Thrips

A Pest Management Plan for Production Nurseries

Background

Thrips are tiny slender cigar-shaped insects with fringed wings, all from the order Thysanoptera (pronounced Thigh-san-op-terra). Most thrips encountered in production nurseries are pale to dark brown, but may sometimes be black. They feed by rupturing the outer layer of plant cells and sucking up cell contents. This results in scarring, stippling, flecking, russeting or silvering of the leaf surface, scaring of the developing fruit, discolouration and scaring of flowers or distortion of new growth, depending upon where feeding occurs. Thrips can also vector a number of serious plant viruses that can affect a large number of plant species. Thrips feeding is usually accompanied by black flecks of frass or excrement (Fig. 1). Not all thrips are plant feeders, some species feed on fungi or pollen and are often non-damaging. Certain thrips are predators that feed on other insects (including thrips) and mites.

In Australia, there are more than 35 species of thrips recognised as pests of a range of horticultural, ornamental and forestry crops (Table 1). Some of these thrips are more serious pests to the production nursery industry than others; i.e. they tend to cause greater damage and may feed on a larger number of plant species. For example, western flower thrips is a very serious pest for which a factsheet has been specifically written. Some species can also be resistant to a range of pesticide products.

Since many thrips have significant variation in colouration, it is not possible to identify them based on this trait. Identifying thrips in the field is extremely difficult and can only be carried out by an experienced diagnostician with a high powered microscope; in most cases thrips must be slide mounted to be identified to species level. Species

Fig. 1. Greenhouse thrips infestation including larvae stages and a single adult (top right of image). Also note black excrement. Photo by David Cappaert, Bugwood.org

level identification is recommended when damage consistently occurs, if management actions fail and occasionally as part of routine monitoring. This can allow access to additional information that may be specific to the management of the particular species

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in the crop, e.g. alternate host plants seasonality and pesticide efficacy.

General biology

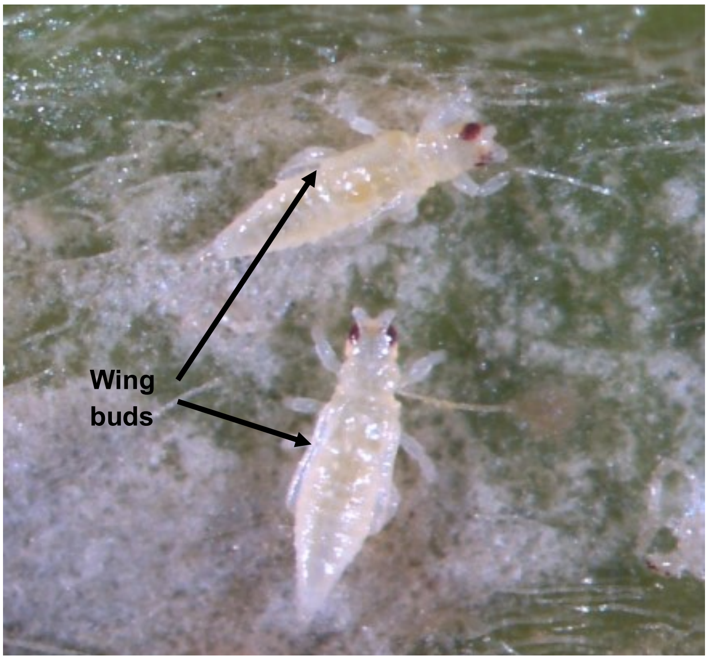
The word Thysanoptera is derived from the Greek word "*thysanos*" meaning fringe and "*ptera*" meaning wings, referring to the distinct setae, or fringed hairs on their wings. Thrips are small insects ranging from 0.5-2mm and occasionally up to about 14mm in length. The thrips body is cylindrical in shape, the head is narrow forming a conical mouth opening. Adults may be winged or wingless. When present, both pairs of wings are slender, with long marginal hair-like fringes.

The life cycle of thrips includes an egg, two larval stages that actively feed, followed by two or three non-feeding pupal stages (Fig. 2 – lifecycle diagram). Eggs are often laid into plant tissue (stems, leaves, flowers or fruit), but some species lay their eggs on the plant surface. Immature thrips (larvae) are similar in appearance to adults, but are generally paler in colour and are always wingless. Many species pupate in soil or leaf litter layers, but some pupate on the plant itself, particularly in flowers and other protected areas on the plant. This has management implications that will be discussed later. The emerging adults are generally winged, but depending on the sex and species, some have short wings and others are wingless.

Thrips are similar to bees, ants and wasps in that a fertilised egg becomes a female individual and an unfertilised egg becomes a male. Most species have males and females, but some lack males or only produce males rarely. In such species, females can lay eggs that become female individuals without mating. Some species can reproduce sexually or asexually, though the exact reason for doing so is not clearly known.

The length of the life cycle depends on environmental conditions and the quality of the food source. In warm conditions, around 30°C, the life cycle can be completed in less than 2 weeks. The same species at 20°C might take 3 weeks to complete the lifecycle. Development time and reproduction decreases in winter but breeding is likely to continue throughout winter in most of Australia, particularly in protected cropping environments. In very cool periods, thrips tend to overwinter as larvae or adults in the soil or as adults on plants, leaf litter or bark. For species that overwinter in the soil, it is typically achieved at a depth of 20-30cm but some species may pupate as deep as 100cm depending on soil conditions. For those species that overwinter, dormancy tends to end when temperatures rise in spring.

Under good conditions, adult thrips may live for 2-6 weeks, depending on the species. Females may lay 80-300 eggs, depending upon the species, host plant and environmental conditions. As such, thrips



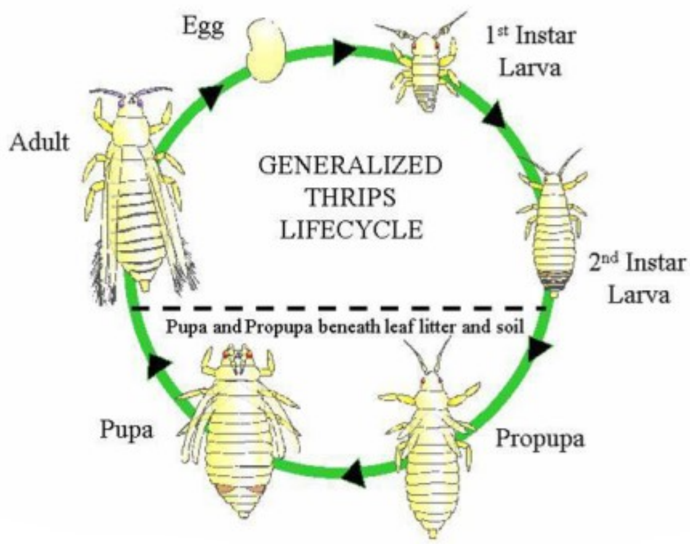


Fig. 2. Thrips pupal stages (above); adult thrips of various species (middle); generalised thrips lifecycle (below - reproduced with permission, Mark S. Hoddle UC Davis)

have the capacity to build up to large numbers in a relatively short period of time.

World-wide there are about 6000 species of thrips currently described. Of this number, less than 10% are considered economic pests of plant commodity crops. There are two groups (sub-orders) of thrips. The most commonly encountered group in production nurseries are relatively small, cream to pale, dark brown or sometimes black. Larvae tend to be cream to pale brown in colour. This suborder (Terebrantia – pronounced Terra-brant-eea) includes many of the serious economically damaging species, e.g. western flowers thrips, onion thrips, plague thrips and other species that often feed on a relatively large number of plant species. This group tends to feed in flowers and growing tips and on leaves and fruit. Not all thrips from this sub-order feed on plants, some are predators and a very few feed on moss.

The other sub-order (Tubulifera – pronounced tube-you-lif-era) tend to be larger (up to about 14mm) and often have a relatively long tube-like terminal abdominal segment (hence the name). This group is dominated by fungal feeding, leaf-litter species, but some species feed on plants and may cause economic damage. In many cases, tubuliferan thrips are black, heavily scleritised and larvae are often yellow to orange in colour (Fig. .

Damage

In Australia, only a relatively small number of species are considered pests (Table 1), although this does not include tubuliferan pest thrips. Thrips larvae and adults feed on various plant parts, pupal stages do not. Members of both sub-orders probe vegetation with their stylets, using their rasping-sucking mouthparts to damage individual cells, emptying cell contents which are sucked up. While collectively thrips can feed on growing tips, flowers buds, petals, pollen, new and old leaves and stems, some species feed in specific areas. Some species may exclusively feed within flowers, others may feed on flowers, leaf buds and expanding leaves.

Feeding on older leaves may cause relatively mild damage including the formation of silvery patches that turn brown as the cell tissues dry up beneath the epidermis (Fig. 3). This reduces photosynthesis and can induce premature leaf fall. Damage tends to be visible almost immediately after feeding occurs. Damage resulting from feeding on new growth or between plant parts tends to be delayed, i.e. plant growth must occur for the damage to become visible (Fig. 4). As the tissue develops it may then cause leaf distortion, leaf scarring, petal scarring and or leaf drop and rind blemishes. Faecal droplets, which turn black as mould grows on them, frequently accompany damage. Larvae tend to be more damaging than adults as they are often in greater numbers and are less mobile than adults. As such, damage is concentrated. Oviposition can also cause damage to

Fig. 3. Typical leaf scarring from thrips feeding (above - photo by Whitney Cranshaw, Colorado State University); leaf puckering caused by thrips (below - photo by Carroll E. Younce, USDA Agricultural Research Service). Both Bugwood.org.

developing fruits, e.g. tomatoes. Damage from thrips can also predispose plants to fungal or bacterial infection, allowing a point of entry to the pathogen.

Virus transmission

Some thrips may also vector a number of important plant viruses (Tospoviruses). Globally, tospoviruses are amongst the most formidable of plant pathogens causing severe economic losses in a wide range of cultivated crops. The three tospoviruses found in Australian crops are *Tomato spotted wilt virus* (TSWV), *Capsicum chlorosis virus* (CaCV) and *Iris yellow spot virus* (IYSV). Four species of thrips transmit these pathogens - WFT, tomato thrips and melon thrips. Refer to the WFT factsheet for more information on Tospovirus symptoms of nursery crops and weeds.

Only first or early second instar larvae feeding on infected plants can transmit these viruses. More mature stages of thrips can acquire the virus, but the virus cannot complete the lifecycle within the insect, and therefore cannot be transmitted. A larva can acquire the virus in less than 30 minutes of feeding on an infected plant. Once the larva acquires the virus, it circulates and multiplies within the insect. When the individual becomes an adult it can then readily move and infect any susceptible plant on which it feeds for the rest of its life. The virus is not passed on to their offspring through the egg.

Monitoring

Plants susceptible to thrips damage should be inspected on a weekly basis for the presence of thrips and data recorded, preferably electronically. Increase the frequency of monitoring during expected periods of infestation, spring and summer, particularly during periods with strong winds. Frequent monitoring will

Table 1. Relatively common pest thrips in Australia (Terebrantia only).

Pest Species	Common name	Host Crop and Distribution
Anaphothrips obscurus	None	Grass species (Poaceae) and various cereal crops. Feeds on leaves resulting in yellow streaks as leaves mature. Present in southern Australia.
A. sudanensis	None	Feeds on grass species (Poaceae). Feeding on leaves results in yellow streaks as leaves matures. Widespread in Australia.
Chaetanaphothrips leeuweni	Banana rust thrips	Feeds and breeds on leaves of *Musa* spp. Only known from NT.
C. orchidii	Orchid thrips, banana thrips	Feeds and breeds on leaves of orchids, *Musa* spp., *Citrus* and some greenhouse plants. Present in SA, NSW and Qld. On banana it can cause markings on fruit and leaves.
C. signipennis	Banana thrips, orchid thrips	Main hosts are anthurium, dracaena and banana, but may also feed on citrus, tomato, orchids and beans. Present in Qld, NT and NSW
Dichromothrips corbetti	Orchid thrips	*Venda* spp. found in NT and Qld. Feeds and breeds on leaves and flowers.
Echinothrips americanus	Poinsettia thrips	Impatiens, *Euphorbia pulcherrima*, Dieffenbachia, Syngonium, Cardamine and Hibiscus. Feeds and breeds on leaves.
Frankliniella occidentalis	Western flower thrips (WFT)	Fruit, vegetable, flower and ornamental crops. It has been recorded on over 250 plant species. Feeds on leaves and flowers. Widespread in mainland Australia.
F. schultzei	Tomato thrips	Feeds on leaves and flowers of a wide range of plant species including many from the families Solanaceae, Fabaceae and Cucurbitaceae. Also feeds, on *Allium* sp. and many ornamental crops. It is widespread throughout Australia.
F. williamsi	Maize thrips	*Zea mays* and perhaps other grass species. Feeds and breeds on leaves, particularly in leaf axils. Present in Qld, Tas and Vic.
Helionothrips errans	None	Feeds on many orchid species, potentially causing serious damage to leaves.
Heliothrips haemorrhoidalis	Greenhouse thrips	Feeds on a wide range of trees and shrubs, including ferns, tea, *Pinus* spp. Feeds on older leaves, particularly of plants that are stressed. Widespread throughout Australia.
Hercinothrips bicinctus	Banana silvering thrips; banded greenhouse thrips	Many host plant species including bananas. Feeds and breeds on leaves. Present in NSW.
H. femoralis	Banded greenhouse thrips	Banana, beetroot, celery, eggplant, tomato, some grasses, ornamental plants and pineapple. Reported from bananas in Carnarvon, WA.
Leucothrips nigripennis	Fern thrips	Feeds on fern fronds, particularly *Adiantum* sp., *Davallia* sp., *Pteris cretica*, *P. argyraea* and *Hypolepsis rugulosa*. Recorded in NSW and Qld.
Limothrips cerealium	Grain thrips	Various grasses (Poaceae) and cereal crops. Present in southern regions of Australia (i.e. Not Qld, NT and northern WA).
*Megalurothrips usitatus**	Bean flower thrips	Various legume crops (Fabaceae), notably feeding on bean flowers. Found across northern Australia (WA, Qld and northern NSW).

Table 1. cont'd

Pest Species	Common name	Host Crop and Distribution
Microcephalothrips abdominalis	Sunflower thrips	Various species from Asteraceae, notably sunflowers. Breeds in flowers, sometimes causing flower distortion. Widespread throughout Australia.
Neohydatothrips samayunkur	Marigold thrips	Marigolds (*Calendula* and *Tagetes*), breeding in flowers and on leaves sometimes causing severe leaf deformation. Reported in NSW and Qld.
*Odontothripiella australis**	Gorse thrips	Various legume species including *Pultenaea*, *Bossiaea*, *Jacksonia*, *Genista* and *Lupinus*. Known from most of Australia, except NT.
Parthenothrips dracaenae	Palm thrips	Various species, particularly *Kentia* palm, but also recorded on *Ficus* spp., *Emilia sonchifolia* (Asteraceae), the fern *Adiantum formosum* and species from a number of other distantly related plant families. It has been reported in NSW, Qld, SA, Tas and Vic.
Pezothrips kellyanus	Kelly's citrus thrips	Mainly citrus in SA, but also reported in NSW, Qld and WA. It has also been reported from tomatoes, various Asteraceae, Brassicaceae, Rosaceae, Pittosporum and other plants.
Pseudodendrothrips mori	Parlour palm thrips	*Morus* spp., including mulberry, and *Ficus* spp. Only recorded in Qld.
Scirtothrips. aurantii	South African citrus thrips	In Australia, this species has only been found damaging species of *Bryophyllum* and *Kalanchoe*. Citrus and mango have not been damaged in Australia. It is present in northern NSW and Qld.
*Scirtothrips dorsalis**	Strawberry thrips, chilli thrips	Highly polyphagous including many species from Solanaceae, Fabaceae and Cucurbitaceae. Plants from many other plant families also are hosts. Populations may show localised specificity. It is widespread across northern Australia.
Selenothrips rubrocinctus	Red banded cacao thrips	Mainly feeds on mature leaves of many tree species including mango, avocado, cacao, and a large number of ornamental and shade trees. It is widespread in Australia, reported in NSW, NT, Qld, SA and WA.
Stenchaetothrips biformis	Rice thrips	Various Poaceae, normally in damp places. It is present in NSW and Qld.
Thrips florum	Oriental flower thrips	Feeds and breeds in a large number of flowering plants, but is only sometimes considered to be a pest. It has been recorded from plants in the families Ericaceae, Rosaceae, Rubiaceae, Rutaceae and Verbenaceae. It has been mainly recorded in Qld, but sometimes in NSW, NT and WA.
*T. hawaiiensis**	Banana flower thrips	Feeds and breeds in a large number of flowering plants, but is only sometimes considered to be a pest. It has been recorded from plants in the families Anacardiaceae, Apocynaceae, Arecaceae, Asteraceae, Brassicaceae, Caricaceae, Musaceae (particularly bananas), Lecythidaceae, Fabaceae, Proteaceae, Rosaceae, Rubiaceae, Rutaceae, Verbenaceae and others. It is mainly present in Qld, NT and NSW but has also been reported in SA, WA and Vic.
*T. imaginis**	Plague thrips	Mainly feeds on stone and pome fruit, but may also feed on legumes, tomato *Eucalyptus* spp. and grape. It is widespread in Australia, from Tasmania to as far north as Brisbane.
T. nigropilosus	Chrysanthemum thrips	Many ornamental flowers particularly in Asteraceae, e.g. *Achillea*, *Chrysanthemum* and *Lactuca*. No significant damage has been reported in Australia on these plants. It is present in NSW, Qld, SA and Vic.
T. novocaledonensis	None	Adults have been taken from various herbs, shrubs and trees including rose, mango, avocado, Dodonaea, hibiscus, ageratum and other plants. It is only reported from Norfolk Island, not mainland Australia or Tasmania.
T. palmi	Melon thrips	Many species, particularly from Cucurbitaceae, Solanaceae, Fabaceae, Asteraceae and other families and orchids. It is only known from around Darwin, north Qld and southeast Qld – quarantine restrictions apply.
T. parvispinus	Taiwanese thrips	Tends to be highly polyphagous and often highly attracted to gardenia. It is recorded from Asteraceae, Apocynaceae and others in Australia. Widespread across northern Australia. No significant damage reported in Australia.
T. simplex	Gladiolus thrips	Feeds and damages *Gladiolus* flowers and is found wherever these plants are grown. Also feeds on other Iridaceae species.
T. tabaci	Onion thrips	*Allium* sp. are preferred hosts but it will feed on many other species including brassicas, tomatoes, beans, cucurbits, roses, potatoes and species from Asteraceae, Caryophyllaceae, Crassulaceae, Fabaceae, Euphorbiaceae, Lauraceae, Malvaceae, Mimosaceae, Moraceae, Myrtaceae, Poaceae, Rosaceae, Rutaceae, Solanaceae and many others. It is widespread across Australia.

enable infestations to be spotted while they are still light, and thus easier and cheaper to manage. Methods of monitoring may include:

1. *Visual inspection and plant beating* can be completed simultaneously. Examine young leaves and new growth of plants that look stunted, chlorotic or have silvering on both leaf surfaces using a 10x hand lens. Thrips tend to inhabit crevices near leaf veins and growing tips. Move through the crop and gently but firmly hit foliage against a beating tray (which can be a folder, bucket or plastic plate). The beating tray should be a single colour; white, grey or black is preferable as this will make moving organisms more visible. Beating plants is a relatively efficient way of monitoring for insects and mites that can be knocked from plants, including thrips, herbivorous and predatory mites, aphids, whiteflies, lady beetles, small caterpillars and a variety of other insects. However, thrips may fly off the beating tray quickly, so beat a few metres worth of plants and then examine the tray. Once something is found, a 10x hand lens can be used to inspect the catch.

2. *Yellow sticky traps* are useful tools for monitoring thrips adults. Adults are most attracted to young foliage and flowers, so traps should be positioned just above the plant tops. Traps should also be placed near doors, vents and any susceptible crops or areas. At least one trap per 100 m^2 is recommended for greenhouse crops, more in varieties that are known to be susceptible to thrips. Inspect sticky traps at least weekly and change traps every 2 to 4 weeks. Where thrips have been associated with prevailing winds in spring, traps can be placed at the leading edge of the property (i.e. upwind) and monitored at least weekly during high risk periods. This may assist in allotting monitoring effort in susceptible crops more efficiently.

For both types of monitoring, record the level of infestation (low, medium, high) and extent of damage. Your records can help to identify areas and varieties that are more susceptible to infestations. It is also important to continue monitoring following application of insecticides or release of biological controls to determine the effectiveness of treatments. These records can assist with making management decisions in the future. Insect monitoring data sheets are available in the BioSecure HACCP protocols available on the NGIA website (www.ngia.com.au). Simple and effective spreadsheets can also be created and modified to suit your nursery. Remember that damage to growing tips requires some time to grow out. Thus symptoms may still occur for some time after thrips have been eradicated, depending upon the growth rate of the plant.

Management

Put in place as many cultural management practices as possible. These actions reduce pest pressure passively, reducing the number of thrips that occur in each crop.

Fig. 4. Leaf stippling caused by WFT (above - Photo by Chazz Hesselein, Alabama Cooperative Extension System); deformed growth from thrips feeding in buds (middle - photo by Ronald S. Kelley, Vermont Department of Forests, Parks and Recreation); damage to capsicum flowers (below - Gerald Holmes, California Polytechnic State University, San Luis Obispo) All Bugwood.org.

1. Identify infestations early through regular monitoring (see section above).
2. Manage sources of infestation: control broad-leaf weeds and reduce other alternative hosts (identified through monitoring) in the production area and surrounds. The use of weed matting, plastic or gravel on the floor can help in production nurseries. Good weed management will also help reduce a variety of other pest problems including aphids, whiteflies and mealybugs, quite apart from other growing considerations.
3. Check incoming stock, new seedlings and other new planting material to ensure it is clean and to break the lifecycle of pest thrips. Never propagate from mother stock that is infested with pests.
4. Prune and thin plants with light to moderate infestations to reduce pest load, increase airflow and access by insecticides.
5. Remove and destroy heavily infested stock. Retaining unsaleable stock provides a source of further infestation. Infested material should be bagged and deep buried or placed in a black bag in the sun for several hours to kill pest thrips. Leaving unbagged, infested plants or cuttings in the bin encourages pests to reinfest the nursery, particularly as the plant material starts to wilt and die.
6. Screens placed over greenhouse vents and doors can be used to help prevent entry by thrips. Placement of such screens can increase the humidity in the structure, causing ventilation problems. It is recommended to use a protected cropping consultant/designer before retrofitting or building an insect-proof tunnel or glasshouse.
7. UV absorbing cladding material and films on protected cropping structures can reduce thrips populations and virus infection. Photoselective shade netting is also beneficial, yellow- or pearl-coloured shade netting can reduce a variety of pests from entering the crop, sometimes with 2-10 fold reductions compared to standard black shade cloth.
8. If infestations persist for long periods in a particular area or glasshouse, grow plants that are not hosts of thrips for a season to break the life cycle. Having the thrips identified to species will assist in this process. Contact your local department of agriculture or primary industries or Grow Help Australia.
9. Practice good crop hygiene to avoid contamination between greenhouses or production sites. Mark areas that are known to have infestations with visible signs so that workers can avoid moving through that area.
10. Avoid broad spectrum, residual chemicals that will cause high mortality of naturalised parasitoids and predators (see section on biological control).
11. Discontinue growing crops that regularly receive significant damage.

In field crops, highly reflective mulches can reduce thrips populations, reducing the numbers that fly into the crop. Protected cropping structures that are highly reflective may act in a similar way, but requires further study.

Pesticides

Many thrips species inhabit protected regions of plants, within flowers, growing tips and leaf curl galls. For this reason, contact pesticides are only likely to strongly impact those species that mostly are on the leaf surface, unprotected. For all other thrips, systemic or translaminar products are required. Populations of some species of thrips can develop pesticide resistance quite rapidly, most notably western flower thrips, onion thrips and melon thrips. For this reason, it is important to rotate between mode of action groups and to cease the application of products that have been ineffective. The presence of some thrips, particularly those feeding on pollen in flowers, cause little or no damage to plants. Therefore it is important to distinguish between those populations that are incidental, and those that are likely to cause economic loss.

Most products registered against thrips relevant to production nurseries are organophosphates (1B), synthetic pyrethroids (3A) or neonicotinoids (4A) (Table 2). These products will have a high negative impact on natural enemies present in the nursery, both those that are commercially available and those that come from surrounding habitats. It is recommended to avoid the use of these products unless there are no other options available. See recommendations section for suggested pesticide rotations. If thrips are likely to cause economic damage, it is important to apply a product on multiple occasions within a short period of time, i.e. at least weekly for three weeks. This will assist in breaking the lifecycle for those species that pupate in growing media or are otherwise protected from the pesticide application.

Biological Control

There are a number of natural enemies that can manage thrips, including commercially available predators and naturally occurring parasitoid wasps and predators. A range of pathogens may also infect thrips but are less likely to contribute to substantial control unless they become very abundant. There are three predators available commercially that feed on thrips on foliage. These are the predatory mites *Transeus montdorensis* (montdorensis) and *Neoseiulus cucumeris* (cucumeris) and the pirate bug *Orius tantillus*

(Orius). These species are more likely to contribute to significant thrips management in nursery crops. Orius in particular is the only commercially available predator that feeds on all stages of thrips found on plants including adults.

There are also four soil predators that feed on thrips pupae, two mites commercially known as Hypoaspis mites, a rove beetle (Dalotia) and an entomopathogenic nematode. Details on the biology of these species can be found at the webpages of Biological Services and Bugs For Bugs; the nematode is available from Ecogrow. Soil predators and nematodes are probably best suited to crops in propagation that are prone to thrips damage and for which the thrips species in question is known to pupate in the soil. These same biological control agents also feed on fungus gnat larvae.

There are also many naturally occurring thrips predators that will move into production nurseries and become abundant under the right conditions. These include lacewings, certain lady beetles, predatory flies, predatory thrips, mites and bugs. In addition there are a range of parasitoid wasps that attack thrips. These species can be encouraged by limiting pesticide application, particularly broad spectrum products with long residual activity. Flowering plants will often attract and retain predator species and can be used to encourage their presence in production nurseries.

Recommendations

For crops that receive consistent, regular damage, particularly in spring, it is recommended to take action early. This may involve the pre-release of a suitable biological control agent. Orius is a good choice as they feed on a range of food items including pollen and adult thrips (which are likely to be blown into the nursery on the wind in spring). Monitor thrips populations in susceptible crops regularly during high risk periods. Follow up releases of predatory mites (cucumeris or montdorensis) can be applied regularly to limit build-up of thrips populations (probably weekly until predator populations have established). Contact biological control agent producers for advice on how to best release predators to optimise success whenever applying predators for the first time, or when uncertain of how to proceed.

If moderate numbers of thrips have occurred in the crop and predators are either already present or their release is planned, it may be necessary to apply a low risk pesticide. The following products will have limited negative impacts on predator populations, particularly if predators are released three days after pesticide application (Table 2).

- Spirotetramat
- Spinetoram
- Abamectin

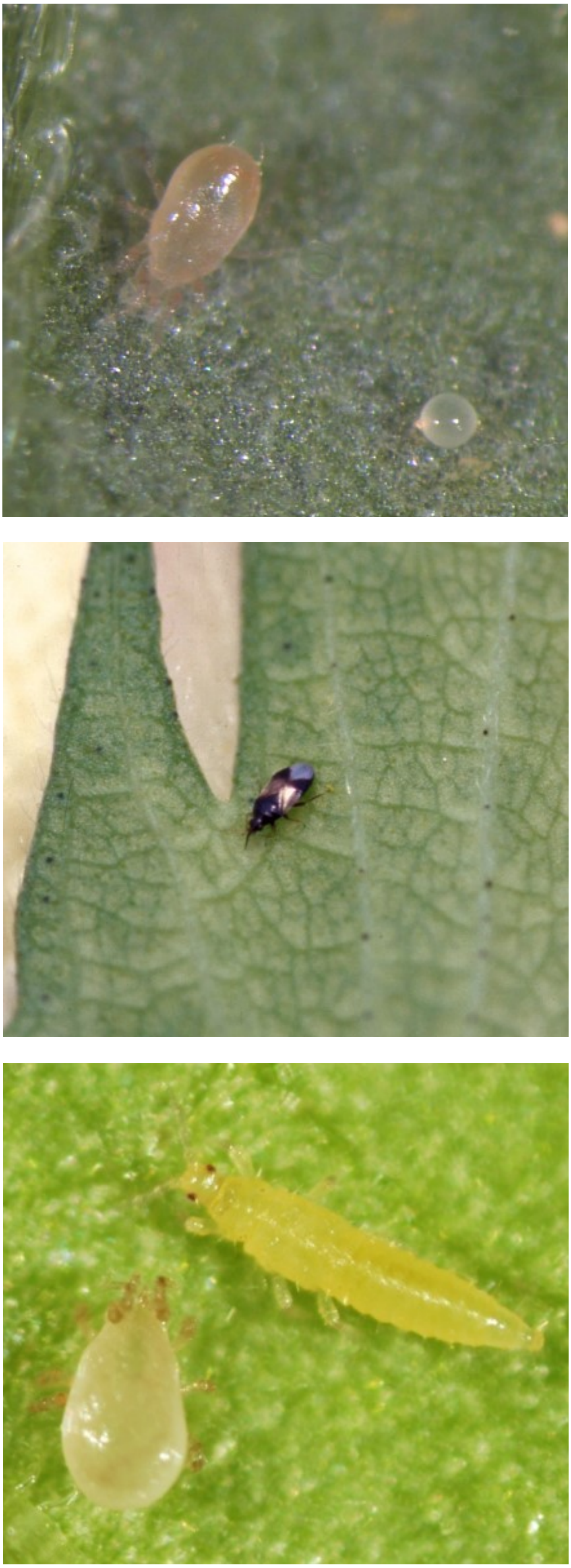


Fig. 5. Montdorensis feeding on a spider mite egg (above); Orius searching for food (middle - Photo by Ronald Smith, Auburn Universtiy, Bugwood.org); Cucumeris next to a thrips larva (Photo by Biological Services).

Add an oil compound at label rates if feasible, particularly if some thrips are present on exposed plant surfaces. Always follow label pesticide resistance management strategies if they are present. Again, if planning on releasing predators, contact the biocontrol agent producer to discuss your plan and optimise success.

There are a range of factors that may prevent successful release of beneficial insects. The predator may not feed on the thrips species infesting the plants (particularly if they are tubuliferan thrips). Environmental conditions may prevent their successful release. This can occur during high summer heat, e.g. above about 35°C, or cold night time temperatures, below about 10°C. If the area of infested plants is very small, i.e. only a few square metres it may not be cost effective to apply predators. However, some products are available in 'garden packs' specifically for management of relatively small areas. In these cases, cultural management practices and pesticide applications are likely to be the major components of your management plan for thrips. Refer to Table 2 for more detailed information on products registered for thrips in Australia.

Where biological control is not practiced and naturally occurring beneficial species are not to be conserved, the addition of the following products can be added to the rotation.

- Group 1B product (preferably a systemic product)
- Fipronil
- Group 4A product (particularly in Durivo)

Exotic Thrips

There are a number of thrips recorded as pest overseas that would be of concern if introduced into Australia. These include **Bean thrips** (*Caliothrips fasciatus*), a pest of legumes and citrus. In particular it causes problems in relation to the import of citrus into Australia and is regularly intercepted on navel oranges. Relatively recent surveys indicate that it is not present in Australia. **Florida flower thrips** *Frankliniella bispinosa,* a citrus pest in Florida. **Tobacco Thrips,** *Frankliniella fusca,* a pest of a wide range of host plants and vector of TSWV. **California citrus thrips,** *Scirtothrips citri*, a significant pest of citrus. **Avocado thrips** *S. perseae*, a serious pest of avocados. Other exotic thrips would likely impact certain crops in Australia, as would exotic Tospoviruses, e.g. *Impatiens necrotic spot virus*.

This document was prepared by John Duff and Andrew Manners (Agri-science Queensland, Department of Agriculture and Fisheries, Ecosciences Precinct, GPO Box 267, Brisbane QLD 4001) as part of NY15002 Building the resilience and on-farm biosecurity capacity of the Australian production nursery industry in 2016. All photos by DAF, unless otherwise stated.

Fig. 6. Some Tubuliferan thrips are also pests. Ficus thrips gall (above); damage from yucca thrips (below) and close up of thrips under leaf sheath (insert).

Table 2. Active ingredients registered against scale insects relevant to Australian production nurseries. Action C = contact, S = Systemic and T = Translaminar, I = Ingestion. Toxicity to beneficials is just a guide based on current information; some products may differ in their impact to beneficial populations.

Mode of action	Active ingredient	Example product name	Registration information	Action	Toxicity to beneficials
1B	Acephate	Lancer	PER81707 WFT on nursery stock.	C, S	H – 8-12 weeks residual
1B	Diazinon	Diazinon	All thrips on nursery plants; various thrips on specific vegetable and fruit crops.	C, I, V	M-H – about 3 weeks residual
1B	Dimethoate	Dimethoate	All thrips on ornamental plants. Various thrips on certain fruit and vegetable crops.	C, S, I	H – 8-12 weeks residual
1B	Maldison	Hy-Mal	Thrips on ornamentals and citrus.	C, I	H – at least 3 weeks residual.
1B	Methidathion	Suprathion	Thrips on ornamentals and most nursery plants.	C, I	H – 6-8 weeks residual
1B	Methomyl	Marlin	PER82428 Thrips on most vegetables and non-bearing ornamental nursery seedlings.		
1B	Omethoate	Folimat	Thrips on onions, bananas, carnations, chrysanthemums, pelargoniums, roses, callistemons, Eucalyptus spp., Grevillea spp., paperbarks and wattles.	C, S, I	H – 8-12 weeks residual.
1B	Phorate	Thimet	Granular compound for thrips on onions, some brassicas, potatoes, tomatoes, carnations, chrysanthemums, dahlias, lily bulbs, azaleas, roses and other woody ornamentals.	S	Unknown, probably high toxicity with long residual.
2B	Fipronil	Regent, Instar Granular	PER81707 All thrips in soil.	C, S, I	H – at least 1 week residual
3A	Alpha-cypermethrin	Crop Care Dominex Duo	PER81707 All thrips except WFT on nursery stock.	C	
3A	Bifenthrin	Bifenthrin	*Thrips imagines*, *T. simplex* and *T. hawaiiensis* on ornamental plants; Flower thrips on banana. Labels vary.	C	High – 8-12 week residual
3A	Piperonyl butoxide, chilli, garlic, pyrethrins	Beat-a-bug	Plague thrips on nursery plants.	C	
3A	Pyrethrins	PyGanic	PER81707 All thrips on nursery stock.	C	
4A	Acetamiprid	Crown	Greenhouse thrips, and plague thrips on ornamental plants.	C, I, S	H – 6-7 weeks residual
4A	Imidacloprid	Spectrum, Confidor	Greenhouse thrips on ornamental plants, shrubs, flowers and non-bearing ornamental trees and citrus. Melon thrips on eggplant. Labels vary.	C, I, S	H – 2-4 weeks residual as a foliar spray; L toxicity as a soil drench.
5	Spinetoram	Success Neo	WFT on brassicas, cucurbits, fruiting vegetables, leafy vegetables, legume, ornamentals and berryfruit.	C, I T	Unknown – probably moderate toxicity with low residual.
6	Abamectin	Vantal	WFT on various cucurbits, eggplant, leafy vegetables, strawberries, tomatoes and ornamentals. Ornamental plants for purposes of interstate quarantine of melon thrips. Refer to resistance management strategy.	T, I	M – 1-2 week residual.
23	Spirotetramat	Movento	PER81707 All thrips on nursery stock.	S, I	L – low residual
28 & 4A	Chlorantraniliprole & thiamethoxam	Durivo	PER81707 All thrips on nursery stock.	C, I, S	M-H – probably moderate to long residual activity
NA	Natrasoap	Potassium salts of fatty acids	Thrips on ornamental plants.	C	M-H – no residual.
NA	Paraffinic oil	Sacoa BioPest	Thrips on selected vegetable and ornamental plants.	C	M – low residual
NA	Petroleum oils	Caltex Summer Spray	PER81707 All thrips on nursery stock.	C	M – low residual