Fungus gnat pest management plan for production nurseries

Fungus gnats are small, mosquito-like flies that are a common problem in propagation nurseries and greenhouses. Larvae feed on plant material, fungal growth, algae and other organic matter. During wet conditions they may also feed on root hairs, callus, crown and stem material of newly germinated seedlings or cuttings causing serious damage or plant death. Established plants generally are not affected except under very wet conditions and high populations. Both adults and larvae are known to spread a range of fungal pathogens including Botrytis, Pythium, Phytophthora, Fusarium *and others; minor damage from larvae can make plants susceptible to pathogens and cause further losses.*

Fungus gnat larvae can be difficult to manage using traditional insecticides. Management must focus on cultural practices that reduce populations passively, most notably reducing excessive irrigation, keeping the growing area clean and free of algae and organic matter. Biological control agents available are very effective, including a number of biopesticides that can be applied similarly to standard products. This plan provides details of fungus gnat biology, monitoring, cultural practices, biological control and pesticides that can be used to manage them.

Poor establishment caused by fungus gnats

GENERAL BIOLOGY AND LIFECYCLE

Adult fungus gnats are about 3–5mm, have relatively long, delicate legs and antennae and are very active runners. Adults are weak flyers and can often be observed flying in a zig-zag pattern above plants and resting on plants and containers. Females lay about 100–200 eggs over their lifetime of about 7–10 days. Eggs are laid in crevices of the soil or media and hatch after about 4 days. Larvae are white or translucent with a distinctive shiny, black head; they do not have legs. Upon hatching they are about 1mm and grow to be about 8mm over about 2 weeks, less in warmer conditions. Larvae are most often found in the top 2–5cm of growing media but can also be present deeper in the media, particularly near drainage holes. Larvae pupate on or near the surface of growing media and emerge as adults in less than a week. The entire lifecycle can be completed in 3–4 weeks depending on temperature and conditions.

Hort Innovation
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Adult fungus gnat

Fungus gnat larvae are legless, opaque and have a distinct black head.

Fungus gnats are favoured by wet growing media and 'dirty' growing areas. They feed on a range of fungi including plant pathogens and other soil inhabiting species, bacteria, algae and rotting organic matter; fungi and bacteria are an integral part of their diet. They also feed on plant roots (see damage section below). Larval survival is higher in the presence of diseased plants, where both fungal growth and rotting organic matter are readily available. Rotting plant material that remains in the growing area resulting from non-pathogenic factors (e.g. root rot associated with overwatering and low oxygen conditions) also benefit fungus gnat larvae. Some fungal species have been shown to reduce survival of fungus gnat larvae, e.g. *Trichoderma viride*. To our knowledge commercially available products in Australia have not been evaluated for their affect on fungus gnat populations.

Optimal temperatures for development of fungus gnats occurs between 15–30°C, with temperatures above about 32°C and below about 10°C being unsuitable. They complete many generations per year and usually have all life stages present at any given time.

While there are many species of fungus gnats, the most common horticultural pests are from the genus *Bradysia*, notably *B. impatiens* and *B. ocellaris* and can be found in all states of Australia and around the world. Species from other genera are rarely pests of nursery crops in Australia, though some species of fungus gnats are pests overseas and are not known to occur in Australia.

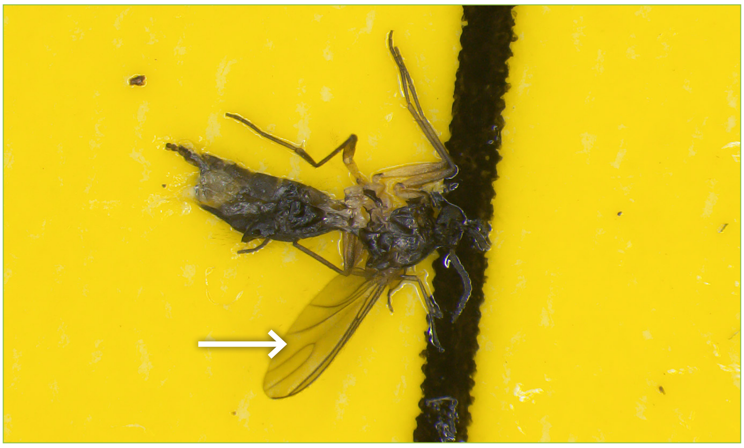
DAMAGE AND HOST RANGE

Larvae may feed on plants, particularly fine hair roots in the top 2–5cm of the growing media. They may also feed on larger roots and stems of susceptible plants. Feeding on roots reduces ability of plants to take up water and nutrients and therefore causes reduction in growth rate, stunting and may cause dieback of cuttings and complete collapse of small plants. In general, newly propagated plants and seedlings are most susceptible to damage owing to their relatively small root system; well established plants are generally unaffected except during very high populations. During high populations larvae may feed internally on larger roots and within cutting stems; all roots may be removed from relatively small plants. Larvae may also feed on foliage touching growing media surface.

Feeding damage causes wounds that predispose plants to infection by root and crown rot pathogens. Fungus gnat larvae and adults are well known for their ability to spread a wide range of fungal pathogens including *Pythium*, *Phytophthora*, *Fusarium*, *Verticillium*, *Thielaviopsis* (previously called chalara) and *Botrytis*. Research indicates that fungal spores and resting structures can be consumed by fungus gnat larvae and remain viable after passing through the insect. It is probably best to assume that any soil borne fungal pathogen can be spread by fungus gnat larvae. In that sense, fungus gnats need to be managed carefully during fungal disease outbreaks in the nursery.

Fungus gnats may feed on a very wide range of host plants, particularly during high populations. However, some plants are more susceptible to damage. Plants with succulent stems, such as geraniums, sedum, coleus and poinsettias, are particularly susceptible and can suffer serious loss if proactive steps are not taken. In addition, fungus gnats have been reported causing damage on begonias, carnations, chrysanthemums, cyclamen, gerberas, asparagus, corn, cucumber and clover, however many more are affected across the nursery sector.

Fungus gnat larvae infesting the stem of a rotting cutting.



Fungus gnat adult on yellow sticky trap. Note the prominent 'Y-shaped' wing vein shared by all fungus gnats.

MONITORING FOR FUNGUS GNATS

The main method used to monitor fungus gnats are yellow sticky traps; they only capture adults. It is important to understand that the number of adults is not always a good indicator of the number of larvae present in a crop or the level of damage. However, it can provide useful information on which to base proactive management actions. Larvae can be monitored using pieces of potato.

STICKY TRAPS

Yellow sticky traps are essential for monitoring fungus gnat adults in propagation houses and susceptible crops. They are also valuable for monitoring a range of pests including whitefly, thrips, moths, winged aphids, beetles and others.

Small sticky traps are only useful if you count and record the number of pests present on a regular basis; they are not mass trapping devices and should not remain in the growing area indefinitely. Rolls of sticky trap can be purchased for mass trapping of various pests including fungus gnats. These may be a supplementary tool, however, should not be relied upon to manage fungus gnats or other pests.

Position traps about 10 cm above the crop canopy, particularly near susceptible crops. 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 fungus gnats. Inspect sticky traps at least weekly and change traps every 2 to 4 weeks, more frequently if numbers are high. As a general guide, less than 20 flies per trap/week may be under the economic threshold but will vary with each crop and nursery. Monitoring will assist you to build more relevant economic threshold for your situation (refer to the recommendations section below for more details).

VISUAL INSPECTION

Actively look for adults flying in the crop. Typically fungus gnats fly in random patterns around plants and skitter quickly across the growing area when disturbed. If relatively large numbers are observed in this fashion further investigation should be undertaken.

Fungus gnat adult on moss.

Shorefly adults are bulkier and are less likely to fly when disturbed. Shorefly larvae primarily eat algae and rarely cause damage to roots of plants.

CAPTURING GNATS FROM MEDIA

It can be useful to understand how many fungus gnat adults are emerging from container plants, trays and media. This can be done by making a temporary cage; placing media in a clear plastic bag or other container (with ventilation). You can use different sized plastic drink containers (e.g. 2L soft drink containers), cut a hole and glue/silicon fine fly screen over the hole. Place a yellow sticky trap in the container to trap adults for counting. This can allow you to determine if certain growing media or plants are producing more fungus gnats than others.

The method can easily be modified for on-farm testing to answer practical questions and develop small scale, in-crop trials. For example:

1. How many fungus gnats are present in the growing media that has just been delivered?
2. Which growing media has fewer fungus gnats?
3. Are my pasteurisation/sterilising techniques eliminating fungus gnats from the media?
4. Which varieties or plant species support greater numbers of fungus gnat larvae?

When conducting such on-farm tests it is important to standardise your trials, using a similar amount of media or particular sized plants/plugs. This allows you to compare results over time more readily. Be sure to include treated and untreated media in separate containers simultaneously otherwise results may be ambiguous.

It is also valuable to repeat the trial, i.e. use multiple traps with the same media at the same time. This is called replication and can be done 3–5 times to provide a better indication of variability across your farm and growing media. For example, if you are comparing whether your coir mix has more or less fungus gnats than your pine bark mix, trap fungus gnats using three traps each of coir and pine bark.

MONITORING FOR LARVAE

Larval monitoring is more difficult because they live in the growing media. It is valuable to inspect the health of the cuttings periodically, including for the presence of fungus gnats. This can be achieved by lifting cuttings out of the media particularly before root initiation.

Some people have used potato plugs to lure larvae to the surface. Place a slice of uncooked potato about 3–5 cm in diameter (and about a cm thick) peeling side up in the growing media. Smaller chunks or slices can be used in small plugs/containers. Ensure that most of the surface is in contact with the media so that the potato does not dry out. After 24–48 hours, lift the potato plug and first examine the growing media under the potato, as larvae will rapidly vanish from view on the surface. Then check the potato itself for larvae. It is recommended to mark pots or plugs where potatoes are placed so you can find and remove them before they rot, sprout, promote fungus gnats and other pests e.g. mice. Note that small larvae can be difficult to spot using this method.

RECORD KEEPING

Keep long-term records to assist identification of areas and varieties that are more susceptible to fungus gnats. It is also important to continue monitoring following application of biological control agents and other control measures to determine the effectiveness of each treatment. These records can assist with making management decisions in the future. For example, one might modify the composition of growing media to reduce infestations or select varieties that are found to be more resistant to fungus gnat attack. It is highly recommended to use an electronic method to store data so that it can be searched and to build trends and patterns over time.

MANAGEMENT OF FUNGUS GNATS

Historically, fungus gnats have been managed using insecticides, but current trends indicate that sole reliance on insecticides to control fungus gnats is unreliable. Preventative measures, use of commercially available predators and biopesticides can be used very effectively. Using a wide array of options to minimise and manage fungus gnat populations is very effective for keeping fungus gnats under damaging levels and can avoid the need to use traditional insecticides altogether.

CULTURAL CONTROL – TAKING PREVENTATIVE MEASURES

There are many ways to modify the growing environment to reduce fungus gnat infestations.

1. Avoid excess watering and constantly wet media. Over irrigating favours fungus gnat populations directly and increases their food sources, e.g. fungal, bacterial and algal growth.
2. Fertilise using the minimum amount required to maintain optimal growth. Excess fertiliser will favour

the growth of algae in the growing area which will promote fungus gnat populations.

3. Use pasteurised and well-composted media to break the lifecycle of fungus gnats before it comes onto your farm
4. Store growing media in a clean, dry area. Storage of media in an unprotected area subject to rain or other sources of moisture may promote fungal growth, which in turn will promote fungus gnat populations. Ideally, cover unused media in a sealable container to prevent further infestations. Refer to the nursery paper on media storage for more information.
5. Use growing media that has relatively low levels of organic matter for seedlings and cuttings, e.g. perlite or rockwool. Otherwise, use a growing media that assists in optimal growth of your stock.
6. Check incoming stock and growing media for signs of pests, including fungus gnats. Employ greater monitoring effort when there are susceptible or high value crops involved. Return stock or change suppliers as required.
7. Quarantine incoming stock as per NIASA Best Practice Guidelines and monitor plants for fungus gnats and other pests prior to incorporation in production areas.
8. Grow cultivars that are more resistant to fungus gnats.
9. Identify infestations early through regular monitoring and manage pest populations proactively to reduce damage to the crop.
10. Disinfest growing surfaces and paths to remove algae, ensure that growing surfaces, below benches, walkways and non-growing areas are free-draining and free of algal growth.
11. Manage weeds proactively.
12. Modify the growing area such that algal and fungal growth is minimised and that water does not pool in or near the growing area; regrade floors and improve drainage if necessary.
13. Ensure that plant waste is removed hygienically into tightly sealing bins or in sealed bags as pests can reinfest the growing area from open or loosely sealing bins. Leave bins in the sun if possible or have them hygienically disposed regularly.
14. Remove unsold or unsaleable infested crops from the growing area quickly to reduce populations spilling into uninfested crops.
15. Do not compost plants with pest or disease infestations on site. Preferably, do not compost on site; fungus gnats will breed to high populations in compost heaps and will re-enter the nursery repeatedly. If compost and discarded plants must be kept on-site, ensure that they are well away from the growing area and do not drain into recycled water catchments. Manage fungus gnats in compost heaps proactively with predators
16. Last, but certainly not least, avoid broad spectrum, highly residual chemicals that will cause high mortality of beneficial insects and mites that feed on fungus gnats (see sections on pesticides and biological control below). Fungus gnats can be managed organically with great success.

Keep media stored in a dry place, under cover

FUNGUS GNATS AND PESTICIDES

Pesticides can be used to assist management of fungus gnat larvae. While pesticide resistance has not been reported in Australia, it may still occur. Resistance has been reported overseas for certain organophosphates (e.g. diazinon), synthetic pyrethroids (e.g. permethrin) and neonicotinoids (e.g. thiamethoxam, clothianidon). Therefore care should be taken to minimise reliance on pesticides to manage fungus gnats as it could result in resistance.

In the event that pesticides are required to reduce an outbreak that will otherwise cause significant damage, all registered and minor-use permits for fungus gnat larvae on ornamental stock, container plants or growing media are provided in Table 1. Included in this table is important information on the effect of products on natural enemies, the mode of action group, and notes on limits of use. Optimal application of pesticides against fungus gnats will assist in greatest control. It is recommended to:

1. Ensure that the product is applied correctly. Most drenches must be thoroughly applied to the medium to reach all larvae in the growing container.

2. Apply the correct amount of water post application. Too little and the product will not contact larvae well. Too much water and it will leach out of the media or move below the top 5cm of the media, where larvae are mainly found.
3. Do not use products consecutively from the same mode of action (MOA) group unless specifically stated on the label insecticide resistance management strategy. Alternate between as many MOAs as possible prior to repeating an application with a product (see recommendations below and Table 1).
4. If you are using biological control in the growing area, be aware of the effect of the product on beneficial insects (Table 1) and the length of time over which beneficials will have reduced capacity or be ineffective after its application.
5. Do not continue to use a product which has not been effective (particularly if it was applied correctly and good control has been achieved in the past). Such continued use will only serve to increase the level of resistance in the population and decrease the likelihood that the product will be effective in the future. Refer to the nursery paper on managing insecticide resistance for more information.
6. Be aware of product shelf-life and phytotoxicity. In particular, Bt products are living organisms that must be stored appropriately to maximise their shelf life.
7. Refer to the Nursery Pesticide Application Best Practice Manual for more details on effective application of pesticides.

BIOLOGICAL CONTROL OF FUNGUS GNATS

Biological control requires the same level of dedication as management with pesticides however is more gradual. Therefore, it is critically important to monitor fungus gnat populations and release predators early, preferably as part of a regular preventative plan. Regular application to high-risk crops reduces the likelihood that economic losses will occur.

HYPOASPIS MITES

There are two species of 'Hypoaspis' mites available commercially but are commonly referred to as Hypoaspis A or killer mite (*Geolaelaps aculeifer*) and Hypoaspis M (*Stratiolaelaps scimitis* or *Hypoaspis miles*). They are both soil dwelling mites that feed on a range of prey including fungus gnat larvae, thrips pupae, other soil mites, nematodes and other small invertebrates. Hypoaspis A has also been used to manage bulb mites and tends to forage deeper in the soil than Hypoaspis M. Both species are relatively large (1mm), brown to orange coloured mites that are slow moving. They take about 2 weeks to complete their lifecycle at about 25°C and adults may live for relatively long periods. Females lay 3–4 eggs per day. Populations will decline in unheated structures where the temperature drops below 10°C in winter. Likewise, temperatures above 30°C may be detrimental. Soil conditions do not always reflect outside air temperatures and this should be taken into account when deciding to use soil predators. Direct sun on the container of plants may increase the temperature for media within pots compared to air temperature. By contrast, soil in the shade may be substantially cooler than air temperature.

Hypoaspis mites are relatively large (1mm). Photo by Marilyn Steiner.

Soil predators may have some protection from foliar insecticide sprays, however, run-off from high impact pesticides can still have a severe negative effect on soil predators, particularly if they have long residual activity. Pesticide drenches are likely to have a high impact.

Biological Services produces both species of mites, while Bugs for Bugs and Bioworks only produce Hypoaspis M.

DALOTIA

Adults and larvae of the rove beetle, Dalotia coriaria, feed on a range of small insects and mites, feeding heavily on fungus gnat and shorefly eggs and larvae and thrips pupae, as well as a wide range of small insects. Adults are slender, fast moving glossy blackish-brown beetles that are 3–4mm long and can fly (their wings are concealed). Optimum temperature for *D. coriaria* is 27°C, at which development is completed in 13 days, but it is also active between 15°C and 32°C. Adults live about 21 days and lay up to about 8 eggs per day, and may consume up to about 150 small fungus gnat larvae or eggs (fewer numbers of large larvae and pupae are consumed). Adults prefer to eat fungus gnat larvae more than shorefly or western flower thrips pupae, when given a choice. Biological Services is the only provider of *Dalotia* in Australia.

Dalotia larvae (left) and adults (right).

INSECT-KILLING NEMATODES (E.G. *STEINERNEMA FELTIAE*)

Insect-killing (entomopathogenic) nematodes (ENs) are tiny, very slender, worm-like, soil-dwelling organisms that are less than 1mm in length. The ENs have limited dispersal capacity and thus must be drenched into the growing media evenly. Once they come in contact with a host, they enter it and release bacteria, which break down the tissue into food. This process causes septicaemia and kills the host, usually within 48 hours after infection. Thousands of ENs can breed within the hosts, largely dependent on its size, the larger the host, the more nematodes are produced. Once the food is completely consumed the prey disintegrates, releasing the ENs into the soil to infect new hosts.

There are a number of factors that can influence successful control of fungus gnats using *S. feltiae*. Media temperatures greater than 30°C and less than 10°C will cause ENs to become inactive and prolonged soil temperatures greater than 25°C may reduce efficacy of *S. feltiae* against fungus gnats. Temperatures above 12°C are recommended at time of application. As mentioned above, air temperatures may not reflect temperatures in the media.

Application of ENs can be completed using watering can, pump sprayer or knap sack where all filters (‹0.5mm) have been removed. ENs are UV sensitive, so application when the area is in high levels of direct sun is not recommended. ENs are compatible with most insecticides and miticides and may even be tank mix compatible (refer to Ecogrow), but application of nematicides will harm them. Ecogrow is currently the only Australian producer of ENs.

ENs can be stored in standard refrigerators for 3–4 weeks. If you anticipate requiring weekly applications, talk to Ecogrow about bulk orders to reduce costs.

BACILLUS THURINGIENSIS SUBSP. *ISRAELENSIS* (BTI)

Bacillus thuringiensis (Bt) is an entomopathogenic bacteria which causes diseases in insects. After ingestion by an insect host, the bacteria produce a number of substances which cause cell disruption and other physiological problems that cause the cuticle to disintegrate and the insect to die. There are a large number of Bt subspecies which are specific to certain pest groups, e.g. mainly flies and caterpillars in Australia. Bti (e.g. Vectobac and other products) is specific to various fly larvae, including fungus gnats. Research has shown that Bti is mainly effective against first instar fungus gnat larvae, not larger second or third instars. This is because larger larvae must consume more bacteria to cause mortality than smaller larvae. If using Bti one must apply the product when fungus gnats first appear and may require multiple applications. Bti is UV sensitive, so one must take this into account before application. Bti is available from most agricultural supply outlets. It is recommended to store in a cool, dry place that is not exposed to sunlight. In general, liquid formulations have a shorter shelf life than dry formulations. It is recommended to check the manufacture date is relatively recent as these products are reported to have reduced efficacy after 2-5 years, depending on the formulation and assuming good storage conditions.

NATURALISED PREDATORS

At least one naturally occurring parasitoid wasp may cause substantial mortality to fungus gnats. *Synacra* sp. are similar in size and habit to fungus gnat and thus are easily confused. They are often found running across growing media similar to fungus gnats. However, *Synacra* have four wings, not two, and are more pointed with a distinct cinctured abdomen that can easily be distinguished on yellow sticky traps. Female *Synacra* lay eggs into larval fungus gnats, the wasp larvae feeds inside the host larva until it pupates. As a result fungus gnat larvae may still cause damage to plants even though they are parasitised and will die shortly after pupating. They have been known to be quite effective against fungus gnats in glasshouses where broad spectrum, long residual pesticides are not in use (Marilyn Steiner, Biocontrol Solutions, personal communication). The biology of this species is not well known. Overseas, closely related species can parasitise 2–300 fungus gnat larvae, survive best between about 15 and 25°C and multiply more quickly than their fungus gnat hosts.

A small parasitoid wasp, *Synacra* sp., parasitises fungus gnats in Australia. It can easily be confused with adult fungus gnats. Photo by Marilyn Steiner

RECOMMENDATIONS: PUTTING IT ALL TOGETHER

Implementing cultural control measures described in this document is critical and will greatly reduce fungus gnat populations passively. If you are growing plants sensitive to fungus gnats it is recommended to take a proactively approach, preferably applying biological control agents on a regular basis. Management options are suggested below are only a guide; modify to suit your exact situation based upon plant species grown, monitoring data and past experiences at your farm.

Very high populations of fungus gnats provide an indication that practices need to change, particularly if high numbers occur regularly. Control actions to completely manage very high populations of fungus gnats may take several applications of multiple predators, perhaps after applying biopesticides or soft insecticides. Broad spectrum, high residual products are not recommended except under extreme duress.

FOCUS ON BIOLOGICAL CONTROL

	Fungus gnat numbers based on adults appearing on yellow sticky traps		
	LOW POPULATIONS < 20 PER WEEK	**MODERATE POPULATIONS 20–50 PER WEEK**	**HIGH POPULATIONS 50+ PER WEEK**
Biological management option 1 Mite focus	Release one of *G. aculeifer*, *S. scimitus* or *D. coriaria* on a regular basis at a preventative rate*. Preferably, release when potting up and once two weeks later.	Release one of *G. aculeifer*, *S. scimitus* or *D. coriaria* at moderate rate* weekly for three consecutive weeks.	Release *S. scimitus* or *G. aculeifer* AND nematodes at a relatively high rate* for three consecutive weeks
Biological management option 2 Biopesticide focus	Apply nematodes or Bti on a regular basis at a preventative rate*, preferably starting when first potting up. Alternate between Bti and nematodes at fortnightly intervals.	Release nematodes 3 consecutive weeks at moderate rates*.	If the population is particularly high, apply Bti once per week in addition to predatory mites and nematodes.

* Refer to your suppliers for guidance on recommended rates of release for preventative and higher level populations.

FOCUS ON CHEMICAL CONTROL

1. Apply when numbers are greater than 20 fungus gnats per sticky trap per week.
2. Rotate chemicals with different modes of action, do not use the same mode of action group on consecutive applications unless directed on the label or minor use permit.
3. Rotations can include up to 9 mode of action groups. Some products have a very broad spectrum and long residual mode of action. Some are relatively low risk and will preserve predator populations.
   a. Low risk rotation
      i. Pyriproxyfen — 7C
      ii. *Bacillus thuringiensis* subsp. *israelensis* — 11
      iii. Diflubenzuron — 15
      iv. Cyomazine — 17
      v. Azadirachtin — 22A
   b. Broad spectrum products can be included in the rotation if predators, pollinators and parasites are not being preserved and include:
      i. Organophosphates — 1B
      ii. Fipronil — 2B
      iii. Neonicotinoids — 4A. Note that some retailers do not allow the use of neonicotinoids in stock that they receive.
   a. ENs may also be used as an additional application at any time; there are no known cases of resistance to ENs.
   b. Avoid using a product from the same group that has been incorporated into the growing media, i.e. skip this mode of action group.
   c. Periodically check minor use permits to see if additional products become available for use against fungus gnat larvae.

FURTHER READING

- Australian biological control agent producers:
  - Biological Services
  - Bioworks
  - Bugs for Bugs
  - Ecogrow
- Nursery paper on managing insecticide resistance
- Webinar on insecticide resistance management
- Webinar on fungus gnat management
- Nursery Pesticide Application Best Practice Manual
- Nursery minor use permits
- Nursery paper on media storage
- Fungus gnat diversity in Australia
  including a taxonomic key

This document was updated in 2023 by Andrew Manners (Agri-science Queensland, Department of Agriculture and Fisheries (DAF), Ecosciences Precinct, GPO Box 267, Brisbane QLD 4001) as part of NY20000 Resourcing, supporting, and assessing biosecurity in nursery production. This project has been funded by Hort Innovation, using the Nursery research and development levy, contributions from the Australian Government and co-investment from DAF. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture. A previous version of this document was produced previously under NY11001 Plant health biosecurity, risk management and capacity building for the nursery industry.

TABLE 1. PESTICIDES CURRENTLY REGISTERED OR WITH MINOR USE PERMIT IN AUSTRALIA FOR USE AGAINST FUNGUS GNATS IN PRODUCTION NURSERIES AS AT NOVEMBER 2023. CHECK FULL PRODUCT LABELS AND/OR PERMITS TO DETERMINE SUITABILITY OF USE. ADDITIONAL PRODUCTS MAY BE AVAILABLE IN CERTAIN CIRCUMSTANCES.

MOA GROUP	ACTIVE INGREDIENT	EXAMPLE PRODUCT NAME	REGISTRATION INFORMATION	LIMITS ON APPLICATIONS PER SEASON	ACTION[a]	OTHER INFORMATION	TOXICITY TO BENEFICIALS[b]
1B	Chlorpyrifos	Suscon green	Registered for fungus gnats and shorefly for ornamental nursery plants (rooted cutting or seedlings or direct seed or unstruck cuttings) but only if in a peat based growing media.	Incorporated into growing media just before young bare root plants, seeds or cutting are planted, sown or struck.	C, I	Refer to label for application instructions.	Probably M-H – probably a very long residual period, perhaps even greater than 12 months.
1B	Diazinon	Diazinon, Diazol	Registered against fungus gnats in ornamental potted plants but only in Qld.	None specified.	C, I	Test in a small area to ensure there are no phytotoxic effects prior to use in a large area.	M — 1–2 week residual.
2B	Fipronil	Regent	PER91804 allows use against fungus gnats on non-food nursery stock.		C, I, S	Drench or granular formulations	H — Probably 1–2 weeks residual
4A	Acetamiprid	Crown	Registered against fungus gnats and shore fly on potting mixes, applied as a drench after potting and plant up.		C, I, S	Refer to label for application instructions.	M — probably 1–2 weeks residual.
4A	Imidacloprid	Suscon maxi	PER91805 allows use against fungus gnats on non-food nursery stock.	Incorporate into growing media prior to potting up. Do not apply as foliar spray in same crop. Do not apply in glasshouses or other covered situations.	C, I, S	Do not allow significant leaching and run-off for at least 3 irrigations or 10 days, whichever is longer.	M–H — 3 weeks residual.
4A	Thiamethoxam	Resolva	Registered against fungus gnat larvae on containerised ornamentals.		C, I, S	Drench or granular formulations. Refer to labels for application instructions.	H — Probably long residual, e.g. 3+ weeks
7C	Pyriproxyfen	Admiral	PER91812 allows use against fungus gnats on nursery stock (non-food): including seedlings and plugs, potted colour trees and shrubs, foliage plants, palms, grasses and fruit trees (non-bearing).	Twice per crop cycle.	C, T	Use as drench to saturate top 2–4 cm of soil. See permit. Immature insect growth regulator.[a]	L–M — 1 week residual.
11	*Bacillus thuringiensis subsp. israelensis*	VectoBac	PER91811 allows use against fungus gnats on non-food nursery stock.	None specified.	I	Refer to label for application instructions. See section on biological control for more details.	None — no residual.
15	Diflubenzuron	Dimilin	PER90454 and PER91812 allows use against fungus gnats on non-food nursery stock.		C, I	Drench. Immature insect growth regulator.[a]	L — probably limited residual when used as a drench
17	Cyromazine	Diptex	PER91811 allows use against fungus gnats on non-food nursery stock.	6 applications per crop at least 7 days apart.	C, I, S	Drench or foliar application. Do not ship plants within 7 days of application. Immature insect growth regulator.[a]	L — probably limited residual when used as a drench
22A	Azadirachtin A and B	Eco-neem; Azamax	Registered against fungus gnats for potting soil of floriculture and ornamentals.	None specified.	C, I	Some sensitive plants have had minor phytotoxic effects. Test in a small area to ensure there are no phytotoxic effects prior to use in a large area.	L — no residual.

[a] Action: C = contact; S = systemic; I = ingestion; T = translaminar; Immature growth regulators are most effective against larvae, causing death as the develop or moult.
[b] In the context of the table, beneficials refers to *G. aculeifer*, *S. scimitus* and *D. coriaria*. Summarised primarily from http://www.koppert.com/ side effects database and scientific literature searches. Probably' represents an educated estimate based limited information.