>719g</td>
<td>719</td>
<td>719kg</td>
</tr>
<tr>
<td>B</td>
<td>2.0</td>
<td>316</td>
<td>632</td>
<td>500g</td>
<td>316g</td>
<td>316</td>
<td>316kg</td>
</tr>
<tr>
<td>C</td>
<td>4.1</td>
<td>556</td>
<td>2,279</td>
<td>250g</td>
<td>570g</td>
<td>570</td>
<td>570kg</td>
</tr>
<tr>
<td>D</td>
<td>3.2</td>
<td>416</td>
<td>1,331</td>
<td>500g</td>
<td>666g</td>
<td>666</td>
<td>666kg</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,271kg</td>
</tr>
</tbody>
</table>

*Total Trees = size (ha) x trees per ha
**Total required per Orchard (kg) = total trees x recommended g per tree / 1,000

i.e. * 3.5 ha x 316 trees per ha = 1,106 trees
    ** 1,106 trees x 650 g per tree = 718,900 g / 1,000 = 719 kg

It is important to note those N-containing fertilizers are not applied as a single dose, but rather spread the application as 2 to 4 applications during the month. Nitrogen is highly soluble in water and if 500g LAN per tree is applied as a single dosage, the ammonium nitrate, may scorch the roots and reduce absorption. The high concentration of ammonium nitrate can also not be absorbed within a short period of
time and subsequent irrigation may leach the nitrogen beyond the reach of the roots.

The solubility and salt index of the fertilizers, the clay content of the soil, and the rooting depth of the plants are the major factors that affect the efficiency of a fertilizer application. Leaching is less of a problem in clay than in sandy soils. The buffer capacity of clay soils is better than that of sandy soils and the temporary increase in salinity due to ammonium nitrate is lower.

The salt index of fertilizers indicates the necessity of splitting an application. Fertilizers with a high salt index, such as potassium chloride, should be split into multiple applications. This may not be necessary in the case of calcium nitrate, which has a low salt index.

After the Soil Application Program has been compiled, an application schedule is developed for each month. During such an exercise, it is planned which orchard will receive its application during what time of the month, taking into consideration available manpower and equipment. Please note that if a number of applications are done in the same orchard in consecutive months, care should be taken to ensure that the applications are done on more or less the same day of each consecutive month.

In practice, it is difficult to apply exactly the recommended quantity per tree to all of the trees in orchard. It is therefore necessary to calculate the actual average rate of application once the application has been completed. This is done by dividing the total quantity applied to the orchard by the number of trees per orchard, and thus calculating the average volume per tree. The actual average quantity per tree may vary somewhat from the recommended quantity per tree, but it is important to ensure that this variation is not larger than 10%, i.e. 618-683g per tree in the case of orchard A.

Soil application programs are developed for August, September and October, with two separate programs for the application of LAN and potassium chloride in August and September.

**Developing a Foliar Application Program**

A foliar application program is developed in a similar manner, although the calculations are somewhat different. The recommended foliar applications are supplied in g or ml per 100l water. The size of the trees will determine the total amount of spray mixture required. Foliar feeds are applied as medium cover sprays. The larger the tree the higher the volume applied per tree and thus the volume per hectare. On average, between 1250 and 2,500 litres of spray mixture is applied per hectare on mature citrus trees using a medium-cover spray.
### Foliar Application Program

<table>
<thead>
<tr>
<th>Month:</th>
<th>July 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product:</strong></td>
<td>Low Biuret Urea</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Orchard</strong></th>
<th><strong>Size (ha)</strong></th>
<th><strong>Litres per ha</strong></th>
<th><strong>Total Litres</strong></th>
<th><strong>Recommend (g per 100l)</strong></th>
<th><strong>Total Recommend per Orchard (kg)</strong></th>
<th><strong>Applied (g per ha)</strong></th>
<th><strong>Total Applied per Orchard</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.5</td>
<td>2,500</td>
<td>8,750</td>
<td>1,000</td>
<td>88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>2.0</td>
<td>2,250</td>
<td>4,500</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>4.1</td>
<td>1,250</td>
<td>5,125</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>3.2</td>
<td>1,750</td>
<td>5,600</td>
<td>1,000</td>
<td>56</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>144</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Litres = size (ha) x litres per ha
** Total Recommended per Orchard (kg) = recommended g per 100l / 100 x total litres / 1,000
i.e. * 3.5 ha x 2,500 litres per ha = 8,750 litres
** 1,000 g per 100l / 100 = 10g per litre x 8,750 litres = 87,500g / 1000 = 88kg

The average actual application per hectare is calculated once the application has been done to ensure that the variance between the recommended quantity and the actual applied quantity does not vary by more than 10%.

A foliar application program is developed for October as well. Note that it was stated in the fertilization program that the Manganese Sulphate and Solubor® sprays are compatible, and can therefore be sprayed at the same time.

### Maintaining Stock Levels and Placing Orders

Ordering of fertilization must be coordinated with the production manager and the administrative staff. Ensure that documentation is provided to the responsible person in good time, and ensure that the manager is aware of all orders that are to be placed.

The fertilization program for the next season (remember that a season is from the beginning of August of one year to July of the next year) is usually prepared during March to June. During this period, leaf and soil samples are analysed and the results used inter alia to formulate the fertilisation program. March to June is also the harvesting period for the early cultivars and a good time to evaluate the yield and quality of the late cultivars. Ordering should start during May or June to ensure that stocks are on hand when the very important application of nitrogen starts in July or August.

The time required between ordering and delivery depends on the agreement between manager and supplier. Ensure however that the fertilizers will be delivered in time if orders are placed for instance thirty days prior to the application date.
Economic considerations could limit the time between ordering and delivery. If payment is made on delivery, one would not submit an order in March for fertilizer required in July.

### Fertilizer Order

**Fertilizer Requirements**

<table>
<thead>
<tr>
<th>Product:</th>
<th>Limestone Ammonium Nitrate (LAN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orchard</strong></td>
<td><strong>Required July</strong></td>
</tr>
<tr>
<td>A</td>
<td>719</td>
</tr>
<tr>
<td>B</td>
<td>316</td>
</tr>
<tr>
<td>C</td>
<td>570</td>
</tr>
<tr>
<td>D</td>
<td>666</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,271</td>
</tr>
</tbody>
</table>

Requirement reports, such as the one above, are developed for each fertilizer and each month, and are done for the low biuret urea required in July (foliar spray), LAN and potassium chloride required in September, the lime in October and manganese sulphate and Solubor® in October.

**Substitution of Recommended Fertilizer**

Recommended fertilizers and chemicals for foliar sprays can be substituted with an equivalent elemental base provided that:

- The chemistry of the replacement chemical and its reaction in the soil and on the leaf will not create unwanted side-effects; and
- The recommended mass or volume is adjusted to compensate for variations in concentration of the active ingredient/s.

The person responsible for the formulation of the fertilization program should be consulted before substitutions are made. Fertilizer manufacturers may also be able to assist in this regard.

The rate of application for the replacement fertilizer is calculated as follows:

- The rate of application for recommended product multiplied by % active ingredient in recommended product divided by % active ingredient in replacement product
- Rate of application for replacement product
Fertilizer Substitution

- Borate A, containing 16% B, can substitute Solubor®, containing 20% B. The application rate must be changed accordingly, i.e. if 150g per 100l was recommended, 187.5g Borate A per 100 litre water should be applied, calculated as follows: 150x20/16 = 187.5
- LAN (28% N) can be substituted by ammonium sulphate (21% N) but keep in mind that the acidification of ammonium sulphate is more than twice that of LAN. The calculation in this case is: 500g LAN x 28/21=667g ammonium sulphate
- Double super phosphate (20% P) can be substituted by twice as much single super phosphate (10,5% P)

The application of fertilizers for sunflower and field grown vegetables and other field crops differ in that from citrus, due to the fact that we replant each year. Therefore most of the fertilizers will be incorporated into the soil during soil preparation, some can be applied with plant and a third part can be applied after the crop is established. In some cases, especially with high value crops or crops with specific needs, a farmer can also apply some elements as a foliar application. Learners are referred to the previous section on citrus for information on timing fertilizer orders and replacement fertilizers.

In this section we investigate:

- Broadcast application of fertilizers to the soil
- Applying fertilizer during ploughing
- Band application of fertilizers with planter
- Fertiliser top dressing after planting
- Foliar feeds

As for citrus, it is important to keep record of what and when fertilizers have been applied. Some of the information to be recorded includes:

- Field number – same number as the one indicated on the soil analysis
- Crop and cultivar
- Details for soil applications:
  - Quantity (kg) to be applied per ha
  - Name of fertilizer
  - Time of application
- Details for band placing:
  - Quantity (kg) to be applied per ha
  - Name of fertilizer
  - Time of application
- Details for top dressing:
  - Quantity (kg) to be applied per ha
  - Name of fertilizer
  - Time of application
- Details for foliar applications:
• Quantity in grams (g) or millilitre (ml) to be mixed per 100l water
• Name of fertilizer
• Time of application
♦ Additional information or special instructions

## Determining the amounts of N, P, K and B to apply.

During the course of this section, the information in tables 1.1 to 1.6 will be used. Table 1.1. is the information we received back after the Laboratory did the soil and plant analysis. This information will be used in conjunction with tables 1.4 and 1.5 to determine the amount of phosphorus and potassium to apply per ha of crop field.

Table 1.2. provides an indication of the yield potential for sunflowers under a certain set of conditions. The higher the yield potential the more nutrients will be required and visa versa.

Table 1.2. will be used in conjunction with tables 1.3 to 1.5, to determine the amount of nitrogen as well as phosphorous and potassium to apply per ha of crop land under sunflower. The information in table 1.6. provided information on the volume of boron required.

Table 1.1. Test results received from the Soil Laboratory for the soil sample we took.

<table>
<thead>
<tr>
<th>Field no</th>
<th>Texture class</th>
<th>pH (KCl)</th>
<th>P mg kg⁻¹</th>
<th>K mg kg⁻¹</th>
<th>Ca mg kg⁻¹</th>
<th>Mg mg kg⁻¹</th>
<th>Na mg kg⁻¹</th>
<th>Ca/Mg mg kg⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sa</td>
<td>4.9</td>
<td>8</td>
<td>53</td>
<td>228</td>
<td>46</td>
<td>11</td>
<td>3.02</td>
</tr>
<tr>
<td>2</td>
<td>LmSa</td>
<td>6.1</td>
<td>12</td>
<td>88</td>
<td>316</td>
<td>73</td>
<td>11</td>
<td>2.64</td>
</tr>
</tbody>
</table>

**Extraction method**

P = Bray 1
Cations = NH₄OAc

**Soil Texture classes (% = % clay in soil)**

Sa = 0 - 10%; SaLm = 10 - 20%; LmSa = 20 - 30%; Clay = > 30%
Table 1.2. Production potential for sunflowers under dry land conditions at specific soil clay contents and soil depths. (Du Toit et al., 1994)

<table>
<thead>
<tr>
<th>Rainfall (mm)</th>
<th>%</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>110</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>572</td>
<td>715</td>
<td>857</td>
<td>1001</td>
<td>1143</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
</tr>
<tr>
<td>0-15</td>
<td>728</td>
<td>910</td>
<td>1091</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
</tr>
<tr>
<td>15-20</td>
<td>860</td>
<td>1063</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
</tr>
<tr>
<td>20-30</td>
<td>990</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
</tr>
<tr>
<td>35+</td>
<td>970</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
<td>1192</td>
</tr>
</tbody>
</table>

Table 1.3. Nitrogen recommendations for sunflower according to yield potential (FSSA, 2000).

<table>
<thead>
<tr>
<th>Potential, t ha(^{-1})</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>N, kg ha(^{-1})</td>
<td>22</td>
<td>54</td>
<td>87</td>
</tr>
</tbody>
</table>

My Notes ...

...
Table 1.4. Phosphorus recommendations for sunflower according to soil analysis and yield potential (FSSA, 2000).

<table>
<thead>
<tr>
<th>Soil P (Bray 1)</th>
<th>P application for yield potential t ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>mg kg⁻¹</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>20*</td>
<td>7</td>
</tr>
<tr>
<td>25*</td>
<td>6</td>
</tr>
<tr>
<td>30*</td>
<td>5</td>
</tr>
</tbody>
</table>

* Some agronomists will recommend less P in these situations

Table 1.5. Potassium recommendation for sunflower according to soil analysis and yield potential (FSSA, 2000).

<table>
<thead>
<tr>
<th>Soil K (Bray 1)</th>
<th>K application for yield potential t ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>mg kg⁻¹</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>60</td>
<td>7</td>
</tr>
<tr>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>120</td>
<td>0</td>
</tr>
</tbody>
</table>

* These are tentative guidelines

Table 1.6. Boron recommendation (kg ha⁻¹) for sunflower

<table>
<thead>
<tr>
<th>Product</th>
<th>Clay percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-15</td>
</tr>
<tr>
<td>Borax (11.3% B)</td>
<td>9</td>
</tr>
<tr>
<td>Boric acid (17.5% B)</td>
<td>6</td>
</tr>
<tr>
<td>Sodium oktaborate (20.5% B)</td>
<td>5</td>
</tr>
</tbody>
</table>
Determining yield potential (Table 1.2.)

To determine the yield potential for sunflower we use the information provided in Table 1.2. The first step is to identify the field. Once the field is known, gather information on the soil depth and long term average rainfall.

Let us assume the field of interest has a soil depth of 0.9 m, the average rainfall is 550 mm for the growing season and the clay content between 0 and 10%. Using this information and applying it to the data provided in Table 1.2, the sunflower yield potential for the field number is 1.501 ton ha⁻¹.

- Determining the amount of nitrogen (N) needed per ha (Table 1.3.)
  
  To determine the N required, the yield potential must be known. If we use the data in example 1.3.1., we assume a yield potential of 1.501 ton ha⁻¹, Table 1.3 indicates a nitrogen requirement of 22 kg ha⁻¹.

- Determining the amount of phosphorus (P) required (Table 1.4.)
  
  To determine the P requirement, we need to know the yield potential for the crop as well as the amount of available P in the soil.

  If we use the data in example 1.3.1., we require a yield of 1.501 ton ha⁻¹. If we assume an available P status of 8 mg kg⁻¹, the P requirement can be determined. Table 1.4 indicates that for a yield of 1.5 ton per hectare with a P status of 8 mg/kg, we will require 11 kg P ha⁻¹. We thus need to apply 11 kg P per ha of sunflower.

- Determining the amount of potassium (K) needed per ha for field number one (Table 1.5.)
  
  To determine the K requirement, we need to know the yield potential and the available K in the soil. If we assume the K status of soil is 53 mh/kg and a yield of 1.501 ton ha⁻¹, the corresponding value in Table 1.5. is 10 kg K ha⁻¹. We thus need to apply 10 kg K for every ha of sunflower we are going to plant in field number one.

- Determining the amount of boron (B) needed per ha for field number one (Table 1.6.)
  
  To determine the B requirement, we need to know the clay percentage. If we assume clay content of 0 to 10%, the B requirement is given as (Table 1.6) 9 kg Borax or 6 kg Boric acid or 5 kg Sodium oktaborate per ha.
Compiling a fertilization program

The information in the previous section can now be incorporated into a fertilization program. Below is an example of such a program for sunflower.

<table>
<thead>
<tr>
<th>Fertilization programme:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fertilizer application – Planting in November</strong></td>
</tr>
<tr>
<td><strong>Orchard:</strong></td>
</tr>
<tr>
<td><strong>Crop:</strong></td>
</tr>
<tr>
<td><strong>Fertiliser</strong></td>
</tr>
<tr>
<td>Broadcast application – before plant</td>
</tr>
<tr>
<td>Calcitic or Dolomitic lime</td>
</tr>
<tr>
<td>2:3:2 (22%)</td>
</tr>
<tr>
<td>1:0:1 (36%)</td>
</tr>
<tr>
<td>Bandplacing – with plant</td>
</tr>
<tr>
<td>Limestone ammonium nitrate (LAN)</td>
</tr>
<tr>
<td>Top dressing – after plant</td>
</tr>
<tr>
<td>Limestone ammonium nitrate (LAN)</td>
</tr>
<tr>
<td>Foliar application – after plant</td>
</tr>
<tr>
<td>Sodium oktaborate (Solubor®)</td>
</tr>
</tbody>
</table>

**Remarks:**

- Solubor are compatible with most herbicides.
- If beans are in rotation with sunflower, be careful not to apply too much B, as it can be toxic to the bean crop.
- Solubor can also be applied to the soil before plant, if the field is known for its lack in boron.
- Calcitic or Dolomitic lime can be used. The price and transport of each will determine which to use.
- The amount of fertilizer placed in the band is restricted to prevent burning of the seed. The amount should never exceed 15 kg N fertilizer per ha.

Compiling a fertilizer plan for all crop fields allows that the correct type of fertilizer is stocked and available at the relevant time. Keep in mind that you are not the only farmer who is going to need the fertilizers. Place your fertilizer order well in advance time to ensure that the fertilizer will be delivered at least a month before you will need it.
Fertilizers application strategies and timing of application

In this section the reasons for applying certain fertilizers at a specific time will be explained.

♦ Broadcast application of fertilizers to soil

Broadcasting refers to the even distribution of lime and fertilizer before it is incorporated into the soil. Broadcasting is efficient and often the method of choice in areas with perennial plants. Lime has to be incorporated in the soil, at least two months before planting. This will allow the lime to rectify a pH problem, as the lime has a long reaction period.

Phosphorus containing products have to be applied to the soil before or with plant, as phosphorus do not easily move in the soil. It can therefore not be applied as topdressing later on, as it will not wash into the soil easily as in the case of nitrogen.

Broadcasting can be done with a tractor pulling the fertilizer spreader or by hand (Fig 1.1.). Most of the spreaders can also be used to spread other dry formula chemicals (insecticides, fungicides etc.) or even broadcasting seed. After the fertilizer has been broadcasted, it is ploughed into the soil. The two actions can also be combined into one, whereby the tractor’s spreader and plough are attached at the same time.

Figure 1.1. Tractor drawn fertilizer spreader on the left and a hand operated version on the right.

♦ Placing fertilizer in the soil while ploughing

With this application the fertilizer is placed in a continuous band into the furrow during the process of ploughing. Each band is covered as the next band is turned over. No attempt is usually made to sow the crop in any particular location with regard to the plough sole bands, as is the case with band placing of fertilizers.

This method has been recommended in areas where the soil becomes quite dry up to a few centimetres below the soil surface during the growing season, and especially with soils having a heavy clay pan a little below the plough-sole. By
this method, fertilizer is placed in moist soil where it can become more available to growing plants during dry seasons.

This is an alternative to broadcasting. The application of lime is always done by broadcasting, while application of fertilizers containing N, P, K and other elements are mostly done in this way.

An exception on broadcasting of lime is when the subsoil is quite acidic. Then lime will be placed deep into the soil while the soil is being ripped with a heavy tooth implement, which penetrates the soil (Fig 1.2.) to a depth of 20 to 50 cm.

Figure 1.2. A hand-held ripper on the left and a mechanical drawn ripper on the right.

- Band placement of fertilizers at plant
  This method refers to the application of fertilizers into the soil close to the seed or plant. Localized placement is usually employed when relatively small quantities of fertilizers are to be applied, otherwise it can burn the seed leading to low germination and poor stands. Localized placement reduces fixation of phosphorus and potassium in the soil. Localized placement is done with specialized planters and the fertilizer is placed to the side and often below the seed during the seeding operation.

  This practice is done to give the young seedling a boost. The fertilizer is placed close to where its roots will grow. The seedling’s roots need not search for the fertilizer which has been mixed with the soil during tillage.

- Top dressing of fertilizers after planting
  Nitrogenous fertilizers containing nitrates, like sodium nitrate, calcium ammonium nitrate etc. is applied as top dressing to closely-spaced crops. In addition urea is also top dressed. This helps in supplying nitrogen in readily available form to growing plants. Top dressing can be done with fertilizer broadcasters.

- Foliar feeding
  This refers to the spraying of suitable fertilizing solutions on leaves of growing plants. These solutions may be prepared in a low concentration to supply a plant with a single nutrient or a combination of nutrients.

  It has been well established that all plant nutrients are absorbed through the leaves of plants and this absorption is remarkably rapid for some
Implement Soil Fertility and Plant Nutrition Practices

Primary Agriculture

NQF Level 4

Unit Standard No: 116311

Version: 01                 Version Date: July 2006

nutrients. Foliar application does not result in a great saving of fertilizer but it may be preferred under the following conditions.

♦ When visual symptoms of nutrient deficiencies are observed during early stages of deficiency.
♦ When unfavourable conditions (physical and chemical) which reduces the efficiency (FUE) of fertilizers occurs.
♦ During a drought period where soil application could not be conducted.(soil moisture insufficient)

There are certain difficulties associated with the foliar application of nutrients:

♦ Marginal leaf scorching may occur if concentrations of solutions are too high.
♦ As solutions of low concentrations (usually three to six per cent) are to be used, only small quantities of nutrients can be applied during a single spray.
♦ Several applications are needed for moderate to high fertilizer rates, and hence
♦ Foliar spraying of fertilizers is costly compared to soil application, unless combined with other spraying operations taken up for insect or disease control.

<table>
<thead>
<tr>
<th>Concept (SO 1)</th>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>A soil nutrition programme is developed based on a recommendation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stock levels are maintained and orders are placed timeously.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Please complete **Activity 1.1**: Use the information supplied below to complete the questionnaire:

**FERTILIZATION PROGRAM – CITRUS**

<table>
<thead>
<tr>
<th>Orchard:</th>
<th>Orchard 10</th>
<th>Size:</th>
<th>3.0ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivar/Variety:</td>
<td>Delta Valencias</td>
<td>Trees per ha:</td>
<td>100</td>
</tr>
<tr>
<td><strong>Fertilizer</strong></td>
<td></td>
<td><strong>Quantity</strong></td>
<td><strong>Time of Application</strong></td>
</tr>
<tr>
<td>Soil Applications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limestone Ammonium Nitrate (LAN)</td>
<td>500g</td>
<td>July</td>
<td></td>
</tr>
<tr>
<td>LAN</td>
<td>250g</td>
<td>August</td>
<td></td>
</tr>
<tr>
<td>LAN</td>
<td>100g</td>
<td>September</td>
<td></td>
</tr>
<tr>
<td>Potassium Chloride (KCL)</td>
<td>500g</td>
<td>September</td>
<td></td>
</tr>
<tr>
<td>Potassium Chloride (KCL)</td>
<td>250g</td>
<td>October</td>
<td></td>
</tr>
<tr>
<td>Dolomitic Lime</td>
<td>4000g</td>
<td>October</td>
<td></td>
</tr>
<tr>
<td>Foliar Sprays</td>
<td>g per 100l water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Biuret Urea</td>
<td>1000g</td>
<td>July</td>
<td></td>
</tr>
<tr>
<td>Manganese Sulphate</td>
<td>200g</td>
<td>October</td>
<td></td>
</tr>
<tr>
<td>Zinc Nitrate (5%)</td>
<td>150ml</td>
<td>October</td>
<td></td>
</tr>
<tr>
<td>Solubor®</td>
<td>150g</td>
<td>October</td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**
- Manganese, Zinc nitrate and Solubor® are compatible.
- Spread the lime over the entire area allocated per tree.
- Apply 10 litres of the spraying solution per tree.

**Fertilization program for soil applications for orchard 10 - (grams per tree)**

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fertilization program for foliar sprays for orchard 10 - (grams or millilitre per 100 litres water)**

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. What is the total mass LAN required in July for orchard 10?
2. What is the total mass of potassium chloride required for the orchard?
3. How many litres of zinc nitrate must be ordered for orchard 10?
4. If the only zinc nitrate available contains 10% Zn, what will the application rate be?

Please complete Activity 1.2: Questionnaire.

1. The fertilizer example for sunflower indicates that you would need 22 kg N, 11 kg P and 10 kg K per ha and that translated in buying 117 kg 2:3:2 (22%), 14 kg 1:0:1 (36%) and 43 kg LAN per ha. Re-do the problem and see if you get to the same answers. The fertilizer requirements are for one ha, how much of each fertilizer type would you have to buy for 100 ha? Clearly show all calculations.
2. If the sunflowers were planted on field two, instead of field one, how would it affect the P and K requirements? Why would it affect the requirements?
3. If the sunflowers were cultivated with irrigation, how would it affect the N, P and K requirements for field number one? Why would it affect the requirements?
4. If you did not check the fertilizer stock levels and/ or did not place an order on time and the only fertilizers available from the supplier is: 1:0:1 (40%), ammonium sulphate (21% N), potassium nitrate (13% N and 38%K) and super phosphate (10.5% P). How much of these fertilizers would you buy to fulfil in the fertilizer program set out for field one? Now compile a fertilizer programme for field one, using these new fertilizers.

Fertilization programme.

<table>
<thead>
<tr>
<th>Fertilizer application – Planting in November</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orchard:</strong></td>
</tr>
<tr>
<td><strong>Crop:</strong></td>
</tr>
<tr>
<td><strong>Broadcast application – before plant</strong></td>
</tr>
<tr>
<td>Calcitic or Dolomitic lime</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Bandplacing – with plant</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Top dressing – after plant</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Foliar application – after plant</strong></td>
</tr>
<tr>
<td>Sodium oktaborate (Solubor®)</td>
</tr>
</tbody>
</table>
Session 2 Soil utilization plan

After completing this session, you should be able to:
SO 2: Implement soil utilisation plan for specified crops
AC 1-2

In this session we explore the following concepts:
♦ Selecting the appropriate soil.

2.1 Selecting the Appropriate Soil

A permanent crop like citrus, which may remain in the same soil for more than fifty years, proper selection of the soil, is essential. One is, however, limited to the soil types that occur on the farm, but have to select the best from what is available. Tree crops are often not planted on ideal soils and the subsequent horticultural practises need to be developed to compensate for the deficiencies of the soil.

In evaluating soils for crop production one strives to get as close to the optimum soil characteristics as possible. This is a fairly specialised activity and should ideally be done by an experienced pedologist.

Pedologist: A pedologist studies the processes of soil development and conducts soil profile analyses and soil surveys.

This process of soil surveys on a farm should culminate in the creation of a soil map indicating positions of the various orchards overlaid onto the map produced by the soil survey. Once this is done, soil preparation and the irrigation layout can be planned.

Slope – Orchard crops requires the use of fairly heavy machinery, such as spray-carts and picking trailers. During soil preparation, the tractors and implements used to prepare the soil must also be able to drive safely. The slope must therefore not be so severe that workers and equipment are put in danger. A flat surface with a slope of less than 2 degrees is however also not suitable, as surface drainage of rainwater will then be too slow. These recommendations also hold true for other crops.
In crop production, other than tree crops, slopes are often contoured (Fig 2.1.) to reduce the flow of water (runoff) across the land surface, thus reducing erosion.

Figure 2.1. Contour ploughing to restrict runoff in a crop field (http://www.thamesweb.com/page.php?page_id=27&topic_id=16).

Apart from the influence of the slope of the site on safety and ease of vehicle movement in the fields, it is also important for row orientation, surface drainage and erosion. Planting on contours is no longer done and if the slope poses any potential problems with surface drainage and/or erosion, orchard layout should be adapted accordingly. The orchard roads and vehicle paths between rows are usually protected by grass-cover. If the orchard layout facilitates water movement at a moderate speed, erosion can be avoided. Row orientation is more important in the southern parts than in the northern parts of Southern Africa and can be changed to facilitate surface drainage. Also remember that in South Africa, northern slopes are warmer than southern slopes. The crop selection should therefore be done in accordance, namely crops with a lower tolerance to heat on the southern slopes and those crops which growth is encourage by more heat on the northern slopes.

Some of the benefits of contour ploughing are:

♦ Soil erosion can be reduced by as much as 50%
♦ Increased water infiltration promotes better water quality.
♦ Increased soil retention encourages root development, binding the soil and preventing erosion.
♦ Limits the release of nutrients/particulates into nearby river systems or lakes, minimizing harmful effects such as eutrophication.
♦ Can disrupt wind currents, therefore reducing wind erosion.

**Soil Depth**

In general tree crops will require a minimum soil depth of 30cm to 40cm if micro-jet irrigation is used, and 40cm to 50cm where drip irrigation is used. It is important that the layer below this potential rooting zone does not restrict drainage.

The ideal soil depth varies between crops. In the case of crops like onion and cabbage, they have a shallow root system that will be restricted to the top 15 cm soil layer. Such crops can therefore be planted on shallow soils. Deep rooted crops such as tree crops require an effective soil depth of at least 60 to 90 cm, with no restriction layers present. In the case of shallow rooted crops an effective soil depth
of 20 to 30 cm is required. In all cases, the soil requires effective drainage to prevent water logging.

Where the potential effective rooting depth is limited, it can be improved by ridging. This creates a thicker layer of soil where the crop will be planted.

Ridging also demarcate the path for vehicles to drive in, avoiding re-compaction of the soil after planting. Ridging lowers the preparation cost. Energy required in soil preparation increases the quadratic equation with depth; hence, costs will also increase. Where large quantities of lime are required, ridging can reduce the quantity required. As example, where 10 tonnes of lime has to be mixed in with the top 50 cm of soil, it can be more easily and cheaply done by mixing 5 tonnes into the top 25 cm, and then ridge the field.

Keep in mind that ridging makes harvesting more difficult in tree crops. Due to the undulating surface, the pickers have to walk more.

Ridging improves drainage in areas with such problems and is often used in irrigation or high rainfall areas. Tomatoes, potatoes and tobacco are some of the crops which are often ridged.

Ridging reduces the soil temperature around seed tubers. The deeper one goes into the soil, the cooler it becomes. If seed tubers are to be planted in the summer in very hot soils (> 30°C), they may rot. To prevent high soil temperatures, the soil is ridged to a height of 15 – 20 cm which effectively cools the soil temperature to 20°C around the seed tubers.

### Soil Clay Content

The optimum clay content varies between crops. In the case of citrus optimum clay content is between 5% to 20% for micro-jet irrigation and 5% to 35% for drip irrigation.

In general the ideal soil type for most crops is sandy loam soils, with a clay content of 10 to 20%. Most crops will adapt to soils with higher clay content provided that no other growing factors are limiting. The use of non-ideal soils may require additional production practices, which could lead to additional costs. One should therefore ideally use a recommended soil type as far as possible.

Some crops, such as potatoes and peanuts that bear their produce under the soil surface, may be more sensitive to soil clay content. With these crops, clay soils may affect the crop in reducing the value of the crop by discolouring the crop or make it difficult to harvest. These crops are also more prone to diseases as the soil tends to remain wet for longer periods.

Under dry land production crops soils with higher clay content (>25%) are often preferred, as the heavier clay soils have a better water holding capacity than sandy soils.
The clay content of soil influences its water holding capacity, (volume of easily available water), its cation exchange capacity and its aeration. These are all factors that will influence the crop.

The water holding capacity influences the irrigation scheduling, yield and fruit size.

The cation exchange capacity influences the frequency of fertilizer application, leaching of nutrient cations and utilisation of potassium.

Poor aeration affects the root system negatively. Under anaerobic conditions, roots cannot function properly and diseases like Phytophthora proliferate.

As one cannot increase or decrease the clay percentage in the soil in the field, one has to adapt to the conditions or try to improve the soil conditions. Adapting implies the use of adapted crops and applicable irrigation systems and good irrigation scheduling. Improvement may include the incorporation of organic matter to improve aeration, or installing a drainage system to improve drainage.

### Soil Stratification

During soil preparation, all forms of stratification must be removed, i.e. layers in the soil are broken up and mixed. The type and depth of these layers will determine the implements that may be required. The fewer layers present in a soil, the lower the preparation cost, as soil with little or no stratification can merely be loosened.

**Soil Stratification:** Soil is stratified when layers of vastly different textures are deposited on top of each other. The thickness of the layers varies from a few millimetres to several centimetres. These differences in texture prevent the free flow of water and restrict root-growth.

Stratification, or layering, restricts water movement and root development, resulting in soil volumes with few roots. These volumes become water logged and create pockets in the soil where root-rot starts. These unoccupied volumes also contain water and nutrients that are unavailable to the plant due to a lack of roots. During soil preparation, all forms of layering must be eliminated. This can be done by deep ripping the soil. Special implements (Fig 1.2.) are needed, but are worthwhile in using as they promote root growth and development.

### Soil Salts Content

Salts may accumulate in a soil for various reasons. If salt accumulation is due to poor drainage and high levels concentrations of sodium are also encountered, such sites should be avoided. It is difficult and expensive to remove salts from soil, because the causes of accumulation also require removal.

If high salt content is caused by the lack of leaching, the site may be reclaimed. Consult a specialist to determine the reclamation process, cost and impact. Calcium carbonates accumulate in the subsoil due to limited leaching. Depending on the depth of accumulation, the soil can still be utilised successfully.
Soils with accumulated salt anywhere in the top 60cm to 100cm should however be dealt with caution. The measurement of resistance or EC of the soil may aid in identifying accumulated salts. Clay soils that provide resistance readings below 250 ohm should be investigated intensively before preparation. The same applies to lighter soils where resistance readings are below to 500 ohm. If such soils are identified, it is best to consult an expert.

While accumulated salts also include nutrients, it usually contains high concentrations of sodium, calcium, chlorides, sulphates and carbonates. The chemical conditions in the layers where the salts accumulated restrict root development and function.

Where sodium is the dominant cation, the conditions damage the structure of the soil and hence the physical properties required for proper root functions.

Where calcium and carbonate are dominant, the pH will reduce the availability of many nutrients such as Fe, Mn, Cu, Zn, P and K.

Where chloride and sodium are the dominant ions, the osmotic pressure of the water in that zone will restrict utilisation of water by the crop plants.

Managing soils with high salt concentrations are extremely difficult and expert advice should be called upon to prevent further degradation of the soil. Managing tools can vary from planting salt tolerant crops (example Oldman Saltbush), to adapting the irrigation scheduling to the application of soil amendments.

Please complete Activity 2 before proceeding to the next session.

1) Name four soil properties that will determine the suitability of a soil for a specific crop, cultivated in your area. Note the reasons why these properties are important in a table similar to the one shown below.

2) Also discuss the term stratification as used in describing the soil profile.

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<thead>
<tr>
<th>Properties</th>
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The ability to select the appropriate soil for various crops is demonstrated.

The influence of soil characteristics or crop growth is explained.
Session 3

Symptoms of nutritional deficiencies

After completing this session, you should be able to:
SO 3: Identify and interpret symptoms of nutritional deficiencies and make full recommendations.

In this session we explore the following concepts:
- Symptoms of some nutrient deficiencies,
- Recommendations for rectifying nutrient deficiencies.
- Soil and leaf samples.

3.1 Introduction

The identification of nutrient deficiency symptoms in plants is a very powerful diagnostic tool for evaluating the nutrient status of crops. However, identification of a specific single visual symptom is seldom sufficient to make a definite diagnosis of plant nutrient status. Many of the classic deficiency symptoms such as leaf tip scorch, chlorosis and necrosis are characteristically associated with more than a single mineral deficiency. In addition, other stress factors may also cause similar symptoms. Identification remains a most useful tool.

Deficiency symptoms develop as a result of specific physiological process cannot be completed. In general the deficiency symptoms appear about six weeks after the deficiency develops. In crop production, the development of deficiencies must be avoided and strategies should be in place to monitor the nutritional status of the plants, especially in the case of trees, continuously.

One such strategy is annual leaf and soil analyses. It is however possible for the concentration of certain nutrient elements to decline below the threshold for the crop. Supplemental to leaf and soil analyses, the plants in the field must be monitored for these hidden deficiencies. Observations must be reported when supplying information to the person preparing the fertilization program.
3.2 Symptoms of some Nutrient Deficiencies

Stress factors such as soil salinity, pathogens, and air pollution induce characteristic symptoms. Often, these symptoms resemble those of nutrient deficiency conditions. Pathogens often produce interveinal chlorosis, whereas many air pollution and salinity stresses may cause tip scorching. Although, at first these symptoms might seem similar in their appearance to those of nutrient deficiencies, they do differ in detail and/or in their overall developmental pattern.

Pathological symptoms can often be separated from nutritional symptoms by their distribution in the crop. If the plants are under a nutrient stress, all plants of a given type and age in the same fields tend to develop the same symptoms at the same time. If the stress is the result of a pathogen, symptom development will have a tendency to vary between plants until the pathogen is relatively advanced.

At first glance, it would appear as if the distinction between deficiency symptoms for the 13 known essential mineral nutrients should be relatively simple. But such an assumption is incorrect. The deficiency symptoms are however quite complex because each nutrient has a number of different biological functions and each function may have an independent set of interactions. In addition, the expression of these symptoms varies depending on how acute or chronic deficiency conditions have developed. Acute deficiency occurs when a nutrient is suddenly no longer available to a rapidly growing plant. Chronic deficiency occurs when there is a limited but continuous supply of a nutrient, at a rate that is insufficient to meet the growth demands of the plant.

Most of the classic deficiency symptoms described in textbooks is characteristic of acute deficiencies. The most common symptoms of low-grade, chronic deficiencies are a tendency towards darker green leaves and stunted or slow growth. Typically, most published descriptions of deficiency symptoms arise from experiments conducted in greenhouses or growth chambers where the plants are grown in hydroponics or in media where the nutrients are fully available. In these conditions, nutrients are readily available while present, but when a nutrient is depleted, the plant suddenly faces an acute deficiency.

The interaction between nutrient mobility in the plant, and plant growth rate can be a major factor influencing the type and location of deficiency symptoms that develop. Mobile nutrients such as nitrogen and potassium, deficiency symptoms develop predominantly in the older and mature leaves. This is a result of these nutrients being preferentially mobilized during times of nutrient stress from the older leaves to the newer leaves near the growing regions of the plant. Additionally, mobile nutrients newly acquired by the roots are also preferentially translocated to
new leaves and the actively growing areas. Thus old and mature leaves become depleted of mobile nutrients during times of stress while the new leaves are maintained at a more favourable nutrient status.

The typical presence for deficiency symptoms of very less mobile nutrients such as calcium, boron, and iron initially develop in the growing regions and new leaves. In plants growing slowly for reasons other than nutrition (such as low light), lower levels of nutrients may be sufficient for the plant to slowly develop, maybe even without symptoms. This type of development is likely to occur in the case of weakly mobile nutrients because excess nutrients in the older leaves will eventually be mobilized to supply newly developing tissues. In contrast, a plant with a similar supply that is growing rapidly will develop severe deficiencies in the actively growing tissue such as leaf edges and the growing region of the plant. A classic example of this is calcium deficiency in vegetables such as lettuce. In lettuce calcium deficits symptoms develop on the leaf margins (leaf margin tip scorch) and the growing region near the meristems. The maximal growth rate of lettuce is often limited by the internal translocation rate of calcium to the growing tissue rather than from a limited nutrient supply in the.

When moderately mobile nutrients such as sulphur and magnesium are the limiting nutrients in the system, deficiency symptoms are normally seen on the entire plant. If the nutrient supply is marginal compared to the growth rate, symptoms will appear on the older tissue, but if the nutrient supply is low compared to the growth rate, or the nutrient is totally depleted, the younger tissue will become deficient first.

Prominent nutrient elements that develop hidden deficiency symptoms are nitrogen, magnesium, copper and iron.

In the following section, the deficiency symptoms expected in citrus and tomatoes are provided as examples.

### Nitrogen

#### Citrus

Nitrogen is a mobile nutrient in plants and is translocated to areas where it is required the most. The nitrogen in older leaves is moved to new leaves shortly before leaf drop. This is a natural process, which starts when the leaves are about twenty-four months old.

Leaves of under the age of twenty-four months can however be dropped prematurely when the tree experiences a nitrogen deficit. The leaves receiving the translocated nitrogen will contain elevated levels, but at the cost of the older leaves. If the leaves with elevated nitrogen concentration are picked during sampling, the leaf analysis will present an incorrect reflection of the nitrogen status of the trees.

The symptoms of this process are:

- The entire tree is a slightly lighter green than normal;
- The oldest leaves turn deep yellow in colour and drop;
- Twigs have leaves at the tips and few or none at the middle or base;
The tree is sparsely foliated with only one or two generations of leaves; Excessive leaf drop occur a week before and during a vegetative flush.

The nitrogen concentration in the leaves decreases but stabilises at a level in the “below normal” range, not indicating that this status is sustained by relocated nitrogen from leaves dropped prematurely. The leaves on the tree have a reasonable nitrogen status but this “fairly good” status is applicable to much fewer leaves.

**Information:**

**Nitrogen Relocation.**

- To explain what happens during the relocation of nitrogen and premature leaf drop, the following calculation is helpful:
- When the leaf analysis indicates a nitrogen content of 2.00%, the unsaid assumption is made that the trees have a normal leaf-cover. However, if N was relocated from 20% of the leaves to the leaves sampled, this 2.00% N at an 80% leaf-cover actually would have been 1.60% N if no leaf drop occurred.
- Therefore, although the leaf analysis indicates a “below normal” nitrogen status, the actual status is actually “deficient”.

Additional information is required to interpret the analytical data if the trees are growing under abnormal conditions or showing abnormal symptoms such as sparse foliation.

- **Tomato**

  Figure 3.1 provided a photograph of chlorosis (yellowing) developing due to nitrogen deficiency. A light red discolouration can also be seen on the veins and petioles. Under nitrogen deficiency, the older mature leaves gradually change from their normal characteristic green appearance to a much paler green. As the deficiency progresses these older leaves become uniformly yellow (chlorotic). Leaves approach a yellowish white colour under extreme deficiency. The young leaves at the top of the plant maintain a green, but paler colour, and tend to become smaller in size. Branching is reduced in nitrogen deficient plants resulting in short, spindly plants. The yellowing in nitrogen deficiency is uniform over the entire leaf including the veins. However in some instances, an interveinal necrosis (between veins) replaces the chlorosis commonly found in many plants. In some plants the underside of the leaves and/or the petioles and midribs develop traces of a reddish or purple colour. In some plants this colouration can be quite bright. As the deficiency progresses, the older leaves also show more of a tendency to wilt under mild water stress and become senescent much earlier than usual. Recovery of deficient plants to applied nitrogen is immediate (days) and spectacular.
Magnesium

Citrus

Magnesium is a mobile nutrient and the same process as with nitrogen occurs when the supply of magnesium is too low. Magnesium deficiency symptoms are more prominent on seeded cultivars.

The symptoms are:

- No change in the green appearance of the entire tree;
- The oldest leaves develop yellowing from the margins and tip towards the petiole, leaving a unique inverted V-shaped green area with its broadest side at the petiole;
- Twigs have leaves at the tips and few or none at the middle or base;
- The tree is sparsely foliated with only one or two generations of leaves;
- Excessive leaf-drop occurs during the onset of spring and/or during a vegetative flush;
- Excessive leaf-drop can also occur after a foliar application of potassium. Applications of potassium will aggravate the hidden magnesium deficiency.

The magnesium concentration in the leaf decreases but stabilises at a level in the "below normal" range, not indicating that this status is sustained by relocated magnesium from leaves dropped prematurely.

Tomato

Figure 3.2 provided a photograph of Mg-deficits in tomato leaves indicating advanced interveinal chlorosis, with necrosis (browning dying leaf tissue) developing in the highly chlorotic tissue. In its advanced form, magnesium deficiency may superficially resemble potassium deficiency. In the case of magnesium deficiency the symptoms generally start with mottled chlorotic areas developing in the interveinal tissue. The interveinal leaf tissue tends to expand proportionately more than the other leaf tissues, producing a raised puckered surface, with the top of the puckers progressively going from chlorotic to necrotic tissue. In some plants such as the Brassica or mustard family, which includes vegetables such as broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, kohlrabi, mustard, rape, rutabaga and turnip, tints of orange, yellow, and purple may also develop.
Implement Soil Fertility and Plant Nutrition Practices

Primary Agriculture NQF Level 4 Unit Standard No: 116311

Figure 3.2. Symptoms of Magnesium deficiency on a tomato plant. (Epstein and Bloom 2004)

**Copper**

- **Citrus**

  Copper moves slowly through plants. When a strong vegetative flush develops, the supply of copper to the leaves formed on new shoots might be too low and copper deficiency symptoms develop. The symptom will be more pronounced on the lower leaves on a shoot and becomes less obvious towards the tip of the shoot.

  The typical leaf symptom of copper deficiency is abnormally large leaves. The leaves at the base of a shoot are two to four times the normal size and are sometimes the shape of a boat.

  When copper deficiency symptoms appear on leaves of a twig exceeding 50 cm in length, it can be attributed to a natural slow supply of copper. However, if symptoms appear on shorter twigs, the copper supply must be supplemented.

  Gumming is often connected to a copper deficiency but gumming is a natural response of the tree to many adverse conditions and not only a copper deficiency.

**Gumming:**
Gumming refers to the excretion of gum in droplets or patches. It can occur as a result of deficiencies such as a copper deficiency, but may also be due to injuries or adverse climatic conditions such as frost, heat and drought.

- **Tomato**

  Figure 3.3. provides a photograph of typical copper-deficiency symptoms in tomato leaves. The leaves are curled, and petioles bent downward. Copper deficiency may be expressed as a light overall chlorosis along with a permanent loss of turgor (wilting) in young leaves. Recently matured leaves show netted, green veining with areas bleaching to a whitish grey. Some leaves develop sunken necrotic spots and have a tendency to bend downward. Trees under
chronic copper deficiency develop a rosette form of growth. Leaves are small and chlorotic with spotty necrosis.

![Copper deficiency symptoms in tomato.](image)

**Figure 3.3.** Copper deficiency symptoms in tomato. (Epstein and Bloom 2004)

### Iron

#### Citrus

Iron is present in leaves as both physiologically active and inactive forms. Traditionally leaf analyses do not distinguish between these forms and will only indicate the total iron content.

The availability of iron depends on external factors such as soil pH and the concentration of bicarbonates in the soil, the water and the plant. When the soil pH is high, less iron is available to be taken up by the plant. Once taken up, the iron can be inactivated by bicarbonates. Bicarbonates are present in the irrigation water, but also in the cell-sap in the plant. Inactive iron accumulates in the leaves and forms part of the iron concentration detected during analysis. A plant can therefore suffer an iron deficiency although the leaf analysis indicates normal, high or excess concentrations of iron. Leaf analyses are only useful when the results indicate a low to deficient iron concentration.

Iron is not relocated in the plant and deficiency symptoms develop on the newly formed leaves. The symptoms are more prominent during winter and at the lower shaded part of the canopy.

#### Tomato

Figure 3.4 provides a photograph of iron-deficient leaves showing severe chlorosis at the base of the leaves with some green netting. The most common symptom of iron deficiency starts out as interveinal chlorosis of the youngest leaves, which develops into overall chlorosis. These areas often develop into necrotic spots. Up until the time where leaves become almost completely white they will recover if supplemental iron is provided. In the recovery phase the veins are the first to recover as indicated by their bright green colour. This distinct venial re-greening observed during iron deficit recovery is probably the most recognizable symptom in all of classical plant nutrition. Because iron has a low mobility, iron deficiency symptoms appear first on the youngest leaves. Iron deficiency is strongly associated with calcareous soils and anaerobic conditions, and it is often induced by an excess of heavy metals.
Common deficiency symptoms on tomatoes and other vegetable crops.

Phosphorus

Figure 3.5 provides a photograph of phosphorus-deficient leaves, showing necrotic spots. As a rule, phosphorus deficiency symptoms are not very distinct and thus difficult to identify. A major visual symptom is that the plants are dwarfed or stunted. Phosphorus deficient plants develop very slowly in relation to other plants growing under similar environmental conditions but without phosphorus deficiency. Phosphorus deficient plants are often mistaken for unstressed but much younger plants. Some species such as tomato, lettuce, corn and the brassicas develop a distinct purpling of the stem, petiole and the under sides of the leaves. Under severe deficiency conditions there is also a tendency for leaves to develop a blue-grey lustre (shine). In older leaves under very severe deficiency conditions a brown netted veining of the leaves may develop.

Potassium

Figure 3.6 provides a photograph of potassium deficiency in tomato plants showing marginal necrosis (tip scorch). Advanced potassium deficiency is seen as chlorosis of the interveinal spaces between the main veins as well as with interveinal necrosis. This group of symptoms is very characteristic of K deficiency.
Figure 3.6. Potassium deficiency symptoms in tomato. (Epstein and Bloom 2004)

✧ Calcium

Figure 3.7 provides a photograph of calcium-deficient leaves showing necrosis at the base of the leaves. The low mobility of calcium is a major factor in determining the expression of calcium deficiency symptoms. Classic symptoms of calcium deficiency include blossom-end rot in tomato (browning or rotting of blossom end of tomato fruit), leaf tip scorch in lettuce, blackheart in celery and death of the growing regions in many plants. All these symptoms show soft dead necrotic tissue at rapidly growing areas, which is generally related to poor translocation of calcium to the tissue rather than a low external supply of calcium. Very slow growing plants with a deficient supply of calcium may withdraw sufficient calcium from older leaves to maintain growth with only a marginal chlorosis of the leaves. This ultimately results in the margins of the leaves growing more slowly than the rest of the leaf, causing the leaf to cup downward. This symptom often progresses to the point where the petioles develop but the leaves do not, leaving only a dark bit of necrotic tissue at the top of each petiole. Plants under chronic calcium deficiency have a much greater tendency to wilt than non-stressed plants.

Figure 3.7. Calcium deficiency symptoms in tomato. (Epstein and Bloom 2004)

✧ Boron

Figure 3.8 provides a photograph of boron-deficient leaves showing a light general chlorosis. The tolerance of plants to boron varies greatly between species. Boron requirements necessary for one crop may be toxic to other boron sensitive crops. Boron is poorly transported in the phloem of most plants.
In plants with poor boron mobility, boron deficiency results in necrosis of meristematic tissues in the growing regions, leading to loss of apical dominance and the development of a rosette condition. These deficiency symptoms are similar to those caused by calcium deficiency. In plants in which boron is readily transported in the phloem, the deficiency symptoms localize in the mature tissues, similar to those of nitrogen and potassium. Both the pith and the epidermis of stems may be affected, often resulting in hollow or roughened stems along with necrotic spots on the fruit. The leaf blades develop a pronounced crinkling and there is a darkening and cracking of the petioles often with exudation of syrupy material from the leaf blade. The leaves are unusually brittle and tend to break easily. Also, there is often a wilting of the younger leaves even under an adequate water supply, pointing to a disruption of water transport caused by boron deficiency.

Boron also plays an important role in reproduction of plants. Boron deficiency sunflower will show poor seed set and in severe cases of B deficiency it may lead to misshapen sunflower heads and even snapping of the stem directly below the sunflower head. It is therefore very important to monitor the B status of the soil and plants when sunflower is cultivated, as B deficiencies can cause severe yield losses.

Figure 3.8. Boron deficiency symptoms in tomato. (Epstein and Bloom 2004)

♦ Sulphur

Figure 3.9 provides a photograph sulphur deficient leaves, showing a general overall chlorosis while still retaining some green colour. The veins and petioles show a distinct reddish colour. The visual symptoms of sulphur deficiency are very similar to the chlorosis found due to nitrogen deficiency. However, in sulphur deficiency the yellowing is much more uniform over the entire plant including young leaves. The reddish colour often found on the underside of the leaves and the petioles has a more pinkish tone and is much less vivid than that found in nitrogen deficiency. With advanced sulphur deficiency, brown lesions and/or necrotic spots often develop along the petiole, and the leaves tend to become more erect and often twisted and brittle.
Figure 3.9. Sulphur deficiency symptoms in tomato. (Epstein and Bloom 2004)

Figure 3.10. provides a photograph of a zinc deficient leaf showing an advanced state of interveinal necrosis. In the early stages of zinc deficiency the younger leaves become yellow and pitting develops in the interveinal upper surfaces of the mature leaves. As the deficiency progress these symptoms develop into an intense interveinal necrosis but the main veins remain green, as in the symptoms of recovering iron deficiency. In many plants, especially trees, the leaves become very small and the internodes shorten, producing a rosette like appearance.

**3.3 Recommendations for Rectifying Nutrient Deficiencies**

Deficiency symptoms should never be the basis on which fertilization programs are developed.

The symptoms described above should be used in conjunction with leaf and soil analyses and should form part of the process that culminates in the formulation of a fertilization management plan.
The best policy is to prevent deficiencies by applying the necessary elements before or at plant. As growing conditions are, however, not always ideal, the plant may experience deficiencies in certain elements. Deficiencies often occur during fast/active growth and during the reproduction phase of a plant. Applying the necessary element to the soil at the stage of deficiency will often not resolve the problem as it takes a relatively long time for the plant roots to take up the nutrients and relocating of the nutrients in the plant where it is needed may also take some time (up to a week or more). Therefore the deficient element(s) are most often applied by foliar application, as the plant will react on the element within 24 to 48 hours after application.

- **Nitrogen**

Nitrogen can be supplemented as soil applications and/or foliar sprays depending on the time of the year and severity of the deficiency.

When a hidden nitrogen deficiency is detected in a crop, it should be reported and rectified as part of the overall nitrogen application schedule. Nitrogen cannot be applied to the crop at any time of the year and all corrections should be made during the timeframe for nitrogen applications for the specific crop.

In tree crops, where serious deficiencies are identified, one must consider the potential adverse affects on the current and next crop before deciding on a nitrogen application. In vegetable crops and field crops, N will be applied as soon as the deficiency occurs, as one cannot wait as these are annual crops. Applying N too late will reduce the uptake of N as the leaves have started their natural senescence and the produce has started to mature. Before applying N as a foliar application, you should consult with your nutrient supplier if it will still have an economical beneficial effect on the crop or not.

- **Magnesium**

Magnesium is supplemented by soil applications and/or foliar sprays depending on the time of the year and severity of the deficiency.

A magnesium deficiency in citrus can be corrected at any time of the year, as long as the correct carrier is used. Do not apply magnesium nitrate during August to 100% blossom or during March to June. Other sources of magnesium have fewer constrictions unless they contain plant available nitrogen.

In annual crops, Mg sprays will only be applied if it is to the financial benefit of the crop. It will thus be restricted to high value vegetable crops.

- **Copper**

Copper is applied as a foliar spray. When applied to small citrus fruit, the sap from damaged cells react, causing a darker blemish. This accentuated blemish grows with the fruit and such fruit cannot be exported and are culled at picking. Copper products, especially copper suspensions, should therefore not be applied on small and green fruit.
In annual crops, Cu sprays will only be provided if it is to the financial benefit of the crop. It will thus be restricted to high value vegetable crops.

**Iron**

Iron deficiency in citrus is best rectified by an application of an appropriate chelate to the soil, preferably during August. Iron chelates are expensive and an application is only economically justifiable when more than 20% of the canopy shows iron deficiency symptoms. Where drip irrigation systems are used, much less chelates is applied and the cost can be justified even as a maintenance application.

When the irrigation water or nutrient solution is not acidified, use a chelate that is stable in an alkaline environment. On alkaline soils, the preferred chelates is EDDHA (ethylene di-amine, di-hydroxy tetra acetic acid), which is applied at a rate of 30g per m² at not more than 300g per tree.

In annual crops, Fe sprays will only be provided if it is to the financial benefit of the crop. It will thus be restricted to high value vegetable crops.

**Other deficiencies**

Where annually crops are grown, it may be late to rectify a deficit if it is identified towards the end of the growing season. Exceptions are where Ca deficiencies are detected in crops like tomato, peppers, lettuce etc. as well as B deficiencies in sunflower. If the plants are, however, still in the seedling stage, then applying applicable foliar or soil-based fertilizers might be of value.

### 3.4 Soil and Leaf Samples

Although soil samples can be taken at any time, except after an application of fertilizers, it has little value in diagnosing or confirming a nutrient deficiency symptom. In commercial citrus production for instance, fertilizers are applied from July to December and, in certain cases, as late as February. Soil sampling is therefore only reliable between February and June, which is the time to take soil samples to formulate the fertilization program for the coming season.

In annual crops, the timing of soil sampling depends on weather double cropping is practiced or not. Double cropping implies the cultivation of one crop in the autumn/winter and one in spring/summer in succession to each other on the same field. In this case soil sampling can only be done after the previous crop has been harvested. The time before planting the next crop is often less than two months and sampling the soil in good time is of essence. If only one crop is being produced on the field, then there is more time, but soil sampling should commence shortly after the existing crop has been harvested, in preparation for the following crop.

There are specific prescriptions for leaf sampling for individual crops. Consult with a fertilizer consultant and the analytical laboratory on the procedure for the specific crop you are working with. A specific example is that of leaf sampling in sunflower to detect a B deficiency. According to the guidelines, the upper most mature leaf,
without the petiole, has to be taken. If the leaf sample was taken a month after plant, is should contain at least 60 ppm B, while a sample taken at the onset of flowering should contain at least 40 ppm B.

Norms to evaluate the results of leaf analyses are developed for a specific leaf type, at a specific position on the plant, taken at a specific physiological stage. This is called the diagnostic leaf. Deficiency symptoms seldom develop on these leaves. Deficiency symptoms mostly develop on young or old leaves and reference norms are usually not available for the symptomatic leaves. Leaf analyses therefore sometimes fail to detect the deficiency and taking leaf samples have limited value. Other factors such as total biomass produced can complicate the interpretation of the results.

Please complete Activity 3 before moving to the next session:

Answer the following question for citrus.
1. Name two reasons why citrus trees will drop leaves before the lifecycle of the leaves are completed.
2. When looking at a citrus tree, how will you know that the tree is lacking nitrogen?
3. Why can leaf analysis not always indicate the exact magnesium status of a citrus orchard or tree?
4. Describe the preferred method to correct an iron deficiency.
5. Leaf sampling of citrus during July to January has limited value. Give two reasons.

Inspect the plant material provided and answer the following questions:
1. Identify the deficiency symptoms on the plant material provided.
2. Explain how you will verify the deficiency.
3. Compile a program to rectify the problem, at present and in the future.

How am I doing?

<table>
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<tr>
<th>Concept (SO 3)</th>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
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<tr>
<td>Colour changes on plants are interpreted and related to specific nutrient deficiencies.</td>
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<td>Full recommendations for both macro- and micronutrients are proposed and presented.</td>
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<td>Soil and leaf samples for are taken for laboratory analysis.</td>
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Session 4 Soil improvement

After completing this session, you should be able to:
SO 4: Manage soil improvement according to soil properties.

In this session we explore the following concepts:
♦ Appropriate soil preparation methods.
♦ Appropriate soil maintenance methods.
♦ Record keeping

4.1 Appropriate Soil Preparation Methods

Soil preparation methods are dictated by the properties of the soil profile, being stratification, texture, pH and salinity. Before soil preparation can be done effectively, a soil survey is required. Some basic soil preparations include:

♦ Primary cultivation
♦ Secondary cultivation
♦ Ridging
♦ Levelling and Contouring

Vegetable and field crops may require seedbed preparation as the most important step in the soil preparation process. A good seedbed is characterized as being fine, firm and level. This is to ensure good contact between the seed and the moist soil in order to facilitate germination and rapid adaptation to field conditions.

To obtain a fine, firm and level seedbed, primary and secondary cultivation is used. Primary cultivation is the first ground breaking of the season which cuts and shatter the soil with relatively deep penetrating tools (15 to 30 cm). The primary cultivation leaves a rough surface texture. Ploughs (mould board or shear ploughs); listers, bedders and rotary tillers are used to mix the soil with plant rests which may still be on the soil surface, lime and other chemicals which need to be applied before plant.

Primary cultivation and ripping

Sometimes, repetitive primary tillage can cause compaction layers (15 to 30 cm below soil surface), which prevents root penetration, encourages runoff and water logging. To break up such a compaction layers, rippers are used. It loosens the soil by the lifting of the soil and letting it down without any mixing, in an up-and-down motion.
These implements can penetrate the soil to a depth of up to 90 cm. The principle of this method is to loosen the soil without changing the downwards sequence, or layering. The best loosening is achieved by ripping the soil in two directions, of which the deepest is down-slope. The angle between the two directions should be 60°. To improve the lifting action, wings are attached to the ripper-tine at an angle of 30° with the horizontal at operating depth. This preparation method is also suitable for soils with clayey, acid, saline or carbonate-rich subsoil. Under these conditions, the subsoil must never be brought to the surface. Due to the cost involved when the soil is ripped, other primary cultivation actions will often not be done after ripping.

**Secondary cultivation**

Secondary cultivation follows on primary cultivation or ripping. This involves operations, which pulverize level and firm the top 5 to 15 cm of soil. It leaves the soil with a crumbly top layer of soil 2 to 3 cm on top of a firm, but not "hard panned," subsoil. The loose top layer is necessary for oxygen supply and temperature regulation for the seed germination and root growth as explained earlier. Implements used during secondary cultivation include disk harrows, cultivators and rotary tillers.

**Ridding the Soil**

*Inter-row Spacing*

The spacing between cropped rows differs between crops. In the case of citrus trees inter-row spacing may vary from 5 to 7 metres. The space required for spray machines and other orchard vehicles is 2.5 metres.

- **Citrus**

  When the depth of suitable soil is limited, the soil from the inter-row spaces can be moved to the area where the trees will be planted, thus excavating the vehicle paths and filling the planting area with more suitable soil. This creates ridges of suitable soil.

  The purpose and advantages of ridging are:

  - Improvement in surface drainage;
  - Increase in soil temperature in the upper layers;
  - Increase in the depth of suitable soil;
  - Savings in fertilizer and energy cost;
  - Facilitation of the mixing of fertilizers; and
  - Control of vehicle movement in the orchard. Ridges clearly indicate the inter-row paths and re-compaction of the soil is limited.

Before ridging, the required lime, gypsum or phosphates are mixed with the top 20 to 30 cm soil layer. The ridges are then built with soil containing the
right amounts of nutrients. The mixing process is more effective and cheaper when this method is used, while also saving on fertilizer cost.

The height of the ridge is determined by the thickness of the suitable layer of soil. If this layer is less than 20 cm thick, ridging will not improve the potential of the soil sufficiently, although it also depends on the layer below this suitable layer.

The disadvantages of ridging are:

- Higher soil temperature, which can be up to 5°C higher compared to a flat soil surface;
- Increased evaporation of water;
- Limitation in irrigation design, as only drip and micro-jets can be used; and
- The undulating surface which makes picking more difficult.

Other crops

Ridges are often used in the production of vegetables and field crops to improve drainage and aeration. To ensure the benefits of ridging, the ridges should be at least 30 cm above the normal soil surface. The width of the ridges will depend on the number of rows planted per ridge and the amount of space needed by individual plants, and can therefore be as wide as 1 meter, as but seldom more than that.

In most crops, the soil is only ridged once during the life span of the crop. In potatoes, however, it is often done twice. First before plant and the second time after the plants have reached a height of 30 to 50 cm. The bottom 20 cm of the plant is then covered with soil coming from between the rows. In this case ridging (also called earth up) is done to cover the tubers, and protect the tubers against attacks from the potato tuber moth and some tuber diseases. By covering the tubers with soil it also prevents sunlight from coming in contact with the tubers. If tubers are left in direct sunlight, it will turn green. Green tubers do not taste nice, and if one consumes too much green tubers at one go, you may become ill. Additional benefits of ridging at this stage are reducing the soil temperature around the developing tubers and physically controlling of weeds growing between the rows. Special ridge-making implements are available for use in potatoes and one should enquire about this from your local implement dealer.

Levelling and Contouring

This involves the shaping of the soil surface within a field to improve surface drainage and eliminates areas where water may pond. The activity requires the use of cultivation and land levelling equipment such as scrapers and heavy tractors. Land grading is generally used to improve drainage but can be used to change the aspect of a site, remove bumps and hollows or provide improved erosion control. See Session 1 of this unit standard for more information on sloping and the handling thereof.
Mulching

In areas where water (erosion and losses) are problematic, a layer of plant rests (mulch) are often placed on the soil surface. This layer prevents excessive water losses through evaporation and runoff. Mulching is one type of conservation tillage and the requirement for this is that at least 30% of the soil surface been covered by mulch. The mulch can be from *in situ* plant rests or applied to the field from another sources.

Mulching can, however, not be recommended where there is a problem with soil borne diseases. The mulch will in this case provide a habitat for the diseases to flourish in and this will be detrimental to the crop.

Minimum and zero tillage

Minimum and zero tillage are also forms of conservation tillage. These types of tillage practices imply that there will be minimum or no soil disturbance.

With minimum tillage only that part of the soil which will be planted to the crop will be disturbed. The disruption of the soil often includes a loosing of the top soil in the planter furrow, followed by sowing of the seed in the cultivated furrow. The previous season's plant rest is often disked into smaller units to form a mulch layer on the soil surface (Fig 4.1.).

![Figure 4.1. Seed drilling (sowing) in minimum tilled soil, covered in wheat mulch.](image)

In zero tillage practices, the soil will only be disturbed by the drilling of a hole in which the seedling or seed is then placed. The plant rests of the previous season will often still be in place on the field (Fig 4.2.). It is therefore not incorporated into the soil, nor disked into smaller units.
Figure 4.2. Seed drilling (sowing) in a zero tilled soil, covered by the stubble of the previous season’s wheat.

4.2 Appropriate Soil Maintenance Methods

Maintenance of the soil after establishing the crop includes:

- Protecting the surface against erosion;
- Minimising compaction;
- Guarding against salinisation; and
- Limiting acidification.

Protection Against Erosion

The best method to protect an orchard-floor against erosion is to use a natural grass cover or cover crop.

The orchard floor should not be kept completely free of weeds. The area underneath and between the trees should be weed-free, forming a strip one metre wider than the diameter of the tree canopies. On the rest of the orchard-floor, including the paths between the rows, a natural grass cover must be established as quickly as possible. This is not always possible in low rainfall areas because the paths between the rows are not irrigated.

The width of the grass-strip will decrease as the trees grow and must never reach underneath the canopy. The grass must be mowed frequently and the cuttings blown underneath the canopy. These strips of grass also harbour beneficial insects and play a major roll in pest control.

As explained in the previous section, by using surface mulch, water infiltration into the soil is improved and it also reduces runoff. If mulch is not or cannot be used, erosion can still be controlled by making sure the soil surface have a crumb structure rather than a smooth structure.
Minimising Compaction and the formation of surface crusts.

Compaction of the soil after soil preparation is inevitable, but must be minimised as much as possible. Practises that accelerate compaction are vehicle traffic, high precipitation rates and salinisation.

Vehicle traffic has the severest impact. All vehicles should be restricted to the 2.5m middle-section in the inter-row paths and must never drive closer to the trees than that. In vegetable and field crops, vehicle traffic should be restricted to fixed pathways (called tram lines) in the field. This will still lead to compaction, but only in certain parts of the field and not the whole crop area.

When water is applied at a rate exceeding the infiltration rate of the soil, the soil particles floats and, on drying out, will settle in a more compacted state. This reduces the infiltration rate even more, with the consequences of more surface compaction. This is also referred to as crusting.

Salinity, and especially an increase in the SAR of the soil, accelerates crusting. Soil analyses will help detect the development of crusting, but the first symptom is runoff halfway through the irrigation cycle.

Guarding Against Salinisation

Apart from crusting, which is the first symptom of salinisation, accumulation of sodium or reduction of calcium deeper in the profile should be monitored continuously. For this purpose, regular soil analyses are required. Although the ratio of the cations is a good indicator of developing salinity, the subsoil should also be sampled from time to time. The intervals will be determined by the conditions prior to planting when the profile was analysed.

As indicators of developing salinity, the calcium to total cation ratio should be 70% to 75% and the sodium <3.00%.

Limiting Acidification

Acidification is more active in the sub- than the topsoil. Subsoil sampling is therefore more important to monitor the pH.

The ammonium form of nitrogen is the cheapest nitrogen source but also one of the greatest sources of acidification. Even in fertilizers like LAN, acidification can be a potential hazard for subsoil pH levels. Liming the subsoil alone is not possible and the pH of the sub-soils must be monitored granularly. The frequency of sampling can only be determined by historic data.
4.3 Record Keeping

During a soil survey, many soil properties are evaluated, analysed, described and recorded. Many of these properties are stable and will not change. These records are therefore valuable for replanting and for future developments, and should not have to be redone. The stable properties include:

♦ Slope;
♦ Aspect;
♦ Soil depth;
♦ Clay content;
♦ Structure;
♦ Water-holding capacity; and
♦ Cation exchange capacity

The variable properties of soil are:

• pH;
• Nutrient content; and
• Resistance

It is in this regard that soil and leaf analyses, especially historical data from routine leaf and soil analyses, have its value. This data indicates the direction in which the nutritional status of the soil and trees are moving. Records of the variable data should be kept in an easily accessible format for at least three years.

The format may vary, but should enable the reader to compare year-on-year figures with ease.
Implement Soil Fertility and Plant Nutrition Practices

Primary Agriculture NQF Level 4 Unit Standard No: 116311

Historical Data on Nutritional Status

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From the historic data a number of valuable tendencies can be identified, namely:

- The sharp drop in the N status for two consecutive seasons indicates possible problems with root-health.
- The potassium level is decreasing and requires serious attention. There is a danger that the level may drop to the point where fruit-size will be negatively affected.
- Chloride and sodium are accumulating in the soil-water-tree-system and could be indicative of salinity.
- The decrease in the manganese content points to increasing alkaline conditions in which manganese is less available.
- The increase in iron and boron concentration confirms to some extent the increase in salinity.
Please complete **Activity 4.1**: Brainstorm with your partner(s) and answer the following questions:

1. Name three considerations when deciding on soil preparation for
   a) citrus
   b) cabbages

2. Define and describe ridging for:
   a) citrus
   b) cabbages

3. What is conservation tillage? What are some of the advantages and disadvantages of zero till?

4. Name three advantages and two disadvantages of ridging in general. What implements are needed for ridging?

**Activity 4.2**: Visit a prominent farmer in the community.

1. Gather information from this farmer on:
   a) the fertilizer programme followed for a specific crop
   b) soil and if available leaf analyses results
   c) cultivation actions conducted throughout the life span of the specific crop for the last 5 years. Now make a summary of what was done over the last five years.

2. Interpret this information in terms of:
   a) changes in fertility over time
   b) changes in cultivation practices over time.

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<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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<td>The appropriate soil preparation method is selected.</td>
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<tr>
<td>Records are maintained over time and changes in soil properties are analysed and used in management programmes</td>
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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>
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<td>Why is it important to Understand the basic mathematical principles required to manage soil fertility and plant nutrition?</td>
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<tr>
<td>Why is it important to establish a crop under conditions of ideal soil properties?</td>
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<tr>
<td>Why should you be able to identify and verify deficiency symptoms in crop plants?</td>
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<tr>
<td>Is it necessary to understand of different cultivation practices for a specific situation?</td>
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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>
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<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>
<td></td>
<td></td>
</tr>
<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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- 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 you 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.

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Bibliography

Books:
- Course Notes, 1986: Identification and Properties of Soils, Department of Agriculture, Natal Region
- ITSG: Die Verbouing van Sitrus, A Pamphlet Series of the Institute for Tropical and Subtropical Crops
- McVicar et al.: Soil Classification, A
- Russell, E. W., 1963: Chapter XXIII Soil Structure and soil tilth, in Soil Conditions and Plant Growth, Longmans

World Wide Web:
- http://3e.plantphys.net/article.php?ch=5&id=289
- http://www.back-to-basics.net/nds/index.htm

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Acknowledgements

- **Project Management:**
  M H Chalken Consulting
  IMPETUS Consulting and Skills Development

- **Donors:**
  Citrus Academy

- **Authenticator:**
  Prof P J Robbertse
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- **Technical Editing:**
  Mr R H Meinhardt

- **Language Editing:**
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- **OBE Formatting:**
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- **Design:**
  Didacsa Design SA (Pty) Ltd

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

Implement soil fertility and plant nutrition practices

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PURPOSE OF THE UNIT STANDARD

A learner achieving this unit standard will be able to set up and supervise the implementation of soil preparation and maintain and conserve soil in a safe, effective and responsible manner 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: Manage Soil Fertility and Plant Nutrition.
- NQF 4: Implement a data collection plan.
- NQF 4: Execute sustainable resource use and quality control.
- NQF 4: Plan and maintain environmentally sound agricultural processes.

UNIT STANDARD RANGE

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

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

SPECIFIC OUTCOME 1
Interpret recommendations and set up a nutritional programme based on recommendations.

OUTCOME RANGE
Recommendations may be from an analytical laboratory, and nutritional programmes may include application of agrochemicals, organic material, lime, etc.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
A soil nutrition programme is developed based on a recommendation.

ASSESSMENT CRITERION 2
Stock levels are maintained and orders are placed in good time.

SPECIFIC OUTCOME 2
Implement soil utilization plan for specified crops.

OUTCOME RANGE
Soil depth, drainage, infiltration rate, pH, water holding capacity, field capacity, soil horizons, soil aeration, erosion risks, organic content, texture, clay content, structure, biological content, compaction.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
The ability to select the appropriate soil for various crops is demonstrated.

ASSESSMENT CRITERION 2
The influence of soil characteristics or crop growth is explained.

SPECIFIC OUTCOME 3
Identify and interpret symptoms of nutritional deficiencies, and make full recommendations.

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

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
Colour changes on plants are interpreted and related to specific nutrient deficiencies.

ASSESSMENT CRITERION 2
Full recommendations for both macro- and micronutrients are proposed and presented.
ASSESSMENT CRITERION 3
Soil and leaf samples for are taken for laboratory analysis.

SPECIFIC OUTCOME 4
Manage soil improvement according to soil properties.

OUTCOME RANGE
Soil improvement methods may include tillage operations (mechanical, non mechanical, organic, minimum and zero tillage.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
The appropriate soil preparation method is selected.

ASSESSMENT CRITERION 2
Records are maintained over time and changes in soil properties are analyzed and used in management programmes

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 ETOA 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 and degradation.
- Physical properties of soil - Texture, structure, soil profiles, crust formation, erosion types, compaction, and degradation.
- Biological properties of soil and processes.
- 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/compost application equipment.
- Nutrients - mixtures, limes, calcite and dolomite lime, single nutrients and compost, liquids, etc.
- Calibration of equipment.
- Chemical, physical and biological properties, degradation and rehabilitation.
- Characteristics of the nutrients.
- Role of nutrients in the plant.
- Rules and regulations for storage and handling of agro-chemicals transport.
- Crop requirements.
- Soil water relationships.
- Mulching and ploughing of mulch layer.
- Pollution prevention.
- Biological processes.
- Mineral cycles e.g. Nitrogen.

**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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