The availability of this product is due to the financial support of the National Department of Agriculture and the AgriSETA. Terms and conditions apply.
Dear Learner - This Learner Guide contains all the information to acquire all the knowledge and skills leading to the unit standard:

**Title:** Apply effective and responsible integrated pest, disease and weed control  
**US No:** 116301  
**NQF Level:** 4  
**Credits:** 3

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>
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<tr>
<td>National Certificate in Plant Production</td>
<td>49009</td>
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</tbody>
</table>

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

**What is assessment all about?**

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

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

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

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

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

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

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

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

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

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

Enjoy this learning experience!
How to use this guide …

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

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

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

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

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

**My Notes …**

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

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What are we going to learn?

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What will I be able to do?

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

♦ A learner achieving this unit standard will understand the basic principles of an integrated pest management system with basic control measures as per agricultural enterprise. Furthermore, the learner will be able to recognise and differentiate between economical damageable pests and diseases and make use and interpret sources for application or product management.
♦ Learners will gain an understanding of sustainable agricultural practices as applied in the animal-, plant and mixed farming sub fields. This unit standard focuses on the application of pest identification in primary agriculture.
♦ They will be able to participate in, undertake and plan farming practices with knowledge of their environment. This unit standard will instil a culture of maintenance and care for both the environment as well as towards farming infrastructure and operations.

Learning Outcomes

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

♦ Life cycle of an insect.
♦ Natural enemies.
♦ Ways of spreading.
♦ Contamination.
♦ Implication of contamination on the quality and marketability of the product.
♦ Importance of hygiene.
♦ Scouting procedures.
♦ Record keeping.
♦ Hygiene.
♦ Spreading of pests and diseases.
♦ Pest levels that cause economic loss.
♦ Safety rules and principles.
♦ Descriptions of pests and damage.
♦ Sources of information.
♦ Procedures.
♦ Interpretation of pictograms, colour coding and symbols.
♦ Legal implications of misuse / abuse i.e. off-label use.
♦ Potential hazards associated with agrochemicals.
♦ Cleaning and maintenance of equipment.
♦ General symptoms of poisoning.
♦ Impact of product on the environment, humans and other organisms.
♦ Basic storage principles and requirements.
♦ Principles and methods of mixing.
♦ Empty container and waste disposal.
♦ Emergency procedures.
♦ Legislation and Codes of Practice.
Apply effective and responsible integrated pest, disease and weed control

Primary Agriculture       NQF Level 4       Unit Standard No: 116301

- First aid.
- Hygiene.
- Contamination.
- Product spectrum.
- Principles of product categorisation and segregations.
- Resistance and management thereof.
- Information resources.
- Terminology.
- Principles of:
  - Weed control.
  - Plant disease control.
  - Insect control.
  - Nematode control.
- Agrochemical application.
- Effective use of standard reference materials and other resources.
- Reading and understanding labels.
- Calibration.
- Principles and procedures of responsible application.
- Correct use of equipment.
- Health and safety.
- Principles of integrated pest management.
- Environmental knowledge.

What do I need to know?

It is expected of the learner attempting this unit standard to demonstrate competence against the unit standard:

- It is assumed that a learner attempting this unit standard will show competence against the following unit standards or equivalent:
  - NQF 3: Monitor pests, diseases and weeds on crops.
  - NQF 2: Apply crop protection and animal health products effectively and responsibly.

My Notes ...

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Session 1 The principals of integrated pest management

After completing this session, you should be able to:
SO 1: Demonstrate a basic understanding of the principles of integrated pest management.

In this session we explore the following concepts:
- Introduction
- Insect Control Practices
- Monitoring crop fields for pests, diseases, weeds and beneficial insects
- Record keeping

1.1 Introduction

As end users move away from the IPM foundation, they will experience...

Increasing...
- Costs
- Environmental impacts

Decreasing...
- Sustainability
- Species diversity

Pesticides

Other Tools
- Cultural controls (grazing, crop rotations, tillage, cultivation, reseeding, etc.);
- mechanical controls (prescribed fire, mowing/clipping, etc.);
- genetics & host plant resistance; pheromones; sterile-male techniques.

Biological Control
- The use of natural enemies, such as parasites, predators and naturally occurring pathogens, to reduce the competitive advantage of exotic invasive weed & insect pests, nematodes & plant pathogens.
Farmers continually battle insects and diseases that attack their crops. Also they struggle with weeds growing in the midst of the crops and competing with the crop for vital nutrients, air, water and space. When used correctly and with care, pesticides are helpful in improving the quality and dependability of food supplies. Some pesticides have however shown detrimental effects on the environment and human health. In addition, some pest species have developed resistance against these once effective pesticides.

Because of this, farmers have turned to integrated programmes of pest management. These controlling programmes involve the use of pesticide sprays, biological control measures, mechanical control, trapping methods and agricultural methods. The use of other alternatives such as intercropping and moving away from monoculture (continuous growing of a single crop on the same fields or growing the same crop over an extended area) toward the rotation of crops during a set period of time is also included. This has aided in improving pest management in the crops. Some rotational programmes may be somewhat limiting due to different soil types, climatic conditions and financial limitations.

Monitoring crops for the presence of pests is an integral and important aspect of integrated pest management.

### 1.2 Insect control practices

Insect control methods include chemical control and non-chemical control. Integrated control is achieved when chemical and non-chemical control methods are integrated in a programme. Non-chemical pest control includes physical control, agricultural control, natural control as well as biological control.

Insect control practices are detailed below:

- **Natural control**

  Natural control is concentrated around the environmental factor which prevents increases in pest numbers and their spreading. It also includes the presence of natural pest enemies in the environment.

- **Physical control**

  Pests can be controlled by making use of physical or mechanical actions, meaning that physical changes are made in the environment. Physical control methods include:

  - Physical removal of the pest, disease or weed by hand, which is impossible in a crop situation
  - Mechanical execution of the pest making use of fly screens on windows
  - Mechanical traps i.e. those that are non toxic, such as sticky traps and electric traps
Manipulation of the environment has limited application, but can be used with success in processes such as dehydration, low relative humidity and regulating temperature.

Control through agricultural practices

Pest control through agricultural practices is used in the large-scale cultivation of crops. It is relatively cheap and environmentally friendly. Such practices include:

- Ploughing in of host plants for pests
- Sanitation practices
- Destroying remnants of pest infested crops
- Crop rotation
- Mixed cultivation
- Strip cropping
- Establishment of trap crops
- Cultivation of pest resistant crops

**Biological control**

Biological control is the manipulation of pest's enemies (parasites, predators and pathogens) in such a way that pest numbers are reduced. Biological control agents for pests are specific to a pest species and once established can increase and spread independently making the control self perpetuating. The control is however expensive, slow and the pest cannot be eliminated even for short periods of time.

**Genetic manipulation**

The Sterile insect technique, also called Genetic manipulation, is a form of biological control where numerous sterile male insects are released into an area where these insects are problematic. The sterile males will mate with females but nothing will come of it, meaning that she can not add to the population. The release of sterile males into a normal population has shown to be effective in parasitic fly pests in Central America. This process however is very expensive.

By manipulating the genetics of crop plants can produce pest resident crops. The plant will either repel the pest or produce toxic compounds. An alternative is a crop plant where growth is stimulated through insect attack, the crop thus compensates for the losses due to the pest. An example of this is found in cotton and soybean plants.

**Chemical pest control**

Chemical pest control is done by using pesticides. The term pesticides refer to the wide spectrum of agrochemicals used in plant protection. Pesticides include herbicides (plant or weed killers), insecticides, fungicides (killing fungi), bactericides
(killing bacteria), rodenticides (rodent killers), avicides (bird killers), molluscicides (snail killers) and acaracides (mite killers).

Insecticides are classified in three major groups according to their mode of action; the contact insecticides, systemic insecticides and those with stomach action. **Contact insecticides** enter the insect primarily through the exoskeleton and do not penetrate the leaves and are not translocated through the plant, whereas **systemic insecticides** must be taken in during feeding. The compounds are taken up by the plant and translocated throughout the plant. Insects with sucking feeding habits are the primary targets of systemic compounds. **Stomach poisons** must be ingested and is absorbed in the stomach of the insect. Fumigants, pesticides in a gaseous form, enter the insect through the respiratory system. Pesticides with trans-laminar action penetrate the leaves of plants, but are not translocated through the plant.

Insecticides are classified according to their chemical structure. There are four major groups of compound that can be distinguished: The organo-chlorines insecticides, primarily contact or stomach poisons that effect the nervous system through disruption of impulse conduction. The best known pesticide in this group is DDT.

The organophosphate insecticides are also nerve impulse disrupters. The majority of these compounds are contact killers, but some organophosphate act as stomach poisons and systemic compounds.

The carbamates have the same mode of action as the organophosphates. The active ingredient carbaryl and aldicarb fall in this group.

The synthetic pyrethroid insecticides were developed from the natural insecticide found in plants, pyrethrum. These compounds are highly concentrated and are thus applied at very low dosage rates. Pyrethroids have both a stomach and contact action but are not systemic.

### Mating disruption

Mating disruption occurs when pheromones are released (normally full cover spray or selected releases), disturbing the males in a way that they cannot locate the females. In this way mating is interrupted.
1.3 Monitoring crop fields for pests, diseases, weeds and beneficial

- Why pests should be monitored.

In order to prevent crop damage from insects and diseases it is essential that crops are inspected regularly. These inspections could be done in conjunction with inspections for weed densities, diseases and crop nutrient and water status.

Crop monitoring indicates the pest's and disease status of the crop. In this way the crop producer remains informed of the health status of his crop. Information on the crop disease and pest status enables the farmer to make decisions on whether control actions need to be taken and to select a suitable control action when necessary. The farmer can now apply a once-off chemical crop treatment instead of sticking to a strict spraying programme. In this way the amount of pesticide applied and labour inputs can be reduced, thus reducing crop production costs. Some kinds of insecticides and fungicides/bactericides can even be mixed during the same spray action.

- Pest to beneficial ratios

Pests attack crops because it is a food source to them. Under balanced conditions, the pest population will likely be balanced by a population of other predator insects or animals. As the predator population decreases, the pest population increases, as well as the extent of crop damage. Pesticide treatments will have to be applied in such cases. In a balanced system the natural predators will pressurise the pest populations, thus preventing pesticide treatment.

- Scouting for crop pests, diseases and weeds

The monitoring process is generally known as scouting. Scouting is used to identify pest species present as well as the extent of pest infestation. This can also be applied to crop diseases. In the case of crop diseases it is not always possible to identify or see the actual agent of disease. Thus when monitoring for crop diseases the scouting process is aimed at identifying symptoms of disease rather than collecting, identifying and counting individual pests. Plant samples can be collected for identification by experts.

A pest control programme is based on the infestation threshold as well as economic thresholds for pest control. The programmes take into account the growth stages of the crop plant and relate this to pest infestation rates. This aids in evaluating the vulnerability of the crop and the potential for damage that exists. The occurrence of natural pest enemies and pathogens must also be taken into account in the monitoring process.
The monitoring process starts with surveys. Monitoring techniques exist to aid in crop survey. The two most useful survey techniques are; the step-wise and transect method of scouting or placement of traps. Both techniques require the investigator to walk through a field, then stopping and sampling or scouting or counting at pre determined, set intervals. Where scouting is done for diseases the monitor should collect leaf, shoot, bud and fruit samples for identification by experts. Where the presence of diseases is suspected, samples must be collected and sent for analysis and identification by an expert.

The transect-scouting method involves scouting along a line across a field. The line can be diagonally across the field or parallel to the side of the field. A minimum of five sampling points per hectare should be selected.

When using the stepwise scouting method the scout starts in the middle of one side of the field. The scout then moves forward and to his right stopping at pre determined distances. Once he has crossed the whole field, the scout moves to the point of origin and repeats the exercise, but now moving forward and to his left. A maximum distance of 5 m should be used as a pre set distance.

Once samples of insects or diseased plant parts have been collected, the insects and diseases are identified. Counts of the number of pests are done to determine the infestation rates. Based on the identity of the pest and degree of infestations, crop information and environmental information, a management strategy can be implemented.

At the pre-determined intervals, using either of the scouting methods, sampling techniques for insect collection can be used. Sampling techniques generally used in pest monitoring are set out below:

- **Shake and beat method**: involves placing plastic sheeting underneath the crop plants and by shaking or beating the plants with a stick will cause insects to fall on the sheeting and which are then collected and counted.

- **Knock- down sampling**: an insecticide is applied to a small area within the target area which will kill all insects present. Similarly to the shake and beat method, insects are collected on a pre-set plastic sheet.

- **Baits containing insecticides**: can be used to attract and sample insects, e.g. laced molasses.

- **Mites can be sampled** by brushing the crop leaves onto a glass sheet. Alternatively mites can be brushed onto a flattened paper and the stains on the paper counted.

- **Sweeping nets** are used to collect flying insects, such as leaf-miners. The net, made from suitable material, is swept across the plants and collecting insects.

- **Malaise traps** are used for active insects and consists of a net with one open end (tent like). A container for trapping the insects is placed at the highest end.
• **Sticky traps** are made from a suitable surface with a sticky coating. The sticky trap can be baited to attract certain species. The trapping efficiency of these types of traps is influenced by environmental conditions and the positioning of the trap.

• **Water traps** are suitable containers containing water to which a soapy substance and a preservative is added, erected 1 m above soil level. The traps are suitable especially for trapping aphids.

• **Sucking traps** are basically modified vacuum apparatus which sucks the insects into a net.

• **A light trap** is a lamp, usually ultraviolet, surrounded by a vertical baffle; at the top of a funnel-shaped container and a sampling container at the bottom.

• **Pheromone traps** are used for moths and butterflies. Pheromones (sexual hormones) of the targeted species are placed in a suitable container. The traps are set up over a large area and are suitable for monitoring the population increase and also for pesticide application timing. Pheromones are odours produced by an animal that affects the behaviour of other animals.

  Pheromones work in a similar way as hormones in that they send specific chemical signals from one set of cells to another. Once these signals reaching the target site, a reaction takes place. In insect pest management this characteristic is often used to attract a pest to a specific area. The pheromone is placed into a trap which attracts the insect. The insects will enter the trap but can then not escape. In some cases a decoy is used which will attract the insect. The traps are useful in determining the number of insects that are present in the vicinity of a crop field.

• Determining the rate at which insects are moving into a field helps to estimate the potential damage that they could do. This in turn is used to decide how the pest can be controlled.

• Pheromone traps are usually made of plastics nets which are then placed in a field, containing a small container in which the bait (pheromone) is poured. Insect pheromones are very specific and will only attract specific species, thus helping in the identification of the target insect. Pheromones are chemicals excreted by the female that attract male moths. Therefore, only male moths are caught in these traps. The chemicals usually have a short lifespan and must therefore be replaced at regular intervals. The insects caught in the traps need to be removed and counted allowing the next count can be made. This data is called temporal data of insect population.

• **Pit fall traps** are containers with a small volume of preservative which are placed into the soil so that the open end is level with the soil surface. These traps are effective for insects that live on the soil surface.

• **Soil sampling** for soil dwelling insects can be done by using and auger-like soil coring device or a blade sampler. It is important that the volume of soil is known ensuring that the calculating of the infestation is done per volume.
- **Spore traps.** Some fungi like powdery mildew produce airborne spores that can be sampled using special spore traps.

### 1.4 Record keeping

Monitoring goes hand-in-hand with record-keeping. Monitoring create the “farm memory” as it is, with reference to beneficial insects, pests, diseases and weeds that are present on the farm and on specific fields. The records should provide information regarding when and where pest problems have occurred, information on the cultural practices applied (irrigation, cultivation, fertilisation etc.) and their effect on pest and beneficial populations. The records should also include information on the pest management practices that have been applied. Where possible, the effects of aspects such as weather, on pest and beneficial populations, should be recorded.

During monitoring, all data collected must be recorded. It is important to know the density of occurrence of pests, diseases and weeds. Also one has to know where these occurred and when these were first observed. All data must be written down and kept, not only for a particular season, but kept for a number of years, allowing the farmer to trace trends and timing of various problems. Not only should you keep record of the problem, but also of the treatments and interventions made to control the problem. This allows one to track what has been tried and how successful these have been.

The table below is an example of a data sheet that can be used to collect monitoring and treatment data.

<table>
<thead>
<tr>
<th>The table below is an example of a data sheet that can be used to collect monitoring and treatment data.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scouting Data Sheet</strong></td>
</tr>
<tr>
<td><strong>Farm Name:</strong></td>
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<tr>
<td><strong>Monitor Name:</strong></td>
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<tr>
<td><strong>Date:</strong></td>
</tr>
<tr>
<td><strong>Time:</strong></td>
</tr>
<tr>
<td><strong>Crop:</strong></td>
</tr>
<tr>
<td><strong>Pest Type:</strong> (weed/Insect/disease)</td>
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<td><strong>Field no:</strong></td>
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<td><strong>Position:</strong></td>
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<td><strong>Monitoring Method:</strong></td>
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<td><strong>Trap type used:</strong></td>
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<tr>
<td><strong>Sample Collected Y/N</strong></td>
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<td><strong>Concentration Applied:</strong></td>
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<tr>
<td><strong>No of Applications:</strong></td>
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<tr>
<td><strong>Active ingredient:</strong></td>
</tr>
<tr>
<td><strong>Application Type:</strong></td>
</tr>
</tbody>
</table>
Please complete Activity 1:

**Theoretical Activity**

**Individual Activity**

In order to ensure that the learner understand the basic concepts, answer the following questions.

1. Define Integrated Pest Management
2. Why is it important to monitor crops within an IPM programme?
3. Discuss the significance of pests to beneficial ratios in pest management.
4. Why is it important to replace pheromones in traps and clear the taps at regular intervals?
5. Why is it important to keep accurate record of pest management and pest numbers on the farm?
6. What data should be collected?

<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>The fact that integrated pest management is the integration of a number of different methods of pest control is explained.</td>
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<td></td>
</tr>
<tr>
<td>The importance of monitoring at regular intervals is discussed.</td>
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</tr>
<tr>
<td>The influence of the ratios between pests and predators on the decision on which control method to use is described.</td>
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<td></td>
</tr>
<tr>
<td>The importance of replacing the pheromones, clearing the traps regularly and the collecting and assessing of information is explained.</td>
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<td></td>
</tr>
<tr>
<td>The importance of recording the data correctly is explained.</td>
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</tr>
<tr>
<td>Data is recorded by applying the basic principles.</td>
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</tbody>
</table>
In this session we explore the following concepts:

- Pest status
- Beneficial and problem organisms in crop production
- Crop Damage

2.1 Pest status

Most insect pests have a short life cycle which periodically benefits from favourable environmental conditions. Pest control is generally only a short-term suppression of the pest population. The control strategy selected is based on economic principals. The economic benefit of pest control can be calculated only if the cost of control actions, as well as the effects, of the pest on the crop yield is known and these costs to not exceed the yield benefit. We need to know the control methods, as well as the costs for each and the cost implication of the pest if no control action is launched. Once all the factors are known, then the economic benefit of the control action and the correct timing thereof can be calculated. Pest control should only be applied if it is economically justifiable. A similar situation is also true regarding diseases and weeds. The only difference is the length of the life cycle and the intensity of the effects on plant growth. The extent of the effects of an infestation, irrespective of the origin, is influenced by the growth and development stage of the crop. Some pests may influence a crop negatively in the very early growth stage, whereas others will again affect the harvestable of crop directly.

Knowing the stage in the life cycle of the pest, disease or weed that is the most sensitive stage for applying any treatment is of great importance. Climatic conditions should also be considered. Herbicides for example can be applied as a pre-emergence treatment to give the crop a head-start. A selective herbicide is applied at a later stage after the crop has been established.
The factors that should be considered are:

- Control costs
- Potential damage on the crop
- The stage at which the control action should be taken
- Is the control action aimed at the correct stage
- Is the potential loss more than the cost of control

The decision of pest control is not always based on a balance of costs, but sometimes on the potential cosmetic implications if not controlling a pest, such as in the case of parks and grounds.

### 2.2 Beneficial and problem organisms in crop production

#### Micro-organisms in crop production

There are good micro organisms and bad micro organisms. Some micro organisms are so small that they are only visible under a microscope. These may be bacteria, fungi, and viruses. Micro organisms can be very beneficial; this means that they have a good effect on your crops. There are many types of ‘good’ micro-organisms in the soil and they help to decompose (breakdown) plant and animal waste into organic material. They are thus playing an important role in the recycling of other organisms' dead remains and waste products. Micro-organisms also play another vital role in the environment as they participate in the Earth's element cycles.

#### Harmful effects of micro-organisms

- **Fungi**
  
  Fungi are plant-like organisms that lack chlorophyll. Fungi are one of the 5 Kingdoms of Life. Some fungi are useful (like mushrooms we eat), but there are also fungi that cause problems and infect plants and animals, lowering their production, growth and yield. In severe cases, fungi can even lead to the death of parts of or the whole plant. They multiply by releasing spores. Fungi can be yeasts or moulds.

- **Viruses**
  
  Viruses are ultra-microscopic organisms that cannot replicate without being inside a host cell.

  Viruses, such as the leaf roll virus, blocks the food- and water distribution pathways. This leads to the reddening of the veins in red cultivars with the curling of the leaves in both white and red cultivars. The berries are influenced in such a way that the sugar content is never at an optimum.
The effects that other types of viruses (e.g. Fan leaf and Yellow speckle) can have on vineyards are symptoms like flattened shoots, vein clearing and consequent decrease in fruit yields.

Viruses seldom cause the death of the plant, but it often leads to dwarfing of the plant due to the blocked food and water pathways in the plant. Viruses are often spread by insects.

♦ **Bacteria**

Individual bacteria consist of one cell and can be seen only by using a microscope. Masses of bacteria can sometimes be seen with the naked eye when it is excreted from the affected plant part, looking like strands of mucus.

Bacteria also affect the growth, yield and quality of plants and animals. Some bacteria act as pathogens and cause tetanus, typhoid fever, pneumonia, syphilis, cholera, food borne illness, leprosy and tuberculosis (TB). In plants, bacteria cause leaf spot, fire blight and wilts. Insects often help in the spread of bacteria.

- **Nematodes**

Nematodes are microscopic, worm like organisms living in the soil. They attack roots, peanut pods, tubers, bulbs etc. of plants. These attacks can lead to poor water and nutrient uptake (root damage) resulting in stunted plant growth or a reduction in quality (damage to tubers, pods, etc.).

- **Invertebrates**

Invertebrate is a term to describe any animal without a spinal column, which includes insects, jellyfish, roundworms, earthworms, starfish, sea urchins, sea cucumbers, squids and snails. For the sake of this study, we will only be looking at insects, earthworms and snails.

Earthworms play an important role in soil. In compacted soils the earthworm actually eats its way through the soil, cutting a passage with its muscular pharynx and dragging the rest of the body along. The ingested soil is pulverised, digested and the waste deposited behind the worm. This process aerates and mixes the soil and is constructive to nutrient uptake by vegetation. In addition, earthworms often come to the surface and graze on the higher concentrations of organic matter present there, mixing it with the mineral soil. Because a high level of organic matter is associated with soil fertility, an abundance of earthworms is beneficial to the organic gardener.

The major benefits of earthworm activities to soil fertility can be summarised as:

♦ **Biological.** The earthworm is essential for composting; the process of converting dead organic matter into rich humus, a medium vital to the growth of healthy plants and thus ensuring the continuance of the cycle of fertility. This is achieved by the worm’s actions of pulling down below any organic matter deposited on the soil surface (e.g., leaf fall, manure, etc) either for food or when it needs to plug its tunnel. Once in the tunnel, the
worm will shred the leaf and partially digest it, then mix it with the soil by saturating it with intestinal secretions.

- **Chemically.** Apart from dead organic matter, the earthworm also ingests any other soil particles that are small enough to engorge. Miniature grit fragments grind everything into a fine paste which is then digested in the stomach. When the worm excretes this in the form of casts which are deposited on the surface or deeper in the soil, a perfectly balanced selection of minerals and plant nutrients is made available in an accessible form to plants. Investigations in the US show that fresh earthworm casts are 5 times richer in available nitrogen, 7 times richer in available phosphates and 11 times richer in available potash than the surrounding upper 150 mm of soil. In suitable conditions with plenty humus available, the weight of casts produced may be more than 4.5 kg per worm per year, in itself an indicator of why it pays the gardener or farmer to keep worm populations high.

- **Physical.** With its tunneling actions, the earthworm is of great value in keeping the soil structure “open”, creating a multitude of channels which allows the processes of good aeration and drainage. It is, however, not only earthworms which benefit from the crop, but also insects such as bees, predatory - and parasitic insects.

- **Bees** and some other insects also play an important role in the pollination, thus fruit formation.

- **Predatory- and parasitic insects,** as biological agents, controls harmful insects. E.g. wasps lay their eggs in the bodies or eggs of other insects. The wasp's offspring then feed on the inside of the other insect's bodies or eggs, killing those insects.

- **Ladybirds** are well known predators feeding on aphids and thus playing an important role in controlling aphid numbers.

### Harmful effects of invertebrates

Some parasitic plant insects can help in the biological control of weeds. A well known example is the use of cochineal on prickly pears.

- **Snails**

Snails, feeding on cultivated plants, may become serious pests. A list of 49 plant species has been identified in South Africa, which are attacked by snails. These include:

<table>
<thead>
<tr>
<th>Vegetables</th>
<th>Cabbage, carrot, cauliflower, celery, bean, beet, Brussels sprouts, lettuce, onion, peas, radish, tomato, and turnips;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>Barley, oats, and wheat;</td>
</tr>
<tr>
<td>Flowers</td>
<td>Alyssum, antirrhinum, aster, balsam, carnation, candytuft, chrysanthemum, dianthus, dahlia, delphinium, hollyhock, larkspur, lilies, marguerite, mignonette, nasturtium, pansy, pentstemon, petunia, phlox, stock, sweet-pea, verbena, and zinnia;</td>
</tr>
<tr>
<td>Trees</td>
<td>Apple, apricot, citrus, peach, plum</td>
</tr>
<tr>
<td>Shrub</td>
<td>Hibiscus, magnolia, and rose.</td>
</tr>
</tbody>
</table>
Insects

Insects, feeding on any plant part, include:

<table>
<thead>
<tr>
<th>Plant Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roots</td>
<td>Soil living weevils, worms and grubs. When feeding on the roots, it reduces the plant's ability to take up water and nutrients. Plant growth is thus retarded and yield as well as the quality of the produce is negatively affected.</td>
</tr>
<tr>
<td>Seedling stems/shoots</td>
<td>Weevils, worms, beetles and grubs. These can live in or above the soil. It often leads to destruction of the young seedling stem resulting in poor plant stands.</td>
</tr>
<tr>
<td>Leaves</td>
<td>Aphids, caterpillars, thrips, leaf miners, etc... These insects feed on the cell contents (aphids and thrips) or the whole leaf (caterpillars and leaf miners). When they feed on the cell contents, they cause the leaf to become deformed and dysfunctional and can also spread diseases. The caterpillars and other leaf feeders chew the soft parts of the leaves, leaving the mid-rib and veins. The leaves are thus totally destroyed and can no longer function normally.</td>
</tr>
<tr>
<td>Stem borers</td>
<td>The most well know example here is the American bollworm, which will attack any plant. The American bollworm and other stem borers feed on the inside of the stem. Depending on the type of borer, it will feed upwards in the stem or from one side straight through the stem to the other side. Stem borers usually cause the stems to break, reduce the movement of water and nutrients in the stem and can also reduce pollination as in the case of maize. In maize plants the stem borer can feed on the tassel (male flowers with pollen) which is situated at the top of the stem.</td>
</tr>
<tr>
<td>Flowers, fruits and seeds</td>
<td>Larvae of moths and flies (codling moth and fruit flies), aphids, scales and spider mites to name a few examples. These insects can partially or completely destroy the flower, fruit or seed, resulting in serious income losses. Even if they do not destroy the plant parts, visual damage caused to fruit, can lead to a degrading of the fruit/seed with again a loss in income.</td>
</tr>
</tbody>
</table>

Weeds as limiting factor in crop production

Weeds are plants, which grow alongside (in the same field) our crop and interfere with the growth of our crop plants. An example is Khakibos growing in a maize field.

The weed plants compete with the crop plants for light (photosynthesis), nutrients, water and space. Crop plants can normally not compete with weeds having stronger growing plants, thus preventing crop plants from absorbing sufficient nutrients, water etc. This in turn causes the crop plant to grow poorly, implying a smaller yield and products with low quality. It is therefore important to control weeds to prevent these crop losses.
Noxious (poisonous) weed seeds (datura and convovulus spp.) mixed with harvested grain seeds (wheat, sunflower and maize) can lower the acceptability of the grain, leading to lower grades and thus a loss in income. Weeds in cotton production is also disastrous as weed seeds and resins produced by the weeds can contaminate cotton fibre, resulting in lower quality because of dirty and coloured fibre.

2.3 Crop damage

- **Crop Damage Caused By Insects**

Insects’ damage to crop plants implies crop losses. Crop damage is classed in three groups.

**Direct damage** – This is damage influencing the marketability of crop products. This class of damage is caused predominantly by biting-chewing insects (e.g. fruit fly).

**Indirect damage** or secondary damage to a marketable product is caused by insects with sucking-feeding habits (e.g. aphids), sucking plant sap and resulting in decreasing crop yields.

**Cosmetic damage** is caused to the marketable product, but the damage is of a cosmetic nature, thus a consumer issue. An example: citrus scale damage where the citrus is marketable but the product is of lower fiscal value.

- **Identification of common Insects in crop production**

Animals are widely classified in to two main groups; those with a skeleton on the inside and those with the skeleton on the outside. Insects are classified in the group of animals known as Arthropods or animals with an exoskeleton (skeleton on the outside). There are approximately one million known insect species in the world. In Southern Africa approximately 80 000 insect species have been identified. Insects are generally viewed as pests, but the majority of all insects are invaluable for the existences and activities of mankind. Only a small proportion of these insects are in conflict with man in the production of food and industrial crops. These pest insects do however cause huge annual losses to agricultural crops, either, whilst still on the field, or during post harvest storage.

- ♦ What do Insects look like?

Insects are distinguished from other animals by the following morphological characteristics:
Insects have an exoskeleton i.e. the skeleton is on the outside of the body

- The body is divided into three distinct parts, a head, thorax and abdomen
- The head usually carries one pair of antennae and mouth-parts
- They have six legs, attached to the thorax
- Winged species normally have one or two pairs of wings also attached to the thorax

Diagram of an insect showing morphological features

The abdomen is usually divided into 11 segments and carries appendages required in reproduction. Insects generally hatch from eggs. The exoskeleton is a rigid structure that does not allow much expansion. For growth the insect sheds the exoskeleton, replacing it with a larger one during the insects’ development.

### Insect Development

The process in which the insect “loses its skin”, replacing it with a new one in known as moulting. The development stages after moulting are known as instars. In most insects the instars that develop are not alike but look different. The change in morphology of instars within single species is known as metamorphosis. Insects are divided into two groups; those with incomplete metamorphosis and those with complete metamorphosis.

**Incomplete metamorphosis:** the insect hatches from an egg as larvae, called nymphs. The larvae and the adult insects are similar in appearance. There are no pupae. The larvae and adults live in the same habitat and feed on the same food sources. Examples of these types of insects are locusts and cockroaches.

**Complete metamorphosis:** the larvae and adults differ in appearance as well as in habitat and food sources. The insects hatch as worm-like larvae. The larvae undergo a number of larval moults before they go into a pupae phase. Pupae are normally covered in protective material (cocoon). The final development stage is when the pupae turns into an adult (moths and flies).

Often we cannot see the insect but we do observe damage to the foliage or other parts of the crop plant. What follows is a rough guide that links the symptoms to the potential cause.
**Identification of crop damage**

Examples of symptoms and contributory insect agents are given below:

When the symptom of yellowing (chlorosis) is visible, the symptom positioning should be examined.

Yellowing of Foliage with additional curling of leaves, the presence of honeydew and a sooty mould; usually due to **aphids** (a small, green to almost black insects; with spindly legs).

If the foliage is Chlorotic, leaves curled with the presence of fine webbing; due to **spider mite** (a very small, reddish, 8-legged mite).

If yellowing is in the form of spots, turning brown and leaves dying off; caused by **stinkbugs** (greenish, or black and orange or greyish, shield-shaped or elongate and smelly insects).

If the symptoms are primarily holes developing in leaves:

Small holes in leaves, giving them a peppered appearance; caused by **flea beetles** (small, oval, dark-coloured and active beetles).

Round holes in leaves with serrated edges; caused by **snout beetles** (greyish to greyish-brown beetles with snouts, active at night).

Irregular holes in leaves associated with slime trails; caused by **snails and slugs**.

Foliage partially eaten; caused by **bollworm** (green to brownish caterpillars with broad, whitish, lateral stripe).

Sweet-potato foliage partially eaten; caused by **sweet potato hawk moth** (large, green to brown, streaky caterpillars, with horn on last segment).

Leaves folded by silk threads; caused by **painted lady caterpillars** (spiny, black caterpillars feeding on leaf surface).

Fine tunnels in sweet-potato foliage; caused by **sweet potato leaf miner** (small, whitish caterpillars).

Where primary symptoms are damage to roots and lower stem:

Young stems cleanly cut at ground level and plants wilt and die; caused by **cutworms** (light to dark grey caterpillars active at night, hiding shallowly in soil by day).

Holes eaten in stems and sprouts below ground, plants stunted or wilt and die; caused by **black maize beetle**, **spotted maize beetle**, **wireworms** and/or **false wireworms**.

Green larvae, slug-like but not slimy and grey brown beetles feeding only just above ground; caused by **vegetable snout beetle**.

Tunnels on lower stem, roots and tubers of sweet potato filled with excrement and infestation continued in place of storage; caused by **sweet potato weevils** (whitish grubs and dark-coloured, antlike beetles with elongated snouts).

Tunnels in asparagus sprout or mushroom stems below or above ground; caused by **bean seed maggot**, **asparagus fly** or **mushroom flies**.

Plants stunted, crop poor; knots or lesions on roots and sweet-potato tubers cracked; caused by **nematodes**.

Carrots scarred, roots riddled with rust red holes; caused by **carrot rust fly**.

If it ever happens that you cannot identify (100%) the cause of damage to your crop, speak to an extension officer, pest control expert or representative from pest control or seed and seedling companies for advice as well as the correct pesticide to use.
Crop disease symptoms

- Diseases of crops.

A plant disease is a disturbance brought about by a factor which interferes with the manufacturing, transport and utilisation of energy sources, mineral nutrients and water in a way that the plant growth is affected negatively.

Plant diseases are caused by pathogens and environmental factors.

A plant pathogen is an organism settling on a live plant which will provide the necessary foodstuff. These organisms are generally not capable of producing their own food sources. The disease causing pathogenic organisms are fungi, bacteria, mycoplasms and viruses.

Environmental factors which can cause plant disorders include temperature extremes, soil moisture and light extremes, lack of oxygen, pollutants and nutrient stress. This section deals with the pathogenic commencing plant diseases.

- Fungal Diseases

Fungal diseases are caused by Fungi. Fungi are plants that do not contain chlorophyll and therefore not green. Because they are not green, they cannot convert sunlight energy to chemical energy. Fungi cannot produce their own carbohydrates. The vegetative parts of fungi consist of thin filaments, known as hyphae, which mass together to form a body or a mass known as a mycelium.

Fungi reproduce vegetatively through the filamentous hyphae and sexually through spores. Fungi, as a group, is divided into two sub-groups; the slime moulds (lower fungi) and the true fungi (higher fungi). Disease causing fungi are found in both these groups.

- The lower fungi

Diseases are caused by three distinct groups of lower fungi. These diseases are discussed below:

- Diseases caused by lower fungi without hyphae - are soil borne diseases that have a limited host range. The fungi rest and survive as resting spores in soil or in infected plants. They spread by transferring infected plant material, soil and water. Diseases caused by this group entail; club root in crucifers, powdery scab and wart disease in potatoes and brown leaf spot in maize plants.

- Diseases caused by lower fungi with hyphae and zoospores - these fungi produce mycelium, form resting spores and produce living swimming spores (zoospores) which infect plants and spread through infected soil, infected plant material and through airborne sporangia. Examples of these types of fungal diseases are downy mildew and late blight.

- Fungal diseases caused by lower fungi with hyphae but without zoospores - produce mycelium, produce air-borne thin walled spores and...
are generally weak parasites which grow on dead plant material. These fungi will attack live plant tissue only if the plant is under stress. Examples of these diseases are pumpkin fruit rot, vegetable soft rot, fruit rot and bread mould.

- The higher fungi
- **Sooty moulds** - causes a flat blackish film on leaf surfaces which can be rubbed off, leaving a clean surface. It is common in warm, humid areas and is found on all crop types. The organisms are not parasitic but feed on the sugary excretions from aphids. The primary damage caused by this group is the reduction in photosynthetic rates.
- **Leaf curl** - causes leaves to curl as the result of preceding blisters and swelling. Blisters are hollow and are found mainly on stone fruits. The disease leads to leaf drop which could weaken trees. The fungus survives in the buds of trees.
- **Powdery mildew** - A common disease, white to grey in colour, covering leaves either partially or entirely and usually both sides of the leaf. It is normally found on young plant tissues and only grows on the plant surface. These are parasites and infestations are most severe under warm, dry weather conditions.

♦ Foliar diseases

Generally observed as spots and blights on leaves, but may also affect other plant parts. These may survive in soil or on plant debris.

- **Alternaria** - a disease in annual crops causing leaf spots and blights, but may also cause damping off, collar-, fruit- and tuber rot. Commonly found on older plant tissues under nutrient stress. Numerous dark leaf spots usually observed on affected plants. Survive on debris and seed.
- **Cercospora** - small, separate leaf-spots, circular to triangular in shape. Found mainly on broadleaf and grass species. The disease can become most severe under warmer conditions. Spores are airborne and visible as grey mould lesions under humid conditions.
- **Septoria** - small leaf spots that may join together to form blights. Leaves become chlorotic with the infection starting on the lower, older plant parts and gradually progressing upwards.
- **Helminthosporium** - major disease in grass crops, causing root rot and spots and blights on leaves as well as the crown.
- **Stem and twig canker** - starts where the branch or twig is injured, or at the joint of a dead branch or twig. Cankers can kill branches and twigs; the infection is counter acted by the callus formation.
- **Anthracnose** - dark spots or sunken lesions on the leaves, stems, shoots and fruit. Survive on plant debris.
- **Ergot** - common on grass species; produce honey dew on infected florets which is replaced by hard purple black fungal masses called sclerotia. These are toxic to animals and humans.
- **Botrytis** - common in glasshouse grown crops, causing blossom blight and fruit rot. Grey to brown mould surviving on debris.
• **Vascular wilt** - fungi grow in the vascular systems of the plant, blocking the transportation of water, leads to wilting of plant tissues. *Fusarium* and *Verticulum* are soil borne fungi which are difficult to control.

• **Post harvest decay of fruit and vegetable products** occurs after harvest. Injured produce, combined with high temperatures and humidity increases decay.

• **Post harvest decay of stored grain** - is often initiated in the field and causes decay and discoloration of grains, decreasing marketability. Some species produce mycotoxins.

• **Rust** - attack many hosts and causes the highest losses in staple crops, damaging mainly leaves and stems. Rust-to-yellow coloured pustules are formed with a bilious (gall) structure. Rysts are parasitic and generally not systemic.

• **Smut** - normally affects the ovaries of grain crops, but can also attack leaves and stems. May become systemic, cause stunting and survive on debris and seed.

• **Rhizoctonia** - a root and stem disease which is soil borne and difficult to control. Survives in soil or in plant material. Symptoms include damping-off, wire stem, cankers, root lesions, rot and potato black scurf.

• **Sclerotonium** - common in wet areas, causes damping-off, stem cancer, crown blight and rot, fruit rot and wilt.

♦ **Bacterial Diseases**

Bacterial diseases are marked by various symptoms, including soft rot, leaf spot, stems and leaves wilting, cancer, leaf and twig blight and gall forming.

**Spots, streaks and blights** - these bacteria causes stripes and spots on the leaves, stems and fruit of crop plants. Symptoms; necrotic spots and circular spots surrounded by a halo. The blights on a leaf tend to flow into each other and may be angular shaped when limited by leaf veins. On grass crops the symptoms are streaks and stripes rather than spots. The infected tissues eventually dry up and fall out - leaving visible holes - with a “shot gun” effect.

• **Vascular wilt** - found mainly on herbaceous crops where the bacteria multiply in the vascular tissue, eventually blocking the whole transport system. The end result is wilting of the plants which eventually die-back. Discoloration of vascular tissues is not uncommon.

• **Soft rot** - enters plant tissues mainly through wounds and can also spread while fruit are stored. Leads to separation of plant tissue cells and tissue collapse.

• **Galls** - causes crown gall in woody plant species.

• **Cankers** - cankers causes woody tissues to splits. Observed as spots on leaves and fruit and the die-back of buds and blossoms.
• Scab – the bacterium enters the plant tissue and the plant cells around the point of entry divides, forming layers of corky cells. The infected tissue is squeezed out, forming the scabs.

♦ Plant Viruses

The major symptoms of virus infections are reduced growth, mosaic colouring, ring spots, stem pitting, chlorosis and leaf roll.

• Viruses are not transmitted through rain or wind.
• Virus transmission requires a vector.
• Viruses can be transmitted via plant sap which is transported from infected to uninfected plants, such as in grafting.
• Viruses are transmitted via infected seed stocks, pollen, fungi and especially insects.
• The most virulent plant diseases are transmitted through insect vectors.

■ Weed Identification

Where you cannot identify a particular weeds, collect a specimen, take close-up photos of the plant as a whole as well as from individual plant parts and show them to an expert to help you identify them. You can also collect seed from the plant for identification purposes, but accurate identification of weed species from seed is very difficult. It is best to take the seed sample and have an expert do the identification. If there are not experts in your area, send the photographs and seeds to the agricultural or botany department of a university closest to you.

When an unknown plant is observed, it could be a potential weed problem. It is therefore necessary to get hold of the plant's weed status. Only then can a farmer decide whether it requires any form of control. If you cannot identify the plant, a sample must be collected and sent for identification to an expert body as described in the paragraph above.

Collecting a sample: (a) the whole plant, roots and all, where possible. (b) If the plant is too big, you need to sample all the plant parts that are available. Take photographs of the plant from all possible angles and where it grows in the field. If the plants grow in close clusters together, take photographs of this as well. Map the area where the plants were found and note the size of the area that is covered with these plants. Also determine the density of the plant stands. To determine the plant density you will need a strong square frame, ideally 1m X 1m. Place the square over the areas where the unknown plants grow and count the number of individual plants in the square. This will provide you with a plant density as a number of plants per square metre. Now repeat this exercise on at least 10 other places or spots where the plants are found. You can now calculate the average plant density. You can also determine whether the density changes in different fields etc.

Send this information, as well as the plant samples, to the institution that will identify the plant.
The plant material, representative of the plant as it is growing in the fields as well as a whole plant (where possible) must be placed in plastics bags and sent for identification. If the time lapse between sampling and arrival at the identification body is less than 24 hour, you can send fresh samples. If this is not possible, the plants have to be dried between layers of newspaper, applying pressure on top of the paper to flatten the plant parts as far as possible. The pressure can be applied by placing the plant parts neatly on a piece of paper, then placing another sheet on top. Place a layer of adsorbent paper over and below the covered sample. Place layered sample between heavy books and strap together with a suitable belt or rope. Place the sample in a cool dry place to dry.

When collecting seed, it is important that the seed is collected together with the seed pod. This is especially important when seeds are collected from grassy weeds. Grasses are normally identified according to its seeds and it is critical that these are intact. Place the seeds and seed pods in a suitable container and send these for identification.

Please complete Activity 2.

**Practical Activity**

**Group Activity**

1. In your group, select a crop that is grown at your place of work.
2. Identify a field which is to be monitored.
3. Identify the most common pest, disease, weeds and beneficial insects found in a selected field.
4. Name the common control practices in use at your place of work
5. How do you monitor common pest, disease, weeds and beneficial insects these at your place of work. Where diseases are to be monitored – describe the symptoms used during monitoring. Ensure that on farm procedures are adhered to.
6. Identify the sources of information available to you on farm that allows you to identify and monitor pests, diseases, beneficial insects and weeds.
7. Demonstrate the monitoring processes and data recording that is performed for each of these at your place of work.
8. If there are no forms to capture the monitoring data, these should be designed as part of the activity.
9. Interpret the data collected with respect to management of the pest, disease or weeds.
10. Collect weather data and describe the potential influence changing weather conditions may have on the management programme.
### Concept (SO 2)

<table>
<thead>
<tr>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pests and beneficial insects on specific crops (all crops) are recognised, identified, counted and recorded and the impact or findings is assessed.</td>
<td></td>
</tr>
<tr>
<td>The damage and the cause of the damage is observed, categorically explained and identified.</td>
<td></td>
</tr>
<tr>
<td>Access to guides/publications and other resources and the use thereof are demonstrated.</td>
<td></td>
</tr>
<tr>
<td>Selection of method of identification is motivated.</td>
<td></td>
</tr>
<tr>
<td>Symptoms are observed and identified.</td>
<td></td>
</tr>
<tr>
<td>Scouting activities are performed regularly and thoroughly.</td>
<td></td>
</tr>
<tr>
<td>Weather patterns are observed and the effect thereof interpreted.</td>
<td></td>
</tr>
</tbody>
</table>
Session 3  Pest management tools

After completing this session, you should be able to:
SO 3: Understand the different types of control measures that can be applied in integrated pest management programme for pests, diseases and weeds.

In this session we explore the following concepts:
- Insect management practices
- Diseases management practices
- Chemical control of fungal diseases
- Chemical groups of Fungicides
- Weed Management Practices
- Methods of Weed Control
- Herbicide Selection
- Herbicide Classification
- Legal implications of pest management
- Pesticide Application

3.1 Insect management practices

See session 1

It is important that the learner is familiar with crop, site and/or industry specific procedures.

3.2 Disease management practices

The control of plant diseases lean on five basic principals; exclusion, eradication, protection, resistance breeding and certification.

- Exclusion of a disease is based on excluding a disease from an area where the disease in not yet present. Total exclusion is not practical but it can be achieved to some extent by using pathogen free propagation material. A well managed certification scheme is required to succeed in implementing this process.
• **Eradication** - is the eliminating of a pathogen form an area by means of targeting its method of survival.

• **Protection** - this method focuses on the protection of the plant against the pathogen, thus placing a barrier between the crop plant and the pathogen by implementing a chemical spray programme.

• **Resistance breeding** - is the process where the genetic composition of the crop is manipulated in such a way that the crop is resistant to attack from a pathogen.

• **Certification** - includes introducing quarantine measures as well as certifying propagation materials as disease free. Limiting the transport of potentially infected material from a high risk to a low risk area is also included in the certification system. The success of a certification system relies on good management and the introduction of an inspection system.

### 3.3 Chemical control of fungal diseases

Chemicals used in the control of fungi are called fungicides. Chemical measures are introduced to aid in eradication of diseases, protecting the crop against diseases and curing the crop from an existing disease.

• **Eradication** of plant diseases involves the control of the target pathogen while the pathogen is still outside the crop plant. This is being done by way of seed treatment and soil fumigation prior to planting.

• **Protective measures** are taken to place a chemical barrier to the outside of a plant or a systemic compound within the plant. The chemical is applied before the pathogen is present in the plant.

• **Curative measures** are taken once the pathogen has already penetrated the crop. For this type of control the chemical must be taken up by the plant and must therefore have either a trans-laminar or a systemic action.

• **Eradicating or curative fungicides** kill the disease on or inside the plant once the disease has developed.

• **Protective fungicides** form a protective layer around the seed or crop killing fungal spores during their germination.

• Fungicides are divided into three major groupings,
  - **systemic fungicides** are taken up by the plant and been translocated within and throughout the plant
  - **translaminar fungicides** are taken up by the leaves, but are not translocated through the plant
• **Broad-spectrum fungicides** refer to those that are effective against different funguses.

### 3.4 Chemical groups of fungicides

#### Chemical groups of fungicides

Fungicides are categorised according to their chemical similarities.

- **Copper containing compounds** - are used against a range of bacteria and funguses. It has a contact action and must therefore be used with care to avoid crop damage. These compounds are not easily washed from the leaves, thus providing a long lasting protection.
- **Sulfur containing compounds** - are available in two forms, either as sulfur (in wettable or powder form) or as polysulfide-sulfur. The effect of sulfur on pathogens is primarily by contact and is effective against powdery mildew. It is used for controlling powdery mildew on apples and peaches, scab on apples and anthracnose on grapes.
- **Dithiocarbamates** - are the most important group of fungicides with a contact action. Many are broad-spectrum fungicides such as Mancozeb, Maneb and Zineb. Thiram is used on stone fruit and other orchard species. Thiram is an important compound for seed treatment and can also be used as soil treatment in seed-bed preparation.
- **Aromatic compounds** - are contact fungicides and act by binding –NH₂ and –SH groups. Quintozene is a soil fungicide against soil pathogens as Rhizoctonia, but is ineffective against Pythium. Dichloran is used against rotting, including post harvest rot in peaches. Dinocap is used for powdery mildew in a number of crops.
- **Heterocyclic compounds** - are broad spectrum contact fungicides such as Captab, Folpet, Difolatan and Iprodione.
- **Acylalanines** - are systemic compounds with residual action. These include metalaxyl, curative against Phytophthora and oxadixyl and used for controlling downy mildew in grapes.
- **Benzimidazoles** - systemic, broad spectrum fungicides used in foliar sprays, seed dressings and soil drenches. Examples include Benomyl and thiabendazole. (Look out for resistance development.)
- **Oxathiins** - systemic compounds for use against smut and rust fungi and Rhizoctonia. The compounds include Carboxin and oxycarboxin.
- **Morpholines** - Preventative and eradicating foliar applied compounds used for powdery mildew. Include dodemorph and tridemorph.
- **Organic phosphates** - systemic fungicides, active for prolonged periods and used as sprays and fumigants. Examples are Fosetyl-al which is effective against Phytophthora and Pythium.
- **Pyrimidines** - inhibit sterol synthesis and include bupirimate and fenarimol.
- **Triazoles** - are systemic compounds with a protective function. Includes triadimefon, bitertanol and propaconazole.
Before a fungicide is applied, the user must be sure of the identity of the pathogen in question. Once this is identified, the user must make use of a registered fungicide ensuring it can be used on the specified crop and that it will be effective against the pathogen in question.

### 3.5 Weed management practices

The influence of weeds on a crop and natural vegetation and the rate and extent of weed growth is more predictable than that of crop pest. Weeds can therefore be better managed than the other pests and diseases. Weed control includes; prevention, control and eradication.

- **Prevention** – measures taken to prevent a new weed from entering an area. Preventive measures must also be taken to prevent weed seed from forming. Prevention includes avoiding:
  - Crop seed contaminated with weed seed
  - Spreading plant parts with implements
  - Using contaminated manure
  - Using contaminated irrigation water.
  - The development of seed on the weed plant
  - Spreading of vegetative reproductive plant parts

- **Control** - Weed control is the general objective in weed management. Controlling weed with chemicals or mechanically, is the most predominant weed control techniques used. Weed control is performed to reduce the numbers of weeds to such levels that they do not adversely affect the yield of a crop or interfere with the harvesting process. A balance must be created between weed control costs and economic advantages in the form of larger profits.

- **Eradication** - is the elimination of weed plants and their reproductive capacity from an area. The only way in which eradication can be performed in soil is by means fumigation. The application of fumigants is expensive and therefore only profitable when used in small areas of high-production soils or systems with the production of high value horticultural and specialised vegetable crops.

### 3.6 Methods of weed control

Weeds can be controlled by using four major strategies. These strategies include mechanical control, control through cultivation practices, chemical control and biological control.

- **Mechanical weed control.**

  Mechanical weed control includes cultivation of fields, hand hoeing, mowing and the use of mulches, burning of fields and flooding of fields.
Cultivation - Cultivation can be divided into two forms of cultivation, primary cultivation and secondary cultivation. Primary cultivation includes conventional ploughing and is aimed primarily at soil preparation, whereas secondary cultivation is a disturbance of top soil, aimed at weed control and breaking a cloggy surface simultaneously. During tillage weed seed can be brought from deeper soil layers to the surface, which could stimulate seed germination.

Mechanical hoeing - the development of row cropping systems was aimed to facilitate cultivation. Mechanical hoeing can only be carried out in such row crops. The cultivation process breaks the contact between the weed roots and the surrounding soil and may even separate foliage from roots burying foliage and seed. The best soil conditions for hoeing are when the top-soil is dry and sub-soil is wet. Hoeing by hand is taking up much time and expensive, considering high labour costs, yet it remains highly effective and more selective than mechanical hoeing. It is also important in subsistence farming systems.

Mowing prevents seed development and weakens food reserves in perennial weeds. Although mowing may favour crops that are adapted to mowing, it has a disadvantage since weeds growing below the cutting line may benefit from it as the weed spectrum is changed from upright growers to horizontal growers.

Mulches - weeds, covered in mulch are smothered primarily due to light deprivation. Mulches can be made from materials such as plastic, straw or other plant residues. Planting a cover crop can also serve as mulches.

 Burning - needs to be controlled. Burning is non selective and may stimulate the emergence of certain weed species.

Flooding - Weed control by flooding of lands with water has a limited application. Soil saturated with water has low oxygen content and it is this factor that causes the drowning of plants. Seeds of plants, sensitive to low oxygen concentrations in soil, will remain dormant. Flooding is used in rice fields to control certain weeds as rice can tolerate waterlogged conditions.

Weed control by way of cultivation practices is only relevant in the agriculture sector. It must be kept in mind that management practices of natural fields and pastures could also aid in managing encroachment and invader species. Weed control through cultivation practices starts with the crop selection. The choice of a crop determines the weed control programme to be used. Crop choice may also guide the programme developer as to the weed spectrum he could expect to encounter. Crops that germinate rapidly and produce leaf covering will develop faster than the competing weeds, get a head start and keep on suppressing it.

Once a crop is selected, the time of planting must be considered as some crops, adapted to lower temperatures, may get a head start on some weeds that are not adapted to it. Early planting may favour crops, but a weed, adapted to lower temperatures, may need chemical control measures for extended periods which may lead to increased input costs. Plant spacing is also of importance as dense crop stands in narrow rows will naturally suppress weed growth by depriving them of light. The growth of the crop can be manipulated through fertilisation and
irrigation. The addition of extra fertilisation is not always effective in overcoming the weed competition since the weed may also react positively to fertilisation.

**Chemical control**

An herbicide is a mixture of chemicals prepared to suppress plant growth or kill plants. The wide use of herbicides in crop fields and on range-land is based primarily on herbicide selectivity which can be used to control weeds without causing damage to the crop plants.

Herbicides are made up of chemical compounds known as active ingredients (a.i.) which affects the life processes within weed plants in a way that it die off. The herbicides are sold as herbicide formulations, which are a combination of active ingredient and other chemicals. A formulation can be in a liquid form, as powders or granules.

These formulations also contain solvents to disperse the active ingredient; stabilisers to prevent the active ingredient from reacting with other chemicals and to prolong its shelf-life; emulsifiers to enable the active ingredient to mix with water or oils; adjuvants to improve its entry into the plant; dyes, an inert substances that show where the herbicide has been applied. The addition of dyes to a formulation is especially handy where invader species are controlled.

The herbicide is sold as a formulated product or product. The formulated product may require dilution before it can be applied. The dilution of the product is mixed with a suitable carrier to ensure an even distribution of the active ingredient over the target plants. Most active ingredients are formulated so that they mix with water, the most common carriers. Diesel is also used in specific situations, such as the application of Garlon® in cut stump treatments.

### 3.7 Herbicide selection

It is important to know the desired end result of an application before the final decision is made on the type of herbicide that will be used. Herbicides can be classified in a number of ways, but the most useful classifications are those that aid in the selection process; (a) their ability to be transported or translocated in a plant, (b) the compound’s ability to selectively kill weed species without damaging desired plants, (c) their persistence in the soil environment and the mobility of a herbicide in the soil, (d) the time of application, relative to the growth stage of the crop.
3.8 Herbicide classification

Classification according to crop growth stage

It is important to remember that when a weed control programme is based on the use of herbicides, the crop’s growth stage will be the main decision-making feature. When one considers herbicide application schedules in agriculture they include: pre-plant, pre-emergence and post-emergence application.

Pre-plant application take place before the crop is planted and the herbicide can be incorporated into the soil by implements.

Pre-emergence application take place after of the crop is planted but before the crop emergences. The herbicide must be washed into the soil by rain or irrigation.

Post-emergence applications occur directly to the plant foliage. This aids in the sense that the weed problem is already visible and soil factors do not influence activity.

When alien invaders and industrial weeds are controlled chemically, the terms Pre- and post-emergence have another meaning as it refers to the development stage of the weed as no crop plants are present. Thus, when weed is controlled by using a Post emergence application, it is done directly onto the plant.

Direct application onto vegetation can be done by using different methods:

♦ Foliar application
Foliar application occurs when the herbicide mixture is applied to the foliage (leaves and stems) of the plant. The volume of herbicide mixture required depends on the density and height of the plants. In this type of application, leaves are sprayed to the point of run-off.

♦ Stem and stump applications
Alien invaders, mainly perennial plants may produce regrowth after being injured or cut down, it is therefore important that all dormant buds near the soil surface and the roots are killed. In achieving this, the herbicide mixture is applied to the stems and stumps to ensure efficient uptake of the herbicide.

♦ Stem applications
Stem applications are divided into three main groups. These are basal stem-, partial frill- and stem injection:

• Basal stem application is suited for plants with a thin bark which in general do not exceed 20 cm diameter. The herbicide mixture is applied to the bark to a height of approximately 30 cm from the ground. The application can be made by using a paintbrush or sprayer. The herbicides are absorbed through the
bark of the plant from where it is translocated to its site of action.

- **Partial frill application** requires a ring of evenly spaced cuts to be made through the bark of the plant. The cuts can be made with an axe. Ideally the cuts should be made low on the stems. A suitable herbicide mixture is then administered into each cut by using a syringe or hand-held sprayer. The herbicide will eventually be taken up in the plant. Take care as not to spill the solution as it may affect other plants. This method is time consuming and tedious.

- **Stem injection** is used only in the control of the Cactus family because of the growth habit of these plants. The presence of thorns and thick cuticles layers handicap other application techniques. A hole is made into the lower part of the stem by means of a thrusting spike or drill. The herbicide mixture is then sprayed into the hole.

- **Stump application** - the plants are cut down as close to ground level as possible by using a chain saw or brush cutter, leaving a clean cut. The stump should be cut to provide a short stump with a level surface and with the bark still intact. The herbicide must be applied within 2 hours. The herbicide mixture can be applied either to the outer ring of the cut surface (close to the bark) or to the cut surface and sides of the stump, as well as any exposed roots parts.

- **Soil application** - the herbicide is applied to the soil around the base of the target plants. Herbicides designed for this type of application are available either as a granule that is applied as it is, or as a formulation mixed in a carrier. This type of application is more suited for industrial weed control where total weed control is aimed at. It can however also be applied in the invader control and encroachment control sectors, but only under certain conditions. The compounds used in encroachment control are selective compounds, which normally require only a single application. These compounds generally have a prolonged soil activity and thus with residual activity. It is important when soil application is considered, that the compound will suit for the area where it is to be applied. This type of application should not be done close to crop fields or when desirable plants are in close proximity. The compounds should not be applied more than once a year to the same area. Remember; always follow the instructions on the label to the letter!

### Classification according to herbicide translocation in plants

Herbicides are classified according to the ability of being translocated within a plant:

- **Contact herbicides** cause injury, limited to a small area, to the leaves where they come in contact with the plant. They cannot be translocated within the plant and will not reach the root system of the weed. These compounds will kill annual plants but
only cause defoliation in perennial plants. Contact herbicides are applied to the plant as a whole.

**Systemic herbicides** can be translocated or “transported” in the plant to the sites where active growth occurs. These compounds can be applied either as foliar sprays or soil applications. Systemic herbicides are ideally suited for the control of perennial weeds, invader species and encroachment species.

### Classification according to herbicide selectivity (ability to select weeds)

**Herbicide selectivity** is one of the most important concepts in modern weed control. The ability to choose specific weeds makes it possible to control a weed plant within a crop, without damaging the crop plant. Similarly, one is able to control an invasive tree within grassland without any detrimental effects to the grass. A **selective herbicide** therefore affects weed growth, but does not affect the desired plants. Selective herbicides are however only selective within limits and is affected especially by environmental conditions and the sensitivity of the plant to the compound. It is especially important within a crop situation that the selected care is taken to ensure that an herbicide can indeed be safely applied to the specific crop cultivar. The instructions on the herbicide formulation label must always be strictly adhered to. Always ensure that the herbicide is certified as safe for use on a specific crop cultivar. This can be done by checking the herbicide label and consulting with both the relevant seed and chemical companies.

Herbicide selectivity is affected by **environmental conditions** which cannot be manipulated during crop cultivation. An herbicide can only be effective if it is absorbed by the target plant. Once absorbed, it is translocated to the metabolic sites of action. Varying environmental conditions (temperature and water availability) affects the extent and rate of absorption of herbicides by the plant. Soil type and soil structure also affects the selectivity of herbicides because the extent of adsorption of the herbicide to soil will determine the amount available for root uptake.

Certain plant characteristics such as; plant age, plant growth rate, plant morphology, plant physiology, plant biophysical processes, biochemical processes and plant genetics can also play a role in the uptake and translocation of herbicides. In general, younger plants are more sensitive to herbicides than older plants as the uptake of herbicides are more efficient and the growth rates of younger tissues are higher. Young plants growing vigorously will have a larger up-take and transporting ability, thus be the more susceptible to herbicides.

The most important factor of a plant, its genetic make-up, must always be taken into account as plants may be naturally resistant to certain herbicides. This natural resistance may stem from specific degradation pathways which the plant may posses or a mechanism which could prevent herbicide activity. Resistant weed biotypes will only develop if the herbicide is present in the environment of the weed, enabling the genetic make-up to build up a resistance to the already existing compound. The repeated exposure to this herbicide then eventually leads to the killing of all the
susceptible individual plants and leaving only the resistant plants to propagate. When a weed management programme is developed the potential development of resistant weeds must thus be considered. Rotation of the herbicides with different modes of action on fields could aid in reducing the risk of resistant weed populations to develop.

Regarding their classification, herbicides are generally placed in two groups concerning selectivity. These two groups are; the grass herbicides and the broad leaf herbicides. Grass herbicides will kill primarily grass weeds and will not damage broad-leaved weeds/plants. Broad-leaf herbicides will kill primarily broad-leaved weeds and not the grasses. (Remember however, selectivity is not absolute, as explained above.)

### Classification according to herbicide residual activity (persistence) in soil

The duration of herbicides remaining active in soil is determined by the amount applied and the rate of loss. It is therefore important that it stays active long enough to allow effective weed control, but not too long to damage the follow-up crop. The activity of herbicide remainders is thus critical when deciding on which compounds to use.

Herbicides have withholding periods for specific crops which are specified on the label. Herbicide residual activity is of major importance in the crop situation. The duration of active herbicide remains in soils will determine the time a farmer has to allow to pass before a new crop is planted. This time is determined by soil type as well as the follow-up crop to be planted. In the case of certain crops the herbicide label specifies the time period, which has to laps before a follow-up crop can be planted, as the **withholding period**. The withholding period is normally specified in days and it refers to the period of time that has to laps, before a follow-up crop can be planted. These specifications must be followed at all times, or damage to the follow-up crop may occur.

Some herbicides remain active in soil for some time (weeks to months) and are referred to as **residual herbicides**. This herbicide group is usually used for industrial weed control purposes. They allow a single application once or twice per year whilst keeping an area weed free. Residual herbicides are also ideally suited for the control of encroachment species as long as the compound is selective towards the tree species, i.e. the grasses are not damaged due to the application. Residual herbicides are usually systemic compounds. **Non-residual herbicides** are those that do not last for long periods in soil. These compounds could have either a systemic or contact activity. Non-residual herbicides are normally applied to the target plants by means of foliar application.

### Classification according to herbicide behaviour in soil

When herbicides are applied to soil the compounds become absorbed to soil particles or soil colloids. Colloids are microscopic particles in soil which carries an electrical charge. Nutrients and herbicides are also electrically charged and can thus bind to soil particles. **Mobile** herbicides though, will not become absorbed with the colloids and will thus leach away through the soil profile. **Immobile** herbicides on the other
Hand will bind more easily to soil particles and limited leaching will thus be expected. Absorbed molecules are temporarily unavailable to plants in both cases.

This characteristic plays an important role in the selection of herbicides for use in weed control. The herbicide, tebuthiuron, used in bush encroachment control, is based on the ability to leach with ease. Once the compound enters the soil, it leaches past the root zone of grass species but leaches into the root zone of the encroaching trees. In this way the target trees take up the herbicide whilst the grass species remain intact. In a crop situation where a selective herbicide has been applied, the compound should not leach readily but remain within the top 10 – 20 cm soil layer long enough to allow the crop to emerge and develop a sufficient canopy.

Herbicide absorption to soil is not only determined by the chemical structure of the herbicide, but also by soil structure. The most important colloids in soil that determine the extent of absorption are organic colloids and clay minerals. The absorption capacity of a soil is quantifiable and is expressed in terms of the cation exchange capacity (CEC) of soil. The main two groups of clay particles are montmorilinite clay (2:1 layer clay) and kaolinite clay (1:1 layer clay). Organic colloids are represented and made up primarily by humus fractions. On a mass basis, the absorption capacity of the colloids is:

- Kaolinite, Montmorilinite and organic colloids

Because of soil absorption, a proportion of the herbicide applied will be unavailable to the plant. Herbicide labels usually specify higher dosage rates for higher clay soils than lower clay soils. The clay layer is thus used as indicator of absorption. Do not use the doses recommended for high clay content soils on sandy soils, this may lead to crop damage and severe residual problems.

In general, the following applies:

- Soils with high organic matter require higher herbicide doses
- Soils with high clay content require higher herbicide doses
- Herbicides will remain for a longer period of time in soils with high clay content and high organic matter than in sandy soils.
3.9 Legal implications of pest management

Pesticides are chemicals used to control pests. The three main categories of pesticides are insecticides, herbicides and fungicides. Herbicides are used for the control of problem plants, insecticides to control problem insects or plant pests and fungicides are used to control fungi causing plant diseases.

**Pesticide registration**

All pesticides must be registered under the regulations of Act 36 of 1947, which is the Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, governed by the National Department of Agriculture. Before a pesticide can become commercially available to the public (farmer) it must undergo the registration process which involves submitting data on the composition, toxicology, pharmacology, efficacy and phytotoxic to the Registrar of Act 36. Trials in which data is generated must be carried out according to guidelines set out by the office of the Registrar. The results must show that the pesticide does control the pest against which it is aimed under a range of environmental conditions before registration is granted as well as results showing that the compound will not adversely affect the health of operators and the environment.

The registration process has specific requirements for information that should appear on the label. The label is viewed as a legal document and must show:

- the method of application
- the recommended dosage
- the application volume per hectare
- the precautionary steps to be taken during mixing and spraying to avoid health effects,
- the measures to be taken to avoid environmental contamination

The importance of the label on a pesticide container and the information it contains cannot be overemphasised. Read the label before the container is opened and adhere to it. It is technically an offence to use or recommend the use of an agricultural remedy for any purpose or in any other manner than that specified on the label of the container.

A pesticide label has a centre panel flanked by two side panels to cater for multilingual labels. Each group of pesticides is identified by a coloured square in the top right-hand corner of the centre panel next to the product’s name. A colour band at the bottom of the centre panel indicates the hazard group. The label also contains one or more pictograms placed within the coloured band. These are used to communicate important safety information to the user. Three kinds of pictograms
are used, those giving Advice those giving Warnings and those giving Information as to the correct handling and application of the product.

The label further contains the trade name, the registration number (L number followed by Act 36/1947), the name of the active ingredient and its concentration in the formulation as well as the formulation type. In addition the label states the name, address and telephone number of the registration holder as well as the batch number, the manufacturing date and expiry date. The instructions for use such as dosage rate, the recommended volume per hectare, compatibility and registered tank mixes.

### Pesticide formulations

The actual chemical compound, known as the active ingredient, actually affects the pest in such a way that death may occur. A pesticide, a mixture of the active ingredient (or a.i.) with other compound, the so-called INERT or non-active ingredient, is offered for sale under a specific trade name. Some formulations contain solvents to dissolve the active ingredient in the solution. They also contain stabilisers, emulsifiers, adjuvants and dyes.

The pesticide which is sold is called a formulated product or product. The formulated product must normally be diluted with a carrier to ensure an even distribution of the active ingredient over the target area before it can be applied in the field. Most active ingredients are formulated in a way enabling it to mix in water, thus the common carrier. There are a number of formulation types available and are identified by a code on the label (see Table 1).

<table>
<thead>
<tr>
<th>Formulation type</th>
<th>Formulation code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid applied undiluted</td>
<td>AL</td>
</tr>
<tr>
<td>Capsule suspension</td>
<td>CS</td>
</tr>
<tr>
<td>Emulsion concentrate</td>
<td>EC</td>
</tr>
<tr>
<td>Emulsion, oil in water</td>
<td>EW</td>
</tr>
<tr>
<td>Gas generating product</td>
<td>GE</td>
</tr>
<tr>
<td>Gel</td>
<td>GL</td>
</tr>
<tr>
<td>Macro granule</td>
<td>GG</td>
</tr>
<tr>
<td>Granule</td>
<td>GR</td>
</tr>
<tr>
<td>Suspension concentrate</td>
<td>SC</td>
</tr>
<tr>
<td>Suspo-emulsion</td>
<td>SE</td>
</tr>
<tr>
<td>Water soluble granule</td>
<td>SG</td>
</tr>
<tr>
<td>Soluble concentrate</td>
<td>SL</td>
</tr>
<tr>
<td>Soluble powder</td>
<td>SP</td>
</tr>
<tr>
<td>Water dispersible granule</td>
<td>WG</td>
</tr>
<tr>
<td>Wettable powder</td>
<td>WP</td>
</tr>
</tbody>
</table>

Every pesticide formulation contains a different combination of chemicals. These will appear on the label.

Formulations with solid carriers are usually called granules. They may be macro-granules for soil-application, dry fluent (DF) and water dispersible (WG) granules for sprays. Macro-granules are prepared by spraying a solution of the herbicide onto a
pre-formed granule or by compacting herbicide powders and a carrier. The carrier is usually chalk, (Calcium carbonate).

### ADJUVANTS

Adjuvants are commercial products that are sold as an additive to pesticide mixtures which enhances the effect of the used pesticide. Adjuvants can perform a variety of functions depending on the composition. A list of adjuvants and their properties is given below.

- **Buffers**
  Buffers are added to the tank mixture to keep the pH (acid/alkaline) balance within certain limits.

- **Compatibility aids**
  These substances are added to enhance and maintain the physical mixing of different components of a spray mixture where tank mixes are used. Mixtures should only be made if so recommended on the label.

- **Spreaders**
  Spreaders are used to improve spreading and contact of the spray mixture on the leaf surface.

- **Sticking agents**
  The addition of sticking agents to a spray mixture ensures that droplets stick to the plant surface.

- **Drift control agents**
  These additives change the physical character of the spray mixture, enlarging the droplets to avoid drift.

- **Anti-evaporants**
  These are used to slow down the evaporation of droplets until it reaches the plant surface.

- **Anti-foam agents**
  Anti-foam agents prevent the forming of foam in the spray tank, thus preventing the loss of active ingredient in the foam.

- **Penetrating agents**
  Penetrating agents are added to the spray mixture to promote the penetration of especially herbicides through the wax layer on the plant surface into the plant.
PESTICIDES AND WATER QUALITY

Water is the most commonly carrier used in pesticides application. The quality of non-tap water on farms etc. is variable and the water obtained from some sources can cause problems. Most pesticide formulations compensate for the use of hard water. Ideally the carrier water should be clear, colourless, odourless and with a neutral pH. The spray mixture must be applied directly to the plant to avoid potential chemical interactions. A number of factors which should be considered when selecting a water source;

- Solids in the water - Water with sediments in suspension may block nozzles. Sediments normally consist of fine organic matter and clays. The pesticide’s active ingredient will bind to these, thus being removed from the spray mixture.
- Water pH - Some pesticides are hydrolysed under acid or alkaline conditions thereby neutralising the pesticide.
- Salts in water - Excessive salts in water may cause damage to the crop plant when sprayed onto the leaves.
- Water "softness" - "Hard" water contains calcium or magnesium salts which can lead to mixing problems and reducing the stability of suspensions and emulsions.

Storage, mixing and application of pesticides

Pesticides should always be stored under secure, dry and dark conditions, away from other goods. Pesticides must not be stored in unmarked containers and must never be decanted into other containers, especially not those used for food and drink.

Ideally mixing should take place near a storeroom with suitable facilities, such as good ventilation, water supply, suitable containers, sand and or sawdust to clean up spills and a disposal area away from a watercourse. Workers should always wear protective clothes, boots, gloves and masks during mixing and spraying. Empty containers must either be recycled or punctured and buried, but must never be used for any other purpose, especially for transporting food or water. Never eat, drink or smoke when mixing or applying pesticides. All workers must be trained so that they are not exposed to unnecessary risks.

Pesticide hazard classification and risk

The word hazard refers to the ability of a pesticide to cause harm. The main hazards associated with pesticides are the toxicity and flammability. The word risk refers to the possibility that the hazard will accidentally be encountered by a person handling the product, even if used according to the manufacturers’ directions. The directions referred to includes storage, transport and use. The risk is due to either a single or repeated exposure to the pesticide over a short period. Safety refers to the degree of freedom from risk. Safety precautions on labels are intended to reduce risks to acceptable levels.
The registration of a pesticide places a pesticide in one of four hazard groups. The hazard groups are based on their toxicity to humans, as tested on the formulated product. The hazard groups are:

- **Group 1a** *Very toxic*, carries a red colour band on the label
- **Group 1B** *Toxic*, carries a red colour band on the label
- **Group 2** *Harmful*, carries a yellow band on the label
- **Group 3** *Caution*, carries a blue band on the label
- **Group 4** *Acute hazard unlikely during normal use*, carries a green band on the label

The safety precautions printed on pesticide labels are concerned with the “toxicity” hazard to people and the environment and how these hazards can be reduced.

An indicator of hazard is the acute toxicity of a pesticide or the capacity of a compound to produce injury or death due to a single dose. This dose is expressed as an Acute LD<sub>50</sub> value. The acute LD<sub>50</sub> is the dose of a compound which will kill 50% of the test group of animals and is expressed mg pesticide per kilogram body mass. Three methods of administering the chemical are generally used, oral (by mouth) dermal (applied to the skin) and inhalation (through the nose). When comparing LD<sub>50</sub> values, they should be interpreted as; the lower the LD<sub>50</sub>, the more toxic the compound and vice-versa is. The grouping of pesticides according to acute toxicity is given in Table 2.

**Table 2** Grouping of pesticides according to acute toxicity

<table>
<thead>
<tr>
<th>Hazard Group</th>
<th>Oral</th>
<th>Dermal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Solid</td>
<td>Liquid</td>
</tr>
<tr>
<td><strong>Group 1a Very toxic</strong></td>
<td>&lt; 5</td>
<td>&lt; 20</td>
</tr>
<tr>
<td><strong>Group 1B Toxic</strong></td>
<td>5 - 50</td>
<td>20 – 200</td>
</tr>
<tr>
<td><strong>Group 2 Harmful</strong></td>
<td>50 – 500</td>
<td>200 – 2000</td>
</tr>
<tr>
<td><strong>Group 3 Caution</strong></td>
<td>&gt; 500</td>
<td>&gt; 2000</td>
</tr>
<tr>
<td><strong>Group 4 Acute hazard unlikely during normal use</strong></td>
<td>&gt; 2000</td>
<td>&gt; 3000</td>
</tr>
</tbody>
</table>

The hazard grouping for some common substances is:

- Strychnine - Group I
- petrol - Group II
- aspirin - Group III
- and table salt - Group IV...

The LD<sub>50</sub> values for pesticides used in RSA can be found in the most recent edition of the "Guide to Use of Herbicides ", “A Guide to the Control of Plant Pests” and “A Guide to the Control of Plant Diseases” available from the Directorate of Agricultural Input, National Department of Agriculture.

Detailed information on pesticide safety and responsible use is set out in the “Responsible use Guide” of the Crop protection and Animal health Association.
3.10 Pesticide application

Pesticide droplet size and behaviour

Effective pesticide application is to a large extent equivalent to an even pesticide application to the target area. This is referred to as coverage and the better the coverage, the better the control. A pesticide is mixed with a carrier (normally water), poured into a spray apparatus and applied to a crop. To obtain coverage, the mixture is forced out of the sprayer through its orifice, delivering a set spray pattern. The spray pattern consists of a spectrum of droplets ranging from small to large droplet sizes. Effective coverage of the target is dependent primarily on the droplet size and not necessarily the volume of the mixture used. Droplet sizes are therefore crucial. The diameter of a droplet is measured in µm and sized accordingly. Droplets made by an aerosol can are less than 50 micron in diameter and are classified as aerosol droplets, mainly used for flying insects. Ultra-low volume (5 l/ha and less) with a very low volume application apparatus (5-50 l/ha) produce a mist, with droplets between 51 and 100 micron. Droplets sized at 101 to 200 micron are classified as fine spray; those of 201 to 400 micron are medium spray droplets and are used with 50-300 l/ha application volumes. Droplets in excess of 400 micron are known as course spray droplets and are used at volumes of more than 200 l/ha.

When small spray volumes are needed, use equipment with small droplets as it will be more cost-effective than using standard application equipment with high volumes.

Small droplets will provide a better coverage to the target area in comparison to larger droplets. Smaller droplets are however inclined to drift away and eventually evaporate.

Where potential drift needs to be controlled in the field, herbicides can be applied by using medium and course sprays. Fine sprays represent a midway between good coverage and minimum drift.

A spray apparatus do not produce droplets with the same sizes. The average droplet size in the spray cloud can be calculated and referred to as volume. The Volume Mean Diameter (VMD) is used to describe the spectrum of droplet sizes in the spray cloud. It is revealed that droplet sizes in a spray volume are divided into two equal parts.... half of the volume is made up by droplets larger than the VMD and the other half by droplets smaller than the VMD.

A droplet spectrum can also be defined by using the numeric median diameter (NMD). This implies that the spectrum of droplets is divided into two equal halves by the number of droplets. Again, half of the volume is made up by smaller droplets and the other half by larger droplets.
Droplet homogeneity

The homogeneity of droplet sizes refers to the variation in droplet sizes in the spray cloud. An indication of the variation in droplets sizes is given by the ration of VMD to NMD (VMD/NMD). The closer the ration to 1, the more homogenous the droplets are in size.

Droplet size selection

The movement of the droplet from the spraying apparatus to the target plant must be considered when deciding on a droplet spectrum to suit a specific application.

The movement of droplets is influenced by height of application, wind speed and direction, temperature and humidity which is directly related to size of the droplet. There is a tendency to use smaller spray volumes, associated with smaller droplet spectra. This tendency is due to primarily commercial implications. The smaller the droplet spectrum, the higher the number of droplets, thus provides a better coverage which theoretically should increase efficacy. It should be kept in mind however that smaller droplets are more susceptible to environmental factors, such as wind, as smaller droplets will drift away further with less wind for instance. The volume of a droplet determines the surface area exposed to the environment. The rule is that the smaller the droplet volume, the larger the area exposed. It can thus be said that small droplets are more exposed to environment and therefore more sensitive to meteorological factors than larger droplets. Small droplets are also more inclined to evaporation than a large droplet. A droplet may decrease in size due to evaporation to such a degree that only the formulation remains. The rate of evaporation increases with the increasing of air temperature and humidity.

The size of a droplet also determines the time it takes to reach ground level from the point of release. Smaller droplets will remain in the air for a longer period than the larger droplets and can thus drift further than large droplets, if wind speed remains constant. Because of the risk of drift, more care should be taken regarding environmental condition before and during spraying. An increase in drift will lead to a decline in coverage, thus decreased efficacy.

It is also important to remember that spraying should not be done during the heat of the day. This is because the sun heats the ground, which again heats the surrounding air above it. Warm air rises, causing a current in the air which will allow the droplets to float away. The result…..a decrease in coverage!

Small droplets are forced to the target plant via the spray device, thus following the air current into the plant. Some of these droplets are forced beyond the plant but because of a vacuum formed behind a leaf, for instants, the droplets are pulled back to the leaf, thus allowing coverage at the back of a leaf. Droplet coverage can be improved by increased air velocity.

Large droplets have greater momentum when forced to the target area and will not go through the plant as easily as smaller droplets.
The fate of the droplet, once deposited on the target, depends primarily on the formulation, the presence of a wetting agent as well as the spreading, penetration and sticking properties of the spray mixture used.

**Meteorological conditions and pesticide application: (a guideline)**

Pesticide should not be applied when:
- there are sudden bursts of wind
- the wind speed exceeds 15 km/h (insect and plant disease control)
- the wind speed exceeds 8 km/h (herbicides)
- the wind direction changes towards a susceptible crop or sensitive area
- the difference between wet and dry bulb thermometer readings is equal or less than 8ºC
- an anti-evaporator has been added to the mixture, a difference of 12ºC is allowed
- plants are wet (dew, rain or irrigation)
- plants are wilted

**Pesticide application volume**

The application volume refers to the total volume of mixture which is applied to an area. The application volume is expressed in mixture as litres/hectare (l/ha). The volume largely depends on the apparatus used, the crop type, the pest which must be sprayed and also the pesticide. A tendency has developed to make use of lower application volumes which gives good coverage, but not to the stage of drip-off.

There are five application volume classes, classified according to spray volume per hectare.

- **For field crops:**
  - High volume (HV) Volumes of 600 l/ha and higher
  - Medium volume (MV) 200-600 l/ha
  - Low volume (LV) 50-200 l/ha
  - Very low volume (VLV) 5-50 l/ha
  - Ultra low volume (ULV) 5 l/ha and lower

- **For orchards:**
  - High volume (HV) Volumes of 1000 l/ha and higher
  - Medium volume (MV) 500-1000 l/ha
  - Low volume (LV) 200-500 l/ha
  - Very low volume (VLV) 50-200 l/ha
  - Ultra low volume (ULV) 50 l/ha and lower
A reduction in application volume requires reduced droplet sizes in order to ensure effective coverage. The pesticide label must be followed at all times when deciding on volumes to be applied. The label will recommend not only the dosage rate (pesticide per hectare), but also the suggested volume. Note that the application volumes specified on labels for Ultra-low and Very-low volumes are not always corrected.

### Some General Rules:

**Aerial application with a boom and nozzle** - use volumes of 20 to 40 l/ha.

**Aerial application with Micron-air type of spray heads** - volumes of 20 l/ha can be used which will apply smaller droplets. These droplet sizes can be reduced without the drop in coverage, but avoid or limit drift. Never apply herbicides by means of air using small droplets.

**Aerial applications with volumes lower than 30 l/ha** - add an anti-evaporant to the mixture.

**Application of volumes lower than 5 l/ha**, requires a specially developed pesticide formulation; few of these are commercially available.

**Ground application for Weed control** - use Boom and nozzle type apparatus applying at 200-450 litre/ha with droplets of 250-400 µm.

Ground application to row crops; to control insects and red spider mite - **use a boom and nozzle with drop arms, droplet size of 150-250 µm and a volume of 100-200 litre/ha (dryland) and 50-200 litre/ha (irrigated fields).**

**Ground application to row crops; to control insects and red spider mite** - use boom and nozzle without drop arms, 150-250 µm at a volume of 200 - 600 l/ha.

**Ground application to non-row crops using Mist blower** - Droplet size of 150-200µm at 100-200 l/h (irrigated crop)

**Ground application to non-row crops using Micron-air spray heads** - Droplet size of 100-150µm at a volume of 30-100 litre/ha for a pesticide mixed in water and 10-30 l/ha for pesticides mixed in oil or other anti-evaporate or 5-10 l/ha for specially formulated ULV formulations.

### Pesticide application equipment

- Knapsack sprayer

This is probably the best-known spray apparatus and consists of a tank, which forms the main body of the sprayer, with a capacity of up to 20 l. The tank and is usually carried on the back. The sprayer is fitted with a pressurising system and a hand lance, with one or more nozzles. The nozzles fitted in this sprayer are usually of the hydraulic types. The hand lance is equipped with a simple open and shut valve. The knapsack sprayer is ideally suited for small-scale spraying operations such as
household applications, small scale farming, green-houses and invader plant control.

♦ Boom and nozzle sprayer

Boom and nozzle spray equipment is similar in principal to the knapsack sprayer with the exception that it is much larger. The sprayer also consists of a spray tank with a capacity which ranges from 900 l to 3 000 l and a pump. The boom, which replaces the lance, is with a spray line, drop arms and nozzles. The tank and boom is mounted on a frame, which is fitted to a tractor, using the standard hydraulic system for adjusting spray height. The boom length may vary from 2.5 m to 30 m, depending on the model purchased. The larger booms can fold up into sections to ease transportation. The height adjustment is essential as this enables adjustment of the degree of overlapping between nozzle swaths. The actual spray swath is measured as the total spray width. The pump system can either be of the type which connects to the tractor's PTO, or a separate unit. Some tanks are equipped with agitators which stirs the mixtures during the spraying process, this is essential when applying wettable powders and soluble concentrates. The spray lines are (PVC-plastic or nylon hose piping) fitted with nozzles. The internal diameter of the spray line must be large enough so that the pressure drop along the line does not exceed 10% of the operating pressure of the system.

It may be necessary to ensure good coverage of the lower leaves and the bottom of leaves, such as cotton planted in rows. In these cases vertical drop arms, designed to travel in the inter-row space and flexible to prevent breakage when brushing through foliage, are used.

♦ Air stream sprayers

Mist blowers are designed to force droplets into the foliage of tree canopies, vine yards and row crops with large air volumes. They are especially used in orchards for the application of fungicides and insecticides. The optimal droplet size for these sprayers range between 50 - 120 μm. Mist blowers use larger volumes of spray mixture ranging from 200 to 1000 l/ha because of hydraulic nozzles with hollow cones and defined droplet characteristics.

A rotary atomiser can be added to the mist blower and connected to the pipeline carrying the spray mixture from the spray tank; thus providing a more uniform droplet spectrum.

♦ Rotary atomizers

• Rotating cage type (Micron-air)

The "Micron-air" is an example of advanced spray head technology.

The spray head is made up of a propeller fitted on a shaft with a mesh cage on the outlet side. The inlet allows a pesticide mixture into the rotating cages which break down the liquid into fine droplets. The flow-rate of the mixture through a Micron-air spray head ranges from 0.29 to 40 l/min, depending on the model used. This means that the volume output per ha can range from (ULV) 5 l/ha to 50 - 200 l/ha. The droplet size can be changed
by changing the blade angle which in turn will influence the rotating speed of the cage.

When "Micron-airs" are fitted to an aeroplane, the flying speed of an aeroplane will influence droplet sizes as the propeller will rotate faster\slower according to the wind speed passing through the fan blades.

When "Micron-airs" are fitted onto a ground application structure, the cage is rotated by the hydraulic system (from a tractor) which in turn rotates the fan blades. These rotating blades cause a strong air turbulent behind the sprayers which blow the spray in a cloud form into the foliage of the crop.

- Spinning disc type (micron)

In the case of spinning disc applicators, the spray mixture runs over a specially designed rotary atomiser which breaks down the mixture into evenly spread and narrow ranged droplet sizes. The size of droplets can be altered by the rotating speed of the discs. At low revolutions, larger droplets are generated where as high revolutions will again generate smaller droplets.

A major advantage of this type of apparatus in the narrow ranged droplet sizes produced, thus the standard name; controlled droplet application (CDA). Examples of these types of sprayers are the Micron Ulva+, Herbi-4 and Ulvamast (X-10 spray head)

Nozzle selection

The most commonly used application equipment consists of a tank (containing the spray mixture), a pump (which provides pressure) and a pipeline (system to which nozzles are connected). The nozzles are designed to break down the pesticide mixture stream into droplets. A number of nozzle types are available to match the different spray patterns as prescribed per crop.

- Flat fan nozzles

Flat fan nozzles are effective in systems where a number of nozzles are mounted on a boom for the application of especially herbicides. The nozzles can be selected according to the angle of the swath produced and the volume that must be applied. The selecting process of nozzles is simplified as each nozzle contains a code number. The number on a T-jet 8004 refers to a nozzle with an 80 degree spray angle and which delivers 4 gallons spray mixture per minute at 40 PSI. These nozzles are suitable for use at a pressure of 150 - 450 kPa. The spray pattern is such that the majority of the spray is produced in the middle of the spray width. The nozzles are therefore mounted on a boom allowing the swaths to overlap. The standard spacing on a boom is 50 cm with the boom at 50 cm above the soil and an overlap of 30% on the sides. The nozzles are usually mounted at an angle of 5 degrees relative to the boom.
Even flat fan nozzles

The Even-flat-fan-nozzles are similar to flat fan nozzles, with the exception that the Even-flat-fan-nozzles produce an even amount of spray mixture over the spray width. The nozzles are recognisable by the “E” at the end of the number code. This type of nozzle is ideal for application of herbicides on row crops.

Cone type nozzles

The Cone type nozzles are used primarily in the application of insecticides and fungicides. The nozzle has a single circular orifice. Behind the tip is a core plate with two or more edged angular holes. When the spray liquid strikes the core plate it is forced through the holes, causing the spray liquid to swirl (in a cone design) when exiting the orifice. Hollow cone nozzles provide a hollow circular spray design whilst full cone nozzles provide a full circular spray pattern. Hollow cone nozzles are used for insect spraying on foliage because the droplets strike the target from different angles. This ensures good penetration and coverage. Hollow cone nozzles however, should not be used for herbicides due to the risk of drift. Full cone nozzles produce a narrower spray angle with larger droplets and are ideal for directed or spot spraying of insects. Solid stream and adjustable nozzles are also available. The solid stream nozzle is used primarily for soil application into furrows or holes.

Dual outlet nozzles

Dual outlet nozzles are used when wide angle spraying, close to the soil surface is required.

Off-centre nozzles

Off-centre nozzles are used for herbicide application in orchards, under the trees.

Calibration

It is of the utmost importance that all spray equipment is calibrated before application. Incorrect calibration could cause phytotoxic effect on the crop and unacceptably high pesticide residue levels at harvest. The correct nozzles must be selected as prescribed per crop, spray equipment and the specific application. Recommended nozzle spacing, operating pressure and forward speed should be adhered to.

Before calibration, the spray system must be cleaned thoroughly. The apparatus should be in good running order and the required nozzles and sieves installed. If the system uses more than one nozzle, ensure that all nozzles are identical and properly secured.
♦ Knapsack sprayer

The calibration procedure for a knapsack sprayer is based on the same principals as for most other spray equipment. Calibration involves the determining of the volume delivered by the sprayer on a given area and taken into account the speed of movement of the spray swath over the area.

- Mark off a test area in the field to be sprayed and determine the plot area in square metres. (It is recommended that a test area of at least 20 m² is used.)
- Fill the spray tank with clean water (the volume as needed for 20 m² in litres)
- Now spray the water at operational pressure and at an even walking pace (approximately 50 m/min).
- Ensure that the area is evenly covered (be careful not to overlap)
- If there is still water remaining in the tank or the area was not covered as a whole, the application rate must be altered by means of; the spray pressure (pumping action too fast\slow), walking speed (too fast\slow) and/or nozzle size (too big\small).

♦ Boom and Nozzle sprayer

### Determining of tractor speed

This should be done in the field of application.

1. Select the correct gear ratio and engine speed (RPM) which will deliver the required operating pressure.
2. Measure and mark off a distance 50 - 100 metre (use a tape measure)
3. Determine the time required for the tractor to travel the measured distance (use a stop watch).
4. Calculate the tractor speed
5. Repeat the procedure until the required speed is attained
6. Calculate the overall time to cover the distance of 3 - 5 replicates and calculate the final operating speed

Determination of the flow rate per nozzle
The flow rate per nozzle required can be calculated by:

**Where:** \( w \) = nozzles spacing on boom in cm for full-cover spray

\[
\text{Flow rate} \ (l/\text{min}) = \frac{\text{application volume} (l/\text{ha}) \times \text{operating speed} (\text{km/h}) \times w}{60 \ 000}
\]

or \( \text{w} \) = spray width in cm for row application

Once the flow rate has been calculated, the actual flow rate must be determined. Measure the volume of spray mixture delivered per minute. Make use of a suitable container which is placed underneath a nozzle. Set the operating pressure of the sprayer to the desired pressure and spray tank mixture into the container for one minute. Measure the volume delivered.

### Correcting the operating pressure to deliver the required volume

If the volume is not satisfactory, it can be corrected by adjusting the operating pressure.

The procedure is as follows:

1. Check the condition of the nozzles and replace if required.
2. Adjust the pressure and repeat action for one minute and again measure the volume delivered.
3. Repeat until the required volume per minute is correct.
4. The flow-rate of each nozzle on the boom must be determined. If the flow-rate of any nozzle differs by more than 10%, replace the faulty nozzle.
5. If more than 10% of the nozzles on the boom are faulty all the nozzles must be replaced.
6. The sprayer is now calibrated to deliver the correct volume in litre/ha at the correct tractor speed and spraying pressure.

Should the nozzles in the sprayer not deliver the required volume, it can be by replaced with other nozzles to achieve required volume. The instruction manuals and catalogues available from nozzle manufacturers will supply guidelines as to the volumes that can be expected at set pressure. These volumes are determined for water and must therefore be re-calculated for the spray mixture.

### Determination of swath width

Park the tractor and sprayer on a level surface. Lift the spray boom to the same height (plant canopy height) as it will be spraying in the field. Put the sprayer into operation (calibrated conditions). The wetted area sprayed on the soil represents the effective spray swath which is measured and used to mark off the swaths in the field. Avoid overlap but remember when flat fan nozzles are used to allow a ± 30% overlap between each nozzle.
The recommended heights and nozzle spacing can be gathered from nozzle manufacturers.

**Formulae used in calibration**

- **Pesticide application rates:**
  - Nozzle volume delivery (l/min)

  \[
  \text{volume delivery (l/min)} = \frac{\text{volume application rate (l/ha)} \times \text{forward speed (km/h)} \times \text{nozzle spacing (cm)}}{60000}
  \]

- **Application volume (l/ha)**

  \[
  \text{volume application rate (l/ha)} = \frac{\text{volume delivery (l/min)} \times 60000}{\text{forward speed (km/h)} \times \text{nozzle spacing (cm)}}
  \]

- **Sprayer speed requires (km/h)**

  \[
  \text{forward speed (km/h)} = \frac{\text{volume delivery (l/min)} \times 60000}{\text{volume application rate (l/ha)} \times \text{nozzle spacing (cm)}}
  \]

- **Tractor speed measured (km/h)**

  \[
  \text{tractor forward speed (km/h)} = \frac{\text{distance travelled (m)} \times 3.6}{\text{time taken (s)}}
  \]

- **Formulated pesticide product dilutions**

  A pesticide is preparation containing an active ingredient and other compounds. The quantity of active ingredient is indicated as a percentage (grams active ingredient per 100 ml or 100 g) of the preparation.

  When a pesticide is diluted with a carrier (water) in a spray tank, the concentration of active ingredient per hectare is then calculated to determine the quantity pesticide required in spray tank.

  \[
  \text{amount of product per hectare} = \frac{\text{amount of active ingredient required (g/ha)} \times 1000}{\text{amount of active ingredient in product (g/l) or (g/g)}}
  \]
Please complete Activity 3:

**Practical Activity**

**Group Activity**

1. In your group, select a crop that is grown at your place of work.
2. Using the information in Activity 2 to identify the range of management strategies that are applied at your place of work to manage the pests, diseases and weeds identified in Activity 2.
3. Is biological control in use at your place of work? If yes, identify the organism and the target and describe the affect thereof.
4. What forms of agricultural control is used on the farm for the control of predominant weeds?
5. Does mating disruption form a part of the control programme for major insects? If yes, describe the programme in use. Refer to the pest, the methods used and the success rate on the farm.
6. Taking into account the monitoring data you collected in Activity 2, which control method do you feel is the most effective under the circumstances. Motivate your answer against the IPM and environmental policies that are in place at your place of employment.
7. Describe the pesticide resistance management plan that is followed on the farm.
8. How does the pest management plan, used on the farm, help the farm to comply with the regulatory and market requirements for the crop produced?
<table>
<thead>
<tr>
<th>Concept (SO 3)</th>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>The different control measures that can be applied within an integrated management are explained.</td>
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<tr>
<td>The concept of biological control is explained.</td>
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<tr>
<td>The concept of cultural control is explained.</td>
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<tr>
<td>The concept of mating disruption and its use is described.</td>
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<tr>
<td>The sterile insect technique and its application are explained.</td>
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<tr>
<td>Other methods that can be integrated into the control management programme are explained.</td>
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<tr>
<td>The application of some of these concepts in disease and weed control is explained.</td>
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<tr>
<td>The most appropriate control measures, taking into consideration integrated pest management and the environmental impact is selected.</td>
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<tr>
<td>Access to guides/publications and the use thereof are demonstrated.</td>
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<tr>
<td>Environmental considerations that should be considered are explained.</td>
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<tr>
<td>Resistance and mode of action regarding rotation is determined.</td>
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<tr>
<td>Institutes to contact for advice are identified.</td>
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<tr>
<td>Legal and market requirements are adhered to.</td>
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Session 4

Developing pest management processes

After completing this session, you should be able to:
SO 4: Assist in developing a plan to assist the decision making process on the type of control to apply.

In this session we explore the following concepts:

♦ Group Activity

Please complete Activity 4:

Group Activity

(Consult with the facilitator or farm manager, local cooperative etc. where necessary)

In your group, select a crop that is grown at your place of work.

1. Using the information from Activity 2 and 3 to identify the most suitable control measure for the pest.
2. Show how the monitoring data is measured against the farm management plan and to what extent did it help you in making a decision on control practices (not ignoring farm data monitoring procedures).
3. Describe the on farm process you followed that helped you to make a decision on control practices.
4. If the control measure selected is chemical, identify the following from the label:
   • The product name and active ingredient
   • The product registration number
   • Manufacturing company
   • The mode of action group in which the compound falls
   • The registered application dosage and application rates
   • Is the compound registered on the intended crop and target pest
   • What is the legal MRL and withholding period for local and overseas markets
   • The suitability of the application relative to the growth stage of the crop
   • The suitability of the on farm water for use with the product. Are any additives required?
5. Record all data regarding the actual measurements done during the making up of solutions and applications.
6. Describe what equipment is the most suitable for the application of the product and why?
7. Describe how you would calibrate the equipment used.
8. If the control measure was non-chemical, go through the exercise in any case and make use of any pesticide's label information. The mixing and application can then be done by using water and a natural food colorant which is applied to open unplanted lands.

<table>
<thead>
<tr>
<th>Concept (SO 4)</th>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring data is collected and used.</td>
<td></td>
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<tr>
<td>Data is incorporated into a management plan.</td>
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<tr>
<td>The process followed to assist in the decision making process is described.</td>
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<tr>
<td>The type of control is decided on, selected and implemented.</td>
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<tr>
<td>Application instruction per etiquette is followed.</td>
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<tr>
<td>Weather, growth stage and type of product are considered.</td>
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<tr>
<td>Type of production system is considered.</td>
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<tr>
<td>Appropriate application method is decided on.</td>
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<tr>
<td>Safety measures are selected and managed.</td>
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<tr>
<td>Calibration and mechanical integrity of the equipment is determined.</td>
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<tr>
<td>Quality and availability of water is according to requirements.</td>
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</table>
Session 5

Post control monitoring

After completing this session, you should be able to:
SO 5: Execute post-application monitoring.

In this session we explore the following concepts:

♦ Practical Activity (Group Activity)

Please complete Activity 5:

Practical Activity
Group Activity
(Consult with the facilitator or farm manager, local cooperative etc. where necessary)
In your group, select a crop that is grown at your place of work.
Use the information from Activity 4.
In the fields to which the control practices were applied, determine:
1. The effectiveness of the practice applied
2. Identify the follow-up generation to that which had been controlled
3. Determine whether there are any side-effects or damage caused by the control practice.
4. Maintain the equipment used during control practices

<table>
<thead>
<tr>
<th>Concept (SO 5)</th>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness of a product is determined.</td>
<td></td>
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<tr>
<td>Follow-up generation is identified.</td>
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<tr>
<td>Side effects and/or damage are determined.</td>
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<tr>
<td>Equipment is cleaned and serviced.</td>
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</table>
Environmental and community considerations

After completing this session, you should be able to:
SO 6: Apply environmental and community considerations.

In this session we explore the following concepts:

♦ Poisoning and contamination;
♦ Disposing of waste;
♦ Warnings.

Please complete Activity 6:
Practical activity / Group Activity
At your place of work, identify and report on the on farm specific policies in use to ensure that:
(Consult with the facilitator or farm manager, local cooperative etc. where necessary)
1. Potential damage to wildlife and beneficial insects are avoided during pest control management is
2. Potential soil and water contamination is avoided
3. Potential drift onto non-target areas is avoided
4. Empty containers are appropriately disposed of
5. Rinse water is properly managed
6. Required warnings were adhered to where aerial application was performed.

<table>
<thead>
<tr>
<th>Concept (SO 6)</th>
<th>I understand this concept</th>
<th>Questions that I still would like to ask</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poisoning of wildlife and beneficial insects is avoided.</td>
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<tr>
<td>Soil and water contamination is avoided.</td>
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<tr>
<td>Drift onto non-targeted area is avoided.</td>
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<tr>
<td>Empty containers are appropriately disposed of.</td>
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<tr>
<td>Rinse water is properly managed.</td>
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<tr>
<td>Aerial application warnings are performed.</td>
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</table>
Session 7

Storage of agrochemicals

After completing this session, you should be able to:
SO 7: Oversee the management of an agrochemical storage facility effectively and responsibly.

In this session we explore the following concepts:

- Storage of agrochemicals
- Cleaning and house keeping
- Arranging stock in a store
- Ventilation
- Use, handling and storage of tools

Storage of agrochemicals

Agrochemicals include pesticides, adjuvant and additives, stock remedies and fertilisers. These should be kept in a pre-determined store on the farm. Within the store one should segregate the different types of agro-chemicals, keeping similar chemicals together. The pesticides should be kept separate from the fertilisers and herbicides stored separate form insecticides to ensure contamination. When pesticides are stored, powder or dry pesticide formulations should be stored on the top shelves, above the liquid formulations. Seeds and feeds should never be kept in the same store as agro-chemicals.

- Agrochemicals must not be stored in:
  - Cellars.
  - Garages.
  - Workshops.
  - Other rooms which are used frequently.

There are set rules and specifications regarding an agrochemical store in order to ensure safety to human health and the environment. The section below deals with the construction and specifications of an agrochemical store.

- Positioning an agrochemical store on farm
  - An agrochemical store should be located at least 5 m from other farm buildings and should not be built close to:
    - Houses.
• Buildings for livestock.
• Rivers, dams, boreholes.
• Areas likely to be flooded.
• Buildings where feed, fodder, fuel and other inflammable materials are stored.

♦ Requirements for Floor construction of agrochemical stores
• Concrete floors.
• Floors should be screened to a smooth finish.
• Floor to wall joints must be made waterproof.
• The floor should preferable be sunken to ensure that should a spill occur, it will be contained inside the facility.
• Earth, timber, bitumen, PVC or linoleum are not acceptable surfaces for a floor.

♦ Requirements for Wall construction of agrochemical stores
• Walls should be constructed of bricks or concrete blocks.
• Airbricks or vents must be positioned in the walls, 200 mm from the floor surface as well as at roof level.
• Good ventilation is important but prevailing wind direction must be considered when installing the vents. In areas where severe sandstorms occur the vents should be positioned in a way that sand and dust will not be blown into the store.

♦ Requirements for Roof construction of agrochemical stores
• The roof must be leak proof.
• It should be fitted with suitable insulation to maintain a constant temperature within a reasonable range.
• Additional vents in the roof will allow hot air to escape during summer.

♦ Requirements for Doors of agrochemical stores
• Steel doors with a secure locking system are recommended.

♦ Requirements for Windows of agrochemical stores
• The windows must allow sufficient light into the store enabling workers to read the product labels easily.
• Windows should be positioned at/or above head height and must have burglar bars.
Equipment required in a agrochemical store

- The store should contain:
  - Table.
  - Facility to store documentation such as procedures and logs.
  - Scoops, jugs and scale to measure powder and liquid formulations.
  - It is a good idea to keep separate pieces of measuring equipment for different types of chemicals.
  - Buckets.
  - A wash basin.
  - Emergency shower facilities.

- Spills handling equipment include:
  - Broom.
  - Spade.
  - Dry fine sand or sawdust to absorb liquid spills.

Clean all used equipment at the end of each working day to avoid possible contamination.

Where small volumes of Agrochemicals are used, these can be stored under lock and key in a suitable cupboard inside a store. Keep in mind that the requirements for ventilations etc. within the store must be adhered to.

Cleaning and house-keeping

Good housekeeping, personal cleanliness and equipment maintenance are important irrespective of the chemical used.

Cleanliness and order should be maintained at all times in the workplace. Ensure that:

- Spills are cleaned promptly and safely.
- Accumulation of corrosive materials is removed regularly and safely.
- Dispose of unlabelled or contaminated chemicals by using the correct disposal procedures and legal routes.
- Remove empty containers from a work area and store it in a designated area until it are disposed of or placed in a suitable recycling programme.
- Ensure that all waste containers are correctly and properly marked and stored in designated areas.
- Ensure that wastes are suitably separated.

Personal cleanliness is an important way of protecting the health of personnel working with hazardous chemicals. The points below are the minimum measures that should be implemented:
Apply effective and responsible integrated pest, disease and weed control

Primary Agriculture

NQF Level 4

Unit Standard No: 116301

Wash hands before eating, drinking, smoking or going to the toilet.

Remove contaminated clothing which must be cleaned (or discarded) before wearing it again.

Do not smoke, drink, chew gum or eat in any areas where hazardous chemicals are present.

Store food and tobacco products in uncontaminated areas.

Avoid touching yourself with contaminated hands.

Clean yourself thoroughly at the end of the workday.

Regular maintenance of equipment is important in preventing leaks or emissions of corrosive materials into the workplace.

Ensure maintenance personnel know the possible hazards of the materials they might be exposed to.

Always follow the procedures provided and maintenance intervals prescribed or equipment.

Be sure they know all special procedures and precautions that should be adhered to before they begin to work with equipment.

Regular inspections at the workplace may help in spotting areas where health and safety problems are developing. Ensure that the prescribed inspection intervals are adhered to and that all findings are properly reported.

### Arranging stock in a store

Chemicals should be stored under dry, cool conditions to prevent rapid deterioration. The store should be well organised with the shelves labeled and areas designated for specific materials or equipment. Chemicals should be well separated from other items, preferably in a separate store.

A list of the contents of the store must be kept. The distribution or use of stored items should be logged and a maintenance records kept for equipment. This will allow you to replace items in good time and ensure that equipment is kept in optimal working order. A well-organised store will prevent that agro-chemicals are wrongly issued.

Water tends to condense on cement floors. In order to prevent wetting and damaging to carton boxes, paper bags and rusting of metal containers and other materials, these should be placed on pallets but not stacked against exterior walls.

- Correct and efficient storage

Correct storage is important because it prevent accidents and injuries from occurring, it prevents contamination and spread of bacteria, it improves the daily work routine, stock takes are made easier, inventory control & ordering is made easier and maintenance is completed more efficiently.
Below are a number of points which will help to ensure that equipment and materials are stored correctly:

- Hooks and clips can be used to hang up items such as brooms & mops.
- Storerooms must be lockable.
- There must be good ventilation.
- Sufficient light must be present.
- Chemicals must be labelled & stored away from other materials.
- Chemicals must NEVER be stored or kept in disused food or drink containers.
- Chemicals must be stored away from direct sunlight or heat.
- Chemicals dispensers with taps should have a drip tray to prevent accidental spillages.
- Diluted chemicals must be marked or labelled properly for identification purposes.
- Waste must not be allowed to accumulate in storeroom but must be disposed of in the prescribed manner.
- Chemicals, by law, are not to be stored on the floor, but on shelves or pallets.
- Use a ladder when reaching for items from shelves.
- Clean shelves and floors regularly.
- Always store items in the correct place as specified by organisational procedures.
- Only authorised staff should have access to the storeroom.
- Keys to the storeroom should be kept by a responsible person, such as the supervisor or foreman, who will sign it in and out according to procedures.
- All issues of stocks and supplies should be recorded by the responsible person to keep track of stock levels and to ease stock takes.

 Ventilation

Well-designed and well-maintained ventilation systems remove corrosive vapours, fumes, mists or airborne dusts from the work area and reduce their hazards implications.

The amount and type of ventilation needed to minimise the hazards of airborne corrosives and volatiles depends on the kind and volume of the material used, the size and layout of the work area.
An assessment of the specific way in which such chemicals are stored, handled, used and disposed of should be done. Such assessments will determine whether existing ventilation controls (and other hazard control methods) are adequate.

Some workplaces may need a complete system of hoods and ducts to provide acceptable ventilation. Others may require a single, well-placed exhaust fan. Use corrosion-resistant constructions in ventilation systems for corrosive materials. No special ventilation system may be needed when working with small quantities of corrosives as these do not give off airborne contaminants.

- Prevention of contamination

Use products on the basis of “first in first out”.

If chemicals and fertilisers stay in the store for a long time, they might become ineffective or they might even become dangerous due to the chemical processes that take place over time.

### Use, handling and storage of tools

Below are six simple basic steps that should help you to ensure a more organised tool storage area:

- **Step 1: Clear out the junk**

  Sort out and discard all the junk that you do not need: only keep what you use and remove everything else. Some may still useful but belong in a different storage area. Throw away the broken stuff which is just taking up space. (Remember to discuss this with the foreman or farm manager first).

  A stain-resistant floor and considerable storage in the form of cabinets, hooks and shelving racks (for hand tools and equipment) will transform a disorganised place into a neat and tidy one.

- **Step 2: Paint the walls and floor**

  Measure the floor and sketch a floor plan to help you visualise what will fit in where. Don’t forget to consider the walls for storage.

  This is also the ideal chance to paint the walls, especially if they are currently exposed plaster or brick walls. Use light colours in smaller spaces to make these appear bigger.

  You may want to consider painting the floor before you start installing storage systems and moving everything back into the store. Preferably use an epoxy paint that is designed for floors.

- **Step 3: Storing smaller and larger items**

  Many storerooms have untapped potential that can be utilised to make room for more storage. Shelving is vital – inexpensive shelves can be purchased from most co-operatives or more expensive custom-designed cabinets can be installed. Keeping
things in containers does not only allow you to get them off the workbench or the floor, but also keeps them clean and dust free.

Always label unclear containers so you know what is inside them.

Allocate space for hand tools separately from other equipment such as tractors, spray pumps, mowers and weed trimmers. Decide which items are used frequently (such as hand tools) and store these near the door.

- Step 4: Organise your work area

Use transparent jars to store smaller items so that you can easily see what they contain.

- Step 5: Safeguard your expensive tools

Install a lockable latch on a cupboard door to keep expensive items under lock and key.

- Extra storage in the roof

Storage boxes or crates that are not used on a daily basis may be stacked on a storage shelf which is raised or lowered when necessary by means of pulleys (a hanging shelf).

- Light

Mount spotlights on the rafters above the work surfaces to ensure that the area has adequate light. A standard store light is likely to cast shadows over the work area. These lights are relatively inexpensive and easy to install.

Please complete Activity 7:

Practical Activity - Group Activity

At your place of work conduct an inspection on the agro-chemical store and complete a inspection report in which you report on the following:

(Consult with the facilitator or farm manager, local cooperative etc. where necessary)

1. Discuss whether the storage facility adheres to minimum requirements and report on all potential shortcomings found and possible improvement.
2. Are products correctly categorised and separated, make recommendations where required.
3. Report on the record keeping process. Does the system allow for sufficient traceability of products issued and entered into the facility? Make recommendations where improvement can be made
4. Are the products stacked correctly? Make recommendations as to any finding that may have arisen during the audit.
5. Is there an emergency and safety plan in place and can it be applied by store managers and personnel?
6. Are there sufficient access control and security measures in place?
### Concept (SO 7)

<table>
<thead>
<tr>
<th>The storage facility adheres to minimum requirements.</th>
<th>I understand this concept</th>
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<tbody>
<tr>
<td>Products are categorised and separated.</td>
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<tr>
<td>Record of incoming and outgoing products is in place and complete.</td>
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<tr>
<td>Proper stacking methods are applied.</td>
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<tr>
<td>Emergency and safety plan is in place.</td>
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<tr>
<td>Access control and security is according to requirements.</td>
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</table>

Questions that I still would like to ask

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### My Notes ...

...
Am I ready for my test?

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

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

<table>
<thead>
<tr>
<th>Questions</th>
<th>1. I am sure</th>
<th>2. I am unsure</th>
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<tbody>
<tr>
<td>1. What is Integrated Pest Management (IPM)</td>
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<tr>
<td>2. Why is it important to monitor crops within an IPM programme?</td>
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<td>3. Discuss the significance of pest to beneficial ratios in pest management.</td>
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<td>4. Why is it important to replace pheromones in traps and clear the taps at regular intervals?</td>
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<tr>
<td>5. Why is it important to keep accurate record of pest management and pest numbers on farm?</td>
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<tr>
<td>6. What type of data should be collected in order to keep relevant pest management records?</td>
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<tr>
<td>7. What are the major pest and diseases of the crop you work with?</td>
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<tr>
<td>8. Name the major beneficial organisms in the crop you work with?</td>
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<tr>
<td>9. Describe the damage caused by the major pest and diseases that affect the crop you work with?</td>
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<tr>
<td>10. Name the major guides and publications or other tools that are used to identify pest and diseases in the crop you work with?</td>
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</tbody>
</table>
11. Describe the symptoms used to identify the major diseases of the crop you work with?

12. How often is scouting for pest, disease, weeds and beneficial done at your place of work?

13. How are weather patterns monitored at your place of work?

14. How does the weather influence the pest and disease management practices in the crop you work with?

15. How would you control the major pests, diseases and weeds at your place of work?

16. What biological control agents will you use when designing a Pest Management programme for your crop?

17. What cultural control practices are used at your place of work in the pest management programme?

18. What are the major control practices that are critical for pest management at your place of work?

19. Describe the resistance management programme you would follow for the most important disease in the crop you work with.

20. Name the most important crop specific market requirement for the crop you work with.

21. How would you describe the production system for the crop you work with?

22. If you have to apply a chemical product for weed control in the crop you work with, which is the most common weeds, where does it grow, what compound would you use and how would you apply the compound.

23. Describe the safety measure followed at your place of work with reference to pesticide use on farm. Are there any specific industry guidelines that are followed for the crop?
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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<tbody>
<tr>
<td>Can you identify problems and deficiencies correctly?</td>
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<tr>
<td>Are you able to work well in a team?</td>
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<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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<td>Are you able to communicate your knowledge orally and in writing, in such a way that you show what knowledge you have gained?</td>
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<tr>
<td>Can you base your tasks and answers on scientific knowledge that you have learnt?</td>
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<tr>
<td>Are you able to show and perform the tasks required correctly?</td>
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<tr>
<td>Are you able to link the knowledge, skills and attitudes that you have learnt in this module of learning to specific duties in your job or in the community where you live?</td>
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</table>

- The assessor will complete a checklist that gives details of the points that are checked and assessed by the assessor.
- The assessor will write commentary and feedback on that checklist. They will discuss all commentary and feedback with you.
- You will be asked to give your own feedback and to sign this document.
- It will be placed together with this completed guide in a file as part of 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.

<table>
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<th><strong>Learner Information Form</strong></th>
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<tr>
<td><strong>Unit Standard</strong></td>
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### SOUTH AFRICAN QUALIFICATIONS AUTHORITY

**REGISTERED UNIT STANDARD:**

**Apply effective and responsible integrated pest, disease and weed control**

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<td>SGB Primary Agriculture</td>
<td>NSB 01-Agriculture and Nature Conservation</td>
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<td>2007-10-13</td>
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### PURPOSE OF THE UNIT STANDARD

A learner achieving this unit standard will understand the basic principles of an integrated pest management system with basic control measures as per agricultural enterprise. Furthermore, the learner will be able to recognise and differentiate between economical damageable pests and diseases and make use and interpret sources for application or product management.

Learners will gain an understanding of sustainable agricultural practices as applied in the animal-, plant and mixed farming sub fields. This unit standard focuses on the application of pest identification in primary agriculture.

They will be able to participate in, undertake and plan farming practices with knowledge of their environment. This unit standard will instil a culture of maintenance and care for both the environment as well as towards farming infrastructure and operations.
LEARNING ASSUMED TO BE IN PLACE AND RECOGNITION OF PRIOR LEARNING

It is assumed that a learner attempting this unit standard will show competence against the following unit standards or equivalent:

- NQF 3: Monitor pests, diseases and weeds on crops.
- NQF 2: Apply crop protection and animal health products effectively and responsibly.

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.

UNIT STANDARD OUTCOME HEADER

N/A

Specific Outcomes and Assessment Criteria:

SPECIFIC OUTCOME 1
Demonstrate a basic understanding of the principles of integrated pest management.

OUTCOME RANGE
Principles of integrated pest management include but are not limited to the regular monitoring or scouting for pests, diseases and weeds.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
The fact that integrated pest management is the integration of a number of different methods of pest control is explained.

ASSESSMENT CRITERION 2
The importance of monitoring at regular intervals is discussed.

ASSESSMENT CRITERION 3
The influence of the ratios between pests and predators on the decision on which control method to use is described.
ASSESSMENT CRITERION 4
The importance of replacing the pheromones, clearing the traps regularly and the collecting and assessing of information is explained.

ASSESSMENT CRITERION 5
The importance of recording the data correctly is explained.

ASSESSMENT CRITERION 6
Data is recorded by applying the basic principles.

SPECIFIC OUTCOME 2
Identify and differentiate between economically damageable pests, sporadic pests, diseases and symptoms using guides or resource material.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
Pests and beneficials on specific crops (all crops) are recognized, identified, counted and recorded and the impact or findings is assessed.

ASSESSMENT CRITERION 2
The damage and the cause of the damage is observed, categorically explained and identified.

ASSESSMENT CRITERION 3
Access to guides/publications and other resources and the use thereof is demonstrated.

ASSESSMENT CRITERION 4
Selection of method of identification is motivated.

ASSESSMENT CRITERION RANGE
Method of identification includes but is not limited to macroscopic and microscopic, and chemical.

ASSESSMENT CRITERION 5
Symptoms are observed and identified.

ASSESSMENT CRITERION 6
Scouting activities are performed regularly and thoroughly.

ASSESSMENT CRITERION 7
Weather patterns are observed and the effect thereof interpreted.

SPECIFIC OUTCOME 3
Understand the different types of control measures that can be applied in integrated pest management programme for pests, diseases and weeds.

OUTCOME RANGE
Control measures include but are not limited to chemical control, biological control, mechanical control etc.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
The different control measures that can be applied within an integrated management is explained.
**ASSESSMENT CRITERION 2**  
The concept of biological control is explained.

**ASSESSMENT CRITERION 3**  
The concept of cultural control is explained.

**ASSESSMENT CRITERION 4**  
The concept of mating disruption its use is described.

**ASSESSMENT CRITERION 5**  
The sterile insect technique its application is explained.

**ASSESSMENT CRITERION 6**  
Other methods that can be integrated into the control management programme is explained.

**ASSESSMENT CRITERION 7**  
The application of some of these concepts in disease and weed control is explained.

**ASSESSMENT CRITERION 8**  
The most appropriate control measures, taking onto consideration integrated pest management and the environmental impact is selected.

**ASSESSMENT CRITERION 9**  
Access to guides/publications and the use thereof is demonstrated.

**ASSESSMENT CRITERION 10**  
Environmental considerations that should be considered are explained.

**ASSESSMENT CRITERION 11**  
Resistance and mode of action re rotation is determined.

**ASSESSMENT CRITERION 12**  
Institutes to contact for advice are identified.

**ASSESSMENT CRITERION 13**  
Legal and market requirements are adhered to.

**SPECIFIC OUTCOME 4**  
Assist in developing a plan to assist the decision making process on the type of control to apply.

**OUTCOME RANGE**  
Decision-making includes but is not limited to, assisting with deciding whether a problem exists or what type of control to apply.

**ASSESSMENT CRITERIA**

**ASSESSMENT CRITERION 1**  
Monitoring data is collected and used.

**ASSESSMENT CRITERION 2**  
Data is incorporated into a management plan.
ASSESSMENT CRITERION 3
The process followed to assist in the decision making process is described.

ASSESSMENT CRITERION 4
The type of control is decided on, selected and implemented.

ASSESSMENT CRITERION 5
Application instruction per etiquette is followed.

ASSESSMENT CRITERION 6
Weather, growth stage and type of product are considered.

ASSESSMENT CRITERION 7
Type of production system is considered.

ASSESSMENT CRITERION 8
Appropriate application method is decided on.

ASSESSMENT CRITERION RANGE
Appropriate application includes but is not limited to hand, mechanical, aerial, fogging.

ASSESSMENT CRITERION 9
Safety measures are selected and managed.

ASSESSMENT CRITERION 10
Calibration and mechanical integrity of the equipment is determined.

ASSESSMENT CRITERION 11
Quality and availability of water is according to requirements.

SPECIFIC OUTCOME 5
Execute post-application monitoring.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
Efficacy of product is determined.

ASSESSMENT CRITERION 2
Follow-up generation is identified.

ASSESSMENT CRITERION 3
Side effects and/or damage are determined.

ASSESSMENT CRITERION 4
Equipment is cleaned and serviced.

SPECIFIC OUTCOME 6
Apply environmental and community considerations.
ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
Poisoning of wildlife and beneficials is avoided.

ASSESSMENT CRITERION 2
Soil and water contamination is avoided.

ASSESSMENT CRITERION 3
Drift onto non-targeted area is avoided.

ASSESSMENT CRITERION 4
Empty containers are appropriately disposed of.

ASSESSMENT CRITERION 5
Rinse water is properly managed.

ASSESSMENT CRITERION 6
Aerial application warnings are performed.

SPECIFIC OUTCOME 7
Oversee the management of an agrochemical storage facility effectively and responsibly.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1
The storage facility adheres to minimum requirements.

ASSESSMENT CRITERION RANGE
Minimum requirements include but are not limited to safety signs, equipment, safety equipment, protective gear, drainage, ventilation and lighting.

ASSESSMENT CRITERION 2
Products are categorised and segregated.

ASSESSMENT CRITERION 3
Record of incoming and outgoing products is current and complete.

ASSESSMENT CRITERION 4
Proper stacking methods are applied.

ASSESSMENT CRITERION 5
Emergency and safety plan is in place.

ASSESSMENT CRITERION 6
Access control and security is according to requirements.

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

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

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

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

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

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

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

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

**UNIT STANDARD ESSENTIAL EMBEDDED KNOWLEDGE**

The person is able to demonstrate a basic knowledge of:

- Life cycle of an insect.
- Natural enemies.
- Ways of spreading.
- Contamination.
- Implication of contamination on the quality and marketability of the product.
- Importance of hygiene.
- Scouting procedures.
- Record keeping.
- Hygiene.
- Spreading of pests and diseases.
- Pest levels that cause economic loss.
- Safety rules and principles
- Descriptions of pests and damage.
- Sources of information.
- Procedures.
- Interpretation of pictograms, colour coding and symbols.
- Legal implications of misuse / abuse i.e. off-label use.
- Potential hazards associated with agrochemicals.
- Cleaning and maintenance of equipment.
- General symptoms of poisoning.
- Impact of product on the environment, humans and other organisms.
- Basic storage principles and requirements.
- Principles and methods of mixing.
• Empty container and waste disposal.
• Emergency procedures.
• Legislation and Codes of Practice.
• First aid.
• Hygiene.
• Contamination.
• Product spectrum.
• Principles of product categorisation and segregations.
• Resistance and management thereof.
• Information resources.
• Terminology.
• Principles of:
  - Weed control.
  - Plant disease control.
  - Insect control.
  - Nematode control.
  - Agrochemical application.
• Effective use of standard reference materials and other resources.
• Reading and understanding labels.
• Calibration.
• Principles and procedures of responsible application.
• Correct use of equipment.
• Health and safety.
• Principles of integrated pest management.
• Environmental knowledge.

**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 ORGANIZING**

Self-organisation and management relates to all specific outcomes.

**UNIT STANDARD CCFO COLLECTING**

Information evaluation relates to all specific outcomes.

**UNIT STANDARD CCFO COMMUNICATING**

Communication relates to all specific outcomes.

**UNIT STANDARD ASSESSOR CRITERIA**

N/A

**UNIT STANDARD NOTES**

N/A