

## THE PEST COMPLEX AND CONTROL OPTIONS

### 1 INTRODUCTION

As fresh fruit producers, southern African citrus growers have to deal with a range of pests that are threats to external fruit quality and/or yield. In certain instances, pest infestation in the orchard is responsible for increased fungal decay during the long journey to overseas markets. Furthermore, certain pests are considered phytosanitary threats by some countries.

The recorded list of pests attacking southern African citrus is a long one. In these recommendations 34 pests or pest groups that are most likely to be of commercial importance in the major citrus production areas are discussed. Some basic information relating to these pests is summarised in Tables 10.1 to 10.3 (Chapter 10).

The false codling moth, *Thaumatotibia leucotreta* (Meyrick) is a regulated pest for the European Union and as that market is the single largest market for South African export citrus, the management of that pest is critical. However, from an IPM viewpoint the citrus thrips, *Scirtothrips aurantii* Faure, can be considered a key pest in the northern areas because the means by which this pest is controlled largely determine the extent to which biological control can be used to control other pests in the complex. Red scale, *Aonidiella aurantii* (Maskell), can also be placed at the core of the pest complex by virtue of: (a) the threat it presents to tree and crop, (b) the costs and hazards involved with its control, and (c) the influence of its control on other pests. The pest control strategies used for citrus thrips and red scale are often responsible for elevating the pest status of mealybugs to one of the key pests during late summer due to disruption of biocontrol.

### 2 THE CONTROL OPTIONS

In these guidelines reference is made to biological control options, cultural options and registered plant protection products for the control of individual pests.

### 2.1 Biological control options

Biological control options rely on a close relationship between pest and natural enemy to achieve results of commercial significance. Natural enemies need to achieve a balance with their specific hosts, and because they are living organisms subject to the vagaries of climate, as are the hosts, their relationship with the host will have a certain fragility. This means that natural enemies may not always be able to prevent the development of commercially significant host populations and damage during a season. As a result, the relationships between pests and their natural enemies must be monitored frequently. This is the responsibility of the grower and his immediate advisors. Sensitivity to what is happening in the orchard cannot be achieved overnight. Developing an understanding of natural relationships and the means of fostering them is a growth process which ideally should be approached on a proportionate basis as is advocated for chemical options. It also needs to be accepted that plant protection products may have to be resorted to when the export quality of crops in such plantings is threatened.

Biological control may be seen as consisting of three major components, namely classical biological control, conservation of biocontrol agents and augmentation. **Classical biological control** (CBC) relies on the co-evolution of the host plant, pests and their natural enemies over long periods. Many pests originate from outside of southern Africa. The co-evolved natural enemies of particular pests often do not accompany the pests when first introduced into southern Africa.

Many indigenous biocontrol agents adopt new pests as their host or prey, but they seldom provide adequate control because they have not evolved in association with the pest insects. In CBC an attempt is made to restore the natural balance between plant, pest and its natural enemies by also introducing the relevant biocontrol agents from areas where the pest originated. The aim of CBC is to permanently establish these introduced biocontrol agents and consequently, reduce the status of the pest below an economically damaging threshold. These translocations are strictly controlled to ensure that they are ecologically safe and as such provide the most sustainable, cost-efficient

and environmentally sound solution to pest problems.

Unfortunately, CBC does not provide a solution to all pests since endeavours to find an appropriate biocontrol agent in the area of pest origin may be unsuccessful, the pest may be better adapted to its new environment than its biocontrol agents, or the pest may be an indigenous organism which has adopted citrus as a new and favourable host. Furthermore, the need to routinely resort to chemical intervention for the control of other pests may compromise the efficacy of the biocontrol complex.

**Conservation** of biocontrol agents relies on the cultural control practices described below and the minimisation of the effect of plant protection products on an existing biocontrol complex. Judicious selection of plant protection products to be used goes hand in hand with limiting reliance on chemical intervention to instances where it is essential to avoid financial losses.

**Augmentation** of critical components of the biocontrol complex relies on the timely release of insectary-reared biocontrol agents. This technique is only available for certain pests in the southern African citrus industry but it potentially offers a highly attractive, sustainable and environmentally acceptable component of an IPM strategy. This step from passively allowing the biocontrol complex to realise its inherent pest control potential, to actively manipulating the population dynamics of particular biocontrol agents, is what characterises bio-intensive IPM. Commercial insectaries currently supply parasitic wasps for the control of citrus mealybug, red scale and false codling moth, and predatory beetles for the control of mealybug and red scale.

Certain basic principles of natural enemy augmentation need to be implemented in order to enjoy success with this approach. These natural enemies must be released into an orchard environment that is suitable for their survival. Augmentation of parasitoids cannot be used to correctively control high pest levels. Parasitoid augmentation is a preventative approach, and therefore releases should be initiated as early as possible in the season. Releases should be conducted approximately monthly and should continue for a few months, Vol. III, Chapter 2: Supporting Information for IPM

preferably until parasitism of the target pest is at an acceptable level. Predators can more easily be released correctively against high levels of pest infestation. Through research, recommended release densities of certain natural enemies have been determined. These densities can be obtained from the insectaries or the appropriate expert. Pest control achieved through natural enemy augmentation is gradual. It is therefore necessary that intensive monitoring of the target pest, and if possible its natural enemies too, is continued until it is clear that the pest is under good biocontrol.

## 2.2 Cultural control options

Cultural practices can contribute both directly and indirectly towards the control of citrus pests. By increasing plant diversity, the susceptibility of the main crop can be reduced, populations of natural enemies can be increased and alternative food supplies for natural enemies can be provided. This increased diversity can be achieved through the use of natural ground cover, windbreak trees, other natural vegetation and possibly the use of catch crops. Other operational systems can have a direct bearing on the pest population within an orchard or the ability of the tree to withstand pests. Topics in this category include irrigation, orchard sanitation, pruning, suppression of dust and reducing detrimental effects from adjacent non-citrus crops.

Details on the above cultural practices are given below in this chapter. Recommendations for specific pests are addressed under each pest in Chapter 3.

## 2.3 Registered product options

More information on plant protection product options mentioned in these recommendations can be obtained from AgrilIntel <https://www.agri-intel.com/>.

**From time to time new options are registered in terms of Act 36 of 1947. It is recommended that growers approach the use of all new product options on a proportionate basis even when they are reported to be "breakthroughs" for the control of one or more key pests. This means that during the initial season of usage a new option should**

**be applied only to single orchards of particular citrus species or cultivars to see how it compares with options in current use. The proportionate concept is primarily intended to clarify the potential of a new option to cause repercussions from other pests. These could result from effects on natural enemies or reduced impact on certain pests routinely controlled by options in current use on the farm concerned.**

One feature that unites all the product options is that, to reduce the hazard potential of pest populations, they must be applied **within their registered format.**

### **3 INTEGRATED PEST MANAGEMENT**

IPM incorporates a harmonious combination of all the pest control approaches mentioned above into a coherent, economically attractive, sustainable and environmentally sensitive strategy. The basis on which an IPM system must be built is an appreciation for the ability of a particular level of biocontrol activity to provide economic control of a pest in a highly complex ecological relationship. The predator-prey or parasitoid-host relationship is extensively affected by extraneous factors such as climate, cultivar, tree age, time of the year and effects of pesticide use. This requires, in addition to a great deal of expertise and experience, the implementation of an effective monitoring system and the use of traps and intervention thresholds.

The nature of the general pest complex is such that there are no citrus producing areas in which orchards can consistently yield crops of export quality in the total absence of treatment with registered pesticides. In most cases, the more that can be done to achieve biological control of the key pests, the more opportunities will be created for the biological control of other pests. This will need to be achieved while maintaining the control of pests which are less amenable to biological control, with the aid of registered products. It may sometimes make financial sense to tolerate some economic damage from a particular pest rather than resort to chemical intervention which disrupts the biocontrol complex of other pests resulting in the need to resort to further pesticide use.

The rewards for implementation of an IPM system are multiple. Firstly, cost efficiency of production, when calculated over several years, has been found to be marginally improved with implementation of IPM. IPM incorporates both resistance management and the minimisation of environmental impact, ensuring the pursuit of long-term sustainability. Worldwide recognition of IPM as the basis for good agricultural practice has made implementation of IPM a basic requirement for continued acceptance of citrus on the world market.

### **4 RESISTANCE MANAGEMENT**

A strategy which works hand in hand with IPM is pesticide Resistance Management (RM) because the reduction of pesticide use in an IPM programme is the most effective strategy for reducing the development of resistant pests. An RM strategy is becoming increasingly important as the number of available pesticides suitable for IPM diminishes due to more stringent residue restrictions and increasing development costs. The use of IPM-compatible pesticides must therefore be sustained for as long as possible.

#### **4.1 The status and development of resistance in arthropods**

There are now more than 500 species of arthropods throughout the world which have developed resistance to at least one pesticide. This resistance includes products such as Insect Growth Regulators (IGRs) and microbial pesticides such as Dipel, which at one stage were thought to be immune from this problem. Resistance develops in a pest population by the process of natural selection. This means that in the environment where the pesticide is being used, the fittest individuals will survive. Unless immigration of susceptible individuals occurs, or mortality due to a non-pesticide-related factor occurs, tolerance to the pesticide in use will increase. Extreme development of tolerance which can be attributed to a genetic change in the population is described as resistance. There are many more cases of resistance being controlled by a single gene (monogenic) than there are cases where several genes are involved (polygenic). Unfortunately, the monogenic resistance develops and spreads more rapidly. Resistance develops faster under the following conditions:

- Shorter life cycles.
- Little immigration of susceptible individuals.
- Increased intensity of pesticide use.

As growers have little influence over the length of the life cycle and rate of immigration, they must concentrate on the intensity of pesticide usage to slow the development of resistance.

## **4.2 Intensity of pesticide use**

### **4.2.1 Application frequency**

The more often the same, or a closely related pesticide is applied, the more rapid is the selection of resistance towards that pesticide or pesticide group.

### **4.2.2 Proportion of population exposed**

If only part of the population is exposed to the pesticide and susceptible genes are maintained in the non-exposed portion of the population, the development of resistance can be slowed. This is most likely to occur with short-residual pesticides applied to the outside canopy or where spot sprays are used. The term **refugia** is used to describe places where arthropods are not exposed to pesticide.

Certain life stages are more susceptible to pesticides than others. If the most susceptible life stage is targeted the treatment will be most effective and there will be less need to reapply the treatment. This also makes good IPM sense because a lower dosage may be able to be used and non-target effects on natural enemies can be minimised. This strategy is essential for most IGR products and Dipel, but could also apply to the use of more conventional pesticides against pests such as scale insects.

### **4.2.3 Dosage**

Dosage is a controversial topic in RM because it can have different effects depending on the genetics involved and the environment in which the pesticide is used. In most cases, RM strategies must be developed without knowing the genetics involved in resistance. In all cases

of monogenic resistance and in a few cases of polygenic resistance where one gene plays the major role, low doses select more slowly for resistance than higher doses so the lowest registered dose should be used. In a closed environment such as a greenhouse where natural enemies are of no concern and material costs are relatively low, an extremely high dosage of pesticide can stop the development of resistance when the dose is high enough to kill all the pests with resistant genes (assuming 100% coverage). In citrus orchards this technique is impractical because the dosage required would be too expensive, it would eliminate all natural enemies, 100% coverage would be impossible and it may select for resistance in other pests. The use of moderately high dosages of 2-4 times the lowest registered dose will accelerate the development of resistance because these dosages more effectively select for resistant individuals.

### **4.2.4 Residue Persistence**

A pesticide with a persistent residue has the same effect as several applications of shorter residual pesticides in that pests are exposed to it for a long period of time and therefore more opportunity exists for the selection of resistant individuals.

## **4.3 RM strategies which exclude IPM**

### **4.3.1 Pesticide Mixtures**

The mixing of pesticides that are equally persistent and belong to different groups can be used as a strategy to delay the development of resistance. However, the results can be variable, there is a chance of developing cross resistance between the groups used and mixtures are more detrimental to natural enemies.

### **4.3.2 Rotation Or Alternation**

The strategy of rotating or alternating pesticides assumes that the resistant individuals are less fit when there is no selection pressure and that there is no cross or multiple resistance between the pesticides used. Once again the pesticides to be rotated or alternated must belong to different groups (see <https://www.irac-online.org/modes-of-action/> or download the



IRAC MoA app). This strategy does slow the development of resistance where it is caused by mixed function oxidases but it is less effective against knockdown resistance and mechanisms involving acetylcholine esterase.

#### 4.3.3 Mosaics

The strategy of mosaics is equivalent to geographic rotation where different pesticides are used in different orchards or parts of the farm from year to year.

This is most effective against less mobile pests such as scale insects.

#### 4.4 RM and IPM

Natural enemies are usually more susceptible to pesticides than pests. Two theories have been proposed to explain this phenomenon and they are probably both applicable. The **preadaption hypothesis** states that herbivorous pests have to detoxify plant defence chemicals and are therefore preadapted to detoxify pesticides. The **food limitation hypothesis** states that the pesticides kill the prey and reduce the amount of food for natural enemies which then die or emigrate, whereas resistant prey have an abundant food source without natural enemies.

Apart from these theories, it has become evident that the Hymenoptera, which include most insect parasitoids, are the least likely of the insect orders to develop resistance. This may be partly due to the fact that most parasitoids and predators are more mobile than their hosts or prey and therefore come into contact with more pesticide residues. Furthermore, predators consume numerous prey individuals, each of which may contain sub-lethal concentrations of pesticides. The predator is consequently exposed to far higher pesticide levels than individual prey is.

#### 4.5 Optimising RM and IPM

Tabashnik (1989) stated that “Reducing pesticide use through IPM is more productive than any other RM strategy”. The following recommendations will optimise RM and at the same time promote IPM.

- Use treatment thresholds where possible

and treat the most susceptible life stage.

- Use the lowest registered dosage, or less if effective, to reduce selection pressure and increase natural enemy survival.
- Use short residual pesticides if practical.
- Leave refugia if practical, e.g., apply sprays for thrips, red mite and bollworm on the outside canopy only by reducing pump pressure and fan speed on spray machines.
- If multiple applications are required, rotate different groups of pesticides.