

Weed Control

Introduction

Almost any plant found in propagation structures in a citrus nursery other than citrus trees, can be considered a weed. There is however some weeds that are also invasive species and they pose a considerably greater threat than other unwanted plants.

Invasive Plants

In terms of commercial nurseries, invasive plants are the most dangerous weeds, because they are not susceptible to the pests and diseases that the citrus tree may be subjected to, and because they are most effective at competing with the citrus tree for water and nutrients.

definition

Weeds

'Weeds' is a generic word for plants growing in a place where they are not wanted. Weeds become important in commercial nurseries when they damage trees.

Alien Plants

Alien plants are plants that originate from other countries or areas. Alien plants were brought to this country or region for economic or ornamental reasons.

Invasive Plants

Invasive plants are alien plants that have become harmful to the natural ecosystem. Not all alien plants are invasive – in South Africa only 2.5% of plants that are introduced become invasive.

Invasive plants do not have natural enemies or other limitation on their growth, and they tend to overrun ecosystems that they are introduced into. Invasive plants are a major threat to biodiversity and ecosystem stability.

For the purpose of this guide, we will discuss the listing and identification of invasive plants that are most frequently found in citrus-growing areas. Please note that these lists do not include all invasive plants and that other invasive species may also be found in your geographical area.

Invasive plants have been categorised by the Agricultural Research Council (ARC) and the Botanical Society of South Africa into three categories, depending on the threat that they hold for indigenous plant and animal species.

Category 1 Invasive Plants: Declared Weeds

Category 1 invasive plants are specific plants that have been identified as weeds and that are prohibited by the Department of Agriculture. If these plants are found at a nursery, one is obligated by law to eradicate them. Most of the plants in this category produce copious numbers of seeds that are dispersed by wind or animals, or they have highly efficient means of vegetative reproduction.

Plant species are included in this list for one or more of the following reasons:

- ❖ They pose a serious health risk to humans or livestock
- ❖ They cause serious financial losses to land users
- ❖ They invade undisturbed environments and transform or degrade natural plant communities
- ❖ They use more water than plants they replace
- ❖ They are particularly difficult to control

While some of these plants have no obvious function to fulfil and are generally regarded as undesirable, many of them are popular garden or landscaping plants. It is important to look in house gardens near nurseries for invasive plants that might spread.

What all these species have in common is that their harmfulness outweighs any useful properties they might have. Care was taken not to include a plant in this category if any part of the population of South Africa would suffer if it were eradicated.

Common name	Botanical name
Triffid weed (Chromolaena)	<i>Chromolaena odorata</i>
Lantana	<i>Lantana camara</i>
Barbados gooseberry (Pereskia)	<i>Pereskia aculeata</i>
Bugweed	<i>Solanum mauritianum</i>
American bramble	<i>Rubus cuneifolius</i>
Red sesbania	<i>Sesbania punicea</i>
Mauritius thorn	<i>Caesalpinia decapetala</i>
Inkberry	<i>Cestrum laevigatum</i>
Balloon vine	<i>Cardiospermum grandiflorum</i>
Field bindweed	<i>Convolvulus arvensis</i>
Perennial morning glory	<i>Ipomoea indica</i>
Madeira vine	<i>Anreda cordifolia</i>
Water hyacinth	<i>Eichhornia crassipes</i>
Brazilian pepper tree	<i>Schinus terebinthifolius</i>
Yellow-flowered Mexican poppy	<i>Argemone mexicana</i>
Montanoa tree daisy	<i>Montanoa hibiscifolia</i>
Camphor	<i>Cinnamomum camphora</i>
Indian laurel	<i>Litsea glutinosa</i>

Category 2 Invasive Plants

Category 2 invasive plants have the potential to become harmful, but have certain beneficial properties that warrant their continued presence under certain circumstances. There are strict regulations about where category 2 plants are grown, including:

- ❖ The land user must obtain a water use license
- ❖ The plants may not be planted within 30m of the 50-year flood-line
- ❖ The plants are only allowed in demarcated areas under controlled conditions
- ❖ The plants have to primarily serve a commercial or utility purpose, such as a woodlot, windbreaks, building material, animal fodder, soil stabilisation, medicinal or own consumption
- ❖ All reasonable steps must be taken to curtail the spreading of seeds or vegetative reproductive material outside the demarcated area
- ❖ All specimens outside the demarcated area have to be controlled
- ❖ The conditions under which the plants are cultivated must be controlled
- ❖ Plants may only be sold by permit holders

Common name	Botanical name
Guava and hybrids	<i>Psidium guajava</i>
Johnson grass	<i>Sorghum halepense</i>
Leucaena	<i>Leucaena leucocephala</i>
Castor oil bush	<i>Ricinus communis</i>
Black wattle	<i>Acacia mearnsii</i>
Silver wattle	<i>Acacia dealbata</i>
Blue gum	<i>Eucalyptus grandis</i>
Pine trees	<i>Pinus patula/elliottii</i>
Beefwood	<i>Casuarina cunninghamiana</i>

Other species currently recommended for listing in category 2 are as follows:

Common name	Botanical name
Couch grass (Kweek)	<i>Cynodon dactylon</i>
Perennial ryegrass	<i>Lolium perenne</i>
Kikuyu	<i>Pennisetum clandestinum</i>
Napier grass	<i>Pennisetum purpureum</i>

Category 3 Invasive Plants

Category 3 invasive plants have the proven potential of becoming harmful, but most of them are popular ornamentals or shade trees that will take a long time to replace. Some were placed into this category because they do not cause problems in all situations.

Reproductive material from these plants, such as seeds and cuttings, may no longer be propagated, imported, bought, sold or traded in any way. Category 3 plants may only be planted with special permission and may not be planted within 30m of the 50-year flood-line. It is legal to trade in the wood and other products that do not have the potential to grow or multiply.

Common name	Botanical name
Syringa	<i>Melia azedarach</i>
Peanut butter cassia	<i>Senna didymobotrya</i>
Annual morning glory	<i>Ipomoea purpurea</i>
Jacaranda	<i>Jacaranda mimosifolia</i>
Orange cotoneaster	<i>Cotoneaster franchetii</i>
Loquat	<i>Eriobotria japonica</i>
Australian silky oak	<i>Grevillea robusta</i>
Common mulberry	<i>Morus alba</i>

information

Invasive Plants Used in Citrus Production

It is interesting to note that there are two invasive plant species that are commonly used as windbreaks on citrus farms, this being *Casuarina cunninghamiana* (category 2) and *Grevillea robusta* (category 3).

Grevillea is no longer recommended for use, but is still found on some farms. *Casuarina* is still widely used, in line with the regulations set out in the section on category 2 plants above, being that they are planted for a specific commercial purpose in controlled, demarcated areas. It is very important to be aware of the status of the plant, so that one can ensure that it is not planted within 30m of the 50-year flood-line and that it is not allowed to spread outside the demarcated area.

Weed Control Methods

The following methods are commonly used in commercial nurseries to control weeds:

- ❖ Chemical control (herbicides)
- ❖ Manual control

Chemical Control (Herbicides)

Chemical control means spraying agricultural herbicides. Some herbicides react to different types of weeds, while others are very specific and target only a specific category of weed, such as broad-leaved plants. Chemical weed control usually involves the spraying of herbicides in a liquid form with knapsacks.

Herbicides are classified according to how they react with the weed in order to eradicate it, being as:

- ❖ Contact herbicides that burn the top growth of the weed
- ❖ Systemic herbicides that is taken up by the plant and poisons it

It is very important that herbicides are only applied as recommended and according to the instructions. It is also important to take precautionary measures to prevent the herbicide from causing damage to or killing citrus trees.

Always remember that herbicides are made to kill plants, and that it will just as easily damage a citrus tree than an unwanted plant. In a citrus nursery, herbicides are only ever applied in the rows between trees, and never close to the citrus trees.

Measures that can be taken to prevent damage to citrus trees include:

- ❖ Never spray herbicides in windy conditions, because the spray drift may cause the herbicide to end up on the citrus trees
- ❖ Apply the herbicide with a nozzle that has a cover around it to prevent the chemical from drifting, and keep the cover tightly against the ground or weed surface during application
- ❖ Place screens or covers along the rows of citrus trees
- ❖ Spray herbicides at a very low pressure to avoid any misting, which may cause some of the material to drift onto the citrus trees

Manual Control

Manual control of weeds means take some type of physical action against the weed plant in order to damage or destroy it, such as removing the above soil parts of the plant (mowing or slashing) or removing the entire plant. Manual control involves physical labour, such as pulling weeds up by hand or using hoes. Mechanical equipment is also sometimes used, such as slashers and mowers.

Never try to use manual methods on weeds or alien species that have gone to seed or are in flower, as the method is likely to spread the seeds and cause a bigger problem in the future. Always try to eradicate weeds before they form seeds. If the weeds have already formed seeds, herbicides might be a preferable method of control. If the weeds are not listed as invaders, it may be suitable to simply chop them down with a spade or slasher.

Weed Control in the Nursery

Inside the greenhouse or shade house, different control methods may be used for weeds that grow in the planting bags and for weeds that grow between the rows. Weeds that grow in planting bags must be pulled out by hand. In between the rows herbicide applications may be used, but great care must be taken to ensure that the citrus plants are not exposed to the herbicides, as described above. Hoes can also be used to remove weeds in between rows.

In the rest of the nursery, weeds must be controlled as part of nursery sanitation.

practical

Activity 6.4 – Poster

Make a poster to educate your co-workers on the following. Include a copy of your poster in your workbook.

- ✓ Give a detailed pictorial description of the ten most common weeds in the nursery.
- ✓ Explain in detail how each weed affects the citrus plants or environment.
- ✓ Explain how to prevent the spread of the weeds in the nursery.
- ✓ Explain how to deal with the weeds in the nursery if you find them there.

Activity 6.5 – Mind Map

Draw a mind-map that includes the following:

- ✓ Different weed control methods used in citrus nurseries in South Africa.
- ✓ Detailed information of when which method would be appropriate to use in your nursery.
- ✓ Detailed information of how each method is applied in the nursery.

Activity 6.6 – Practical

Complete the following practical tasks.

- ✓ Attach copies of the procedures that are followed when herbicides are mixed and applied in your nursery.
- ✓ Attach a copy of the procedure that is followed when the herbicide application has been completed.
- ✓ Attach proof from your supervisor that you have applied herbicide correctly and that you followed the correct post-application procedures.

summary

Common Weeds

- A weed is any plant that is not wanted in the area where the citrus trees are produced.
- Invasive plants are plants that come from a different country or area and that have no natural enemies in the area they have invaded.
- Invasive species pose a threat to ecosystems and can cause the decline of natural vegetation and beneficial organisms.
- Invasive plants have been categorised by the Botanical Society of South Africa and the ARC

into three categories.

- Category 1 plants have to be removed wherever they are found and category 3 plants are the least threatening.
- The methods that are commonly used in commercial nursery production to control weeds are chemical control (herbicides) and manual control.
- Chemical control means spraying agricultural herbicides.
- Contact herbicides burn the top growth of the weed, while systemic a herbicide is taken up by the plant and poisons it.
- Great care must be taken to ensure that herbicides never come into contact with the citrus trees.
- Manual control of weeds means taking some type of physical action against the weed plant in order to damage or destroy it, such as removing the above soil parts of the plant (mowing or slashing), or removing the entire plant.



Scouting

Introduction

definition

Scouting

Scouting means observing nursery and plant conditions in order to gain information about the visible signs and symptoms of pests and diseases.

The presence of pests and diseases in a citrus nursery is often detected by the damage caused to the trees. To detect the presence of pests and diseases it is necessary to scout nurseries repeatedly in a structured and organised manner. These inspections should be done regularly and could be done in conjunction with inspections of weed densities, and plant nutrient- and water status.

Scouting involves looking at the whole nursery and recording pest numbers and disease symptoms. Scouting is aimed at identifying the pest or disease species that are present and the extent of infestation. If it is not possible to accurately identify the pest or disease responsible for damage, an expert in the field should be asked for assistance.

Pest and Disease Scouts

The success of scouting depends on the scouts in the nursery. Scouts must have excellent vision and a positive attitude to their job, and they must be well trained to understand the principles of scouting so that results are not biased.

Apart from initial training in basic identification of pests, damage symptoms and natural enemies, scouts must be kept informed of new developments and research findings in the field. If it is for instance determined through research that a specific pest has spread to a new area, the scouts must be informed immediately to be on the lookout for it.

Scouting Procedures

Experienced scouts are often able to do what is referred to as an 'impression survey'. This means getting a general impression of the nursery and the plant condition, and of the insects that are present. It gives the experienced scout a fairly accurate idea of the pest and disease prevalence in the nursery, but is not exactly accurate and it is very difficult to verify by management.

It is much more effective to have a specific scouting procedure in place that all the scouts are familiar with. A formal scouting strategy that includes all the necessary procedures – including reporting and recordkeeping procedures – is much easier to supervise and monitor.

In a large nursery it is not practical to inspect every tree. The trees and rows that are inspected should be selected to be as representative as possible of the shade house or tunnel.

Scouting procedures normally include the following:

- ❖ Inspections
- ❖ Pest traps
- ❖ Cursory examinations
- ❖ Recordkeeping and reporting

Inspections

Scouts inspect trees in the shade house or greenhouse at regular intervals. The presence or absence of pests and disease symptoms are recorded on a scouting form.

It is important that scouts are properly equipped for inspections. Generally scouts inspect the selected trees with the naked eye, but it may also be necessary to do microscopic evaluations if more information is required.

Microscopic evaluations are done with the help of a handheld magnifying glass. They are very useful for determining for example whether scale insects are alive or dead (and in what proportion), and the level of parasitism of scale insects, and to get a more accurate indication of infestation levels of very small insects, such as silver mite.

Pest Traps

Traps are set in some cases in the nursery to record the presence of pests such as thrips, aphids and Psylla. Traps are yellow cards with a sticky surface that is hung in the shade houses and greenhouses. Insects are attracted by the yellow colour, and are caught and retained when they land on the card. Scouts check the traps at regular intervals and count and record the types and numbers of insects.

Another type of trap that is used in citrus nurseries is called a water spore trap. They are installed at two places in the water line, where pathogen spores – most specifically those of *Phytophthora* and *Pythium* – are trapped on leaf discs. The leaf discs are then placed on a growth medium in specially prepared Petri dishes that are sent to the diagnostic centre for analysis. Trapping for pathogen analysis must be done at least every three months, as prescribed by the protocol of the Citrus Improvement Scheme. The complete procedure for sampling for pathogen analysis can be found in the Irrigation module of this learning program.

Cursory Examinations

Inspections are supplemented by cursory examinations of the shade house or greenhouse in order to gain a general impression of the populations of beneficial and pest insects. The presence of insects such as ants and spiders will for instance be noted during this examination. The impressions gained during the examination are recorded as general remarks on the scouting form.

Recordkeeping and Reporting

Records must be kept of all observed damage, the cause of the damage, and actions taken to eradicate the pest or diseases. During scouting a scouting form is completed, such as in the example below.

example

Scouting Form

Name:						Block / House:						
Date:												
		Row										
		1	2	3	4	5	6	7	8	9	10	Totals
Observation Point	1											
	2											
	3											
	4											
	5											
	6											
	7											
	8											
	9											
	10											
General Observations:												

The number of incidents of a pest insect or disease symptom is counted and noted on the scouting form, per row and per observation point.

The data from the scouting form is transferred to a permanent record. The current pest and disease activity in this nursery can now be compared to historical information, and to the information from other nurseries.

skills

Please see the instructions on **Scouting** in the Skills module.

Old and New Damage

An important aspect of scouting is distinguishing between old and new damage to the plant. The same person or team of people should be responsible for scouting a specific shade house or greenhouse on a regular basis, because they will be in a better position to recognise new damage.

Old damage means damage that was caused at some point in the past by a pest, disease or organism that might already have been eradicated. Old damage can be identified by old scarring.

New damage is a sign that a new pest, disease or organism is present and causing damage. New damage is for instance injuries that have not yet healed or dried out. If new damage is found it must be reported and dealt with immediately, before the pest or disease causing the damage becomes a major problem.

Timing of Symptoms

Certain symptoms occur under specific conditions or at a specific time of the year. This may for example be because climatic conditions have become favourable for the emergence of that specific pest or disease, or because the growth stage of the plant has made it more attractive to a specific insect.

Below are guidelines for the appearance of specific types of pests and diseases:

- ❖ Chewing and sucking insects, including aphids, Psylla and worms, will most likely be found when the plant part which they feed on is still young and tender, and will therefore not normally occur in the winter months.
- ❖ Fungal infections are most likely to occur under humid conditions – rain and heat increase the humidity in shade house if airflow is hampered.
- ❖ *Phytophthora* could occur in shade houses during heavy or prolonged rainy periods, because water-logged growth medium conditions promote the development of the disease if spores are present.

Because climatic conditions have an impact on the occurrence of pests and diseases, it is important that weather records are also kept and consulted when scouting. Records about the development of the plants will aid further in predicting the occurrence of pests and diseases.

Post-Application Monitoring

Once plant protection products have been applied, it is essential that the efficacy of the application is monitored, both in terms of its impact on targeted pests and diseases and on beneficial insects. Scouting must continue as per usual after treatments are applied. From the recorded data, it is possible to determine whether there has been a decline in pest level.

Where it is found that treatments did not have the desired effect, alternative treatments may be considered. It is advisable to consult an expert in this regard, as this may be an indication that the specific pest is resistant to the prescribed treatment.

practical

Activity 6.7 – Poster Design

Design an educational poster for your co-workers in the nursery. Include a copy of your poster in your workbook.

- ✓ Show the five most important pests and the three most important diseases that affect the citrus nursery, and include pictures to identify these pests and diseases.
- ✓ Show how these pests and diseases can be prevented, and how they can be controlled.

Activity 6.8 – Logbook

Prove that you have scouted for pests and diseases in the nursery.

- ✓ Attach a copy of the procedure for scouting in the nursery where you work.
- ✓ Complete at least eight scouting sessions in the nursery and hand in a logbook proving that you have successfully completed this task.

summary

Scouting

- Scouting means observing nursery and plant conditions in order to gain information about the visible signs and symptoms of pests and diseases.
- Scouts must have excellent vision and a positive attitude to their job, and they must be well trained to understand the principles of scouting so that results are not biased.
- A formal scouting strategy is required for the nursery, and should include all the necessary procedures including reporting and recordkeeping.
- Scouting procedures normally include inspections, pest traps, cursory examinations, and recordkeeping and reporting.
- Old damage refers to damage that was caused before by pests and diseases that may already have been eradicated, while new damage refers to new injuries to plants caused by a new outbreak of a pest or disease, which should be identified and dealt with.
- Certain symptoms occur at specific points in the production cycle or under specific climatic conditions.
- Recordkeeping of pest and disease populations, damage found and actions taken will assist in active pest and disease control.
- Recordkeeping of climatic conditions and the developmental stages of the plant aid in predicting the occurrence of pests and diseases.

Plant Protection Product Application

Introduction

Proper planning for protecting citrus trees from pests and diseases is critically important. Poor planning could result in financial losses due to 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 plant protection program is compiled to control the pests and diseases commonly found in the area where the nursery is located and that incorporates compulsory control measures in the nursery for citrus Psylla and citrus blackspot. The plant protection program is developed, with the assistance of an independent, reliable consultant that is aware of all the latest developments in the field, by the plant protection manager. He decides which chemicals to use, in what concentration to apply the chemicals, and the schedule of application.

This information is incorporated in a plant protection program that is strictly followed. Minor changes may be made once the plan is implemented if circumstances change, but only under the direction of the plant protection manager or the nursery manager.

The second step in the planning is the pre-application plan. Pre-application planning is done before each application stipulated on the plant protection program, and is best accomplished by using a simple checklist.

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

Plant Protection Products

The first step in the pre-application planning is to identify the product indicated in the plant protection program. Plant protection products are generally classified as:

- ❖ **Insecticides** are plant protection products (PPPs) that are used to control insects
- ❖ **Fungicides** are plant protection products (PPPs) that are used to control fungi
- ❖ **Herbicides** are plant protection products (PPPs) that are used to control weeds

Plant Protection Product Registration

Only chemicals that have been registered with the National Department of Agriculture 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, and which can be obtained from the National Department of Agriculture:

- ❖ Guide for the Control of Plant Pests
- ❖ Guide for the Control of Plant Diseases
- ❖ Guide to the Use of Herbicides
- ❖ Guide to the Use of Plant Growth Regulants, Adjuvants, Defoliants and Desiccants

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 plant protection manager may need to consult a representative of an agrochemical company.

Plant Protection Product Identification

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

- ❖ **Full instructions on how to use the chemical**, 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**, including its colour and whether it is in liquid, powder or granular form. The plant protection manager should inspect the chemical in the container to ensure that it answers to this physical description. If it does not and the container has never been opened before, it should be brought to the attention of the manufacturer or supplier immediately. If the container had been opened before, the container and its contents should be discarded in the prescribed manner.
- ❖ The **chemical composition** of the product.
- ❖ The **toxicity** of the product, along with instructions for its safe handling.
- ❖ The **pre-harvest interval (PHI)** of the product.
- ❖ The product **expiry date**, being the date on or before which the chemical should be used. Chemicals should be used before the expiry date to make sure that it is still effective.

Plant Protection Product Availability

The plant protection program indicates the concentration at which the product must be used. It may also indicate the total quantity of chemical required for the application, but if not, it can be calculated by using the information provided.

The plant 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.

Application Methods

Plant protection products can be applied in various ways. The decision on which method to use depends on the product, and the specific requirements and purpose of the application. The application method should be stated on the plant protection program. Application methods include:

- ❖ Foliar spray application
- ❖ Trunk application
- ❖ Soil drench

Foliar Spray Application

The most common method of applying insecticides and fungicides to trees in a nursery is by way of applying a foliar spray. This means that 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

Outside Cover Spray

Outside cover sprays are applied at low volume and achieve a light covering of the tree. Droplet size is small, and the tree is sprayed with a fine mist of spray material that only covers the outer leaves of the tree.

Outside cover sprays are not used often in a nursery, because the trees are packed together and it is difficult to apply such a small volume of spray material to each tree.

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 runs off the leaves.

Full Cover Spray

Full cover sprays are designed to thoroughly wet the tree, drenching not only the foliage, but the branches and framework as well.

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.

Soil Drench

This method involves diluting the chemical in water and then pouring it onto the growth media 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 the irrigation system, which allows their uptake by the roots.

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 plant 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 workers available

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

The plant 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.

Foliar Applications

Foliar applications are applied in a nursery mostly with knapsacks and handguns. Nurserymen however also sometimes design their own machinery for applying foliar sprays. The main requirements are that the equipment must be able to apply the spray material evenly, ensuring that each tree is covered properly and that every tree receives the same volume of spray material.

Knapsacks

There are two types of knapsacks that are commonly used in nurseries, being manual (pump action) and motorised knapsacks. Knapsack sprayers are most commonly used for low volume applications of plant protection products. Manual knapsacks are used for herbicide applications in the rows between the trees.

Care must be taken that the same knapsacks used to spray trees are not used for herbicide application, because this may cause contamination and damage to trees.

Handguns

Handguns are used to apply spray material at a higher pressure to achieve better penetration into the rows of trees, because of the high density of trees in a greenhouse and shade house.

A high-pressure spray cart that is driven by a tractor is parked outside the greenhouse or shade house, and a drag line and handgun is used to apply the spray material to the trees inside the house.

The technique that is used with handgun applications is very important. The sprayer moves the handgun in circular motion to ensure that every tree is completely covered with spray material. Care must also be taken to ensure that all the trees receive the same amount of spray material, otherwise trees may be damaged by chemical burns.

Stem Applications

The amount of chemical applied in a stem 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 nurserymen use a paint brush for trunk applications.

The quantity of product required is calculated according to the diameter of the tree stem. There are tables available that indicate how much chemical to apply to trees of different sizes.

Soil Drench

The chemical solution is applied by using measuring cups or jugs that ensure with relative accuracy that the correct quantity is applied. In some cases soil drench chemicals are also applied through the irrigation system.

Influence of Climatic Conditions

Climatic conditions play an important role in the application of PPPs if the product is applied through a spray application. 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.

The climatic conditions that must be taken into account are:

- ❖ Wind
- ❖ Rain and dew
- ❖ Temperature and humidity

Wind

Inside shade houses and greenhouses wind is not often a problem, although care must be taken that 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. It can also cause spray drift, which will result in the chemical contamination of areas that were not targeted for spraying.

Rain and Dew

Trees must be dry before foliar sprays are applied. If trees are wet, spray material is diluted and less effective.

Temperature and Humidity

Oil sprays must not be applied if temperatures are expected to exceed 30°C and / or if relative humidity (RH) is expected to be lower than 30%. If oil is applied under very hot conditions, there is a high risk that trees can be damaged.

summary

Plant Protection Product Application

- The two steps in planning for the protection of citrus trees against pests and diseases are the compilation of a plant 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 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 plant 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 three main types of foliar applications are outside cover sprays, medium cover sprays and full cover 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 and handguns are commonly used in the nursery for foliar applications.

- Calibra applicators and paint brushes are commonly used for trunk applications.
- Measuring cups and jugs are used for soil drenches, while some chemicals can be applied through the irrigation system.
- The climatic conditions that must be taken into account for foliar applications are wind, rain and dew and temperature.
- If the wind is too strong during spraying, it can cause insufficient coverage, and may result in spray drift.
- Trees must not be wet when they are sprayed, as this will dilute the spray material and make the chemicals less effective.
- Spray material that contain oil must not be applied if the temperature is above 30°C, as this can cause damage to the plants.



Safe Handling of Chemicals

Introduction

All agrochemicals should be considered dangerous and should be handled with the utmost care, according to the prescribed procedures. Every chemical container has colour codes, symbols and pictograms that provide more information about the contents. In addition, the container label has instructions for the manner in which the chemical should be handled.

It is important that the requirements of the Occupational Health and Safety Act (No 85 of 1993) are actively implemented and adhered to. The prime purpose of this Act is to protect the health and safety of persons in the workplace, and it contains a number of procedures that are required to be implemented by law.

Emergency situations occur even where every precaution has been taken to prevent it. 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.

Colour Codes, Symbols and Pictograms

It is essential that every person that handles chemicals has a thorough understanding of the nature of the chemicals that will be handled, especially with regard to its toxicity, 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.

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.

Group	Group description	Hazard statement	Colour band
Ia	Extremely hazardous	Very toxic	Red
Ib	Highly hazardous	Toxic	
II	Moderately hazardous	Harmful	Yellow
III	Slightly hazardous	Caution	Blue
IV	Acute hazard unlikely in normal use		Green

The table above 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.

Symbols

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

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	

Pictograms

Pictograms are used to indicate the storage requirements for the product, the manner in which the product is handled, 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

Protective Gear and Safety Equipment

All chemicals should be considered hazardous until proven 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.

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

The biggest risk to the person that handles and applies PPPs is poisoning. The chemical can enter a person's body by way of the mouth (orally), through contact with the skin (dermal contact), and by breathing (inhalation). Protective gear and clothing is designed and used to protect or cover these entry points.

Types of Protective Gear and Clothing

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

- ❖ **Cotton overalls** – Cotton, in comparison with lightweight synthetic alternatives, has proven to be more durable, protective and comfortable. A two-piece overall is preferred.
- ❖ **Apron** – An apron is used when mixing chemicals for added protection.
- ❖ **Rain coat and hat** – Rain gear is used during foliar spray applications with handguns to protect the sprayer 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 skin contact.
- ❖ **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 indicated on the product label.

Maintenance of Protective Gear and Clothing

All protective clothing and safety equipment must be in good repair at all times. Before protective gear and clothing is used, 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, and must be replaced on a regular basis in line with the manufacturer's specification.

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.

Storage of Plant Protection Products

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. The basic principles are:

- ❖ 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, 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.
- ❖ Containers should be arranged so that they are 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. The label should always be visible.
- ❖ In the event that a label is destroyed or lost, the container must be marked with a marking pen, clearly stating its contents.
- ❖ 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.



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.

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

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 well. Fill it to about a quarter with clean water, close it and shake 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 are 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.

skills

Please see the instructions on **Disposal of Empty Containers** in the Skills module.

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.

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

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



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:

- ❖ No smoking, drinking or eating is allowed in the vicinity of where chemicals are mixed, applied or stored.
- ❖ 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 for the use of chemical application equipment.
- ❖ Regulations for proper utilisation of protective clothing and equipment.
- ❖ 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 area 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 unauthorised workers be allowed to handle or apply chemicals.

On the day of the application, all personnel working in the vicinity of the nursery 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.

Procedures in Case of Poisoning

The local doctor must be advised of which PPPs are used in the nursery. The doctor should be given copies of the product labels of PPPs that are used regularly, so that appropriate antidotes can be kept on hand.

Every person that works 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, first aid procedures must be administered.

skills

Please see the instructions on **First Aid Procedures in Case of Poisoning** in the Skills module.

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 helpful numbers 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

Procedures for Spills and Leakages

In areas where chemicals are stored, equipment for dealing with the spill should be available and easily accessible at all times. The equipment that is required is listed in the skills section. If the equipment is available and accessible, the personnel can react rapidly as soon as a spill or leakage occurs.

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.

All persons that regularly work within a chemical storage area must be able and cope if a spill or leakage occurs. The procedures must be well known to everyone, and should be practiced in dry runs so that rapid reaction is possible in case of emergency.

skills

Please see the instructions on **Procedures for Spills and Leakages** in the Skills module.

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 compromise
- ❖ 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 the people 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

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.

practical

Activity 6.9 – Worksheet

Obtain a label from a plant protection product used in your nursery. Paste the label into your workbook and get the following information for this product from the label:

- ✓ Name and manufacturer
- ✓ Expiry date
- ✓ PHI
- ✓ Registration information
- ✓ Level of toxicity
- ✓ Information indicated by pictograms
- ✓ Protective gear and clothing required
- ✓ Procedures in case of poisoning

summary

Safe Handling of Chemicals

- 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.
- Health and safety requirements include the use of protective gear and safety equipment.
- The protective gear and safety equipment that are required is indicated on the label of each product with pictograms.
- 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.
- All protective clothing and equipment must be washed and safely stored after use.
- 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.
- Empty chemical containers must be rinsed, punctured and disposed of, either by being buried or by being incinerated.
- Signage must be used at all areas designated for specific purposes
- Safety regulations and procedures for emergency situations must be in place, known to all

workers and enforced strictly.

- 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.
- Emergency contact details must be displayed in an accessible place.
- 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.
- Care must be taken during the preparation for and application of foliar sprays to ensure that water sources and soil are not contaminated by chemicals.



Mixing Plant Protection Products

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 section. As for all PPPs it is, however, imperative to **READ THE LABEL** of these products before applying them.

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

Pre-Application Checklist

A pre-application checklist is compiled from the plant protection program for each application. The format of the pre-application checklist is not standard, and different nurseries 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 mixing and application. The checklist must contain all the necessary information to avoid confusion and the need to consult different records.

A pre-application checklist is prepared for every application that has to be done according to the plant protection program. The pre-application checklist is 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 nursery.

Below is an example of a pre-application checklist.

Pre-Application Checklist

Plant Protection Program Instructions

Shade House/Tunnel Number

Application Date

From:

To:

Target Pest(s)/Disease(s)

Chemicals

Chemical Concentration

Chemical

Concentration

Per

Application Method

Trunk Application

Soil Drench

Spray

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>

Labour Requirements

<i>Description</i>	<i>Name</i>	<i>From</i>	<i>To</i>

Other Requirements

Notes:

Signed:

Date:

Mixing Requirements

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

- ❖ Pre-application checklist
- ❖ Protective clothing
- ❖ Measuring equipment
- ❖ Mixing equipment

Water and soap must be available so that the person can immediately wash if chemicals come into contact with skin, and so that he / she can wash up after handling the chemicals.

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)
- ❖ A facemask or respirator, if indicated on the product label

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.

Mixing Equipment

Premixing is normally not required by the product label, and measured 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.

Calculating the Amount of Chemicals Required

Normal practice is for recommendations for the concentration of chemicals to be made in millilitres (ml) or grams (g) per 100ℓ of water. This is also the manner in which it is shown on the plant 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:

Target pest(s) / disease(s)	Chemical	Notation	Explanation
Red scale	Methomyl	100g/100ℓ + Bladbuff @150ml/100ℓ	100g Methomyl plus 150ml Bladbuff per 100ℓ clean water
Thrips, bollworm, aphids and mealybug	Tokuthion	50ml/100ℓ	50ml Tokuthion per 100ℓ clean water

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:

Notation	Spray material required	Calculation	Requirements
100g / 100ℓ + mineral oil @ 1.75ℓ / 100ℓ	500ℓ	$(100\text{g}/100\ell + \text{mineral oil @ } 1.75\ell/100\ell) \times 5$ $= 500\text{g}/500\ell + 8.75\ell \text{ mineral oil}$	500g Methomyl 500ℓ clean water 8.75ℓ mineral oil
50ml / 100ℓ + wetter / buffer @ 50ml / 100ℓ	2,000ℓ	$(50\text{ml}/100\ell + \text{wetter / buffer @ } 50\text{ml}/100\ell) \times 20$ $= 1,000\text{ml}/2,000\ell + 1,000\text{ml wetter / buffer}$	1ℓ Tokuthion 2,000ℓ clean water 1ℓ wetter / buffer

information

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 pH7) and if Cypermethrin is for example mixed with this high pH water, the chemical will be less effective. As the pH increases, the chemical will ultimately not work at all.

To avoid this negative reaction buffering agents are used to reduce the pH of the water. The degree of buffering that is required depends on which product is used and the pH of the water. The plant 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 too much, resulting in phytotoxicity for example when using phosphorous acid such as Aliette.

Oils

Spray oils are often used in citrus nurseries 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 spraying.

Mixing Procedure

The person responsible for mixing must have either the plant 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 plant protection program are taken from the storeroom. The person responsible for mixing must again at this time properly identify the chemicals, check their expiry dates, and ensure that he / she is aware of the toxicity and safety requirements for handling the chemicals.

skills

Please see the instructions on **Mixing Spray Material** in the Skills module.

summary

Mixing Plant Protection Products

- PPPs 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.
- A pre-application checklist is compiled from the plant protection program for each application.
- The pre-application checklist is used during the application to verify that the application is done correctly, and filed after the application as part of the records kept for the nursery.
- 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 plant protection program.
- The same volume of water as the volume of required spray material 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.
- All protective clothing and equipment must be washed after use.

Applying Plant Protection Products

Calibration of Equipment

The machinery or equipment that is used for an application must be prepared prior to application. 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 plants if too much chemicals are applied.

For trunk applications and soil drenches, plant protection products are measured and equipment calibration is not required, with the exception for trunk applications where 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 product label.

For foliar applications the spray equipment must be calibrated to ensure that the correct volume of spray material is delivered. Knapsacks are 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.

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 the section on Safe Handling of Chemicals. 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 handgun, full protection is required, while minimum protection is required for a group 4 chemical applied via the soil drench method. The instructions on the product label must be strictly adhered to.

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

Application of Plant Protection Products

Foliar Spray Applications

Knapsacks

The spray material is prepared and mixed as described before. The manner in which it is applied depends on the type and model of the knapsack. Please follow the manufacturers' instructions.

Handguns

Although the manner in which spray material is applied through handguns depends on the type of equipment that is used, there are general steps that must be followed, as described in the Skills module.

As a rule, handguns are attached to a tractor and spray tank that is parked outside the greenhouse or shade house. Handguns are attached to hoses, which are dragged into the structure and used to apply the spray material.

The tractor drives the PTO that drives the pump of the spray tank, so the pressure and therefore the volume of spray material that is delivered is adjusted by changing the speed of the tractor engine, or by using the valves on the spray tank.

The handgun is constantly moved in a circular motion while spraying, so that the leaves are set in motion. This ensures that the top and bottom surfaces of the leaves are covered with spray material.

skills

Please see the instructions on **Applying Spray Material – Handguns** in the Skills module.

Soil Drench

Soil drench products are specifically formulated. Follow the instructions on the product label with regard to protective clothing and application procedures. Generally, the product is prepared and the correct quantity is measured in a container. The chemical is then poured around the base of the tree around the stem in an even manner, as per the instructions on the product label.

Trunk Applications

Trunk applications vary somewhat depending on the product. Generally, the chemical is painted or applied by a Calibra to the trunk of the tree. Follow the instructions of the manufacturer carefully.

Reporting Problems and Unusual Occurrences

Many of these points are fairly straightforward, but it is very important that the supervisor or plant protection manager is consulted if you are unsure about anything. Do not wait to report problem or unusual occurrences. Report them immediately. Rather be safe than sorry.

Reporting procedures are 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.

practical

Activity 6.10 – Practical

Prove that you have applied plant protection product in the nursery.

- ✓ Attach a copy of the procedure for mixing spray material in your nursery.
- ✓ Attach confirmation from your supervisor that you have mixed the product correctly.
- ✓ Attach a copy of the procedure for applying a plant protection product in your nursery.
- ✓ Attach confirmation from your supervisor that you have applied the product correctly.
- ✓ Attach confirmation from your supervisor that you have worn and used all appropriate safety gear and equipment while applying plant protection product.

Activity 6.11 – Mind Map

Draw a mind map that shows the following:

- ✓ Explain what would be considered an out of the ordinary incident in your nursery while plant protection products are being used, mixed, or applied.
- ✓ Explain what you would report and to whom you would report it.

summary

Applying Plant Protection Products

- Spray equipment must be calibrated before being used to ensure that the spray material will be applied at the correct rate.
- Every person that applies spray material must wear the appropriate protective gear and clothing for the chemicals that are being applied.
- The manner in which spray material is applied with a knapsack depends on the type and model of the knapsack.
- Handguns are attached through hoses to a tractor and spray tank that is parked outside the greenhouse or shade house.

- The handgun is constantly moved in a circular motion while spraying, so that the leaves are set in motion and covered on the top and bottom surfaces.
- The methods used for trunk and soil applications depend on the product and are according to the manufacturers' instructions.
- Problems and unusual occurrences must be reported to the plant protection manager or supervisor immediately.



Post-Application Procedures

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.

Post-Application Procedures

The following procedures must be followed after completing the application.

- ❖ Clean all mixing and application equipment thoroughly and store as prescribed.
- ❖ Clean all protective clothing and equipment thoroughly and store as prescribed.
- ❖ Collect and dispose of empty containers and other waste products correctly, and ensure that no empty containers are reused.
- ❖ Apply personal hygiene.
- ❖ Notify the plant protection manager that the work has been completed.

Cleaning 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.

Spray Tanks

Spray tanks 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. The filter of the tank is removed, and the tank is rapidly filled with water. Water will pour out of the open filter, rinsing out the tank. The tank is considered clean only once all spray material residues have been removed. After the tank has been cleaned thoroughly, it must be parked in the designated area.

Protective Clothing and Equipment

Each item of protective clothing and equipment must be washed with soap and water, examined for damage, especially for holes or tears in clothing, and repaired or replaced if found to be damaged. After cleaning, clothing and equipment must be stored in the designated area.

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.

skills

Please see the instructions on **Cleaning Spray Equipment** in the Skills module.

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 during the spray operation unless they have been laundered properly.

practical

Activity 6.12 – Practical

Complete the following practical tasks:

- ✓ Attach copies of the procedures that you have to follow in your nursery after the application of plant protection products.
- ✓ Hand in confirmation by your supervisor that you have followed these procedures correctly.

summary

Post-Application Procedures

- 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.
- 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 and ensure that no empty containers are reused.
- Apply personal hygiene.
- Notify the plant protection manager that the work has been completed.