CITRUS THRIPS

Scirtothrips aurantii Faure

1 PEST PROFILE

1.1 Distribution and status

Citrus thrips can probably be considered a key element in the general pest complex in all areas except the Western Cape. It occurs in all production areas but its pest status is highest in Limpopo Province.

1.2 Description

Eggs are laid in the plant tissue. The body colour of the two active, wingless larval stages can vary from translucent white to yellow. The larvae reach a length of about 0.7 mm before commencing the pre-pupal and pupal stages which are followed by the adults. The adult females have a body length of between 0.7 to 1 mm while the adult males are slightly smaller at 0.6 to 0.7 mm. Whereas the larvae can be recognised by their presence on young succulent fruit and foliage, the adults have specific features that enable them to be differentiated from other thrips species which may be present on the tree. These features can be seen with 20 to 30X magnification and are depicted in Figure 1 below.

During spring, various other species of thrips are attracted to citrus blossom, including the western flower thrips *Frankliniella occidentalis* (Pergande). They may also be seen on fruitlets for a short period after the petals have fallen. These species do not have the depicted morphological features, and **do not cause damage to fruitlets**.

1.3 Infestation sites on tree

Citrus thrips feed on succulent young foliage and fruit tissue. This activity results in permanent scarring.

1.4 Damage

1.4.1 Foliage

1.4.1.1 Symptoms

In its most acute form, thrips' attack on unfolding buds can result in their destruction and the loss of an entire growth flush. In less severe foliage infestations the leaves are able to expand, but the tissue along either side of the midrib on the dorsal surface is scarred.

This scarring can result in a variable degree of leaf malformation. In the more extreme cases the outer edges of the leaves curl inwards and cause the so-called "rat-tail" effect. Twigs may even defoliate.

1.4.1.2 Seasonal occurrence

All new growth is susceptible until leaves are fully expanded. Damage to foliage is most likely to occur during summer and autumn. However, when winters have been mild it is possible for spring growth to be extensively damaged. Where this occurs it is probable that the ensuing new crop will be exposed to severe thrips pressure.

1.4.2 Fruit

1.4.2.1 Symptoms

In the weeks immediately following petal fall, healthy fruitlets typically have a glossy surface texture. Thrips feeding dulls the gloss. The damaged tissue develops a light tan colour which subsequently assumes a silver-white hue on the green fruit. Initial damage to fruitlets most frequently occurs in the calyx area.

In the case of severe attack, thrips feeding spreads out from the calyx area to the cheeks of fruitlets resulting in large blemished areas. These blemished areas can retain their silver-white appearance until harvest, but frequently they darken with age and become even more unsightly, particularly if exposed to the sun. Honeydew from mealybugs feeding under the calyx also seems to exacerbate thrips damage and makes it rougher in appearance. As fruit expand and mature, their susceptibility to this type of damage declines. During the latter part of the fruit susceptibility period, thrips feeding results in either "scribbling" or a russet type of fruit blemish. This damage is often called late thrips damage and occurs most frequently around the stylar or navel end of the fruit, and on the fruit cheeks. Scribbling is usually found on the outward-facing fruit cheeks and is often caused earlier in the season than the russet. The russet may start where two fruit are touching or where a leaf makes contact with the fruit. It also occurs around the edges of blemished areas resulting from previous thrips feeding or wind. Severe russetting can be similar in appearance to damage caused by rust mite. Scribbling and russetting are most likely to occur where chronic thrips attack persists during the fruit susceptibility period. It can also be a factor on late set fruit resulting from uneven blossom and in drought situations where little new foliage appears during summer and fruitlets remain the most succulent food option.

1.4.2.2 Seasonal occurrence

In normal circumstances the single in-season crop of oranges, grapefruit and soft citrus is susceptible to attack for approximately 11 to 13 weeks after petal fall. Within this period, attacks can commence at any time and be of varying severity. This general fruit susceptibility period also applies in the case of lemons. However, the blossom pattern of lemons is more uneven than that on oranges and as many as four general blossom periods can occur during spring and summer. Thrips control on lemons is therefore more difficult than on other citrus types. The lemon crop set in summer is the most subject to thrips attack.

1.4.2.3 Differences between thrips and wind damage on fruit

Wind damage is one of the major culling factors affecting the citrus industry and generally growers should make every effort to reduce its impact with the aid of windbreaks or nets. In the summer rainfall region, high winds before thunderstorms can cause severe damage in a short time. In certain areas prevailing winds are also a problem. Refer to the Wind Protection Section in Volume 1 of the Integrated Production Guidelines.

In general the damage caused by wind is restricted to the fruit cheeks. Blemishes caused by wind during the first six to nine weeks after petal fall can have a surface texture and colouration at harvest similar to the damage caused by thrips. Judged by these criteria, wind marks are often attributed to thrips infestation and especially “late thrips”. However, it is possible to decide whether a **general** blemish problem in an orchard is due to wind or thrips if the issue is approached along the following lines:

- If typical thrips blemishing is **generally** absent in the calyx area of fruit then it is unlikely that large cheek blemishes, which may have the texture or colour of thrips blemishes, are caused by thrips. If both types of blemish are generally present then thrips is a factor in any case!

- Examine the **general** appearance of the cheek-blemishing present. Thrips blemishes on cheeks **generally** tend to run longitudinally down the cheek as a continuation of heavy scarring around the calyx area. Such scars can also be as a result of thrips feeding along the interface where a leaf or twig touches the fruit surface. Wind blemishes **generally** tend to run diagonally or across the cheek surface as a result of the arc-shaped movement of leaves or fruit resulting from their attachment to the tree framework.

- In mid- and late summer, wind damage to fruit **generally** takes the form of variably abraded tissue around the fruit cheek and bears no resemblance to either the early large scars or late blemishing caused by thrips feeding.

2 MANAGEMENT ASPECTS

2.1 Infestation/damage assessment

2.1.1 Non-bearing trees

Thrips is one of the major pest threats affecting the growth of nursery trees. Many nurserymen respond to the threat by routinely treating their trees on a seven to 14 day cycle for thrips control. Research has shown that the use of yellow traps to monitor thrips activity in the nursery permits major reductions in treatment frequency. As a result, the cost of thrips control in the nursery is reduced, as is the prospect that frequent treatment will promote the resistance of thrips to pesticides (see “Yellow traps in citrus nurseries” in paragraph 2.3.14 below).

Once trees have been planted, precautions need to be taken to ensure that thrips attack does not have a detrimental effect on growth cycles destined to form the primary tree framework. Where necessary, each new growth cycle needs to be protected with a suitable treatment. The need for treatment can be based on systematic orchard inspection, as described in Chapter 2 and also on yellow traps (below). Most attention needs to be given to growth flushes that occur during summer and autumn. General presence of thrips on new growth coupled with yellow trap catches exceeding what has been defined as the threshold for treatment will be adequate justification for applying a treatment. In the section on inspection procedures the importance of maintaining a systematic approach coupled with the recording of inspection data is emphasised. Over time the availability of reliable records will greatly facilitate decisions relating to the protection of new growth on non-bearing trees.

2.1.2 Bearing trees

2.1.2.1 Treatment threshold

The intervention thresholds based on either percentage fruit infestation or yellow traps are described below. The former threshold is approximately 2% during the first four weeks after petal fall. It is recommended that yellow traps be supported by direct observations in orchards according to the recommendations for orchard inspection in Chapter 2.

2.1.2.2 Oranges, soft citrus and grapefruit

Apart from inspection, the success or failure of control programmes against thrips on oranges, soft citrus and grapefruit often depends on the uniformity of the blossom and the grower’s ability to respond to the speed with which thrips can cause permanent damage to fruitlets.

Severe feeding injury to spring growth can be regarded as an indicator of likely thrips attack on the subsequent fruitlets. However, it frequently happens that heavy thrips pressure on fruitlets is not preceded by serious blemish to growth. In these circumstances yellow traps can play a useful role in assessing thrips pressure in orchards and determining the sequence in which orchards should be treated. This could be of added importance when bouts of poor weather limit the time available for applying treatments.

2.1.2.2 Lemons

The management factors that apply to oranges, soft citrus and grapefruit also apply to lemons. However, on lemons there is an added need to limit the multiple use of materials that can cause repercussions from other pests. This applies particularly to the materials used to control thrips on lemon crops set in summer. In addition, semi-mature lemon fruit are often present during this period and care is needed to ensure that the preharvest intervals between application and harvest, pertaining to individual treatments, are adhered to.

2.2 Monitoring thrips on fruit

Monitoring thrips on fruit is a more accurate means of determining the immediate threat of thrips damage than the use of traps. Intervention thresholds based on percentage fruit infestation are described in Table 1. Thresholds are provided for mean infestation over both one- and two-week periods because low numbers of thrips present over a long period can still cause serious damage. The thresholds increase with time as the fruit becomes less susceptible to damage and may have to be fine-tuned for different cultivars and production regions. Only when the thresholds are exceeded are treatments justified. Once thresholds are exceeded, treatments should be applied as soon as possible. This is particularly important for the IPM-compatible treatments such as abamectin plus oil as they will not be effective once infestation levels exceed approximately 15%.

When inspecting fruitlets for thrips at around 80% petal fall, clusters of fruit that still contain some blossom should be avoided as these are likely to have blossom thrips on them that may be confused with citrus thrips. It is also important to look for thrips under the calyx as the thresholds are based on this type of inspection and that is where most early damage occurs.

Table 1. 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 and larvae (%)	Fruit with larvae (%)	Fruit with adults and larvae (%)
PF-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

2.3 Monitoring with the use of yellow adhesive traps

Yellow is attractive to various insect species including the citrus thrips. Light weight, low cost, yellow PVC cards can be coated with a suitable sticky material, but ready-coated yellow card traps are also commercially available. These yellow traps should be placed on the sunny (northern) side of trees where they are highly attractive to thrips.

2.3.1 Suppliers of yellow card traps

Yellow PVC for card traps can be obtained from stationery wholesalers, then cut to size and coated with adhesive just before use. Precoated, disposable, sticky yellow traps can be acquired from several sources but <u>they may have a different surface area to that described below so the correct area will have to be marked on the traps for the treatment thresholds below to apply</u>.

Coated blue traps are sometimes sold for the monitoring of thrips but this colour is most attractive to western flower thrips (*Frankliniella occidentallis*) and should not be used for citrus thrips.

2.3.2 Description

Trap dimensions are 140 mm x 76 mm x 0.2 mm. Notches or black marks 13 mm from one end demarcate the trapping area of 127 mm x 76 mm on either side of the card. The remaining 13 mm portion at one end facilitates handling and provides space for indicating the trap number and any other information required.

2.3.3 Adhesive

The 127 mm x 76 mm trapping area on either side of the card must be coated with Fly-Tac/Reverant adhesive. There are two methods for coating the traps:

2.3.3.1 Dipping

If Fly-Tac/Reverant has not previously been diluted (i.e. it is thick and does not drip) it can be mixed with water in a 1:1 mass ratio and the cards coated simultaneously on both sides by dipping them in the solution. The cards are held at the uncoated end and submerged up to the notches/marks demarcating the coated and uncoated areas. The cards are then hung up to dry with either clips or hooks depending on the method to be used for attaching them to the tree. A piece of PVC guttering below the traps can be used to collect the run-off of excess Fly-Tac/Reverant solution. This solution can be stored for later use. This will result in a thin layer of adhesive that is suitable for thrips and psylla but not stronger insects like leaf hoppers.

2.3.3.2 Painting

The undiluted adhesive can be painted on to both sides of the trap with a brush. In order to do this the trap should be held against some hard, smooth, non-absorbent surface. Most of the adhesive will be cleared from the brush if it is placed in water immediately after use.

2.3.4 Storing of prepared traps

After application of the adhesive the cards can be stacked in a disposable carrier comprising a rigid plastic sheet of convenient size folded in half (e.g., an overhead projection acetate). Dipped cards need to be partially dry before being placed in the carrier, whereas cards painted with undiluted adhesive can be stored while still wet. The cards should be "step-packed" in the carrier so that their untreated ends, which partially overlap, are all placed towards the same side. If these ends are allowed to uniformly protrude from the edge of the carrier it will facilitate peeling off the traps in the field.

2.3.5 Method of attachment in the orchard or nursery

Two attachment procedures are recommended.

2.3.5.1 Electrical "crocodile" clip

These clips facilitate changing of traps. A small hole may need to be drilled through the stem of the clip to take a thin piece of wire required to attach the trap to a suitable object. The trap is held in the jaws of the clip with the uncoated strip nearest the ground. When the trap is changed the card is grasped at the uncoated end with one hand while the other hand is used to release the jaws of the clip. The crocodile clip is especially recommended for windy conditions.

2.3.5.2 Large paperclip

The most economical method is to use a large paperclip which is bent open in the shape of an "S". The top, smaller hook of the "S" is twisted around a suitable object while the bottom, larger hook is used to suspend the trap. A small hole will have to be punched in each card trap in order to use this method of attachment. This hole should be punched in the uncoated portion of the trap and the card hung with the uncoated portion at the top. It is recommended that the end of the trap where the hole is punched be reinforced with masking tape to prevent splitting. After the card has been suspended on the lower hook of the clip the hook should be squeezed slightly to prevent the trap from being blown off the hook in a gust of wind.

2.3.6 Changing the traps

The traps should be changed at weekly intervals. Large polyethylene (plastic) sandwich bags (170 mm x 170 mm) are convenient for covering the sticky sides of the traps but any piece of thin polyethylene with the same dimensions would be suitable. The plastic is placed on a flat surface and the trap removed and placed on one half of the plastic square. The remaining half of the plastic square is then folded over the upper side of the trap. The traps can then be easily handled and no storage folder is necessary. To facilitate inspection of the trapped insects, ensure that only a single layer of plastic is used on both sides.

2.3.7 Counting citrus thrips on the traps

The equipment required to monitor citrus thrips on the traps will depend on eyesight and experience. With experience citrus thrips can be readily identified with either the naked eye or a hand lens. A magnification of 25 to 30X is often necessary to observe some important characteristics and is essential for a novice. The least expensive magnification is obtained through the use of a pocket microscope. Several intermediately priced pocket microscopes are available (the cheapest ones invert the image) while the most expensive is probably an Episcope (www.haverhills.com). Features used to identify citrus thrips are shown in Figure 1.

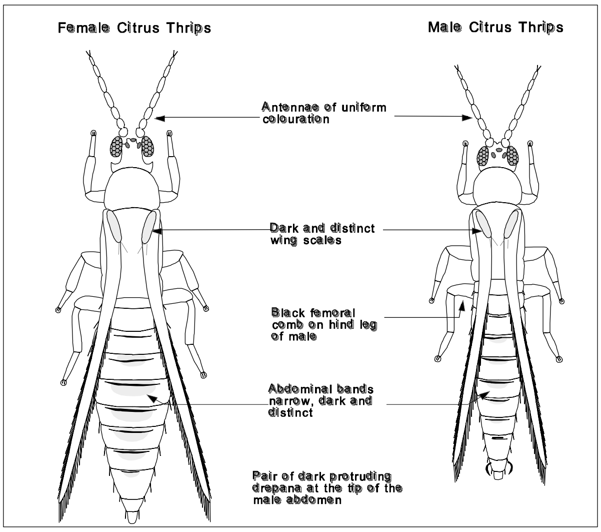

Figure 1. Characteristics used to distinguish citrus thrips from other thrips species.

Lines can be drawn on the plastic covering the traps to aid in counting the insects, or lines (two or three per side) can be drawn on the trap itself with a fine indelible pen before it is coated with adhesive. The quickest method of counting will be to scan the traps using low magnification such as a hand or head lens and mark insects that require further magnification for reliable identification. These can then be scrutinised with a pocket microscope. Obviously the best optical instrument to use would be a zoom stereomicroscope but this could probably be justified by only the larger estates.

2.3.8 Recording of trap data

The weekly trap results obtained for each orchard should be recorded for future reference. These results can be used for comparison with data obtained from routine orchard inspection.

2.3.9 Cleaning the traps

With non-disposable traps, once the trapped insects have been counted and recorded, the plastic cover is peeled off and the traps immersed in mineral turpentine for 30 minutes to remove the adhesive. The traps can then be removed and hung up to dry after checking that no insects remain attached to them. After drying, the traps can be recoated.

The used turpentine can be cleaned of dirt and insects by filtering through household cooking oil filters (Filtera, Unsgaard Packaging (Pty) Ltd, Manhattan St., DF Malan Industrial Area Cape 7525). However, the turpentine will have to be replaced periodically when the concentration of adhesive becomes excessive. Alternative cleaning agents such as paraffin and spray oil can also be used but they require longer soaking periods and an additional washing step to remove oily residue before coating.

2.3.10 Trap longevity

The PVC yellow may slowly fade in the sun but traps used in orchards often last until they are lost or torn. Individual traps may therefore last an entire season. Traps used in nurseries will probably last longer.

2.3.11 Yellow card traps in orchards

2.3.11.1 Position of trap on tree

The trap must be hung from a convenient twig on the **northern** (sunny) side of the tree on the outside of the canopy and approximately 1.8 m above ground. The trap should be adjusted so that one side faces into the canopy of the tree and the other side faces away from the tree. Leaves in the immediate vicinity of the trap should be removed so that they do not stick to the trap or obscure it.

2.3.11.2 Trap distribution in orchards

A minimum of three traps must be used in orchards of up to 3 ha. For larger orchards the number of traps must be increased proportionally. The traps should be evenly spaced in a diagonal across the orchard. The corner traps should be at least three trees in from the border of the orchard.

2.3.11.3 Treatment thresholds for citrus thrips based on trap catches

Two treatment thresholds are used depending on how susceptible the fruit is to scarring. They are indicated in Table 2. The thresholds should only be used as guidelines because they can be affected by variations in orchard conditions and relative cultivar susceptibility to thrips attack. They should therefore be supported by information from routine orchard inspection to indicate thrips activity on fruit and foliage. In this way familiarity with seasonal thrips population trends in a particular planting will increase and it may become progressively possible to base control strategies on trap data only.

The treatment threshold to maintain export cull below 1%, is based on the weekly sum of both sexes of citrus thrips per trap. However, if numbers of thrips on a single trap exceed 70% of the threshold and the area covered by the traps is large, a treatment should preferably be applied. This will also depend on the infestation trends indicated by orchard inspection. <u>If a threshold is exceeded a treatment should be applied within one week.</u>

The lowest threshold is used during the critical period from 90% petal fall to the end of November in the subtropical region, and to the second week of December in the Cape provinces. A higher threshold is used in the late risk period which is from the end of the critical period to the end of December in the subtropical region, and to the first week of February in the Cape provinces. As can be noted from Table 1, both thresholds are related to the latitude of the area concerned. The further south the location, the higher the threshold. This is due to there being a larger difference in the numbers of thrips on the sunny and shady sides of the trees in the Cape, than in the subtropical region.

Table 2. Estimated average weekly citrus thrips threshold levels requiring treatment at different latitudes in South Africa when using yellow PVC card traps

Production area	Average weekly thrips totals per trap	
	Critical period	Late risk period
Limpopo Province, southern Zimbabwe	2-3	5-7
Mpumalanga, North-West Province, Swaziland, southern Mozambique	4-5	7-9
KwaZulu-Natal	5-7	10-13
Northern, Eastern and Western Cape	7-8	15-17

2.3.12 Important points concerning the monitoring of citrus thrips with traps

Monitoring should start during the spring growth flush to obtain an indication of the thrips population density. This information can clarify the sequence in which orchards should be treated and also influence the selection of insecticide treatment. This may be the most popular purpose for using traps. After bloom, the traps will indicate the extent and speed of any thrips infestation. It is particularly important to have early warning of such developments during the critical fruit susceptibility period.

With experience a grower may discover that thrips are always more common on one side of an orchard. In these instances the traps can be moved nearer to this side of the orchard instead of having them on a diagonal.

Windbreak types can influence thrips population density. The presence of different windbreak types around orchards in a particular planting must be catered for when deciding on the distribution of the yellow traps (see Cultural Practices in Chapter 2).

<u>The traps monitor adult thrips activity only, but the second instar larvae are responsible for most damage. Weather conditions such as strong wind, low temperatures, or frequent rain can prevent the adult thrips from flying and produce low trap counts without reducing the numbers of thrips feeding on the fruit.</u> Treatments which do not kill the egg stage or which have a short residual impact may also result in reduced numbers of adults while larval activity remains high. If these factors are experienced, a much lower threshold should be used, and orchard inspection should be <u>intensified</u>.

2.3.13 Other insects attracted to yellow traps

Most hymenopteran parasitoids as well as coccinellid beetles (and psyllids) are also attracted to yellow traps. Information gathered in this way, together with data supplied by routine and specific orchard inspection should play an integral role in pest management decisions.

2.3.14 Yellow traps in citrus nurseries

Yellow card traps can be useful for monitoring citrus thrips in nurseries and help to prevent unnecessary treatments. The traps can be suspended from the roof of the shadehouse or tunnel using a piece of wire. Ideally the traps should be suspended a few centimetres above the plants. The height of the traps can be adjusted periodically by bending loops in the wire as the plants grow.

Each tunnel or shadehouse should have a set of three traps with one on either end and one in the middle. If the shadehouse/greenhouse exceeds 50x50 m, or if plants vary substantially in age and/or the amount of new growth, more than three traps are needed and should be distributed accordingly.

As there are no established standards for foliar damage caused by thrips, nurserymen will have to determine what degree of damage they can tolerate and what number of thrips per trap is associated with this damage. However, as a guideline an average of three thrips per trap per week, if left untreated, will result in 10% of the susceptible foliage being damaged. This guideline does not apply to trifoliate rootstock plants which are more susceptible to thrips damage.

2.4 Control options

2.4.1 Biological

Natural enemies of citrus thrips include predatory mites, predatory bugs, predatory thrips, lacewings, spiders and at least one parasitoid. Pathogens in the soil may also have some impact on thrips that pupate there.

The predatory mites are the most abundant natural enemy and depending on the numbers present relative to thrips, can play an important role in reducing thrips damage. The most abundant predatory mites in the tree are phytoseiids belonging to the genus *Euseius*. *E. addoensis* (van der Merwe & Ryke) is dominant in the Cape provinces and as far north as Richmond in KwaZulu-Natal. In the rest of KwaZulu-Natal, Swaziland, Mpumalanga, the North-West province and the southern part of Limpopo province, *E. citri* (van der Merwe & Ryke) is the dominant species. In the northernmost parts of Limpopo province and in Zimbabwe the most common species is *E. pafuriensis* (van der Merwe). These species are all generalist predators and can survive on various pollens when prey is scarce. They also prey on mites such as citrus red mite and Lowveld mite. Their impact in spring is most noticeable with *E. addoensis* which overwinters in relatively high numbers and occurs in areas where thrips numbers at petal fall are not very high due to cold temperatures. The other species in subtropical areas may play a more important role in suppressing autumn thrips populations and reducing the threat to the next season's crop.

Predatory mites in the soil beneath the tree also contribute to the suppression of citrus thrips by preying on prepupal and pupal life stages.

The anthocorid bugs *Orius thripoborus* (Hesse) and *O. naivashae* (Poppius) are occasionally found in citrus orchards and are effective predators of citrus thrips. Young life stages are orange in colour but adults are black. However, they are usually not abundant enough to play a significant role in reducing populations of citrus thrips.

Predatory thrips such as *Haplothrips* spp. do prey on citrus thrips but are also relatively scarce and are susceptible to treatments used for thrips control.

Lacewings are generalist predators which also prey on mites, mealybugs and scale insect crawlers and are known to prey on citrus thrips. However, their numbers are generally low where broad-spectrum pesticides are applied for the control of mealybug or high populations of citrus thrips.

Up to 10% of citrus thrips may be parasitised by *Goetheana incerta* Annecke. This parasitoid has been collected in spring and late summer. Spiders in and under citrus foliage probably prey on citrus thrips but this has not yet been verified.

Where the use of broad-spectrum pesticides has been reduced after petal fall the pest status of citrus thrips has declined. This could be due to an increase in the numbers of several of the natural enemies mentioned above.

2.4.2 Cultural

On non-bearing trees there are no specific cultural operations that can act as an aid to thrips control. On bearing trees the main cultural issue of relevance is to take all steps to ensure a uniform blossom. Irrigation scheduling can also influence the late autumn growth flush which can be responsible for high numbers of over-wintering thrips. By promoting the earlier summer growth flush the amount of flush in autumn will be minimised. By planting *Casuarina* spp. or *Corymbia (Eucalyptus) torelliana* F. Muell. windbreaks, numbers of predatory mites in the orchards can be increased (see Cultural practices in Chapter 2).

Numbers of predatory mites, parasitoids and lacewings can also be increased by leaving a strip of unmown ground-cover approximately 1 m wide down the middle of the interrow space. When mowing does become necessary, alternate rows can be mown several weeks apart.

Experiments with bark mulch under trees have not benefitted thrips control.

2.4.3 Plant protection products

Except where otherwise stated, products used as dilute (1X) sprays with ground-based machinery must be applied as outside cover film sprays, i.e., to wet the foliage canopy (and outside fruit) to the point of run-off. Citrus thrips seldom damage inside fruit, unless there is a lot of light inside the canopy, so the application of material inside the tree is unnecessary and is detrimental to natural enemies that may otherwise be able to take refuge there.

2.4.3.1 Resistance management

Due to the importance of citrus thrips as a citrus pest and the temptation to control it on every growth flush on young trees, the need for reducing the selection pressure for the development of resistance to insecticides is great. Citrus thrips is variably resistant to organophosphates, carbamates, pyrethroids and tartar emetic in different production areas. However, in all cases this resistance is unstable and will decline in the population with time, although it will never disappear. This means that where resistance has been experienced a single treatment per year of the product concerned is usually effective, provided the population is not exposed to that group of chemicals during the rest of the year. In order to prolong the life of existing thripicides, products should only be used at registered dosages and should only be applied when necessary. Where multiple applications are required, products from different chemical groups should be used. All labels display the IRAC group on the label which makes it easy to determine whether chemicals belong to different groups or not.

2.4.3.2 Non-bearing trees

Traditionally the product options registered for the protection of fruit have also been used on non-bearing trees. In these situations the residue restrictions can be ignored.

If non-bearing orchards are adjacent to bearing orchards under IPM, long residual plant protection products should be avoided during summer and autumn because spray drifting into the IPM orchards will be detrimental to natural enemies. In these situations the use of abamectin plus oil sprays would be preferable.

On non-bearing trees, stem treatments of methamidophos SL (and monocrotophos in Zimbabwe) will give thrips control for approximately three weeks. They are applied according to the recommendation in Chapter 2 (Trunk Application Procedure). A soil treatment of Confidor 70 WG is also registered for the control of thrips in nurseries at the rate of 1.5 g in 200 ml water per seedling.

2.4.3.3 Bearing trees

All treatments recommended below are for fruit destined for export. Growers with orchards destined for the local market can refer to product labels for slight changes to these recommendations.

The selection of chemicals for the control of citrus thrips is complicated and can be controversial. This is because the most effective products against thrips give long residual control and these products are usually the most detrimental to natural enemies and therefore least compatible with IPM. On the other hand, short residual products are not effective in controlling high populations of citrus thrips and, when used more than three times in succession, are more detrimental to natural enemies than some long-residual products. In addition, frequent usage accelerates the development of resistance.

Apart from IPM considerations and the degree of thrips control required, the choice of products used for thrips control will also be influenced by the availability of spray machinery and the possibility of rain. Where spray machinery is limited, or where spring showers may prevent the application of treatments for several days, it is advisable to treat a portion of the farm with longer residual products at petal fall or apply prebloom treatments. These treatments should be used in the orchards with the highest infestations of citrus thrips or the most susceptible cultivars.

The monitoring of citrus thrips is probably more important than the monitoring of any other citrus pest because serious damage to fruit can occur in a short period of time. The duration of control afforded by any plant protection product is dependent on the susceptibility of thrips in that region to the product, the numbers of thrips present, the role of natural enemies and whether or not the product is washed off by rain. It is therefore essential to monitor orchards at least once a week in the first eight weeks after petal fall to ensure that the treatments are effective.

The following products are listed in approximate order of decreasing suitability for use in IPM. Products expected to give less than 2 weeks' control have been excluded. Current restrictions on the use of plant protection products on export citrus must be borne in mind.

Product	Dosage/ 100 ℓ water	Type of spray	Approximate control period (wks)	Efficacy reduced by rain	Comments
Methamidophos (Citrimet)	Depends on stem size	Stem trt.	3	Yes, if not yet dry.	Mainly useful as a prebloom treatment or for summer flush but can control thrips on fruit up to 3 weeks after petal fall.
abamectin plus light/medium narrow range oil	10-20 ml + 300 ml	Film	2-4	No	Trees must be sprayed to run-off, preferably early morning or late afternoon. Controls red mite and oriental mite, suppresses all other citrus mites when used with oil.
Exirel plus light/medium narrow range oil	100 ml + 300 ml	Film	2-3	No	Do not use alternative adjuvants to the mineral oil as fruit burn may result.
Mesurol plus sugar	40 ml + 200 g	Bait	2-3	Yes	Some contact action but less effective than Dicarzol bait. May increase red mite and oriental mite but not scales. Don't use after January for some markets.
Closer	12 ml	Film	3	No	Probably used for control of mealybug just after petal fall
Delegate	10 g	Film	3-5	No	Do not exceed two applications per season. Higher rates used for bollworm and false codling moth. Do not use from December

Product	Dosage/ 100 ℓ water	Type of spray	Approximate control period (wks)	Efficacy reduced by rain	Comments
					onwards if possible to reduce pest repercussions.
Tokuthion	50 ml	Film	3-5	No	Once only at 90% petal fall. Does not increase red mite population.
Profenofos	75 ml	Film	2-4	No	Can be used at 100 ml for mealybug but not later than 50% petal fall. Do not use on grapefruit and soft citrus due to possible leaf drop.
Dicarzol plus sugar	25 g + 200 g	Bait (Aerial)	3-5	Yes	Should not be used after November due to chance of increasing mealybug and red scale. Quicker knockdown than Mesurol and less red mite.
Dursban WG	64 g	Film	2-4	No	Only OP that can be used after petal fall.
Calypso plus light or medium NR oil	30 ml + 250 ml	Film	5	No	Not for lemons. Do not apply later than three weeks after petal fall.
Hunter 24 plus sugar	30 ml + 200 g	Bait	3-5	Yes	Not later than end Nov. Will increase mealybug if present when sprayed, and red mite.
Hunter 24	45 ml	Film	4-7	No	Also controls rust mite but does not kill predatory mites. Petal fall only. Will increase mealybug if present when sprayed, and red mite. Suppresses red scale.
Regent	7.5 to 10 ml	Film	5-8	No	Must be applied before calyx closure. Mainly a stomach poison. Will increase red mite and can increase mealybug and soft scales if present when sprayed. Long lasting disruptant if sprayed inside the tree.
Klartan	30 ml 15 ml	Film Film	4-7 3-5	No No	At 70-90% petal fall. Before mid-November but not after previous sprays of Meothrin, Klartan or Cypermethrin.
Meothrin (plus Elsan)	30-50 ml (+ 100 ml)	Film	4-7	No	Elsan is optional but recommended to reduce repercussions.
Cypermethrin	15-20 ml	Film	4-7	No	One application within the first 6 weeks after petal fall, lowering the rate as time increases after petal fall. Not after previous pyrethroid sprays. Resistance is developing in the subtropical regions.
Akito	20-25 ml 6.5-10 ml	Film	4-7	No	High rate within the first 9 weeks after petal fall. Lower rate up to 20 Dec. Not after previous pyrethroid sprays or where red scale present.
Samurai	15 ml	Film	5-7	No	Only spray as full cover for mealybug to get thrips control

Product	Dosage/ 100 ℓ water	Type of spray	Approximate control period (wks)	Efficacy reduced by rain	Comments
					benefit. Red scale must be under commercial control. Other repercussions likely.