Citrus Orchard Foreman Occupational Learning

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Work Scenario Guide

F1:
IPM Planning

Qualification:	110667 – Occupational Certificate: Orchard and Vineyard Foreman
Work Scenario:	**F1: IPM Planning**
Learning Area:	F: Implement plant protection activities
Scenario Description:	You need to practice Integrated Pest Management techniques on your farm to ensure that your trees are not damaged by pests. You need to work with management to plan and prepare for IPM activities, including creating the programme, securing the necessary stock, consumables, tools and equipment, and organising staff.

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Content originator:
Citrus Academy

Occupational alignment:
Ukudla Namanzi (Pty) Ltd

Contents

Alignment Information

Qualification

The content of this learner guide is aligned to the following occupational qualification:

SAQA QUAL ID	**Qualification Title**			
110667	Occupational Certificate: Orchard and Vineyard Foreman			
Originator				
Development Quality Partner – AgriSETA				
Primary Or Delegated Quality Assurance Functionary		**NQF Sub-Framework**		
-		OQSF - Occupational Qualifications Sub-Framework		
QUALIFICATION TYPE	**FIELD**		**SUBFIELD**	
Occupational Certificate	Field 01 - Agriculture and Nature Conservation		Primary Agriculture	
Abet Band	**Minimum Credits**	**Pre-2009 NQF Level**	**NQF Level**	**Qual Class**
Undefined	147	Not Applicable	NQF Level 04	Regular-ELOAC

Modules

The content of this learner guide is aligned to the following modules of the occupational qualification above.

Module Code	Module Title	Level	Credits
Knowledge Modules			
611202-001-00-KM-01	Plant Structure and Physiology	4	5
611202-001-00-KM-02	Vineyard or Orchard Establishment	3	2
611202-001-00-KM-03	Vineyard or Orchard Manipulation Processes	3	8
611202-001-00-KM-04	Harvesting	3	4
611202-001-00-KM-05	Basic Principles of Plant Nutrition	4	4
611202-001-00-KM-06	Crop Protection	3	3
611202-001-00-KM-07	Assets in Horticultural Production	3	2
611202-001-00-KM-08	Farm Business Management and Farming Process Management	4	8
611202-001-00-KM-09	Human Resource Management and Processes	4	8
611202-001-00-KM-10	Overseeing Farming Resource Utilisation	4	8
Practical Skill Modules			
611202-001-00-PM-01	Organise, Allocate and Monitor Availability and Productive Use of Resources	4	5
611202-001-00-PM-2a	Set Team and Individual Performance Goals to Enhancing Team Performance	4	10
611202-001-00-PM-2b	Control Vineyard or Orchard Practices	4	10

611202-001-00-PM-03	Supply Accurate Daily Orchard or Vineyard and Production Information	4	10
Work Experience Modules			
611202-001-00-WM-01	Vineyard or Orchard Resource Optimisation	4	20
611202-001-00-WM-02	Skilled and Motivated Work Team Output	4	20
611202-001-00-WM-03	Daily Orchard or Vineyard and Production Information Availability	4	20

Learning Outcomes

The content of this learner guide is aligned to the following learning outcomes of the modules above.

Knowledge Topics	
Outcome Code	**Module Title**
KM-06-KT01	**Principles of integrated pest and disease management**
IAC0101	The principles of integrated pest management (IPM) is explained
IAC0102	Principles of usage restrictions for commonly used plant protection products (PPPs) are outlined and explained in terms of maximum residue levels (MRLs) and pre-harvest intervals (PHI)) according to IPM
IAC0103	The need for safety and compliance with regulations is motivated
IAC0104	Control methods for common pests and diseases (e.g. chemical, cultural, biological etc.) are described and relevant examples are given
IAC0105	Commonly used PPPs (application, target pest / disease, mechanism) are outlined
IAC0106	Principles of usage restrictions for commonly used PPPs are outlined in terms of maximum residue levels (MRLs) and pre-harvest intervals (PHI)) according to IPM
IAC0107	Commonly used biological control agents are described in terms of application, target pest / disease and mechanism
IAC0108	Explain cultivation control methods for pest and disease control with reference to rootstock selection, sound soil management practices, orchard or vineyard sanitation, sterilisation of equipment and the use of wound sealers
KM-06-KT02	**Identification of pests, diseases and weed**
IAC0203	Consequences of the presence of pests, diseases and weeds are explained
IAC0205	The reasons why prevention and control measures are recommended to be applied at specific stages of the life cycle of the pest and seasonal cycle of the plant are explained
Practical Skills	
PM-01-PS02	**Determine agricultural input to support the production activities of the orchard related to the production stages of the crop**
IAC0201	Correct agricultural calculations was applied
IAC0202	Costs within budgetary constraints or cost ratios
IAC0203	Standard agricultural norms are identified and applied
IAC0204	List of inputs and factors related to the activity are identified
IAC0205	Ratios and variances are correctly calculated
PA0201	Determine the agricultural input required for maintained orchard and crop quality.
PA0202	Determine the machinery, tools and equipment which will be needed to maintain orchard and crop quality throughout the different seasons of the year.
PA0203	Determine how different scenarios will influence the input.

PM-01-PS03	**Organise and allocate equipment and agri-chemicals to the work team to perform Vineyard or orchard practices**
IAC0301	The equipment identified is correct according to the different production processes
IAC0302	The number of tools/equipment is correct according to the output norms of the Vineyard or orchard
IAC0304	Activities are correctly assigned to team members according to the size of the team and capabilities of the team members
PM-2a-PS04	**Determine personnel requirements to meet production schedules**
IAC0401	The estimations and utilisation plans are correct
IAC0403	The sectional labour plan is correct
PA0401	Develop sectional (orchard) labour plans
PA0402	Estimate requirements
PA0403	Identify human resources shortages
PA0405	Determine labour requirements to achieve production objectives
PA0406	Plan utilisation and allocate human resources in order to achieve consistent production to meet production targets

Chapter 1
Integrated Pest Management Principles

learning outcomes

The content of this chapter is aimed at helping you to:

- Describe the principles of integrated pest management.

1. Citrus Pests

There are numerous insects and organisms that can be found in a citrus orchard. Some are beneficial, while others are considered pests. Most citrus pests are insects, but not all insects are pests. An insect becomes a pest for citrus production when it feeds at a vulnerable stage on the bud, blossom, fruit, branch, or leaf, leading to loss in marketable crops or damage to the tree.

A few examples of citrus pests are:

- Thrips that blemish fruit and cause deformation of young leaves
- Red mites that cause damage to older leaves and fruit
- Bollworms that feed on flowers and young fruit
- Fruit flies that lay eggs in the rind of ripening fruit. The eggs hatch and the larvae penetrate the fruit, where they feed and cause decay

In comparison with many other citrus producing countries, Southern Africa is plagued by many pest species. It is vital that the workers in your orchards are familiar with the different organisms so that they can report pests and keep an eye on the size of the pest populations. Successful pest control requires immediate action against pest populations before they are too high and damage to the fruit or plants too extensive.

2. The Impact of Pests on Citrus Production

The first important impact that pests have on production is the damage that certain pests cause to trees. This damage may result in lower yields or poor-quality fruit. It may even lead to damage that trees are unable to recover from, leading to the loss of productive orchards. The second important factor is the damage that can be caused to the fruit. As you know, the South African citrus industry is export oriented, and consumers in overseas markets require fruit of good external quality with very few blemishes.

Wind is a major cause of cosmetic damage on fruit, occurring when the twigs and branches of the tree scrapes against the fruit in windy conditions. The second major cause of external blemishes on citrus fruit are pests, such as thrips, which can be controlled much more effectively than wind. Certain pests, such as fruit fly, also influence the shelf-life of fruit and may cause accelerated decay.

Certain export markets also have phytosanitary barriers. Phytosanitary pests have particularly important implications for commercial citrus production and food safety. If any of your fruit is found to be infested with phytosanitary pests, that fruit cannot be exported to markets that have phytosanitary restrictions. This can mean entire consignments of fruit being rejected, and huge losses for your farm.

The term "phytosanitary" literally means "plant safe". Phytosanitary practices have to do with keeping the plants in importing countries safe by ensuring that pests that could be harmful to those plants are not introduced there through imported fruit. The most important phytosanitary pests for South African citrus producers are:

- False codling moth
- Carob moth (only for Asia)
- Mealybug
- Fruit fly

3. Pest and Beneficial Insects

definition

Pest Organisms

In agriculture, pest organisms are organisms that cause damage to livestock, crops, humans, or land fertility. Citrus pests are organisms whose feeding and / or reproductive habits lead to a reduction in the quantity and quality of the citrus fruit produced.

Beneficial Organisms

In agriculture, beneficial organisms are organisms that contribute positively by their habits, for example by feeding on pest organisms or by pollinating flowers to enable fruit development.

As we mentioned, not all insects are pests. Bees, for example, are beneficial organisms since they provide honey and pollinate flowers. There are also insects that attack citrus pests. Some organisms, like Aphytis and Comperiella wasps are parasites that lay their eggs in the pest red scale, eventually killing it, helping us with pest control. Chilocorus nigritus ladybird beetles are predators that feed on red scale and aphids. Beneficial organisms are often used as part of IPM in the form of biological control, which is discussed later in this material.

4. Pest Damage

Often, the most common way to know about pest activity is by finding the damage they cause instead of living organisms. The practice of scouting for damage is discussed in greater detail later in this material.

Pest damage can take many forms, including:

- Stinging
- Biting
- Sucking plant sap
- Egg-laying and feeding damage from larvae
- Rubbing or scratching marks
- Leaving access points for secondary insects or diseases
- Serving as a vector for other diseases

definition

Vector

A vector is an organism, such as an insect, that transmits disease-causing microorganisms from infected plants to other plants.

5. Integrated Pest Management

Integrated Pest Management, or IPM, is a system of pest control that uses a combination of all the different pest control approaches in a single approach. IPM aims to be a coherent, economical, sustainable, and environmentally sensitive approach. IPM is particularly built on the use of biological control (i.e. beneficial organisms) to provide more sustainable and cost-effective pest control than using purely chemical controls.

This means that implementing IPM requires a good knowledge of natural predator-prey or parasitoid-host relationships, and the factors that affect these relationships. These factors include climate, cultivar, tree age, time of the year and effects of pesticide use. This means that IPM requires a lot of knowledge, and a lot of experience, to build an effective monitoring and control system.

Unfortunately, chemical control is almost always necessary on top of biological control. There are no citrus producing areas in our country which consistently yield crops of export quality without using pesticides.

Despite this, you should generally aim to use biological control as the first and foremost strategy. In fact, chemical control can be so destructive to the environment and the populations of beneficial organisms that it may sometimes make financial sense to tolerate some economic damage from a particular pest rather than resort to chemical intervention.

Despite this complexity, a well-designed and implemented IPM system is very rewarding to citrus producers. Firstly, it can save money, especially in the long term, by saving on expensive chemicals and equipment and having to pay to fix the damage associated with their use. Secondly, less chemical usage and more environmentally friendly production practices are strong selling points for many markets, and may increase the value of your fruit or your market access.

6. Resistance Management

An important part of IPM is managing resistance. Resistance (in the context of pest control) refers to the fact that certain organisms build up a ‘tolerance’ for certain control methods, such as a certain pesticide. Basically, the more you use a certain pesticide to control a pest, the less effective that pesticide will be against other members of the same species on your farm in future.

This resistance forms because of genetic changes in the pest populations. A few members of the species will have a natural resistance due to genetic mutations. When the pesticide is used, all the members of the species without this natural resistance will die, leaving only those with the natural resistance to breed. Once they breed, their offspring share this resistance, and now your farm is populated with resistant pests.

If not managed properly, this resistance can make chemical control incredibly costly and ineffective, leading to a lot of wasted money, effort, and even possible losses in fruit quality or market access due to excessive pesticide use. As mentioned, IPM places a focus on managing this resistance, in a few different ways.

Firstly, you should rotate the pesticides you use, combining the use of different products with different modes of action. By using agrochemicals that target pests in different ways, it becomes harder for the pest population to adapt and survive to a specific chemical. The use of non-chemical control methods is also a main focus of IPM, and is discussed later in this material.

Monitoring and scouting is the backbone of IPM in general, and forms part of resistance management as you need to regularly monitor pest populations to detect early signs of resistance. Scouting and monitoring is discussed later in this material.

Next, you should aim to avoid sublethal doses. In other words, if you are using chemical controls, you should ensure they are applied at the correct dosage and according to manufacturer guidelines to be as effective as possible. Exposing pests to low levels of pesticides may help them build a resistance faster even without a natural genetic resistance.

Finally, pesticides should be seen as a 'last resort', and used in situations where the damage and costs associated are outweighed by the benefits. Usually, this is only where other control methods have failed to keep pest populations below damaging levels.

7. Recordkeeping

All production practices require good recordkeeping, especially in large export-oriented farms. This is especially true for IPM. As you will see later in this material, the backbone of IPM is good scouting and this requires good recordkeeping and data management to track pest population trends. Each citrus farm has its own recording system, depending on the size and nature of the data they handle.

Data collection, handling, and management are described in detail in other material in this qualification. In terms of IPM-specific systems, the aims of the recordkeeping system control should be:

- To keep track of monitoring dates.
- To keep track of orchards monitored on the specific dates.
- To keep track of the monitoring points within specific orchards on the specific dates.
- To record which staff member is involved in monitoring and scouting actions to ensure that the best staff members are used in terms of productivity and skill.
- To plan a strategy for recording population sizes of pests and beneficial organisms as well as their life-stages in order to react according to threshold recommendations and at the correct life-stage.
- To record all actions taken within specific orchards.
- To record follow-up monitoring actions after taking actions within specific orchards to determine the efficacy of the actions taken.

Without a well-structured and maintained recordkeeping programme, any decisions regarding pests controlled will be uninformed, and you won't be able to tell how effective the control measures taken were. You need to keep records and constantly evaluate to ensure the ongoing effectiveness of the IPM as well as to highlight areas where the system can be improved.

summary

Chapter 1 – Integrated Pest Management Principles

- Most citrus pests are insects, but not all insects are pests.
- An insect becomes a pest for citrus production when it causes a loss in marketable crops or damage to the tree.
- Pest damage may either lower the quality of damaged fruit, or limit the ability of the tree to produce fruit in the future.
- Phytosanitary means 'plant safe', and if any of your fruit is found to be infested with phytosanitary pests, that fruit cannot be exported to markets that have phytosanitary restrictions.
- Pest damage can include stinging, biting, sucking plant sap, egg-laying and feeding damage from larvae, rubbing or scratching marks, leaving access points and serving as a vector for diseases.
- A vector is an organism, such as an insect, that transmits disease-causing microorganisms from infected plants to other plants.
- Integrated Pest Management is a system of pest control that uses a combination of all the different pest control approaches in a single approach.
- IPM is particularly built on the use of biological control to provide more sustainable and cost-effective pest control than using purely chemical controls.
- Resistance refers to the fact that certain organisms build up a 'tolerance' for certain control methods.
- If not managed properly, resistance can make chemical control incredibly costly and ineffective.
- Pesticides should be seen as a 'last resort', and used in situations where the damage and costs associated are outweighed by the benefits.

assessment activities

- ✓ **Activity P1**: Complete this activity to test your knowledge of integrated pest management principles.

Chapter 2
Scouting

learning outcomes

The content of this chapter is aimed at helping you to:

- Supervise the scouting and identification of pests and beneficial insects.

1. Introduction

definition

Scouting

Scouting means observing orchard and plant conditions to gain information about the visible signs and symptoms of pests. It involves looking at strategic positions in orchards and recording pest numbers and disease symptoms.

The presence of pests in a citrus orchard is often detected by the damage caused to the citrus tree, the fruit and in the orchard. To detect the presence of these pests you need to scout orchards repeatedly in a structured and organised manner. These inspections should be regular, and could be done in conjunction with inspections for weed densities, and crop nutrient and water status.

Scouting is aimed at identifying the pest species that are present and the extent of infestation. If it is not possible to accurately identify the pest responsible for the damage that has been caused, an expert in the field (such as an entomologist) should be asked for assistance.

2. Pest Scouts

Successful scouting depends on the scouts you use to inspect the orchards. Scouts must have excellent vision, a positive attitude to their job, and a high level of training 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, you must keep your scouts informed of new developments and research findings in the field. For example, research may determine that a specific pest has spread to your area, in which case your scouts must be informed immediately to be on the lookout for it.

3. Scouting Procedures

Experienced scouts are often able to do what is referred to as an “impression survey”. This is a general examination of the orchard and the plant condition, and of the insects that are present. It gives the experienced scout a fairly accurate idea of the pest prevalence in the orchard. However, this is not always accurate and 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.

Scouting procedures normally include the following:

- Selecting permanent data trees
- Unit inspections
- Pest traps
- Cursory examinations
- Recordkeeping and reporting

4. Identification Techniques

Pest and disease-causing organisms can be identified in different methods. If the pest is large enough, it can be visually seen, and its life stage identified. Some of the problematic organisms, however, cannot be seen with the naked eye and assistance is sometimes required in identifying the organism.

Identification techniques can be categorised as:

- Macroscopic
- Microscopic
- Chemical

Macroscopic techniques refer to large insects that can be seen without assistance such as a microscope. That said, the aid of a hand-held lens is often used by pest scouts to identify the insect more clearly, categorise its life stage accurately and to determine the insect's sex.

Microscopic techniques are used for pest or disease-causing organisms that can't be seen without the assistance of a microscope. Microscopic identification is often called for to confirm that the organism suspected of causing the damage or disease symptom is in fact accurate. Microscopic identification requires skill of laboratory techniques and often requires the expertise of specialists.

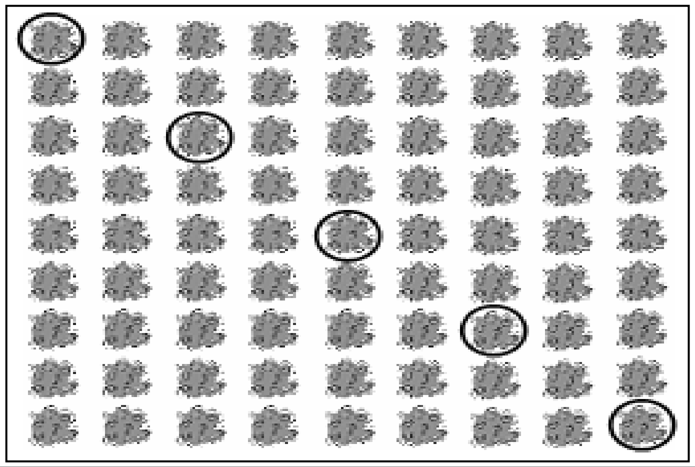
Some laboratory techniques require specific chemical stains to identify the micro-organism. These colour the organism or react with the organism which verifies its identity. This is only really performed for disease identification, not pests.

5. Selecting Permanent Data Trees

Permanent data trees are specific, representative trees in each orchard or block from which your scouts will collect data during every inspection. The number of trees per orchard or block depends on the size of the orchard or block, with five trees per hectare as the general recommendation.

Assumptions about the pest status of the entire orchard or block are made based on the data collected from the permanent data trees. They must therefore be representative of the general conditions in the orchard.

Trees can be selected diagonally across the block, starting with a tree in one of the corners as shown below.



Permanent Data Tree Selection

In larger orchards, the trees can be selected along a V- or W-shaped path. Numbered markers should be fixed to the permanent data trees so that they are easily recognisable.

Apart from permanent data trees, scouts should be aware of specific areas of the orchard that are more vulnerable to infestation of specific pests. Thrips and false codling moth are for example more prevalent in areas close to windbreaks, especially if silky oak is used as windbreak trees.

6. Unit Inspections

"Unit" in the context of scouting refers specific plant parts, such as terminal twigs, leaves, fruit, blossoms, or new growth clusters. Therefore, a "unit inspection" is when a scout inspects a type of unit on a permanent data tree for pest damage. The unit that will be used depends on the pest that is being scouted for. As a rule, ten units per tree are inspected, and the presence or absence of the pest is recorded on the scouting form.

It is important that scouts are properly equipped for unit inspections. Generally, scouts inspect trees with the naked eye. It is however necessary to equip your scouts with magnifying glasses to do microscopic evaluations where more information is required. These microscopic inspections are very useful for determining, for example, whether scale insects are alive or dead, or the level of parasitism of scale insects. Microscopic inspections also allow you to get a more accurate indication of infestation levels of very small insects, such as mealybug crawlers underneath the calyx and silver mite.

7. Scouting Frequency

The frequency of scouting will vary between farms and production areas, but scouting will usually occur at specific intervals for specific periods of time. Your scouting plans should be created before the season starts, ideally for the whole year ahead. This lets you build a consistent set of scouting data, and ensure that the correct procedures are followed.

It is important to remember that additional scouting may be needed, especially as a follow-up procedure after a control method has been implemented. This post-control scouting is necessary to determine whether your control method has been effective or not. The effectiveness of control methods is determined through scouting by seeing whether the population size of the targeted pest is in fact decreasing and if the control action has been effective.

8. 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 area on a regular basis, because they will be in a better position to recognise new damage.

Old damage is 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 through old scars, which may include scar tissue on the branches or trunks of the trees. 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, disease or animal causing the damage becomes a major problem.

9. Timing of Symptoms

Certain symptoms of pest activity occur at specific points in the production cycle or at a specific time of the year. This may be because climatic conditions have become favourable for the emergence of that specific pest, or because the plant has reached a point in its growth cycle where the fruit or flowers are attracting specific types of insects.

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

- Chewing and sucking insects will most likely be found when the plant part which they feed on is still young and tender.
- Stinging and egg-laying insects are usually found after the fruit has already formed. Their larvae can however occur at any time, normally when the plant part on which they feed appears.
- Vector insects appear unpredictably.

Because climatic conditions have an impact on the occurrence of pests, it is important that these records are also kept and consulted when scouting. Records about the development of the plants, for instance containing information on when flowering commenced, will aid further in predicting the occurrence of pests.

10. Assessing the Impact of Pest Damage

As discussed previously, the damage caused by pests has a significant economic impact on the profitability of a citrus farm. It is however necessary to be able to assess when damage may lead to economic losses. We have already seen that pests and diseases attack various parts of the citrus plants. In terms of short-term economic losses, damage done to the fruit is the most significant factor.

Pests that cause cosmetic damage that may render fruit non-exportable include red scale and thrips, while phytosanitary pests that may render fruit non-exportable include false codling moth and fruit fly. Pests also cause damage that may lead to economic losses in the longer term. These are more notably the pests that attack the tree and negatively impact on its ability to produce fruit.

Threshold values, also referred to as action levels, have been established for most pests, and indicate the pest density at which suppression measures should be implemented to prevent the pest population from reaching the economic injury level. Threshold values are expressed in different ways, e.g., pest per square cm, insect per trap, etc. Below is an example of threshold values.

example

Treatment Thresholds - Citrus Thrips

Below are the suggested intervention thresholds for citrus thrips on citrus fruit. To prevent more than 1% cull, treatments should be applied when these numbers are exceeded.

Damage Risk Period	***Mean Infestation Over 1 Week***		***Mean Infestation Over 2 Weeks***	
	Fruit with Larvae (%)	**Fruit with Adults or Larvae (%)**	**Fruit with Larvae (%)**	**Fruit with Adults or Larvae (%)**
Petal Fall - 4 weeks	2	4	1	2
5-6 weeks	3	6	2	4
7-8 weeks	4	8	3	6
9-10 weeks	5	10	4	8
11-12 weeks	6	12	5	10

11. Pest Traps

Traps are another common form of scouting. There are a bunch of different traps that can be used to monitor insect populations, and many have been developed for specific pests. Traps usually contain substances that attract specific pest insects, where they are then caught and retained.

During regular scouting, your scouts will open the traps and count and record the number of insects inside. Where and how traps are placed in the orchard is done according to the manufacturer's instructions.

12. Cursory Examinations

Along with the unit inspection, cursory examinations of the trees are performed to gain a general impression of the populations of beneficial and pest insects. For example, the presence of insects such as ants will be noted during this examination.

13. Recordkeeping and Reporting

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

example

Scouting Form

Name:						**Orchard:**						
Pest:						**Date:**						
Fruit / Leaves / Twigs												
		Inspection Unit										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Totals**
TREE NUMBER	**1**											
	2											
	3											
	4											
	5											
	6											
	7											
	8											
	9											
	10											
General Observations:												

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

summary

Chapter 2 – Scouting

- ✓ Scouting means observing orchard and plant conditions to gain information about the visible signs and symptoms of pests.
- ✓ Scouting is aimed at identifying the pest species that are present and the extent of infestation.
- ✓ Scouts must have excellent vision, a positive attitude to their job, and a high level of training to understand the principles of scouting so that results are not biased.
- ✓ Scouting procedures normally include selecting permanent data trees, unit inspections, pest traps, cursory examinations and recordkeeping and reporting.
- ✓ Pest identification techniques can be categorised as macroscopic, microscopic and chemical.

- ✓ Permanent data trees are specific, representative trees in each orchard or block from which your scouts will collect data during every inspection.
- ✓ A "unit inspection" is when a scout inspects a type of unit on a permanent data tree for pest damage.
- ✓ The frequency of scouting will vary between farms and production areas, but scouting will usually occur at specific intervals for specific periods of time.
- ✓ An important aspect of scouting is distinguishing between old and new damage to the plant.
- ✓ Traps usually contain substances that attract specific pest insects, where they are then caught and retained.

assessment activities

- ✓ **Activity P2**: Complete this activity to test your knowledge of scouting.

Chapter 3
Control Measures

learning outcomes

The content of this chapter is aimed at helping you to:

- Select appropriate control methods for an IPM plan.

1. Pest Control

Traditionally the first, and in most instances, only control measure, that producers used for pest control was the chemical method. This has proven over time to have a negative effect on the environment in general and the production unit specifically. To ensure long-term success of the farming operation, producers began to realise that they have to start looking at different measures to control pests.

In this chapter we look at the different control measures that are available to the modern citrus producer. These measures are not only more environmentally friendly but can also save producers costs in the long run. Once you understand the principles behind IPM, it becomes important to examine how these principles can be applied.

In IPM, the emphasis is on control, not eradication. It is almost always impossible to wipe out an entire pest population permanently, and attempting to do so can be more costly than it is worth, environmentally unsafe, and all-round counterproductive. It is far better to decide on what constitutes acceptable pest levels and apply controls until those levels are reached.

2. Different Control Methods

The three general approaches available for managing pests of citrus are categorised as:

- Biological control
- Cultural control
- Chemical control

The first two are preventative in nature and may have more impact on long-term production, while chemical control provides short-term relief or prevention from pest pressure. Let's discuss each of these three control methods in detail.

3. Biological Control

Biological control refers to methods of controlling agricultural pests that focus on the reduction of pest populations by natural enemies and typically involves an active human role. In other words, biological control relies on the use of beneficial organisms to control pests. Beneficial organisms in this case refers to natural enemies of citrus pests. These beneficial organisms are also known as biological control agents, and include predators, parasitoids, and pathogens.

Below is a list of the important beneficial biological control agents in citrus:

information

Beneficial Organisms

Host (The Pest)	Organism (The Predator)
Mealybug	Anagyrus (Parasitic wasp)
Red scale, circular purple scale, mussel scale	Aphytis (Parasitic wasp)
Soft scales	Coccophagus Semicircularis
Red scale	Comperiella Bifasciata (Predatory wasp)
Citrus mealybug	Coccidoxenoides (Small wasp)
Red scale, circular purple scale	Chilocorus Distigma (Ladybird)
Red scale	Chilocorus nigritus (Ladybird)
Red scale, mealybug, psylla, aphids, mites	Chrysoperla pudica (Green lacewing)
Mealybug	Cryptolaemus Montrouzieri (Ladybird)
Thrips, mite pests	Euseius spp (Predatory Mite)
Mealybug, scale, aphids, occasionally mites	Exochomus spp (Predacious ladybird)
Circular purple scale, red scale	Lindorus Lopanthae (Predatory beetle)
Australian bug	Rodolia spp (Vedalia beetle)
Pest mites	Stethorus spp (Stethorus beetle)
Citrus thrips, lepidopteran eggs, mites, possibly scale crawlers	Orius Thripoborus (Predatory bug)

3.1. Parasitoids

definition

Parasitoids

Parasitoids are organisms with young that develop on or in another organism, eventually killing it.

The parasitoids we are concerned with are mainly wasps that lay their eggs in or on their hosts, resulting in the larvae that feed on the host and kill it off in the process. Some female wasps also puncture their host while laying eggs and consume the escaping body fluid, resulting in the host's death.

This group of biocontrol agents consists primarily of small hymenopteran wasps. These wasps may lay one or more eggs within a single host, after which the larvae then feed on the host, killing it in the process. One or more larvae may develop inside a single host. Each parasitoid larva therefore kills no more than one host, unlike predatory larvae that eat many prey individuals. After pupating, the adult parasitoid emerges.

The lifespan of adult parasitoids is generally short, ranging from only a few days to several weeks. Some newly emerged parasitoids must first mate before they commence parasitizing their hosts, whereas others do not require mating and may commence laying eggs in hosts as soon as they emerge from the pupal case.

Parasitoids have particularly acute senses for mate- and host-location. This makes them especially efficient at locating individual hosts even when the pest population level is very low. This behavioural attribute often results in parasitoids being capable of maintaining stable pest populations at low levels.

Some parasitoids are less effective at controlling higher population levels associated with pest outbreaks (e.g., Aphytis) and in such instances predators become more important (e.g., Chilocorus nigritus). There are, however, instances where parasitoids are capable of rapidly bringing exceedingly high pest population levels under control (e.g., mealybugs).

Parasitoid population levels and their efficacies may be reduced by several factors, some not under the grower's control. Temperature extremes, particularly hot conditions together with low relative humidity, can be very detrimental to some biocontrol agents, whereas the pest may be less sensitive. Parasitoid populations can also be reduced by the activity of hyper-parasitoids which parasitize the immature stages of the primary parasitoids.

Dust can also be very detrimental to parasitoid populations. Fine dust is believed to abrade the insect's integument leading to desiccation and death. Red scale population outbreaks adjacent to dusty roads can often be attributed to dust and every effort should be made to reduce this factor.

Most parasitoids are difficult to identify for untrained individuals, so it is important that IPM managers can at least identify the most common species broadly. It is also important for them to develop an understanding of the potential control that may be expected from various population levels of these natural enemies, something which can only be acquired through experience.

3.2. Predatory Insects and Mites

Ladybird beetles are important biocontrol agents of numerous citrus pests, consuming many prey individuals in both adult and larval forms. Adult beetles are good fliers and like parasitoids can locate small, isolated patches of prey over long distances. Larvae are mobile and generally voracious feeders. The excellent dispersal ability of the beetles means that reservoir populations from outside orchards can play a vital role in providing control of pest outbreaks within the orchard.

3.3. Sterile Insect Technique (SIT)

Though not widely practiced in agriculture, a biological control method to take heed of is the Sterile Insect Technique. SIT is the first insect pest control method that uses genetics. It is most simply described as a form of insect birth control that is carried out on an area-wide basis.

The SIT involves mass breeding huge quantities of target insects in a factory or insectarium and sterilizing the males by exposing them to low doses of radiation. These sterile males are then released by air over infested areas, where they mate with wild females. If the sterile males vastly outnumber the fertile wild males, the wild population quickly dies out. The proportion of infertile males to fertile wild males must be at least 10:1.

The sterile males compete with the wild males for female insects. If a female mates with a sterile male, then it will have no offspring, thus the next generation's population is reduced. Repeated release of insects can eventually wipe out a population, though it is often more useful to consider controlling the population rather than eradicating it.

4. Cultural Control

Cultural control refers to control methods which aim to make the environment (in your case, a citrus farm) less suitable for pests to live in. Cultural practices can contribute both directly and indirectly towards the control of citrus pests.

A common method of cultural control is increasing plant diversity in your orchard, which can reduce the susceptibility of your citrus trees to pests. This is because increased plant diversity can increase populations of natural beneficial organisms, and provide alternative food supplies for pests.

This increased diversity can be achieved using natural ground cover, windbreak trees, other natural vegetation and possibly the use of catch crops. Other production practices can have an effect on the pest population within an orchard or the ability of the tree to withstand pests. This includes practices such as irrigation, orchard sanitation, and pruning, among others.

There is still much to be learnt about cultural control practices but in the meantime, it is recommended that growers adopt as many of the different techniques as possible because few disadvantages are known. As most cultural control advantages are associated with natural enemies, they can be beneficial only where biological control is practised.

Let’s discuss a few common cultural control practices:

4.1. Ground Covers or Cover Crops

The presence of flowering plants (weeds) between rows of citrus has been shown to be beneficial by CRI entomologists. This can largely be attributed to the pollen and/or nectar being utilised as food by natural enemies. Ground cover can also play a key role in hosting alternative prey for beneficial predators such as lacewings, ladybird beetles and predatory mites. Most of these prey species are not citrus pests.

More and more growers are allowing natural plant growth between rows of citrus trees in orchards, which aims to bind loose soil and prevent erosion by wind. It also serves to stabilize orchard temperatures and increase relative humidity. Traditionally, this ground cover would be mowed frequently during the wet season, partially nullifying the benefit of flowering plants.

However, by leaving an unmown strip approximately 1m wide down the middle of the inter-row area, the benefits of the flowering plants can be maximized while maintaining easy access to the citrus trees and reducing root competition. Climate obviously plays a significant role in the survival of any plants in the orchard.

In general, uncultivated plants will survive during the summer in the summer rainfall areas without irrigation, while in the winter rainfall areas broad-leafed plants will only survive on incidental irrigation.

Fortunately, it is not necessary that you have continuous ground cover over a whole orchard to promote natural enemies and other beneficial organisms. Whether specific cover crops are more advantageous than natural mixed ground cover requires further research. Attention will also have to be given to possible disadvantages of ground covers such as effects on fertilizer requirements and the possible harbouring of pests.

4.2. Windbreaks

Windbreaks are trees planted in the orchard to break the force of wind and prevent damage to fruit and citrus trees. Little is known about other relationships between windbreak trees and citrus pests, although the following observations have been made:

- FCM females often prefer protected parts of orchards in the vicinity of large natural or cultivated trees for egg laying. The absence of such protection, however, does not prevent infestation by this pest.
- Chinese poplars can be infested by red scale. Few cases of infested citrus trees adjoining the poplars have been found. This red scale can therefore be of benefit to biological control in the citrus orchard by serving as hosts for natural enemies without the hazard of red scale infestation from the windbreak trees.
- In the USA, signs of less soft brown scale and more positive parasitism have been noticed in citrus trees adjoining windbreak trees.

4.3. Relative Susceptibility of Citrus Cultivars

There are many differences in the relative susceptibility of different cultivars to pests, and unfortunately the reasons for this are mainly unknown. It is worth discussing with your nursery or an expert about the specific susceptibility of your specific cultivars to pests in your areas.

4.4. Irrigation/Fertilization

It is generally accepted that a physiologically healthy tree can resist damage by pest organisms better and recover faster than trees subject to water or nutritional stress. Research in California has shown that the economic threshold for red mite on citrus trees can be raised significantly if water stress in the infested trees can be prevented. This can allow natural enemies more time to suppress the mite infestation and, in doing so, perhaps remove the need for chemical control.

4.5. Orchard Sanitation

Orchard sanitation is an important part of cultural control. It is very important that you collect and destroy dropped fruit in your orchards. Often, larvae of pests (such as fruit fly maggots) do not leave the fruit before it has fallen. Thus, if you pick up the fruit before the larvae inside has had a chance to mature and escape, you will limit pest population growth. Surveys have shown that approximately 70% of all ripe in-season fruit that drops at the end of winter are infested with FCM. This also applies to out of season and late hanging fruit of other cultivars.

4.6. Dust

Dust can have a large effect on pest populations, as dust can cause the absence of natural enemies, leading to booms in pest populations. This is probably the result of the abrasive (scratching) action of dust on the bodies of actively moving natural enemies.

Loamy and clay-containing soils are easily turned into a fine dust by excessive vehicle movement, and this quickly forms a layer on adjoining trees. Certain types of soil, such as sand, are sometimes regarded as coarse enough to prevent dust, but even in such cases there is often room for improvement. This problem can be addressed in several ways with a systematic dust suppression programme.

When new orchards are planned, access roads to farm buildings, etc. which are often visited, must be located as far away as possible. In the case of existing orchards and adjoining roads, attempts must be made to re-route such roads. Dust roads between orchards must only be used by vehicles servicing those orchards.

A dust-limiting upper layer of gravel can be spread over dust roads. Limestone can also be worked into the top layer of dust roads containing a high clay content. Lime can bind to clay to form flakes which do not break up into dust with traffic. Several chemical products are available which can be applied to the roads to bind the upper layer. A by-product of coal, i.e., carbon oxyhumates, can be applied to dust roads as a liquid. It is also available as a solid which can be applied as a suspension in water. Although the treated surface deteriorates due to traffic, binding reoccurs when wetted.

Used lubricating oil can also be used to limit dust. Although this method works well, it is not environment friendly. The use of windbreaks to protect orchards from wind damage, can also double up as a barrier against excessive dust from outside the orchard. Care must be taken to ensure that this barrier is placed between the road and the orchard.

5. Chemical Control

Chemical control was originally the most common method of pest control, and is still necessary at times. However, it is important that you think of chemical control as a last resort, only to be used if all other control methods fail. Of the pesticides registered for citrus, some are specific in their range of pests controlled while some are non-specific.

Choosing the proper chemical requires you to be familiar with product labels and performance. The most important factor to consider is the efficacy of the product against the target pest. Product efficacy refers to the 'effectiveness' of the chemical in killing pests, compared to the performance of other similar products.

Characteristics influencing efficacy include the time required for the product to gain control, the amount of residual control and the spectrum of pests controlled. Knowledge of individual product characteristics is important when choosing the most appropriate pesticide. Residual action may or may not be a desirable quality depending on circumstances. Long-residual pesticides also may reduce the effectiveness of beneficial organisms.

Other factors to consider when selecting a chemical include:

- Cost effectiveness.
- Hazard to beneficial and other non-target organisms.
- Potential hazards to applicators, environment, orchard, or fruit crop.
- Limitations or restrictions on application.
- Impact on development of pest resistance.
- The Maximum Residue Levels specified by importing countries.

When comparing the cost effectiveness of different pesticides, you should factor in the kill rate, length of action, and cost per hectare. Also, a certain pesticide may kill beneficial organisms as well, and it may take an investment to reestablish these populations. Therefore, cost effectiveness must consider cost of pesticide per fruit produced or income received, and is best calculated over a period of at least one season, preferably longer.

When new products come on the market, it is recommended that you approach them with caution. It is easy to fall for marketing and sensational headlines saying that a new product is a cure-all, but you should wait to get reports on its usage from unbiased research bodies and other growers. If you do choose to trial a new product, it should only be used on single orchards of citrus species or cultivars to see how it compares with options in current use.

Mating disruption (MD) involves the use of pheromones, i.e., the chemicals produced by an insect which evoke a specific response in the other individuals of the same species. MD aims to prevent male and female insects from encountering each other. When a specific pheromone is released in the air in an orchard, the males are unable to orient to natural sources of pheromone and fail to locate the calling female and is thus unable to reproduce.

summary

Chapter 3 – Control Measures

- Traditionally the first, and in most instances, only control measure, that producers used for pest control was the chemical method.
- In IPM, the emphasis is on control, not eradication.
- The three general approaches available for managing pests of citrus are categorised as biological control, cultural control, and chemical control.
- Biological control refers to methods of controlling agricultural pests that focus on the reduction of pest populations by natural enemies and typically involves an active human role.
- The parasitoids we are concerned with are mainly wasps that lay their eggs in or on their hosts, resulting in the larvae that feed on the host and kill it off in the process.
- Parasitoid population levels and their efficacies may be reduced by several factors, some not under the grower’s control, such as climatic factors.
- Ladybird beetles are important biocontrol agents of numerous citrus pests, consuming many prey individuals in both adult and larval forms.
- SIT involves releasing sterile males into the environment to act as birth control.
- Cultural control refers to control methods which aim to make the environment (in your case, a citrus farm) less suitable for pests to live in.
- Orchard sanitation is an important part of cultural control. It is very important that you collect and destroy dropped fruit in your orchards.
- Chemical control should be used as a last resort, only to be used if all other control methods fail.
- The most important factor to consider is the efficacy of the product against the target pest.
- When comparing the cost effectiveness of different pesticides, you should factor in the kill rate, length of action, and cost per hectare.
- Mating disruption aims to prevent male and female insects from encountering each other.

assessment activities

- ✓ **Activity P3**: Complete this activity to test your knowledge of control methods.
- ✓ **Activity F1**: Complete this activity to test your knowledge of the entire module.