

LEARNER GUIDE

Crop Protection – Application

Level 2

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Table of Contents

Directions	5
Introduction	6
1. Purpose.....	6
2. Learning Assumed to Be in Place.....	6
Introduction to Citrus Production.....	7
1. Introduction.....	7
2. Background	7
3. Citrus Planting	7
4. Lifespan	8
5. Citrus Plant Phenology.....	8
6. Citrus Learning Material.....	9
Introduction to Crop Protection.....	11
Chapter 1.....	12
1. Introduction.....	12
2. Plant Protection Products.....	12
2.1. Plant Protection Product Registration.....	13
2.2. Plant Protection Product Identification.....	13
2.3. Plant Protection Product Availability.....	14
3. Application Methods	14
3.1. Foliar Spray Application	14
3.1.1. Outside Cover Spray.....	14
3.1.2. Medium Cover Spray	15
3.1.3. Full Cover Spray.....	15
3.1.4. Bait Sprays	15
3.2. Trunk Application	15
3.3. Soil Drench.....	15
4. Application Equipment.....	15
4.1. Foliar Applications	16
4.1.1. Knapsacks	16
4.1.2. Handguns.....	16
4.1.3. Mistblowers	16
4.1.4. Crop Sprayer Aircraft.....	17
4.2. Trunk Applications.....	17
4.3. Soil Drench.....	17
5. Health and Safety	17
5.1. Protective Gear and Safety Equipment.....	17
5.2. Contact Details of Emergency Services	18
6. Pre-Application Checklist.....	19
Chapter 2.....	21
1. Introduction.....	21
2. Safe Handling of Chemicals.....	21
2.1. Colour Codes	21
2.2. Symbols	22
2.3. Pictograms	22
3. Mixing Requirements	23
3.1. Protective Clothing	23
3.2. Measuring Equipment.....	23
3.3. Mixing Equipment	23

4. Calculating the Amount of Chemicals Required	24
5. Mixing Procedure	25
6. Storage of Plant Protection Products	26
7. Disposal of Empty Containers.....	27
8. General Sanitation.....	27
Chapter 3.....	29
1. Introduction.....	29
2. Influence of Climatic Conditions	29
2.1. Wind	29
2.2. Rain and Dew	29
2.3. Temperature and Humidity	29
3. Calibration of Equipment	29
3.1. Mistblower Calibration	30
3.2. Calibration of Other Spray Equipment.....	33
4. Protective Gear	33
5. Application of Plant Protection Products.....	33
5.1. Foliar Spray Applications.....	33
5.1.1. Mistblowers	33
5.1.2. Handguns and Knapsacks	34
5.2. Soil Drench.....	34
5.3. Trunk Applications.....	34
Chapter 4.....	35
1. Introduction.....	35
2. Protective Gear and Clothing.....	35
2.1. Maintenance of Protective Gear and Clothing	35
2.2. Using Protective Gear and Clothing	35
3. Safety Regulations	35
4. Soil and Water Contamination	36
5. Designated Areas	36
Chapter 5.....	38
1. Introduction.....	38
2. Post-Application Procedures	38
3. Cleaning of Equipment	38
3.1. Spray Machines.....	38
3.2. Protective Clothing and Equipment.....	39
3.3. Other Equipment.....	39
4. Personal Hygiene	39
Chapter 6.....	40
1. Monitoring the Application Process	40
2. Reporting Problems and Unusual Occurrences	40
Chapter 7.....	42
1. Introduction.....	42
2. Procedures in Case of Poisoning.....	42
3. Procedures for Spills and Leakages.....	43
3.1. Equipment.....	43
3.2. Clean-Up Procedures	43
4. Incident Reports	44
Bibliography	46

Directions

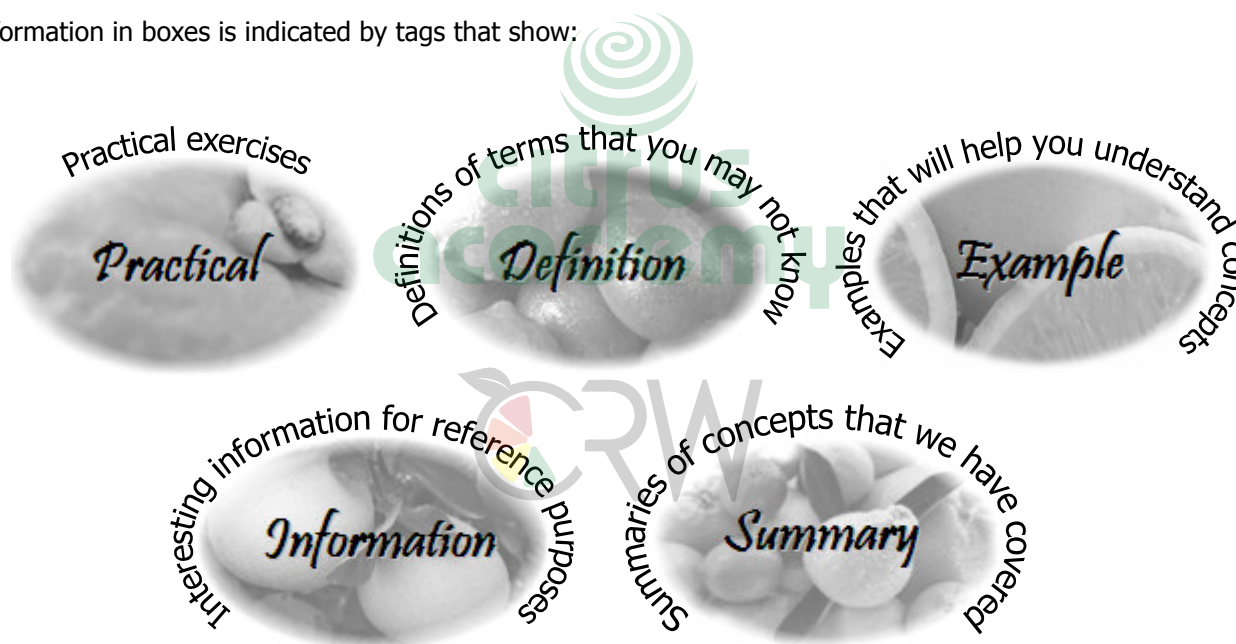
This learning material has been developed to assist the learner wishing to complete this unit standard. The guide contains all necessary learning to ensure that the learner will attain the competencies required by the unit standard.

The learner guide is accompanied by a Learner Assessment Guide. Please ensure that you have access to this guide as well.

The learner guide was designed to be used by a learner during the presentation of a skills program based on the unit standard, and to be kept afterwards by the learner for reference purposes. The learner assessment guide was designed to be completed during and after the presentation of the skills program, and forms part of the assessment process.

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

Information in boxes is indicated by tags that show:



Introduction

1. Purpose

A person achieving this unit standard will be able to apply agrochemical products in a safe, effective and responsible manner with consideration to the environment. Furthermore, the person will be able to deal with emergencies related to the use of agrochemicals.

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 agro-chemicals in primary agriculture.

Learners will be able to participate in, undertake and plan farming practices with consideration for their environment. This unit standard will instil a culture of maintenance and care for both the environment and farming infrastructure and operations.

2. Learning Assumed to Be in Place

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

<i>NQF Level</i>	<i>Unit Standard Number</i>	<i>Unit Standard Description</i>
1 (ABET 4)	Literacy and Numeracy	
1	116204	Recognise pests, diseases and weeds on crops
2 (E)	116065	Store and control agrochemical products effectively and responsibly



Introduction to Citrus Production

1. Introduction

This learning material has been developed in the context of citrus production, which means that the skills area is dealt with in terms of and as applied to citrus production. To help the learner place the material in the right context, it is necessary for the learner to understand the background to citrus production, and the manner in which a citrus plant produces fruit.

2. Background

Citrus originates from the subtropical regions of south-east Asia. In the wild, citrus trees in these regions produce fruit all year round, and the fruit are small, poorly coloured and blemished. In the absence of effective production practices, citrus trees do not produce fruit suitable for the market.

Citrus production is largely concerned with management of the practices and processes that manipulate the tree to produce high yields of marketable fruit. Production management, together with the selection of superior varieties and plant improvement, can be seen as an on-going effort to influence the natural tendencies of the tree.

Consumers want the fruit of their choice to be available at all times. Fruit should look good, be unblemished, well-coloured (superior exterior quality), taste good (high interior quality) and be of the right size. At the same time, the citrus producer wants orchards that will provide high yields over an orchard lifespan of 18 to 30 years. On top of all this, the citrus orchard must be managed in such a way that production practices have the least possible impact on the natural environment. Commercial citrus production management is about achieving these objectives efficiently and cost effectively.

3. Citrus Planting

Citrus trees are planted in rows in orchards. The planting distance, also called tree spacing or espacement, between rows and between trees within rows, is determined by numerous factors including climate, variety, and soil type. A typical tree spacing is 6m between rows by 3m between trees, meaning that 555 trees per hectare (ha) are planted (1ha = 10,000 m²).

Once planted, trees take three or more years before bearing fruit that can be marketed. Thereafter, per tree and per hectare yields steadily increase to 40 to 70 t/ha – depending on cultivar and variety – after a further 4 to 7 years. If the trees are well looked after, this level of production will remain fairly constant until trees start to decline naturally.



Yield

Yield refers to the amount of fruit produced, and can be expressed in terms of:

Tree yield	kg per tree	kg/tree
Orchard yield	tons per hectare	t/ha
Export yield	15kg carton equivalents per hectare (10kg carton equivalents for soft citrus)	cartons/ha

4. Lifespan

The average economic lifespan of a commercial citrus orchard varies between 18 and 30 years, and can be as high as 30 to 60 years in hot, dry areas. Citrus is therefore viewed as a long-term crop. For citrus production to be profitable, the orchard must produce high yields of quality fruit every year, and do this consistently over a long period of time.

In citrus production the challenge is therefore to make production decisions and take actions to ensure high annual production of marketable fruit, while ensuring that these decisions and actions contribute to the long-term sustainability of the orchard.

5. Citrus Plant Phenology

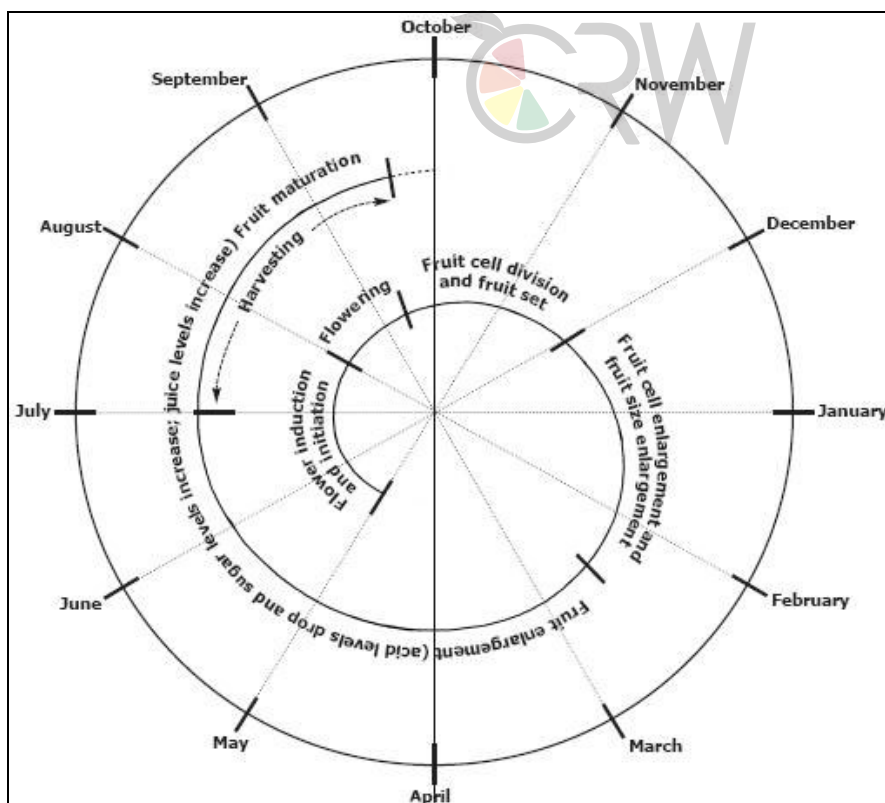


Phenology

Phenology refers to regularly recurring biological phenomena and the environmental and climatic factors that influence them. In citrus, phenology specifically refers to the annual cycle of the citrus tree.

Understanding the phenology of the citrus tree is essential to understanding the reasoning behind many of the practices and actions employed in citrus production. For example, the timing of fertiliser applications is linked to the phenology of the tree, with most fertilisers being applied at appropriate times to optimise flowering, fruiting, fruit development and fruit maturation.

The figure and table below set out the annual cycle of the citrus tree with regard to fruit production. Please note that this figure and table reflect the approximate flower and fruit development cycle of a valencia orange tree, and that the phenology of various cultivars differ.



<i>Stage</i>	<i>Description</i>	<i>Time Period</i>
Flower Induction and Initiation	Flower initiation is the induction and differentiation of vegetative buds into flower buds at a cellular level, and cannot be seen with the naked eye.	May to July
Flowering	Flowering or "bloom" is when blossoms appear on the tree.	August to Mid-September
Cell Division and Fruit Set	Cell division is the period when cells making up the fruit increase in number. Fruit set is the period from flowering or "bloom" until the end of fruitlet drop, after which the final fruit load is determined.	Mid-September to November
Cell Enlargement and Fruit Growth	Cell enlargement is the period during which cells making up the fruit increase in size. Fruit growth is the period during which the fruit grows and develops.	December to Mid-February
Fruit Maturation and further Fruit Growth	During this period fruit enlarges further and matures internally, meaning that the flavour, sugars and acids reach their optimum levels.	Mid-February to September
Harvest		July to September

It is important to note the term **citrus season** refers to the period from when flower initiation begins to the harvest. The season is generally from the beginning of August of one year to the end of July of the next year, although harvesting may extend to September and October for late cultivars.

6. Citrus Learning Material

The following citrus specific learning material is available from the Citrus Academy:

<i>Skills Area</i>	<i>Description</i>
Enterprise Selection, Planning and Establishment	Concerns itself with identifying the various components of an agricultural enterprise, and with the selection and planning processes for a new enterprise, and looks at the physical layout of a farm, with specific reference to infrastructure, orchard layout, etc.
Propagation	Concerns the various methods and requirements for the multiplication of plant material of specific varieties that possess desired qualities.
Crop Establishment	Concerns the establishment of a new citrus orchard, in terms of the physical planting of trees and the care for young trees.
Plant Structures and Functions	Considers the structure and function of various plant parts and the manner in which nutrients, water, air and sunlight is taken up and processed.
Plant Nutrition and Soil Management	Concerns itself with plant nutrients, in terms of the requirements of the citrus plant and the supplementation of nutrient elements through fertilisation, with specific reference to the timing and manner of application.
Water Quality	Considers the various factors that influence water quality and manners in which water quality can be measured and controlled. Considers furthermore the effect of water quality on tree and fruit growth and development, in combination with effective irrigation, fertilisation and pest control.

<i>Skills Area</i>	<i>Description</i>
Plant Manipulation	Concerns various types of physical and chemical plant manipulation, with specific reference to pruning, girdling and the application of plant growth hormones, and tools and equipment used for this purpose.
Irrigation	Looks at the technical aspects of orchard irrigation, with reference to the types of irrigation systems, the installation of new irrigation systems, and the repair and maintenance of an irrigation system. Also concerns irrigation scheduling, and measures to ensure effective irrigation.
Pests, Diseases and Weeds	Concerns the identification of pests, diseases and weeds that threaten citrus production. Also considers various methods of effective control, and the planning required for this purpose.
Crop Protection	Looks at the practical application of crop protection agents through various methods, with specific reference to tools and equipment used, and health and safety requirements.
Food Safety	Concerns the requirements in terms of health and safety, and environmental control for ensuring food safety and hygiene.
Harvesting	Looks at the process of determining fruit maturity through maturity indexing, the harvesting of fruit, and the tools and equipment used for this purpose.
Conservation	Considers the impact of farming practices on the environment, with reference to the measures required to minimise this impact and protect the environment.
Marketing	Concerns the factors influencing citrus marketing, and the development of an effective marketing plan.
Production Management	Concerns the actions and processes involved in effective production management, with specific reference to the coordination of the various production tasks and processes and the creation of a strategic plan for the enterprise.
Industry Overview	An overview of the citrus industry and the various institutions involved.
Packhouse Practices	Concerns the specific principles and practices that are employed in Packhouse environments, and specifically: • Receiving • Sorting • Grading • Fruit Sizing • Cold Chain Management • Packing • Palletising • Storage • Dispatch • Fruit Markets • Fruit Quality • Fruit Treatment • Health and Safety • Hygiene • Product Characteristics

Introduction to Crop Protection

Protecting citrus trees and a citrus crop against pests and diseases is one of the most important functions in citrus management. Without effective pest and disease control, the citrus production unit cannot be financially successful.

Citrus attracts a great variety of pests and diseases that cause external and internal damage to the fruit, and damage to the tree itself. In addition, when a new citrus orchard is planted, it provides a new and rich food-source for many insects in the immediate vicinity.

Control measures for certain common pests are implemented as a matter of routine, even if those pests have not been specifically identified in the orchard. An example of such a pest is thrips, and an example of a disease is blackspot. These control measures are incorporated into a **crop protection program** that is strictly followed during the season.

The citrus farmer must, however, be constantly vigilant for attacks from other pests and diseases, or for outbreaks that were not sufficiently controlled by the crop protection program. Scouting is essential in this regard, and the citrus farmer and his staff require the necessary skills and knowledge for identifying pests and diseases (see unit standard 116204) that will allow them to react with the appropriate control measures.

Identifying and controlling pests and diseases form the subject of other learning material in this series. **Unit standard 116125: Crop Protection – Application** concerns itself with the application of crop protection and therefore the implementation of the crop protection program. It is assumed that the learner already has a basic understanding of the identification of pests and diseases and of the control measures used.

Although some pests and diseases in the citrus orchard are controlled manually or biologically, the greater majority are controlled through the use of chemicals. Manual control is also referred to as cultural control. The crop protection application methods covered in this unit standard refer to the chemical control of pests and diseases.

The term Crop Protection Manager is used in this learning material when referring to the person responsible for the implementation of the crop protection program. In practice, this function is often fulfilled by the farmer or the general manager of the farming operation.

Chapter 1

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

Implement a pre-application plan

1. Introduction

Proper planning for protecting a citrus crop from pests and diseases is critically important. Poor planning could result in financial losses due to a reduced crop or a poor quality crop, and possible damage to the health of the trees. Time and money will also be lost if incorrect or unnecessary applications are made.

Planning entails two steps: Firstly, a **crop protection program** is compiled to control the pests and diseases commonly found in the area where the farm is located. The crop protection manager decides which chemicals to use, in what concentration to apply the chemicals, and the schedule of application. This information is incorporated in a crop protection program, which is normally compiled before the start of the season at blossom time, and must be followed strictly as the season progresses. Minor changes may be made during the season if circumstances in the field change.

The second step in the planning is the **pre-application plan**. Pre-application planning is done before each application stipulated on the crop protection program, and may be best accomplished by using a simple checklist. We will look at the checklist at the end of this chapter, after considering the various components of this planning process.

To properly plan for the application of plant protection products, a thorough understanding of the following components is required:

- Plant protection products
- Application methods
- Application equipment
- Health and safety

2. Plant Protection Products

The first step in the pre-application planning is to identify the product indicated in the crop protection program. Plant protection products are generally classified as insecticides, fungicides or herbicides.



Insecticides

Insecticides are plant protection products (PPPs) that are used to control insects.

Fungicides

Fungicides are plant protection products (PPPs) that are used to control fungi.

Herbicides

Herbicides are plant protection products (PPPs) that are used to control weeds.

2.1. Plant Protection Product Registration

Only chemicals that have been registered with the Department of Agriculture, Forestry and Fisheries in accordance with Act 36 of 1947 are permitted for use in South Africa. These products are listed in the following Government publications, which are updated from time to time:

- Guide for the Control of Plant Pests
- Guide for the Control of Plant Diseases

In these publications, there is a section covering citrus pests and diseases where remedies for specific problems are listed. If these books are not available, the crop protection manager may need to consult a representative of one of the agrochemical companies.

2.2. Plant Protection Product Identification

The first step in identifying a product is to consult the chemical label. All chemicals must, by law, have a label on the container when it is supplied to the end-user.

The following information appears on the product label:

- Full **instructions** on how to use the chemical is indicated, together with detailed information on the uses for which the product is registered. The instructions must be read carefully and adhered to strictly. This will ensure that the best results are attained, that the safety of the user and others is not at risk, and that the environment is not unduly harmed. It is an offence to use a chemical in a manner for which it was not registered.
- A **physical description** of the product is supplied, including its colour and whether it is in fluid, powder or granular form. The crop protection manager should inspect the chemical in the container to ensure that it answers to this physical description. If not and the container has never been opened before, it should be brought immediately to the attention of the manufacturer or supplier. If the container had been previously opened, the container and its contents should be discarded in the prescribed manner.
- The **chemical composition** of the product is indicated on the label.
- The **toxicity** of the product is indicated, along with instructions for its safe handling.
- The **pre-harvest interval (PHI)** of the product is indicated. The PHI, also known as the Withholding Period, refers to the period after application of a chemical treatment during which time the fruit may not be harvested. PHIs vary considerably from chemical to chemical and need to be checked by the crop protection manager when he compiles the crop protection program. It must also be checked as part of the pre-application planning.
- The **product expiry date** is stated, being the date on or before which the chemical should be used. Chemicals should be used before the expiry date to make sure that the chemical is still effective.

Please Note:

All chemicals leave a residue on the fruit, and there are very specific regulations regarding the chemical residues levels that are allowed, especially if they are exported. Minimum residue levels (MRLs) are prescribed for all plant protection products registered with the Department of Agriculture, Forestry and Fisheries. The PHI indicates the period of time during which the chemical residue will be too high and outside the regulatory limits. During this time, the fruit must not be



harvested. It is also important to note that the PHI that appears on the label is only for the local national requirement. If the fruit being sprayed is to be exported, the crop protection manager needs to be aware of restrictions in that particular country.

2.3. Plant Protection Product Availability

The crop protection program indicates the concentration at which the product must be used, and the amount required per tree or hectare. It may also indicate the total quantity of chemical required for the application, but if not, the crop protection manager can calculate this by using the information provided.

The crop protection manager must ensure that a sufficient quantity of the chemical is available before application commences. In this regard, he needs to consult with the person in charge of procurement (buying) and the inventory manager.



Complete activity 1 in the **Learner Workbook**.

3. Application Methods

Plant protection products can be applied in various ways. The manner of application should be stated on the crop protection program. Application methods include:

- Foliar spray application
- Trunk application
- Soil drench

There are many variations of application methods and the decision on which method to use depends on the specific requirements and purpose.

3.1. Foliar Spray Application

The most common method of applying insecticides and fungicides to trees in orchard farming is by way of applying a foliar spray. This means that the spray material is applied to the leaves of the trees. There are three main types of foliar spray applications, being:

- Outside cover spray
- Medium cover spray
- Full cover spray
- Bait spray

3.1.1. Outside Cover Spray

As the name suggests, these sprays are applied at low volume and with a light covering of the tree canopy. Droplet size is small, and the tree is sprayed with a fine mist of spray material that only covers the outer canopy of the tree.

Outside cover sprays are often used for the application of chemical bait sprays, in which case they can also be applied by aerial spraying.

The volume of spray material applied per tree with an outside cover spray varies depending on tree size and shape, but ranges from a half litre to ten litres per tree.

3.1.2. Medium Cover Spray

Medium cover sprays are the most commonly applied sprays.

Medium cover sprays wet the foliage of the tree to the point of run-off, meaning that all leaves of the tree are wet but very little spray material drops off the leaves. The tree canopy is not necessarily penetrated, but some of the branches may be slightly wet, especially the green branches that bear the leaves.

The volume of spray material applied per tree during a medium cover spray varies depending on tree size and shape, but ranges from 10 to 20 litres per tree.

3.1.3. Full Cover Spray

Full cover sprays are designed to thoroughly wet the tree canopy and to penetrate the inside of the canopy, drenching the branches and framework of the tree as well.

The volume of spray material applied per tree during a full cover spray varies depending on the tree size and shape, but ranges from 20 to 50 litres per tree.

3.1.4. Bait Sprays

Bait sprays are commonly used for the control of fruit fly. These applications require a spray with coarse or large droplet size. Sprays are often applied to only a third of the orchard, depending on the intensity of the pest threat.

The volume of spray material applied per tree varies from 100ml to 800ml per tree, depending on tree size.

3.2. Trunk Application

Some chemicals can be applied directly to the trunk of the citrus tree. These chemicals are systemic, meaning that they are absorbed through the bark and translocated within the tree to the area where they are required.

3.3. Soil Drench

This method involves diluting the chemical in water and then pouring it onto the soil around the trunk of the tree where it is absorbed by the roots and translocated within the tree. These chemicals are also systemic. Certain chemicals can also be applied through a drip irrigation system, which also allows their uptake by the roots.

4. Application Equipment

Once the method of application has been determined, the equipment required for the application is identified and checked. Application equipment and measuring equipment is required during most applications. The crop protection manager determines the equipment requirements by taking into account:

- The area or number of trees to which the chemical must be applied
- The time period in which the application must be completed
- The number of farm workers available

Once the equipment requirements have been determined, the crop protection manager must consult with the person responsible for mechanical equipment to ensure that sufficient equipment, such as tractors and spray machines, will be available, and with the person responsible for the stores to ensure that sufficient measuring equipment is available.

The crop protection manager must also ensure that all equipment is in a good working order, as breakdowns during application can cause delays that may result in ineffective pest and disease control. Spray machines and tractors are normally serviced before the start of a season, and must be checked regularly. The crop protection manager must consult with the person responsible for mechanical maintenance in this regard. The application equipment that is required is specific to the application method.

4.1. Foliar Applications

Foliar applications can be applied in a number of ways, being:

- Knapsacks
- Handguns
- Mistblowers
- Crop sprayer aircraft

4.1.1. Knapsacks

Newly planted trees up to the age of one year may be sprayed with a knapsack as they require very little spray volume.

Care must, however, be taken that knapsacks used to spray trees is not used for herbicide application due to possible contamination and damage to trees.

4.1.2. Handguns

Trees between the age of two and four years old, depending on variety planted and the area, are too big to be sprayed with knapsacks, and are often sprayed with handguns. If mistblowers are not available, handguns can also be used for trees of any age

The operator holds a spray gun which is attached to a spray cart with a pump. With handguns, as opposed to knapsacks, a much higher volume of spray material can be applied at speed with little wastage.

4.1.3. Mistblowers

The most popular automatic spray machines are called mistblowers. These machines work on the principle of air displacement, in which air within the tree is “blown out” by the high speed fan on the spray machine. This displaced air is replaced with air laden with spray material that wets the tree.

There are many different types of mistblowers. They can be broadly classified into low, medium and high profile machines. The choice of machine depends on the type of spray required. For example, low- and medium profile machines would not be suitable to apply a full cover spray to large mature trees.

- **Low Profile Machines** are double-sided mistblowers without any tower or deflector.
- **Medium Profile Machines** are raised, double-sided machines with or without a single-sided deflector or a raised machine with a short tower.
- **High Profile Machines** are single or double-sided mistblowers that have tall towers and cover the tree canopy from top to bottom, depending on tree size.

Tractors are used to pull spray machines. Power from the tractor is transferred to the spray machine for operation the pump, fan and spray tank agitator. This transfer takes place via the power take-off (PTO) of the tractor.

The PTO is a short, splined shaft at the back of the tractor. A PTO shaft is connected to the PTO of the tractor and to the spray machine, through which power is transferred enabling the spray machine to operate.

Other machines that require power to operate, such as grass slashers, also make use of power through the tractor PTO.



Figure 1.1: PTO Shaft

Photograph from the Wikipedia Encyclopaedia, Wikipedia Foundation Inc

4.1.4. Crop Sprayer Aircraft

Where large areas have to be covered in a short period of time, aerial applications, using a crop sprayer aircraft, is often used. Aerial applications can, however, only deliver light cover sprays, and are therefore generally only used for bait sprays.

4.2. Trunk Applications

The amount of chemical applied in a trunk application must be measured very accurately. Specialised equipment, which is calibrated very accurately, is used for this purpose. The most common applicator is called a Calibra.

Some farmers use a paint brush for trunk applications. The quantity of product required is calculated according to the diameter of the tree trunk. There are tables available that indicate how much chemical to apply to trees of different sizes.

4.3. Soil Drench

The chemical solution is applied by using measuring cups or jugs that ensure with relative accuracy that the correct quantity is applied.

5. Health and Safety

All chemicals should be considered hazardous until indicated otherwise. Plant protection products can be hazardous to humans, animals and to the environment. When PPPs are being applied, health and safety regulations must be strictly observed.

In terms of planning for PPP applications, the requirements for protective gear and safety equipment for the particular chemical must be known to all who will take part in the application. The contact numbers for emergency services must be displayed prominently and in a place where all workers have access to the information.

5.1. Protective Gear and Safety Equipment

It is of utmost importance that the user is adequately protected when using plant protection products. Pictograms are displayed on product labels advising on the protective gear and safety equipment that are necessary when handling a particular chemical.

 Wear gloves	 Wear protection over nose and mouth	 Wear eye protection	 Wear respirator
 Wear boots	 Wear overalls	 Wear apron	 Wash after use

Table 1.1: Advice Pictograms

The biggest risk to the person that handles and applies PPPs is poisoning. The chemical can enter a person's body in the following three manners:

- By way of the mouth (orally)
- Through contact with the skin (dermal contact)
- By breathing (inhalation)

The most common manner of poisoning is through dermal contact. The following protective clothing must be available to those who use PPPs to eliminate the risk of poisoning.

- **Cotton Overalls** – Cotton, in comparison with lightweight synthetic alternatives, has shown to be superior in durability, protectiveness and comfort. A two-piece overall is preferable.
- **Apron** – An apron is used when mixing chemicals for added protection in case of spillage.
- **Rain Coat and Hat** – Rain gear is used during foliar spray applications with mistblowers to protect the tractor driver against skin contact.
- **Goggles** – Eye protection when working with chemicals is essential.
- **Unlined Rubber Gloves** – Wearing rubber gloves decreases the chance of skin contact.
- **Rubber Boots** – Rubber boots or gumboots are worn to further decrease the chance of dermal exposure.
- **Facemask** – A facemask is used if required on the product label to protect against inhalation.
- **Respirator** – A respirator protects the user more effectively against inhalation, as it provides a separate supply of oxygen. Respirators are used if specified on the product label.

5.2. Contact Details of Emergency Services

Contact details of emergency services must be readily available to all persons who use PPPs. Display emergency telephone numbers close to the telephone so that they are easily noticeable and easy to read. The following is a list of helpful numbers that should be available:

- **Bateleur** (a call centre that provides emergency advice) – 083-1233-911
- **Poisons Information Centre (University of the Free State)** – (051) 444-2134
- **Poisons Information Centre (Red Cross WMC Hospital)** – (021) 689-5227
- **Tygerberg Pharmaceutical and Toxicology Consultation Centre** – (021) 931-6129
- Local doctor
- Local hospital
- Ambulance service

6. Pre-Application Checklist

A pre-application checklist can now be compiled from the above information. The format of the pre-application checklist is not standard, and different farms may use different methods or formats for this purpose.

It is, however, essential that this type of information is recorded in a format that is easy to use for the persons responsible for the application. The checklist must contain all the necessary information to avoid confusion and the need to consult various records.

A pre-application is prepared for every application that has to be done according to the crop protection program. The pre-application checklists can then be used during the application to verify that the application is done correctly.

After the application has been completed, the pre-application checklist is filed with the application reports as part of the records kept for the farm. Below is an example of a pre-application checklist.

Pre-Application Checklist					
Crop Protection Program Instructions:					
Orchard Number			Size and No of Trees		
Application Date	From:			To:	
Target Pest(s)/Disease(s)					
Chemicals					
PHIs					
Chemical Concentration	<i>Chemical</i>	<i>Concentration</i>	<i>Per</i>		
Application Method	Trunk Application		Soil Drench	Spray	
Spray Type	Light Cover		Medium Cover	Full Cover	
Other Instructions					
Chemical Requirements:					
<i>Chemical</i>	<i>Quantity Required</i>	<i>Unit</i>	<i>Units Required</i>	<i>Check</i>	
				<i>Available</i>	<i>Expiry</i>
Equipment Requirements:					
<i>Description</i>		<i>Quantity</i>	<i>Check</i>		
			<i>Available</i>	<i>Condition</i>	

Worker Requirements:			
<i>Description</i>	<i>Number</i>	<i>From</i>	<i>To</i>
Other Requirements:			
Notes:			
Signed:		Date:	



Chapter 1

- The two steps in planning for the protection of citrus crops against pests and diseases are the compilation of a crop protection program and pre-application planning.
- The most important components of pre-application planning are the plant protection products, application methods, application equipment and health and safety requirements.
- Plant protection products are classified as pesticides, fungicides and herbicides.
- Plant protection products must be registered with the Department of Agriculture, Forestry and Fisheries for specific uses, and may only be used for the purpose for which they are registered.
- The information displayed on the product label is full usage instructions, a physical description, the chemical composition, the toxicity, the pre-harvest interval and the expiry date of the product.
- The crop protection manager must ensure that the required products are available in sufficient quantities.
- Application methods that are mostly used are foliar sprays, trunk applications and soil drenches.
- The four main types of foliar applications are outside cover sprays, medium cover sprays, full cover sprays, and bait sprays.
- The equipment requirements are calculated based on the area of application, the period available for the application and the number of workers available.
- Knapsacks, handguns, mistblowers (spray machines) and crop sprayer aircraft are commonly used for foliar applications, depending on the size of the trees and the spray requirements.
- Calibra applicators or paint brushes are mostly used for trunk applications.
- Measuring cups and jugs are used for soil drenches.
- The health and safety requirements include the use of protective gear and safety equipment and posting emergency contact details in an accessible place.
- The protective gear and safety equipment that are required is indicated on the label of each product with pictograms.
- The pre-application checklist must include all the information required to complete the application.



Complete activity 2 in the **Learner Workbook**.

Chapter 2

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

Mix correct pest or disease control products at correct dosage rates

1. Introduction

Plant protection products that are used in trunk applications and soil drenching methods are usually bought ready-for-use, and are therefore not referred to in this chapter. As for all PPPs it is, however, imperative to **READ THE LABEL** of these products before applying them.

Our primary concern in this chapter is plant protection products that are applied by the foliar spray application method, whether it is by knapsack, handguns or mistblowers. The chemical mixture is also referred to as spray material in this chapter, indicating its use in this method only.

Mixing chemicals for foliar applications correctly and accurately is essential. If too low a concentration of chemicals is used, the crop protection measures will not be effective. On the other hand, too high a concentration can result in overdosing and damage to trees, apart from the financial loss due to the waste of expensive chemicals.

Mixing chemicals does not only involve measuring correct quantities and combining the ingredients. The person responsible for the mixing must be aware of the nature of the chemicals being handled, the safety requirements for working with such chemicals, the appropriate equipment that is required, and the correct mixing procedure. **Remember that you are mixing chemicals, and mixing the wrong chemicals may result in combustion and serious injury. Always observe the safe handling procedures and manufacturer's instructions.**

Spray material is normally mixed immediately before application, and will generally not be stored in mixed form. It is therefore essential that the person responsible for mixing the chemicals has all the required chemicals, equipment and information to complete the task without delay.

2. Safe Handling of Chemicals

It is essential that the person responsible for mixing has a thorough understanding of the nature of the chemicals that will be handled, especially with regard to the toxicity of the chemicals, to ensure that the correct safety precautions are taken.

Colour codes, symbols and pictograms are used on the product labels of all chemicals to indicate their toxicity, and the manner in which they should be handled.

2.1. Colour Codes

Colour codes are used to indicate the hazard classification of the chemical. All agricultural chemicals are classified in terms of their toxicity. This information is displayed on the product label of the chemical and informs the user of the potential hazard of the chemical if not used in the correct manner.

<i>Group</i>	<i>Group Description</i>	<i>Hazard Statement</i>	<i>Colour Band</i>
Ia	Extremely Hazardous	Very Toxic	Red
Ib	Highly Hazardous	Toxic	

Group	Group Description	Hazard Statement	Colour Band
II	Moderately Hazardous	Harmful	Yellow
III	Slightly Hazardous	Caution	Blue
IV	Acute Hazard unlikely in normal use		Green

Table 2.1: Hazard Colour Codes

Table 2.1 indicates the terminology used in classifying chemicals according to their potential hazards. This means that in the case of Group Ia and Ib type chemicals, a very small quantity of the substance is a lethal dose and may cause death if ingested, while for Group IV type chemicals, a lethal dose will be much greater.

2.2. Symbols

Internationally recognised symbols are also used to indicate the toxicity of chemicals in group I and group II, as indicated in the table 2.2.

Group	Hazard Statement	Symbol Description	Symbol
Ia – Extremely Hazardous	Very Toxic	Skull and Crossbones	
Ib – Highly Hazardous	Toxic		
II – Moderately Hazardous	Harmful	St. Andrew's Cross	

Table 2.2: Hazard Symbols

2.3. Pictograms

Pictograms are used to indicate the storage requirements for the product, the type of product, the requirements for protective gear and clothing, and the danger that the product holds for animals.

Storage Pictograms			
			
Keep locked away and out of reach of children			
Activity Pictograms			
 Application	 Handling dry concentrate	 Handling liquid concentrate	
Advice Pictograms			
 Wear gloves	 Wear protection over nose and mouth	 Wear eye protection	 Wear respirator

 Wear boots	 Wear overalls	 Wear apron	 Wash after use
Warning Pictograms			
 Dangerous / harmful to livestock and poultry	 Dangerous / harmful to livestock	 Dangerous / harmful to poultry	 Dangerous / harmful to wildlife and birds
 Dangerous / harmful to wildlife	 Dangerous / harmful to birds	 Not for aerial application	 Dangerous / harmful to fish and water bodies

Table 2.3: Pictograms

3. Mixing Requirements

Apart from the chemicals themselves, the items that are required during the mixing process are:

- Protective clothing
- Measuring equipment
- Mixing equipment

Clean water and a bar of soap must also be readily available so that the person can immediately wash if the chemical comes into contact with skin, and so that the person can wash up after handling the chemicals.

3.1. Protective Clothing

The following protective clothing is always worn when handling and mixing chemicals:

- Rubber gloves
- Cotton overall
- Rubber boots (gumboots)
- Plastic apron
- Eye protection (goggles)

If indicated on the product label, a facemask or respirator may also be required.

3.2. Measuring Equipment

To measure the correct amount of a liquid chemical, a graduated measuring container is required, while a weighing scale is used to accurately measure wettable powders or granules.

Electronic scales generally allow for more accurate measurements, but hand-scales can also be used. It is however essential that scales are serviced and calibrated regularly. Scales must be zeroed carefully before the chemicals are weighed.

3.3. Mixing Equipment

Normally premixing is not required by the label and calibrated dosages of chemicals are added directly to the spray tank. If premixing of chemicals is required, a bucket large enough to contain

10ℓ of water is used to premix the chemicals. A mixing instrument, such as a stick, is used to ensure good mixing.

4. Calculating the Amount of Chemicals Required

Normal practice in the citrus industry is for recommendations for the concentration of crop protection chemicals to be made in **millilitres** (ml) or **grams** (g) per **100ℓ** of **clean water**. This is also the manner in which it is shown on the crop protection program.

The person responsible for mixing the spray material must have a thorough understanding of this notation. Below are a few examples of notations:

<i>Target Pest(s) / Disease(s)</i>	<i>Chemical</i>	<i>Notation</i>	<i>Explanation</i>
Red scale	Methomyl	100g / 100ℓ + Bladbuff @150ml/100ℓ	100g Methomyl plus 150ml of Bladbuff per 100ℓ clean water
Thrips, bollworm, aphids and mealybug	Tokuthion	50ml / 100ℓ	50ml Tokuthion per 100ℓ clean water
Thrips, blackspot	Agrimec	15ml / 100ℓ	15ml Agrimec plus 150g Dithane plus 300ml mineral oil per 100ℓ clean water

Table 2.4: Notation Samples

Buffering

Many PPPs are pH sensitive, meaning that their efficacy is affected by the pH of the water used in the spray solution or suspension. For example, borehole water often has a high pH (over pH 7) and if Cypermethrin is for example mixed with this high pH water, the chemical will be less effective as the pH increases. Ultimately, the chemical will not work at all.

To avoid this negative reaction buffering agents are used. These chemicals reduce the pH of the water. The degree of buffering depends on which product is used and on how much buffering solution is added.

The crop protection manager determines whether buffering is needed. Ideally, a pH meter should be used to firstly determine if the pH of the water is too high and therefore needs to be buffered for the particular product being used, and secondly to determine whether the pH of the water is acceptable after buffering. It is possible to lower the pH excessively, resulting in phytotoxicity for example when using phosphorous acid such as Aliette.

Oils

Spray oils are often used in citrus production either to improve the efficacy of other chemicals or as an insecticide. Oil smothers certain insects and kills them.

Spray oils are mineral-based and come in various grades from ultra-light to extra-heavy. All oils recommended for use on citrus are narrow distillation range oils. Oil does not mix readily with water and it is therefore very important that the spray material is constantly agitated (stirred) while the spray tank is being filled and while the spray machine is spraying.

To mix the spray materials in the table above, one has to calculate the quantities of the various ingredients depending on the total quantity of spray material required. The amount of water is normally

used as a basis, meaning that if 500ℓ of spray material is required, 500ℓ of clean water will form the basis of the calculation, as follows, using the examples above:

<i>Notation</i>	<i>Spray Material Required</i>	<i>Calculation</i>	<i>Requirements</i>
100g / 100ℓ + mineral oil @ 1.75ℓ / 100ℓ	500ℓ	$(100\text{g}/100\ell + \text{mineral oil @ } 1.75\ell/100\ell) \times 5$ = 500g/500ℓ + 8.75ℓ mineral oil	500g Methomyl 500ℓ clean water 8.75ℓ mineral oil
50ml / 100ℓ + wetter/buffer @ 50ml / 100ℓ	2,000ℓ	$(50\text{ml}/100\ell + \text{wetter/buffer @ } 50\text{ml}/100\ell) \times 20$ = 1,000ml(1ℓ)/2,000ℓ + 1,000ml(1ℓ) wetter/buffer	1ℓ Tokuthion 2,000ℓ clean water 1ℓ wetter/buffer
15ml / 100ℓ + 150g / 100ℓ + mineral oil @ 300ml / 100ℓ	1,000ℓ	$((15\text{ml} + 200\text{g})/100\ell + \text{mineral oil @ } 300\text{ml}) \times 10$ = (150ml + 2,000g(2kg))/1,000ℓ + 3,000ml (3ℓ) mineral oil	150ml Agrimec 2kg Dithane 1,000ℓ clean water 3ℓ mineral oil

Table 2.5: Spray Material Calculations

Complete activity 3 in the **Learner Workbook**.



5. Mixing Procedure

The person responsible for mixing must have either the crop protection program or the pre-application checklist readily available during mixing so that the chemicals, mixture and concentration can be checked. The correct mixing equipment must also be on hand, checked, calibrated and sterilised as prescribed.

The plant protection products that are indicated on the pre-application plan or crop protection program are taken from the storeroom. The person responsible for mixing must again at this time properly identify the chemicals as described in chapter 1, check their expiry dates, and ensure that he / she is aware of the toxicity and safety requirements for handling the chemicals.

Clean water and a bar of soap must be readily available so that the individual may immediately wash if the chemical comes into contact with skin, and so that the person can wash after handling the chemicals.

After the required quantities for the various ingredients are determined, the following steps are taken:

- Accurately measure the chemical ingredients, meaning all ingredients except water, using the appropriate equipment.
- If premixing is necessary (check label) then add the chemical ingredients to a 10ℓ bucket of clean water.
- Mix thoroughly.
- Add the 10ℓ mixture to the spray tank on the mistblower containing **half** the amount of water to be used.
- If premixing is not necessary, then add the chemical ingredients directly to the spray tank containing half the amount of water to be used.

- Add the remainder of the water to the spray tank, agitating (stirring) the mixture continuously. It is important that the water is run into the spray tank through a coarse filter. This is an orifice filter, which is part of the spray machine.

6. Storage of Plant Protection Products

All chemicals, including plant protection products, must be handled with the utmost care. Chemicals are not only potentially toxic to humans, but can also cause harm to animals and pollute water sources. Proper storage of PPPs is essential to ensure a safe working environment, and to enable one to adequately deal with accidents such as fires and spillage.

The rules for the safe storage of agrochemicals are prescribed by Good Agricultural Practices (GAP) legislation, and certification organisations, such as GlobalGAP. The basic principles are as follows:

- Chemicals must be stored in a secure, well-ventilated, cool, dry building that cannot be accessed by children, animals or unauthorised persons.
- There must be easy access to washing facilities with running water, soap and towels. An eye-flushing bottle must be available in the event that eyes are contaminated.
- The storeroom must have a smooth, level cement floor.
- Warning signs must be placed on the outside of the storeroom and its purpose must be clearly indicated.
- The storeroom must have at least two 9kg dry-powder fire extinguishers on hand, which are located outside the storeroom.
- No food products, animal feed or seeds may be taken into the storeroom.
- No eating, drinking or smoking is allowed inside the storeroom.
- Pesticides, fungicides, herbicides and growth-regulators must be separated in the storeroom. Ensure that each storage area is well demarcated so that there can be no accidental mixing of products. It is recommended that herbicides are stored completely separately.
- Powders and granular products must be stored separately from liquid products to avoid contamination in the event of spillage.
- Stored chemicals must be grouped according to their hazard potential. For example, store red-band (group 1a and 1b) chemicals in the same part of the store.
- Products should be used on a first-in-first-out basis. This ensures that chemicals are used before reaching their expiry date.
- Bags and containers that are not placed on shelves should be stacked on pallets to prevent a build-up of moisture.
- All containers and bags must be adequately marked. In the event that a label is destroyed or lost, the container must be marked with a marking pen, clearly stating its contents. The label should always be visible.
- The containers of chemicals that have been opened and partly used should be resealed and returned to the store.
- Bulk tanks that are used for products such as spray oil should be placed in a “dam” that has a greater volume than that of the tank, so that the spillage can be contained if the tank should leak or rupture.

An accurate stock movement recording system that indicates the quantities of each chemical purchased, issued and subsequently returned must be in place. From the recording system, one should be able to determine the exact type and quantity of chemicals on hand at any given time.

7. Disposal of Empty Containers

Empty chemical containers must under no circumstances be reused for any purpose whatsoever. Even if the container has been washed thoroughly, the risk of contamination is too high. Empty chemical containers must be disposed of.

An empty container must be rinsed by filling it to about a quarter with clean water, closing and shaking it well. Pour the rinse water into the spray tank. Repeat this process at least three times. Puncture the container after rinsing so that it cannot be reused.

Once containers have been punctured, they must be reduced (flattened) in bulk and buried at a disposal site in a pit. The disposal site must be:

- At least 50m from the nearest water source (dam, river and borehole).
- On relatively high ground or where the ground water is at least 2m deep.
- Not in sandy soils that leach easily.
- Fenced and sign posted.

Waste bags, paper and mildly contaminated items must be burned, while severely contaminated items and redundant chemicals must be disposed of using a high-temperature incinerator, which can also be used for empty containers. Please note however that containers of highly flammable chemicals must not be burned, even if they have been rinsed. **It is recommended that a professional waste disposal company is contacted in this regard.**

8. General Sanitation

Ensure that a wash trough or large basin is available in or close to the chemical storage facility. This will allow the washing of contaminated clothing on site, and prevent staff from taking the clothing home where it may or may not be washed.

Equipment, such as scoops, buckets and measuring cups, must be washed at the end of the workday. All protective clothing and equipment must be kept in good repair and cleaned regularly.

Have on hand a spade, broom and a supply of dry, fine sand that can be used to treat chemical spillages. Sawdust must never be used for this purpose, as it presents a fire hazard and, when mixed with certain chemicals, can result in combustion.



Chapter 2

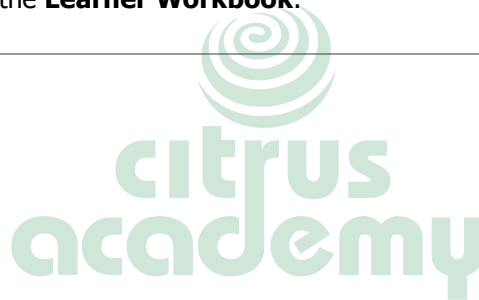
- PPP used for foliar applications must be mixed correctly and accurately immediately before application.
- The person responsible for mixing the chemicals must take note of the safety requirements for handling the chemicals by checking the colour codes, symbols and pictograms that are used on the product labels.
- Colour codes are used to indicate the hazard classification of the chemical.
- Internationally recognised symbols are used to indicate the toxicity of chemicals that are extremely, highly and moderately hazardous.
- Pictograms are used to indicate other information about the product, including the required protective gear and clothing.

- Apart from the chemicals themselves, protective clothing, measuring equipment and mixing equipment is required during the mixing process.
- The amount of chemicals that are required is calculated from the crop protection program. The same volume of water as the volume of spray material that is required is used as a basis.
- Buffers are used to adjust the pH of water.
- Spray oils often form part of spray materials because they assist in controlling pest and diseases.
- The mixing procedure involves measuring the correct amounts of chemicals, mixing these in a bucket if required on the label, adding the mixed chemicals to half the volume of water in the spray tank, and adding the remainder of the water while agitating the mixture.
- Plant protection products must be stored in a safe, secure room that complies with GAP requirements.
- Empty chemical containers must not be reused for any purpose. They must be rinsed, punctured and disposed of, either by being buried or by being incinerated.
- All protective clothing and equipment must be washed after use.

A circular inset image showing a person's hands wearing gloves, mixing chemicals in a bucket. The word "Practical" is written in a cursive font over the image.

Practical

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

A large, light green version of the Citrus Academy logo, featuring a stylized spiral above the words "citrus academy" in a lowercase, sans-serif font.

Chapter 3

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

Apply pest control product to crop

1. Introduction

This chapter focuses on the application of PPPs after the pre-application planning has been done and the chemicals have been mixed for application.

2. Influence of Climatic Conditions

Climatic conditions play an important role in the application of PPPs when the product is applied by way of spraying. The climatic conditions that must be taken into account are:

- Wind
- Rain and dew
- Temperature

The supervisor should take cognisance of the expected weather conditions for the day of the planned spray application, using the various weather services that are available. This will assist in the planning for resource allocation for the following day.

2.1. Wind

Foliar sprays should not be applied when wind speed exceeds 12km/h. High wind speeds will negatively affect spray coverage of the tree, which could result in poor control of the target pest or disease.

Excessive wind will also result in spray drift that could damage other crops, pollute water supplies, and harm the environment. Workers in other orchards may also be affected by spray drift.

2.2. Rain and Dew

Trees must be dry before foliar sprays are applied. If trees are wet, spray material is diluted and less effective. One cannot spray at all while it is raining. As a general rule, six hours of dry weather are required after a spray has been applied. If more than 10mm of rain falls before this time, the application should be repeated.

2.3. Temperature and Humidity

Most PPPs are applied during the summer months. Oil sprays must not be applied if temperatures are expected to exceed 30°C and or relative humidity (RH) is expected to be lower than 30%. It is for this reason that oil sprays are often applied at night in hotter citrus producing areas. If oil is applied under very hot conditions, there is a high risk that fruit burn will occur.

Some products are also sensitive to ultraviolet light (UV) and should also be applied after nightfall.

3. Calibration of Equipment

Most PPPs are applied by some form of machinery or equipment. This equipment must be prepared prior to application so that the correct amount of chemical is applied to the crop.

Calibration is of critical importance. Incorrect calibration could result in the chemical application being ineffective if not enough of the product is applied to the crop, and damage to the crop if too much chemicals are applied. Over application may also poison people or animals and is obviously a waste of money.

For trunk applications and soil drenches, plant protection products are measured, and equipment calibration is therefore not required, with the exception for trunk applications of when a Calibra applicator is used. In this case the Calibra must be calibrated or set at the correct volume required for the trunk size, according to the formula given on the label.

When foliar applications are used, the spray equipment must, however, be calibrated to ensure that the correct volume of spray material is delivered.

3.1. Mistblower Calibration

In order to ensure that the target pest or disease is controlled adequately, it is essential that the spray material is applied in sufficient quantity to adequately cover the tree, and that the coverage of the tree is uniform. It is extremely important that spray equipment must be calibrated correctly before it is used to apply spray material, as the calibration of the equipment will determine the amount of spray material that will be applied to each tree.

The pump of the spray machine pumps liquid from the spray tank through nozzles. The nozzles consist of whirlers and discs. The whirler determines droplet size, the angle of the spray, and a hollow or full cone. Discs have different sized holes which determine the amount of spray material delivered per unit time.



Figure 3.1: Different Sized Discs and Whirlers

In figure 3.1, note that the orifice size of a D2 disc is smaller than the D4 disc. The D2 will therefore allow less spray material to pass through than the larger disc per unit time.

Second from the right in figure 3.1 is a 45 whirler which does not have a hole in the middle like the 56 whirler on the far right. The spray pattern of the 45 whirler is therefore a hollow cone, meaning that no spray material comes out of the middle, while the 56 whirler delivers a full cone, meaning that a solid jet of spray material comes out. The openings of the 56 whirler are also bigger than those of the 45 whirler, which allows more spray material to pass through and gives a bigger droplet size.

The amount of spray material delivered also depends on the pressure of the pump. The pump pressure is expressed in kPa (kilo Pascal). The crop protection manager will be able to provide this information.

The following information is required to complete the calibration:

- Litres required per tree
- Tree spacing in row
- Tractor speed
- Number of nozzles on the spray cart
- Pump pressure

The key is to calculate how many litres per minute each nozzle on the spray machine must deliver if it travels at a fixed speed. To do this, one first needs to calculate how many trees are passed per minute at this speed, from which the total volume that must be delivered can be calculated. If the total volume is then divided by the number of nozzles, the volume that has to be delivered by each nozzle is the result.



Nozzle Delivery

Litres required per tree = 25ℓ

Tree spacing = 3.0m

Tractor speed = 33.3 metres per minute (2.0 km/hour)

Trees sprayed = 33.3 m/min divided by 3.0m tree spacing = 11.1 trees sprayed per minute

Total litres required per minute = 11.1 trees x 25ℓ/tree = 277.5 ℓ/min

(This applies to a spray machine that sprays on both sides. For a machine that sprays on one side only, divide by 2: $277.5 / 2 = 139 \text{ ℓ/min}$)

Number of nozzles on both sides of spray cart = 72

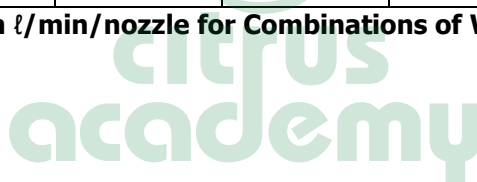
Litres required per nozzle = $277.5 \div 72 \text{ nozzles} = 3.85 \text{ litres/nozzle/minute}$

The delivery in litres per minute per nozzle of the various combinations for whirlers and discs at various pump pressures are set out in table 3.1. The volume closest to the required volume per nozzle is looked up in the column corresponding to the pump pressure. This combination of whirlers and discs are then used.

Whirler	Discs	700 kPa (100 psi)	1000 kPa (150 psi)	1400 kPa (200 psi)	2000 kPa (300psi)	2700 kPa (400psi)
23 Whirler	D1	0.405	0.470	0.526	0.620	0.697
	D1.5	0.492	0.586	0.660	0.790	0.900
	D2	0.606	0.720	0.800	0.950	1.060
	D3	0.680	0.790	0.910	1.060	1.210
	D4	0.870	1.060	1.210	1.440	1.660
	D5	1.060	1.290	1.440	1.740	2.000
	D6	1.210	1.480	1.700	2.050	2.340

<i>Whirler</i>	<i>Discs</i>	<i>700 kPa (100 psi)</i>	<i>1000 kPa (150 psi)</i>	<i>1400 kPa (200 psi)</i>	<i>2000 kPa (300psi)</i>	<i>2700 kPa (400psi)</i>
25 Whirler	D1	0.590	0.700	0.795	0.966	1.100
	D1.5	0.780	0.930	1.060	1.250	1.440
	D2	0.950	1.100	1.290	1.550	1.740
	D3	1.100	1.330	1.520	1.820	2.080
	D4	1.710	2.050	2.350	2.840	3.250
	D5	2.050	2.460	2.840	3.410	3.940
	D6	2.065	3.220	3.680	4.500	5.190
45 Whirler	D1	0.720	0.850	0.970	1.170	1.320
	D1.5	0.950	1.170	1.320	1.630	1.850
	D2	1.210	1.440	1.660	2.010	2.310
	D3	1.360	1.667	1.930	2.350	2.690
	D4	2.120	2.570	2.950	3.600	4.200
	D5	2.690	3.250	3.750	4.620	5.300
	D6	3.520	4.350	5.090	6.210	7.200
56 Whirler	D1	0.870	1.060	1.250	1.510	1.740
	D1.5	1.250	1.550	1.780	2.150	2.460
	D2	1.480	1.780	2.080	2.540	2.910
	D3	2.010	2.460	2.840	3.480	4.050
	D4	3.300	4.010	4.660	5.720	6.580
	D5	4.550	5.570	6.410	7.880	9.080
	D6	6.600	7.720	9.320	11.450	13.170

Table 3.1: Delivery in ℓ/min/nozzle for Combinations of Whirlers and Discs




Whirler and Disc Combination

Using the example above:

Pump pressure = 20 bar (2,000 kPa)

In the table, look under the 2,000 kPa column and select a combination of whirlers and discs to give as close to 3.85 litres per minute per nozzle as possible. In this case, the closest is 3.6 litres per minute per nozzle, which is a combination of D4 disc and 45 whirler.

It is important to select a combination that gives the most efficient coverage. A popular combination for a good medium cover spray when using machines with only average wind output is to alternate 45 and 56 whirlers with D3 discs to give good outside canopy coverage (45 whirlers) and some degree of penetration (56 whirlers).

Before sending the spray machine out to begin spraying, it is very important that the coverage is checked to see if any fine tuning is required. It may for instance be necessary to close a few nozzles to avoid wastage, or maybe the nozzle size towards the top of the spray machine should be changed to get better coverage.

It is important to remember that the speed of the PTO should be 540 rpm. This aspect is often ignored and can lead to incorrect pressure being delivered by the pump and thus lower volumes of spray material being applied.

3.2. Calibration of Other Spray Equipment

Knapsacks and herbicide sprayers may also have to be calibrated, depending on the type of application that is required. The calibration of this equipment varies, and must be done according to the manufacturers' instructions.

4. Protective Gear

Before application commences, the person applying the PPPs must be adequately supplied with protective clothing and safety equipment. The protective clothing that is required when handling chemicals is discussed in detail in chapter 1.

The degree of protection that is required depends on the type of chemicals that are being applied. If a group 1 chemical is for example applied with a mistblower, full protection for the tractor driver is required, while minimum protection is required for a group 4 chemical applied via the soil drench method.

Minimum protection means:

- Cotton overall
- Gum boots
- Rubber gloves

Maximum protection means:

- Cotton overalls
- Rain hat
- Rain coat and trousers
- Gum boots
- Goggles
- Respirator, with appropriate cartridge
- Rubber gloves

5. Application of Plant Protection Products

5.1. Foliar Spray Applications

Once all the necessary preparations for the application of the spray material have been made, the following steps are followed:

5.1.1. Mistblowers

- The mistblower is attached to a tractor and the PTO is connected.
- The spray machine is filled with water and the chosen discs and whirlers are inserted into the nozzles.
- The pH of the water is checked to determine whether a buffering agent is required.
- The spray machine is tested in the orchard with water to determine whether the theoretical calibration that was done initially gives the correct spray coverage of the tree, measured by observation.
- Minor adjustments are usually necessary to ensure good coverage and prevent wastage of spray material.
- The spray material is mixed in the spray tank as prescribed.
- Before spraying starts, the protective clothing of the tractor driver is checked.

- Full instructions are given to the driver regarding the correct gear that the tractor should be in, the pump pressure required, and where the accelerator should be set in order to attain the correct PTO revolutions (540rpm).

5.1.2. Handguns and Knapsacks

The spray material is prepared in the same way as described above. The manner in which it is applied depends on the type and model of the equipment used. Please follow the manufacturers' instructions.

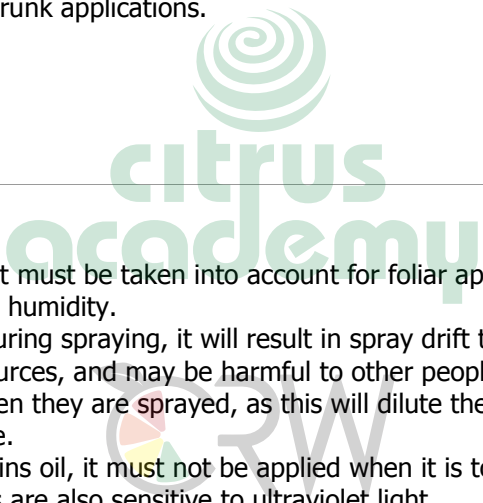
5.2. Soil Drench

In soil drench applications, the chemical is prepared and the correct quantity is measured in a container. The chemical is then poured around the base of the tree around the trunk in an even manner, or as per the instructions on the label

5.3. Trunk Applications

Trunk applications vary somewhat depending on the product. Generally, the chemical is painted or applied in some other way to the trunk of the tree. The instructions of the manufacturer must be followed carefully with trunk applications.

Chapter 3

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- The climatic conditions that must be taken into account for foliar applications are wind, rain and dew, temperature and humidity.
 - If the wind is too strong during spraying, it will result in spray drift that may harm the environment and water sources, and may be harmful to other people in the vicinity.
 - Trees must not be wet when they are sprayed, as this will dilute the spray material and make the chemicals less effective.
 - If the spray material contains oil, it must not be applied when it is too hot, as this can burn the fruit. Certain chemicals are also sensitive to ultraviolet light.
 - Spray equipment must be calibrated before being used to ensure that the spray material will be applied at the correct rate.
 - The most important step in the calibration of mistblowers is selecting the correct combination of whirlers and discs to deliver the correct volume of spray material per tree.
 - The tractor driver, or any person that applies spray material, must wear the appropriate protective gear and clothing for the chemicals that are being applied.
 - For foliar applications, the mistblower is connected to the tractor, set up and tested, and then filled with spray material. Full instructions must be given to the tractor driver.
 - Applications with handguns and knapsacks are done according to the manufacturers' instructions.
 - The methods used for trunk and soil applications depend on the product and are according to the manufacturers' instructions.

Complete activity 6 in the **Learner Workbook**.



Practical

Chapter 4

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

Take the necessary safety and health precautions whilst applying pest control products

1. Introduction

In the previous chapters, the protective gear and clothing that is used while applying plant protection products were described. In this chapter, we will look at the various safety and health precautions that are necessary in more depth.

2. Protective Gear and Clothing

In the chapters 1 and 3, the protective gear that a person handling PPPs must wear to prevent contamination through inhalation or skin contact is described. In this section, we will look at the manner in which protective gear and clothing must be maintained and how it is correctly utilised.

2.1. Maintenance of Protective Gear and Clothing

All protective clothing and safety equipment must be in good repair at all times. Before protective clothing is utilised, the user must ensure that:

- All items are free of holes and tears to prevent penetration of the chemical onto undergarments or onto the skin.
- All items were washed properly after previous use.
- All buttons, zippers or other fastenings are working well.
- Elastic used in clothing and facemasks are not perished or stretched out.

Where protective clothing is torn, or has perished in some way, it must be replaced.

Cartridges are used in respirators to filter out dust and vapours. Cartridges must be replaced on a regular basis in line with the manufacturer's specification.

2.2. Using Protective Gear and Clothing

The use of protective clothing must be strictly enforced at all times. Each individual should have his or her own protective clothing and equipment which fits well and is properly maintained.

Safety precautions do not end when the spray application is complete. All equipment has to be cleaned, maintained and stored in good condition in preparation for future use.

Operators should change out of work clothes and bath or shower once spraying is complete. Work clothes should be washed immediately.

3. Safety Regulations

All workers must be fully trained in workplace safety regulations and these regulations should be enforced at all times.

The regulations must include:

- Regulations regarding the conduct of personnel when handling chemicals, being:
 - o No smoking, drinking or eating is allowed in the vicinity of where chemicals are mixed, applied or stored.
 - o No person that is under the influence of alcohol or other drugs is allowed to handle chemicals for whatever purpose under any circumstances.
- Safety regulations regarding the use of chemical application equipment
- Regulations regarding proper utilisation of protective clothing and equipment
- Regulations on how to handle chemicals safely
- Prescriptive regulations on how chemical spills, leakages and other emergencies should be handled

Instructions concerning the chemical to be applied, the concentration to be used, the orchard to be sprayed and type of spray coverage required must be given in writing on a daily basis and signed by the supervisor.

In the interest of safety, under no circumstances must any non-authorized workers be allowed to handle or apply chemicals.

On the day of the application, all personnel working in the vicinity of the orchard that is to be sprayed, whether they are directly involved in the spraying operation or not, must be informed of the activity. This ensures that they will not wander into the area and be contaminated by accident.

4. Soil and Water Contamination

Care should be taken when applying sprays so that spray drift does not contaminate water sources, such as dams, streams, and springs.

Filling points where chemicals are mixed and where spray machine tanks are filled should be at least 50m from any water source, including boreholes. They must have a suitable drainage system, such as a French drain, that can safely drain away spilt chemicals and excess water.

5. Designated Areas

Chemicals should only be mixed in areas designated for the purpose, such as at filling points. These areas should be clearly marked and unauthorised personnel should not be allowed into these areas while chemicals are being handled.

Adequate signage that is approved by the authorities and is easily observable should be placed in locations designated for a specific purpose. These signs must give a bold, concise message such as:

- Danger
- No Entry
- No Smoking
- No Drinking and Eating
- Fire Extinguisher
- First Aid Equipment
- Emergency Exit
- Protective Clothing Required
- Do not drink the water from this tap

Signs are either informative in nature or give a clear instruction in a manner that is understandable to all irrespective of their language.



Figure 4.1: Examples of Signage

Chapter 4

- Protective gear and clothing must be checked regularly to ensure that it is intact and in working condition.
- Each worker must have his / her own protective gear and clothing, which must be washed after each workday.
- Safety regulations must be in place, known to all workers and enforced strictly.
- Care must be taken during the preparation for and application of foliar sprays to ensure that water sources and soil is not contaminated by chemicals.
- Signage must be used at all areas designated for specific purposes.

Chapter 5

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

Apply post-application procedures

1. Introduction

Once the plant protection products have been applied in the prescribed manner, certain steps must be taken to clean, maintain and store the equipment used, and to ensure that no further contamination can take place.

2. Post-Application Procedures

The following procedures must be followed after completing the application, some of which are discussed in more detail in the remainder of this chapter:

- Clean all mixing and application equipment thoroughly and store in the prescribed manner.
- Clean all protective clothing and equipment thoroughly and store in the prescribed manner.
- Collect and dispose of empty containers and other waste products correctly, as discussed in section 6 of chapter 2, and ensure that no empty containers are reused.
- Apply personal hygiene and safety.
- Notify the crop protection manager that the work has been completed.

3. Cleaning of Equipment

Once the application has been completed, all machinery must be washed with clean water and stored for future use.

If spray equipment is not cleaned properly after use, the danger of contamination remains, and people, animals and the environment may be placed at risk. In addition, certain chemicals are corrosive, and spray equipment that is not properly washed may be damaged.

3.1. Spray Machines

Spray machines must be washed in an area with adequate, safe drainage such as a filling point with a good French drain that is at least 50m away from any water source, as follows:

- Once parked at the filling point, remove the filter normally situated near the pump.
- Rinse the filter out with clean water so that all residues are removed.
- Fill the spray tank rapidly with water while the agitator is running. Water will pour out of the open filter, rinsing out the tank. The tank is considered clean only once all poison residues have been removed.
- Wash the outside of the spray machine with a cloth removing all spray residue.
- When complete, park the spray machine in its designated area.

3.2. Protective Clothing and Equipment

As described in section 1 of chapter 4, each item of protective clothing and equipment must be:

- Washed in soap and water;
- Examined for damage, especially for holes or tears in clothing;
- If damaged, repaired or replaced.

3.3. Other Equipment

All other equipment, such as brushes, knapsacks, and mixing equipment, must be washed with liquid soap and well rinsed in a suitably well drained area.

4. Personal Hygiene

On completing the spray task, all persons involved should bathe and dress in clean clothing. Do not dress again in clothes that were used for the spray operation unless they have been laundered properly.

Chapter 5

- After the application of a PPP has been completed, all the following steps must be followed.
- Clean all mixing and application equipment thoroughly and store in the prescribed manner.
- Clean all protective clothing and equipment thoroughly and store in the prescribed manner.
- Collect and dispose of empty containers and other waste products correctly, as discussed in section 6 of chapter 2, and ensure that no empty containers are reused.
- Apply personal hygiene and safety.
- Notify the crop protection manager that the work has been completed.

Complete activity 7 in the **Learner Workbook**.



Chapter 6

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

Monitor and report on the process, problems and unusual occurrences to supervisor

1. Monitoring the Application Process

Monitoring and managing applications are critical in controlling of pests and diseases. The timing of control measures is of major importance as certain pests, such as thrips or bollworm, or diseases, such as blackspot, can cause severe damage to the citrus crop within days if not controlled in time. The following steps must be taken and monitored continuously:

- Ensure that all necessary information, such as orchards to be sprayed, spray cover, and chemical attributes (especially toxicity), are well communicated to tractor drivers and other personnel involved, as well as other workers that may be active in the area.
- Check that all personnel concerned are wearing suitable protective clothing taking into account the toxicity of the chemical as indicated on the product label.
- Check that the correct chemicals are being used and that each chemical is being used at the correct concentration using the recommended mixing method as per instruction on the label.
- Check that the agitator of the spray machine is functioning adequately and that the chemicals placed inside the spray tank are well mixed.
- Check spray coverage of the trees and ensure that the physical wetting is as desired.
- Ensure that all nozzles are spraying onto the tree. You may have to close or alter the direction of nozzles.
- Check that the number of litres being applied per tree is within an acceptable range by checking the number of spray tanks used against the number of trees sprayed.
- Observe the climatic conditions and react accordingly. Stop spraying immediately if it starts raining, or if it becomes too windy or too hot.
- Finally, the efficacy of the spray against the target pest must be determined. This varies significantly and will depend upon the target pest and the type of chemical(s) being used.

2. Reporting Problems and Unusual Occurrences

Many of the points referred to above are fairly straightforward. It is, however, very important that the supervisor or crop protection manager is consulted if you are unsure about any of the above.

Reporting procedures must be prescribed by management, who must ensure that all employees are aware of the procedures and able to follow them. The procedures must be applied and enforced at all times.

Do not wait to report problem or unusual occurrences. Report them immediately. Rather be safe than sorry.



Chapter 6

- The prescribed procedures for the preparation and application of plant protection products must be followed carefully.
- Problems and unusual occurrences must be reported to the crop protection manager or supervisor immediately.



Complete activity 8 in the **Learner Workbook**.



Chapter 7

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

Deal appropriately and effectively with emergencies

1. Introduction

It is important that Management of the farm or enterprise actively implements the requirements of the Occupational Health and Safety Act (No 85 of 1993). The prime purpose of this Act is to provide for the health and safety of persons at work. There are a number of procedures that are required to be implemented by law that promote the safety of all in the work place.

Emergency situations occur even where every precaution has been taken to prevent it from happening. It is essential that all personnel that are authorised to handle and come into contact with chemicals are aware of the steps that are to be taken in case of an emergency.

The most common emergency situations that occur where chemicals are handled are spills and leakages, and poisoning.

2. Procedures in Case of Poisoning

The local doctor must be advised in advance of which PPPs are going to be used during the season. The doctor should be given a copy of all product labels of PPPs expected to be used so that appropriate antidotes can be kept on hand.

Every person that works with chemicals or comes into contact with chemicals should be thoroughly aware of the symptoms of poisoning, and a list of the symptoms should be displayed prominently within the work area on a poster looking similar to the figure below:

General Signs and Symptoms of Poisoning (AVCASA, 2001)

- Headache
- Dizziness
- Nausea
- Tremors of Tongue and Eyelids
- Salivation
- Cramps
- Vomiting
- Sweating
- Muscular Weakness
- Anxiety
- Blurred Vision

In the event of poisoning, arrange for medical attention as soon as possible, or arrange for transporting the affected person to a hospital or clinic.

While this is being done, administer the following first aid procedures:

- Determine which chemical caused the poisoning.

- If the product is known, consult the label for the specific first aid procedures.
- Ascertain how the chemical was absorbed, being by mouth, through the skin or by inhalation.
- Make sure that the breathing tract is open.
- If the patient is unconscious, turn him or her onto their stomach.
- Start artificial respiration if the person is not breathing.
- If the patient absorbed the chemical via the skin, remove the patient from the contamination point, remove all contaminated clothing and wash affected areas with soap and water.
- If the eyes have been affected, wash with clean water for at least 15 minutes.
- If the chemicals have been swallowed **do not induce vomiting** unless it specifically stated on the product label.
- Keep the patient warm.

The following emergency procedures can be administered to a person that has been poisoned, but may **only** be administered by qualified, authorised medical personnel:

- Organophosphate type chemicals – Atropine by injection
- Organochlorine type chemicals – Treatment will depend on symptoms.
- Carbamate type chemicals – Atropine by injection

3. Procedures for Spills and Leakages

3.1. Equipment

In areas where chemicals are stored, the following equipment should be available and easily accessible at all times and must be used when a chemical spill or leakage occurs:

- Two sets of protective clothing, including respirators and facemasks
- Two brooms
- Two shovels
- 50kg powdered lime
- A number of open-top drums in which to place spilled chemicals

Lime is suitable as a general purpose absorbent for liquid PPPs because it is alkaline, which assists the degradation of many of the more toxic substances such as organophosphates.

If the above equipment is available and accessible, the personnel on hand can react rapidly as soon as a spill or leakage occurs.

3.2. Clean-Up Procedures

All persons that regularly work within a chemical storage area must be able and cope if a spill or leakage occurs.

- Give first aid to anyone affected by the chemical and obtain medical attention immediately.
- Isolate the spill area and keep all unauthorised people away.
- Every person involved in the clean-up operation must wear protective clothing.
- Attempt to contain the spill or leakage as far as possible by constructing an absorbent barrier of sand, soil or lime around the spilt material.

- Place leaking containers, if any, into open-top drums and label the drums clearly for future reference and disposal.
- Collect the spilt material and absorbent substance using the shovels and brooms, and place it into open-top drums for disposal.
- Ventilate the building as much as possible by opening all doors and windows.
- If the spillage is on soil or gravel, dig up the area and remove the contaminated material.
- If the spillage is on concrete neutralise the chemical with lime or a 10% solution of sodium carbonate (Na_2CO_3) or alternatively, with 5% sodium hydroxide (NaOH).
- Clean all equipment used during the clean-up operation thoroughly, including laundering protective clothing, and store it for future use.
- Dispose of the open-top drums and its contents.

4. Incident Reports

An incident normally refers to an accident or a near accident at the workplace where:

- Workers were or could have been injured or killed
- Safety was compromised
- Property was damaged

In an effort to understand the causes of the accident, an incident report is written by the supervisor or manager responsible for the work being conducted. Incident reports are necessary as it compels persons involved to explore every angle of the accident or near accident, in an attempt to prevent any similar accidents in future.

Serious accidents must be reported to the Department of Labour, in terms of the Occupational Health and Safety Act, who will conduct their own investigation, which may lead to the prosecution of the responsible person if negligence is found to be the cause.

An incident report should at least contain the following information:

- Date of occurrence
- Place of occurrence
- Name of department manager
- Name(s) of injured person(s)
- Description of injuries, illness or damage to property
- Full description of how the accident took place
- Names of witnesses to the accident



Chapter 7

- Procedures for emergency situations must be in place and known to all personnel.
- The most common emergencies are poisoning and spillages.
- The symptoms of poisoning must be displayed prominently in the area where chemicals are stored and handled.
- When a person displays symptoms of poisoning, medical attention must be arranged for as soon as possible, and first aid must be administered in the meantime.

- The equipment for containing and cleaning spillages must be on hand at all times.
- The procedures for containing and cleaning spillages must be followed carefully.
- Incident reports must be completed for any incident in which workers were or may have been injured or killed, during which safety was compromised, or in which property was damaged.



Complete activity 9 in the **Learner Workbook**.



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