
Integrated Pest Management for Citrus

4 Interpreting Monitoring Results

Learner Guide



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information

Second Edition

The first edition of the Integrated Pest Management for Citrus learner guides were exact transcripts of the audio-visual modules which they accompanied. This second edition has been updated with additional information and new developments. The changes are in italics and underlined.



Introduction

A lot of information on pests and their natural enemies can be accumulated on the farm through execution of blemish factor analyses pre-harvest, through scouting, through trapping and through microscopic evaluations. But what does one do with this data?

It is the responsibility of the farm manager or the farmer to interpret this data and to use the interpretation of this data in the application of a pest management strategy.



Tools for Interpretation

What are the tools for interpretation of this data? This data can be interpreted immediately on receipt of scouting and trapping data through:

- ❖ The use of **thresholds** where those exist for certain pests
- ❖ The use of Citrus Research International's **production guidelines**, which are very comprehensive for management of all important pests on citrus
- ❖ **Research results** which are generated. Each year, new results are coming through
- ❖ Fourthly, **technical recommendations** that come from experts in the area
- ❖ Fifthly, the **experience of experts** such as consultants
- ❖ Finally, your **own experience** as a farmer



Preventative vs. Corrective Control

Before I move on to talking about decision-making on specific pests, I would like to sketch the difference between preventative pest control and corrective pest control.

Preventative pest control is control of the pest **before** it reaches the plant part on which it causes damage, usually the fruit.

Corrective pest control is only applying intervention against that pest **once it arrives** on the plant part on which it can cause damage.

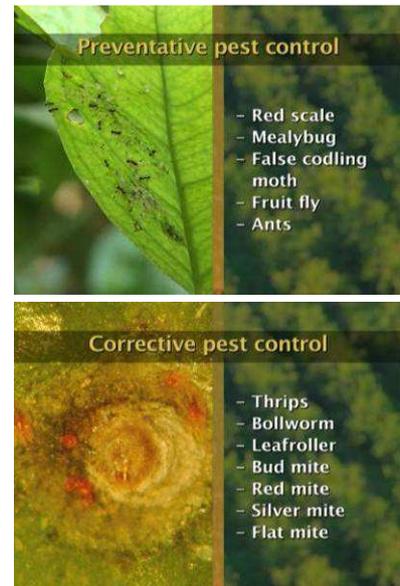


Pests which are most effectively controlled preventatively are insects such as:

- ❖ Red scale
- ❖ Mealybug
- ❖ False codling moth
- ❖ Fruit fly
- ❖ Ants

Pests which are most effectively controlled correctively are insects such as:

- ❖ Thrips
- ❖ Bollworm
- ❖ Leaf-rollers
- ❖ Bud mite
- ❖ Red mite
- ❖ Silver mite
- ❖ Flat mite



Red Scale

Pre-Harvest Blemish Analysis Data

As mentioned, red scale is by far more effectively controlled preventatively than correctively. Therefore, the decision about whether one needs to do anything for red scale control and what one should do should be made at the start of the season.

This would be based on a blemish factor analysis which is conducted at the end of the previous season.

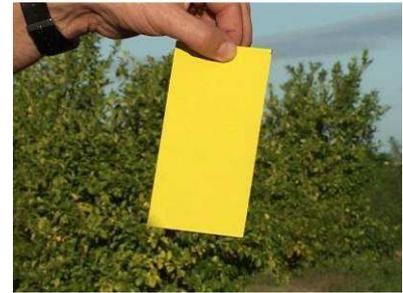
- ❖ If at harvest, between 0% and 5% of fruit are found to be infested with red scale, then a single treatment of whatever the grower's choice is, should suffice for controlling red scale
- ❖ If between 5% and 15% of fruit is infested at harvest, then two applications may be necessary
- ❖ If more than 15% of fruit are found to be infested with red scale at harvest, it may even be necessary to apply three treatments during the course of that season



Trapping Data

In the module about pest monitoring we spoke about the possible use of yellow sticky traps with the use of a red scale pheromone for monitoring red scale numbers. We mentioned that these traps cannot be used for decision-making on whether it is necessary to intervene against red scale or not. Simply, they can be used for the timing of treatments against red scale.

These traps should be monitored weekly. Once a peak in flight numbers – or male numbers – has been determined with the use of these traps, then one can evaluate that within 240 day degrees after this peak there will be a crawler movement.

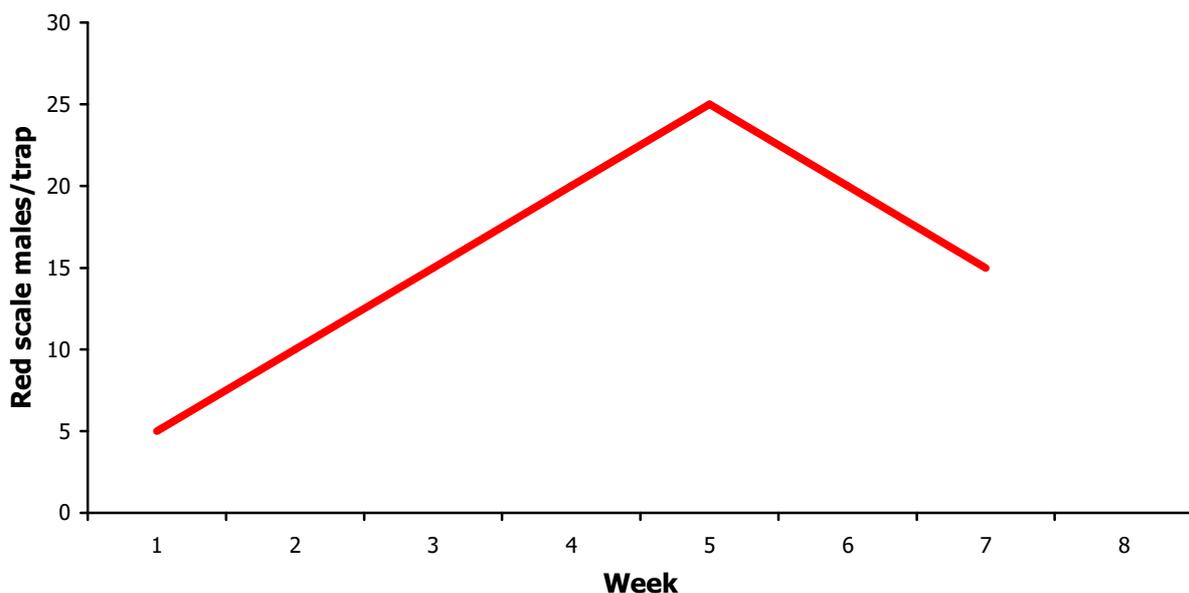


information

Flight Peak

Identifying a peak in male numbers is only possible a week or longer after the peak occurred, once the decline can be detected. Careful and regular monitoring is essential for this purpose, as is accurate recordkeeping of climatological data. If one determines today that there was a peak in male numbers 10 days ago, calculations need to be made using the temperatures for the last nine days.

Male numbers will build up and decline in a linear fashion, as in the example graph below:

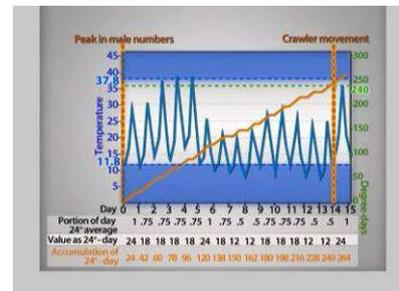
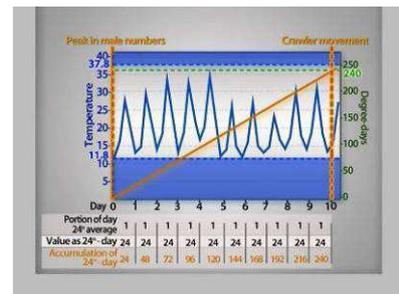


If one wants to spray an insect growth regulator like Buprofezin or Pyriproxyfen, or if one wants to release *Aphytis* parasitoids, then these should be timed against or shortly after a crawler movement.

In calculating these 240 degree days, it needs to be realised that red scale is inactive below temperatures of 11.8°C. Therefore, any hours during which the temperature was at 11.8°C or lower need to be deducted from the total making up those 240 degree days. Similarly, red scale is inactive at temperatures higher than 37.8°C, so any hours during which the temperature has exceeded this also need to be deducted from the final calculation.

To over simplify this calculation, if the average temperature for 10 days running was 24°C, then within 10 days after a flight peak on the trap, a crawler movement would begin.

Obviously in reality it is never quite this simple. Effectively it usually takes between two and six weeks after a red scale flight peak for crawlers to begin moving. This depends on the temperature at that time.



Scouting and Microscopic Evaluations

Traps are valuable in helping to determine when sprays should be applied. It is even more important that red scale scouting is done in the orchards.

Red scale scouting data can be well supplemented with microscopic evaluations of red scale. Obviously a fairly good quality dissecting microscope is required and this will enable one to determine whether red scale is alive or dead, and if the red scale is parasitized and by what.

Such microscopic evaluations help one to determine whether the biological control of red scale is sufficient to bring it under control or whether chemical intervention is necessary, and it also helps one to gain familiarity with and confidence in the effectiveness of biological control complex.

On a regular basis, at least monthly, a well-infested sample of fruit should be collected from each orchard and inspected microscopically. This, one will do by using a sharp object, such as a pin, to lift up the scale covering of the red scale underneath the microscope and to observe and record what one finds underneath that scale covering, whether it is a live red scale, a dead red scale or a parasitoid, or whether the red scale was at one time previously parasitized.



There are various symptoms which one can look for in identifying these different scenarios.

The first distinction that one needs to be able to make during a microscopic evaluation is between male and female insects. Male red scale insects are oval-shaped, while female insects are round. As a rule, microscopic evaluations should focus on female insects, purely for the sake of consistency.

After lifting the scale covering, you will be able to determine if the scale is alive, dead or parasitized. If it is alive, its soft body may either detach from the scale covering and remain on the surface of the fruit, or it may remain attached to the scale covering and come away from the surface of the fruit with the scale covering. This is the case if the insect is in the process of moulting.

If the red scale is dead it should appear emaciated or desiccated, as in this photo. You may also see a red scale insect that has been parasitized. This is what a red scale insect looks like that has been parasitized by *Aphytis*. Be careful not to confuse this with a male red scale, whose elongated body shape and black eyes may be mistaken for a parasitoid. If the *Aphytis* parasitoid has already emerged, you will see its residues.

The other form of parasitism that you may find is by *Comperiella bifasciata*. In this case, the red scale is almost entirely black in colour. Note the hole in each of the two scales on the right, through which the fully developed parasitoid has already emerged.



Corrective Treatments

If the correct decision for red scale control has been made early in the season on whether a preventative spray should be applied or not, hopefully it will not be necessary at any stage later during the season to apply a corrective control measure. Nevertheless, by conducting this monitoring, both scouting in the orchards and microscopic evaluation, it will be possible to determine whether it is *indeed* ever necessary to apply a corrective measure late in the season.

Determining whether a corrective intervention is necessary for red scale or not, is very complicated. The grower needs to build up his own experience and his own history on his farm so that he can develop confidence in the ability of the bio-control complex on his farm.



Despite this complexity and variability, there are guidelines which one can use in helping to determine whether it is necessary to intervene correctively. These are based on red scale levels in the orchard and on parasitism levels which one observes microscopically.

As corrective intervention against red scale decreases in its effectiveness from February onwards, the latest that one would want to make a decision on whether it is necessary to intervene would be during February. In the hotter northern areas of the country this date at which one would make the decision on corrective *treatment* might even be as early as January.

These guidelines are for navel oranges. In February in the cooler Cape regions, *and probably in* January in the hotter northern regions *the following should apply*:

- ❖ Fewer than 40% of *fruit* should be infested with red scale
- ❖ At least 16% of the scale should be parasitized
- ❖ At least 50% of this parasitism should be by *Aphytis* species
- ❖ At least 30% of the scale should be dead
- ❖ In the cooler regions there should be a dramatic increase in the percentage of scale dead from January to February, and in the hotter northern regions a dramatic increase in mortality from December to January

If one considers that navel oranges on average are harvested in mid-May then with later hanging varieties, such as most Valencia types, one could make these threshold values slightly *more lenient* in February, and on earlier harvested varieties, such as most easy-peeler varieties, the threshold values would have to be slightly *more conservative*.



Red scale corrective treatment

- <40% navels infested
- >16% red scale parasitized
- >50% parasitized by *Aphytis* species
- >30% red scale dead

Increase in mortality

- Southern regions - January/February
- Northern regions - December/January

Mealybug

Preventative Treatments

As with red scale, mealybug is far more effectively controlled with preventative spraying than corrective spraying, therefore an early spray *is preferable*. The ideal timing for a mealybug spray is in spring, pretty

much synchronised with 100% petal drop.

There are three factors that need to be taken into consideration when deciding whether a preventative spray is necessary for mealybug or not. The first is based on the pre-harvest blemish analysis. If during this analysis conducted before harvest the previous season, any live mealybug is found on the fruit, under the calyx or in the navel-end, then a spring spray must be applied for mealybug.

The second is a winter and spring analysis. Here the trunks of trees and scaffolding branches need to be inspected for any presence of live mealybug, and as spring approaches, also the new flush and blossoms need to be inspected for any signs of mealybug. If any mealybug is found on these plant parts at these stages, then a spring spray for mealybug should be applied.

The third factor affecting one's decision-making, is the spray programme which has been chosen for the remainder of the season. If any sprays are planned which can be disruptive to the natural enemies of mealybug, then a spring spray for mealybug should be applied.



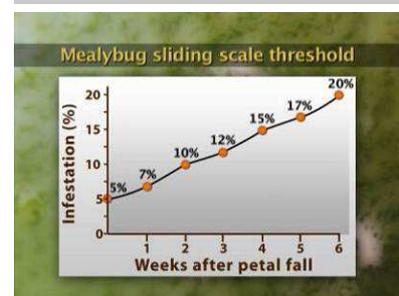
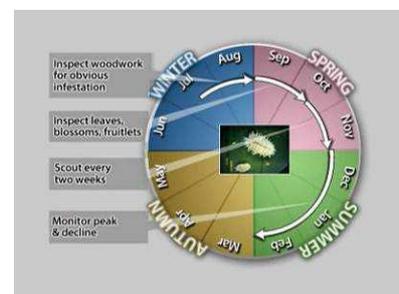
Scouting Data

Now regardless of whether one has applied a preventative spray for mealybug or not, it is essential that regular weekly scouting is conducted from 100% petal fall for the following six weeks.

It cannot simply be assumed that because a spring spray has been applied, mealybug is now under good control. There are various reasons which could lead to a failure or an inadequacy of an early spring spray.

From petal fall until six weeks later, there is a sliding scale threshold which can be applied.

- ❖ If at 100% petal fall 5% or more of fruit are found to be infested with mealybug, a spray should be applied
- ❖ A week later, if 7% are infested a spray should be applied,
- ❖ Two weeks later, 10%,
- ❖ Three weeks after petal fall, 12%,
- ❖ Four weeks after petal fall, 15%,



- ❖ Five weeks after petal fall, 17%, and
- ❖ Six weeks after petal fall, 20%

Thereafter the frequency of scouting can be reduced to once every two weeks. It is very important to continue this regular scouting.

Mealybug infestation normally will continue to increase during the season, even if a spray has been applied. Mealybug will *normally* peak in the northern areas in December, and in the southern cooler areas, normally in January. Thereafter there should be a dramatic decline in mealybug levels. If within a month after that there hasn't been a conspicuous decline in mealybug levels, one should seriously consider the application of a corrective spray for mealybug.



Corrective Treatments

Life-Stages

If one decides that it is necessary to apply a corrective spray for mealybug and the product of choice is an insect growth regulator, then the timing of the spray is very important. Insect growth regulators for mealybug are only effective during the younger life-stages.

It might therefore be necessary to pick a sample of mealybug-infested fruit and to assess it microscopically. One then needs to ensure that the majority of mealybug is in the younger life-stages, either as egg sacs or as crawlers. If the majority is not yet in the correct life-stage then the grower should wait for another week or two before reassessing the situation and possibly applying the spray.



Citrus mealybug adults and crawlers



Citrus mealybug with egg sac

Ant Control

Another important factor to take into consideration before one decides whether it is necessary to apply a corrective spray for mealybug or not, is ant control.

Mealybug has a very effective natural enemy complex; however, this is significantly disrupted through ant activity. Therefore the grower should check the scout's results and ensure that there is not unacceptable ant activity in the orchard.



The first thing that needs to be done before a spray is applied for mealybug is to bring this ant activity under control.

Mealybug Species

Sometimes it is also important for the grower to determine what species of mealybug are infesting his fruit. This could be for one of two reasons. If the grower is considering releasing parasitoids for mealybug control, such as *Coccidoxenoides perminutus*, these parasitoids are only effective against citrus mealybug. The presence of any other mealybug species therefore needs to be discounted before the grower decides to release this parasitoid. *Anagyrus appears to have a slightly broader host range; however, full clarity on this must still be established.*

The second important consideration in talking about mealybug species is that certain markets recognise some of the mealybug species that occurs on citrus in South Africa as quarantine or phytosanitary pests. If one is sending fruit to one of these sensitive markets, one also needs to make sure that none of these unacceptable species of mealybug occur on the fruit.



Karoo thorn mealybug



Citrus mealybug with egg sac

Thrips

Preventative Treatments

Thrips is normally controlled correctively and such control measures are normally satisfactory for thrips. However, a preventative application can be made early in the season before blossom on the new spring flush.

Although only leaves will be damaged at this stage, knocking down thrips levels, which should be well synchronised with the early spring flush, should lead to lower levels of thrips appearing on the fruit once they set.

There are two ways in which one can decide whether a pre-blossom application on this flush is necessary or not. This can be done by the scout inspecting the flush in spring and if any infestation or damage on this flush is noted, a spray can be applied, or this can be done through the use of sticky yellow card traps.

If card traps are used and any citrus thrips are caught on these traps during this time of spring flush, then an application can be made on this spring flush.



Citrus thrips





Corrective Treatments

However, if these traps are used during blossom or after blossom has dropped off the tree, then a threshold applies to the thrips numbers that are caught on these traps.

It is also very important to differentiate between male and female thrips and to identify the species of thrips. There are more than just citrus thrips which are attracted to these traps, particularly blossom thrips and onion thrips, and one needs to be able to differentiate these from citrus thrips.

For this one needs a good microscope; however, to the trained eye a good magnifying glass may be sufficient to identify thrips accurately on the yellow card traps.

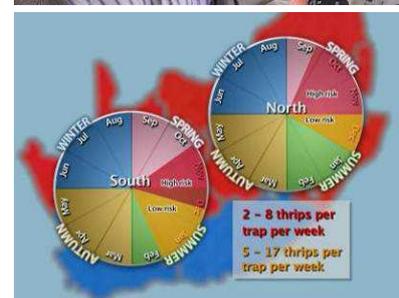
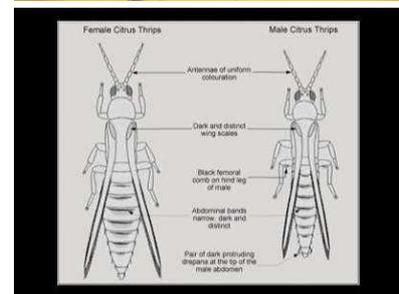
Thresholds on traps differ from region to region and also differ during the high risk period and the low risk period. This is the period when fruit is highly susceptible to thrips damage and the period after which the fruit is no longer as susceptible to thrips damage.

This high risk period in the northern areas runs until the end of November and in the southern areas until the middle of December. The low risk period for thrips damage in the northern areas runs to the end of December and in the cooler southern areas until the first week in February.

The threshold which is used differs during the high risk period and the low risk period. During the high risk period, an average of between two and eight thrips per trap per week would indicate the necessity to spray.

During the low risk period, an average of between five and seventeen thrips per trap per week would indicate the need to spray. However, for the more exact thresholds, which apply to your region, you should consult the CRI IPM production guidelines

Although the use of yellow sticky traps is very valuable, unfortunately the use of these traps alone is not very accurate. One needs to rely very heavily on the



information generated by visual scouting on the fruit conducted by the trained scouts.

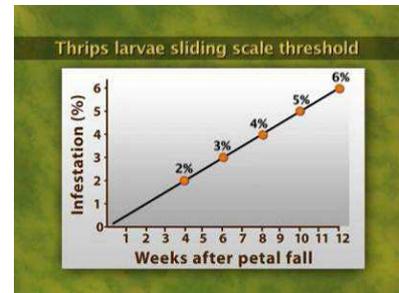
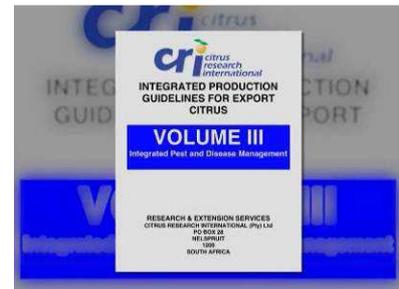
Here the scout needs to differentiate between the adults and larvae of thrips and there are fairly intricate thresholds which apply to both life-stages or a combination of both.

I will outline only those thresholds which apply to thrips larvae here as this is the most damaging life-stage of thrips.

- ❖ From petal fall to four weeks, a 2% infestation of thrips on fruit indicates the need to spray immediately,
- ❖ From five to six weeks, 3%,
- ❖ From seven to eight weeks, 4%,
- ❖ From nine to 10 weeks, 5%, and
- ❖ From 11 to 12 weeks, 6%

Any thrips infestation thereafter, which will lead to unacceptable damage, would have to be higher than a 6% level.

Scouts should also inspect for predacious mites in the way in which they have been trained to do. Presentation of this information to the grower will also help in mitigating the risk of mid-season thrips infestations and increase the probability that a spray would not be necessary late in the season.



False Codling Moth

Trapping Data

Traps used to be used for threshold purposes for false codling moth, i.e. for determining whether it is necessary to spray for false codling moth or not.

However this is not the case anymore. The pest status of false codling moth has reached a level where intervention is always necessary, even if levels are low.

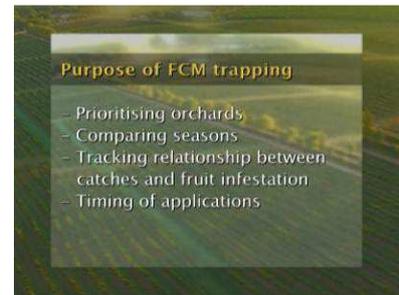
Traps are used for:

- ❖ Comparing FCM levels between orchards and therefore prioritising intervention in particular orchards



- ❖ Comparing one season with another
- ❖ Trying to establish a relationship between moth catches and fruit infestation
- ❖ Accurate timing of virus sprays – if a virus is going to be sprayed in that orchard for FCM control, it should be applied approximately one and a half weeks after a peak in FCM catches.

If it is found that there is no relationship between trap catches and fruit infestation, this could be a sign that the traps are incorrectly positioned. Traps should therefore be repositioned according to the recommendation, which come with the trap or which appears in the CRI production guidelines, or the trap may need to be moved to a completely different position in the orchard. Remember, however, that if FCM levels are low and it is difficult to detect any peak in either fruit infestation or moth numbers, it would be near impossible to try and establish a relationship between the two.



Fruit Infestation Data

Each week your scout would also provide you with fruit infestation data. This data will tell you three things:

- ❖ It will tell you how well your FCM is being controlled
- ❖ It will give you an indication of whether it is necessary to apply any further measures for FCM control
- ❖ Most importantly, it will speak to the postharvest risk of fruit coming from that orchard

There is no universal threshold for fruit infestation. Because FCM is a phytosanitary pest, one should strive to bring infestation levels to as close to zero as possible. However, the sensitivity of the particular market to which the fruit is being sent will dictate what can be tolerated in the orchard and what makes that fruit unsuitable for a particular market or not. *An average of no more than 0.2 infested fruit per tree per week can be used as a benchmark for the maximum acceptable.*



Egg Parasitism Data

Your scout may also provide you with figures for FCM egg numbers on fruit and for parasitism levels of these eggs.

Although this information cannot be directly used in decision-making, the level of parasitism is a very good indication that this parasitoid will play a significant role in suppressing FCM levels and prevent an upturn in FCM infestation towards harvest.

Ideally one would want to see in excess of 80% of eggs parasitized.



Fruit Fly

Trapping

Fruit fly trapping should begin before colour break. Colour break is initiated approximately two months before projected harvest date.

From this time, a routine fruit fly control programme must be employed, regardless of whether anything has been caught in the traps or not. The sole purpose of the traps is to dictate whether additional applications of the treatments must be applied or not.

Capilure loaded traps catch predominantly male flies. The thresholds which apply for Mediterranean fruit fly and Natal fruit fly differ. Therefore the scout or the farmer needs to differentiate between these species. A good magnifying glass is sufficient to do this.

For Mediterranean fruit fly, it would be four flies per trap per week. For Natal fruit fly, it would be two flies per trap per week. Any catch that meets or exceeds these thresholds would mean an additional weekly application would be required, until numbers again drop below this threshold level.

Questlure loaded traps catch predominantly females. The threshold here is the same for both Mediterranean and Natal fly and is one fruit fly per trap per week.

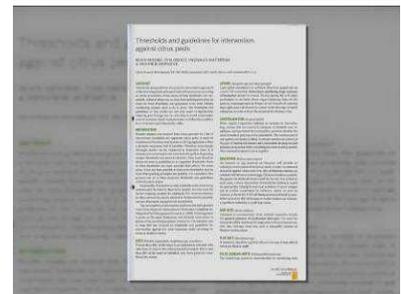
The threshold for Oriental fruit fly is three flies per trap loaded with methyl eugenol per week.



Other Citrus Pests

For many of the other citrus pests, there exist specific thresholds for intervention, for others, there are simply guiding principles to help one in that decision-making process. However, what both of these assume is that there is a reliable and accurate and regular monitoring system in place to generate data that can be used.

All of these specific thresholds and guidelines are given in the scouting book which is provided by CRI and they are provided in an article which was written up in 2008 for the South African Fruit Journal. However, I will cover now some of the thresholds and guidelines for some of the important pests which haven't already been mentioned.



Aphids

For aphids, infestations producing large amounts of honeydew should be treated.



Australian Bug

For Australian bug, if Vedalia beetles are absent and there is a noticeable increase in pest presence, with a resulting increase in sooty mould, then intervention is required.



Bollworm

For bollworm, if 20% of blossom or fruitlet clusters are infested with any life-stage, then a spray should be applied. If it is an orchard of navel oranges with a particular problem with enlarged navel-ends, this threshold can be brought down to 11% infestation.



Bud Mite

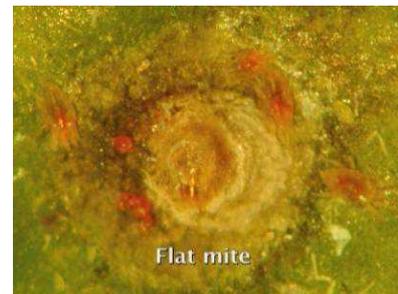
For bud-mite, if there is a general presence of

malformed blossoms, certainly not more than 10% of blossoms, then a spray should be applied.



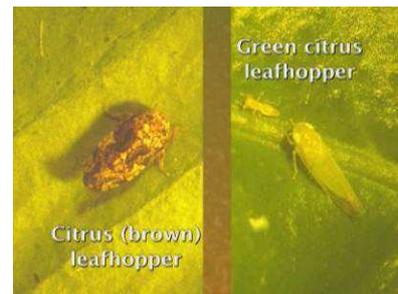
Flat Mite

For flat mite, if one mite or more are recorded per fruit or stalk then a spray is necessary.



Leafhoppers

For leafhoppers or planthoppers, traps are used for monitoring. For the brown citrus leafhopper the threshold is 35 to 40 leafhoppers per trap per week. For green leafhoppers it is in the region of eight per trap per week.



Planthoppers

For planthoppers there is no threshold, however if there is a general build-up of the pests associated with sooty mould, a spray will be required.



Snails and Slugs

For snails and slugs, an average of from two to five brown or dune snails or slugs per tree, depending on tree size, indicates a necessity to treat for these.



Soft Scales

For soft scales, that is soft green scale or soft brown scale, treatments must be applied to ensure that a build-up of sooty mould does not inhibit tree performance or cause fruit drop.



Waxy Scales

For waxy scale, the fairly general presence of infested twigs on trees can be regarded as a potential infestation hazard requiring treatment.



Red Mite

For red mite, a spray should be applied when an average density of five adult mites are noted per leaf.



Conclusion

If there are any pests and thresholds which have not been covered in this material, please consult the CRI production guidelines for IPM volume III or consult the CRI scouting manual.