Integrated pest management for pest and disease control in ornamental crops

Brinsbury College Campus, 8 November 2016
# Seminar programme

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<td>13.30</td>
<td><em>Tea/coffee/biscuits and registration</em></td>
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<tr>
<td>13.55</td>
<td>Introduction to the seminar by the event Chairperson</td>
<td>Richard Hopkins, MD Fargro</td>
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<td>14.00</td>
<td>Essentials of IPM</td>
<td>Neil Helyer, Fargro</td>
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<td>The control of key pests using biological control agents</td>
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<td>Use of nematodes, including their application, for the control of a range of pest species</td>
<td>Jorge Tirado, BASF</td>
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<td>15.15</td>
<td><em>Tea/coffee/biscuits</em></td>
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<td>15.30</td>
<td>The secrets of successfully combining plant protection products within an IPM programme</td>
<td>Josh Burnstone and David Hide, Fargro</td>
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<td>16.15</td>
<td>Creating IPM programmes for key crop groups – protected ornamental crops and hardy nursery stock</td>
<td>Neil Helyer, Fargro</td>
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<td>16.45</td>
<td>How research is improving IPM performance</td>
<td>Jude Bennison, ADAS</td>
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<tr>
<td>17.15</td>
<td>Panel question and answer session</td>
<td>All</td>
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<tr>
<td>17.30</td>
<td>Depart</td>
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</table>
Integrated pest management for pest and disease control in ornamental crops
IPM Workshop
November 2016

Essentials of IPM
Aphid, whitefly, thrips and spider mite control in IPM programmes

Neil Helyer, IPM Specialist
Fargro Ltd

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Integrated pest management

- **Definition**: A systems approach that combines different crop protection practices with careful monitoring and the use of natural enemies. Sustainable Use Directive: legal requirement as of 1 January 2014.
Integrated pest management

- **Cultural**: general hygiene, ground cover materials, weed control, plant movement, change cultivar, monitoring, sticky traps.

- **Biological**: parasitoids, predators and pathogens.

- **Environmental**: disease control for plant and insect pathogens.

- Pesticide backup with selective chemicals.

Sustainable use of pesticides
Sticky trap orientation

100 / ha for monitoring, up to 1 / 2 per m² for mass trapping
Clean-up and spot sprays

• Chess WG + Dynamec: when average temperatures exceed 12 to 15°C for aphids and spider mites, use higher rate of Chess (EAMU) for leaf hopper and whitefly, higher rate (on label) for leaf miner and thrips.

• Chess WG fully safe to majority of beneficials.

• SB Plant Invigorator, Majestik, contact spray.

• Borneo + Dynamec + Attracker for spider mites.

• Gazelle + Dynamec + Attracker end of season clean-up; before diapause.
Aphid control by parasitoids

*Aphidius* species of parasitic wasps

- 1 : 1, up to 60 eggs / female wasp.
- Temperature 10 - 25°C.
- Good at 15°C up to 30°C.
- Naturally found from spring onwards.
Aphid control by predators

*Aphidoletes aphidimyza*

- 1 : 5 to 35, up to 100 eggs per female.
- Temperature 12 - 28°C.
- Nocturnal flying adult.
- Minimum 15.5 h day length to recycle.
- Flight temp 18°C.
- Ideal spring onwards or for heated crops.
Aphid control by predators

*Chrysoperla carnea* (green lacewing larva)

- 1: 250 aphids, more of other prey.
- Feed on most soft bodied prey.
- Ideal for ‘hot spots’ and organic crops.
- Can be introduced to hedges to prevent pest migration.
Aphid control by pathogens

Naturalis-L / BotaniGard

**Beauveria bassiana**

- 1 : 1,000,000 (++).
- Min 60% Rh, 80% at leaf surface.
- Good curative, produces epizootic infection.
- Ideal for ‘hot spots’ or mixing with nematodes and most insecticides.
- **Pandora neoaphididis**
Aphid control with pesticides

- **Aphox**: systemic, translaminar, vapour. IRAC 1A
- **Calypso**: contact, systemic. IRAC 4A
- **Chess**: contact, systemic, translaminar. IRAC 9B
- **Gazelle**: contact, systemic. IRAC 4A
- **Movento**: contact, systemic. IRAC 23
- **Naturalis-L, BotaniGard**: contact. IRAC exempt
- **Plant Invigorator**: contact. IRAC exempt
- **Pyrethrum 5 EC**: contact, short persistence. IRAC 3
- **Decis, Hallmark**: contact, long persistence. IRAC 3
Pesticide MoA’s

- **Insecticides**: target pest usually has to be active; generally active above 8°C.
- **Diapause and hidden life stages.**
- **Contact**: requires good spray coverage, sedentary target is best.
- **Systemic**: moves throughout the plant, good spray coverage, HV is best.
- **Translaminar**: moves through sprayed leaf, good spray coverage, 2 – 3 hr as wet residue.
- **Translocated**: moves from one part to another within plant.
Glasshouse whitefly control by parasitoids

*Encarsia formosa*
- 1 : 1 up to 60 eggs per female wasp.
- Min temp 12°C.

*Eretmocerus eremicus*
- 1 : 1 up to 50 eggs per female wasp, host feeding is high.
- Min temp 17°C but good up to 40°C.
Whitefly control

*Macrolophus pygmaeus*

- 1 : 500 +, 70 eggs per female.
- Mediterranean origin.
- Min temp 15°C.
- Licensed for use on protected crops in production.
- Supplementary food.
Aubergine as a trap / banker plant

Calendula, salvia, tomato
Whitefly control by pathogen

*Beauveria bassiana*

*Lecanicillium lecanii*

- 1 : 1,000,000.
- Min 60% Rh, (*B. bass*), 95% at leaf surface (*L. lecanii*).
- Slow curative.
- Ideal for severe ‘hot spots’ and mixing with selective pesticides.
Thrips

• Western flower thrips and others.
• Wide host plant range.
• Virus transmission.
• Severe economic damage to fruiting and flowering plants.
• Pesticide resistance.
• Aggregation pheromone.
Thrips control

• Synthetic version of sex aggregation pheromone as produced by males, attracts both male and female WFT. Thripline ams.

Kairomone lures; Lurem TR
Thrips control by predatory mites

*Amblyseius species*

- Attack young larval stage.
- Preventative, eat 1 - 2 first instar larvae.
- Can feed on other food sources; pollen, trichomes, extra floral nectaries.
- Prefer leaves with hairs.
- CRS sachets or loose carrier material.
Predatory mites

*Amblyseius cucumeris*

- Controlled release system (CRS) sachets.
- Waterproof bag.
- Active for 6 - 8 weeks.
Thrips control by predatory mites

- Hypoaspis miles
  Soil living predator eats larvae / pupae of sciarid and other pests.
Thrips control by predatory insects

**Orius species** (flower bugs)

- Adults and larvae eat most stages of thrips, 1 : 35 larvae / day.
- Good on long season crops.

**Chrysoperla carnea**

- Generalist predator of most soft bodied pests: aphids, mealybug, moth eggs, spider mites/caterpillar, etc.
Thrips control by pesticides

- Conserve: contact, translaminar. IRAC 5
- Dynamec: contact, translaminar. IRAC 6
- Majestik, Plant Invigorator, Savona: contact.
- Movento: systemic and translaminar. IRAC 23
- Naturalis-L, BotaniGard: contact bio-insecticide. IRAC exempt
- Nemasys: contact very short active life.
- Pyrethrum 5 EC + Codacide Oil: contact. IRAC 3
- Attracker: liquid fructose and glucose sugars.
Improving pest control: Appetent Silica based wetting agents.
Spider mites

Glasshouse or two spotted spider mites (red spider mite)
Spider mite control with predators

*Phytoseiulus persimilis*

- 1 : 5 - 20 / day, average 2 eggs laid / day.
- In use over 45 years on many crops.
- Optimum 22°C.
- Less efficient at low Rh and above 28°C.
- Susceptible to many pesticides.
Spider mite control with predators

- **Amblyseius andersoni**
- UK origin found in most of Europe.
- Wide host plant range: vines, orchard fruit, ornamental deciduous trees and shrubs, coniferous trees, herbaceous plants, raspberries, strawberries etc.
- TSSM, FTSM, CSM, pollen, thrips, rust mites, gall mites.
Spider mite control by pesticides

- **Apollo**: contact, ovicide. IRAC 10A
- **Borneo**: contact, translaminar, long persistence. IRAC 10B
- **Dynamec**: contact, translaminar. IRAC 6
- **Masai**: METI, contact. IRAC 21
- **Naturalis-L**: contact bio-insecticide. IRAC exempt
- **Plant Invigorator**: contact. IRAC exempt
- **Pyrethrum 5 EC + Codacide Oil, Spruzit**: contact. IRAC 3
Integrated pest management for pest and disease control in ornamental crops
Use of Beneficial Nematodes for Pest Control in Ornamentals
Entomopathogenic nematodes – General benefits

- Reliable performance
- Application methods similar to chemicals
- Persistent in the soil/substrate for medium term control
- Safe to crops, users and the environment
- No re-entry interval required
- Suitable for IPM practices
- Suitable for organic farming
Entomopathogenic nematodes – Life cycle

Infective juveniles are produced when resources become limited.

Thousands of infective juveniles released in search of new hosts.

Nematodes reproduce for 2-3 generations.

Infective juveniles enter host through natural openings.

Nematodes release symbiotic bacteria which kill host (Xenorhabdus spp. for Steinernematidae and Photorhabdus spp. for Heterorhabditidae).

Nematodes become adults in dead host.

Thousands of infective juveniles released in search of new hosts.
Entomopathogenic nematodes – Production

- All nematodes are produced using large-scale bioreactors
- Aim to recreate conditions inside the insect cadaver for growth
  - Provide nutrients and oxygen
  - Maintain temperature
- Industrialised process
Entomopathogenic nematodes – Production

- Nematodes are harvested and infective juveniles separated from other life stages
- Infective juveniles are then formulated into final product
  - Addition of an inert gel carrier
  - Allows for storage before use
  - Allows nematodes to easily disperse in water on application
- Packs filled based on number of live infective juveniles
  - Pack weight may vary from batch to batch
General recommendations

- Nematodes should be applied when the target pest is present
- Avoid applications in direct sunlight (nematodes are killed by UV light)
- Apply in wet and humid conditions
- Evening applications are best
- Majority of application equipment suitable for nematode application
- Remove all fine filters (50 mesh – equivalent to 0.3 mm – or smaller)
- Do not exceed 300 psi/20 bar/2000 kPa pump pressure
- Nozzle aperture should be greater than 0.5 mm
  - Suitable nozzles should produce a medium or coarse spray at the intended application pressure
Entomopathogenic nematodes – Directions for use

Storage

- Upon receipt, remove packs out of shipping box/package and use immediately or store in a refrigerator at 5°C
- Avoid the constant opening of the fridge to minimize temperature fluctuations
- Do not overfill the fridge to allow movement of cold air
- Do not use product if past expiry date or incorrectly stored
- DO NOT FREEZE
  - Freezing kills the nematodes as the forming ice crystals rupture their tissues
Entomopathogenic nematodes – Directions for use

Mixing procedure

- Premix nematodes with water in separate bucket
  - Minimum of 10L

- Ensure nematode formulation is fully dispersed before adding to tank
  - Thoroughly stir

- Ensure suspension remains agitated throughout application

- Use entire contents of pack at one time
  - Do not split or subdivide individual packs

- Apply immediately, do not store in suspension
Entomopathogenic nematodes – Most common application equipment

- Knapsack
- Dosing unit (Dosatron models dose between 0.2 – 2%)
  - Hose and coarse rose
  - Boom sprayer
Entomopathogenic nematodes – Application method

Soil or substrate drenches

- Most common nematode application method
- Irrigate prior and after nematode application
  - The soil/substrate should be moist and remain as such for at least 2 weeks after application
  - Use enough water to ensure contact with the pest
- If using spray equipment, apply as a coarse spray ensuring nematodes reach the soil surface
- If applying through foliage, consider post irrigation to wash nematodes onto the soil/substrate
Entomopathogenic nematodes – Application method

Foliar sprays

Removing the nematode from its natural environment

- Manipulate environment to prolong nematode survival
  - Shut vents/ventilation during this period to keep high humidity levels
  - Evening applications/use blackout curtains (avoid direct sunlight)
  - Switch off artificial lighting
  - The foliage should remain wet for as long as possible

- Use appropriate nozzle type
  - Medium droplet size
  - Apply to point of runoff
Entomopathogenic nematodes – Product range

- Nemaslug®
- Nemasys® L
- Nemasys® H
- Nemasys®
- Nemasys® C
- Nemasys® G
- Nemasys® J
- Nemasys® M
# Vine weevil control

**Nemasys® H and Nemasys® L – Product overview**

<table>
<thead>
<tr>
<th><strong>Nemasys® H</strong></th>
<th><strong>Nemasys® L</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Biocontrol agent containing <em>Heterorhabditis bacteriophora</em></td>
<td>Biocontrol agent containing <em>Steinernema kraussei</em></td>
</tr>
<tr>
<td>Soil temperatures should be between <strong>12°C and 30°C</strong> (from Apr to Sept) for at least two weeks after application</td>
<td>Soil temperatures should be between <strong>5°C and 30°C</strong> (from Mar to Nov) for at least two weeks after application</td>
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</table>
Vine weevil control
Nemasys® H and Nemasys® L – Product overview

- Used in nurseries, glasshouse crops and soft fruit production to control vine weevil larvae and pupae (*Otiorhynchus sulcatus*)

- Infective juveniles penetrate vine weevil larvae and pupae through natural openings (mouth, spiracles, anus) and *cuticle* – characteristic of *Heterorhabditidis* only

- Grubs stop feeding within 3 days of infection and are killed within 2 – 4 weeks after application

- Nematodes complete their lifecycle within the grub and enter the soil/substrate seeking out more grubs
Eggs are small and spherical (ca 1 mm). At first white then becoming dark brown.

Larvae have a cream body with no visible legs and a dark brown head capsule. Grow to approximately 1 cm long.

Pupae are cream in colour and show adult features such as legs and mouthparts.

Adults are 0.8 – 1.0 cm in length are black with yellow speckling on their back and have a short snout.

Though adults are flightless, they are very active nocturnal walkers.
Vine weevil (Otiorhyncus sulcatus) lifecycle

- All adults are females and reproduce parthenogenetically
- Adults emerge in May/June and lay several hundreds of eggs each around host plants (2 - 40 cm deep)
- Eggs hatch after 1-3 weeks depending on temperature and the larvae feed on roots
- Larvae overwinter in the soil and resume feeding the following spring for a short while before entering the pupal stage
- The life cycle is completed typically in 11-12 months, however populations in glasshouses may have two generations per year with adults emerging as early as March. Some adults may overwinter
Vine weevil control
Nemasys® H and Nemasys® L

Black vine weevil life cycle

Egg

Larva

Pupa

Adult

Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb

Vine weevil control
Nemasys® H and Nemasys® L

Vine weevil plant damage

- Plant damage caused by adults feeding on leaves (notching of the leaf margins)

- Larvae feeding on roots, limit growth and can cause plant death
Vine weevil control
Nemasys® H and Nemasys® L

Susceptible plant species

- Vine weevil has been found to be able to feed on over 140 different plant species
- Main crops include:
  - Strawberries (table tops and soil)
  - Blueberries (pots and soil)
  - Raspberries (pots and soil)
  - Other soft fruit
  - Hardy ornamental plants (e.g. azalea, camellia, fuchsia, rhododendron, taxus)
Vine weevil control
Nemasys® H and Nemasys® L

Recommendations

<table>
<thead>
<tr>
<th>Application method</th>
<th>Application volume</th>
<th>Dose</th>
<th>Pack size 50 million</th>
<th>Pack size 250 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open soil</td>
<td>4 litres/m²</td>
<td>1,000,000/m²</td>
<td>50 m²</td>
<td>250 m²</td>
</tr>
<tr>
<td>Pots / Containers</td>
<td>4 litres/m²</td>
<td>500,000/m²</td>
<td>100 m²</td>
<td>500 m²</td>
</tr>
<tr>
<td>Strawberry</td>
<td>100 ml/plant</td>
<td>25,000/plant</td>
<td>2,000 plants</td>
<td>10,000 plants</td>
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</tbody>
</table>

- Routinely treat new material coming onto the nursery that may contain vine weevil larvae or pupae
- If product is applied over foliage, irrigate immediately with plain water to wash nematodes onto compost
- Repeat applications every 4 weeks when vine weevil larvae or pupae are present
Sciarid fly control
Nemasys® – Product overview

- Biological control agent containing *Steinernema feltiae*
- Infective juveniles penetrate larvae through natural openings (mouth, anus)
- Soil temperature should be between 10°C and 30°C
- Nemasys® available in 50 and 250 million pack sizes.

https://ladybirdplantcare.co.uk/
Main pest species in ornamental production are Bradysia spp.

Sciarid fly adults are small, black insects (about 3 mm long) with long slender antennae and long legs.

The larva is up to 8 mm long, white-translucent body with a black head capsule and feed on organic matter, plant roots and cutting stems.

In protected environments, the pest survives all year round.

Adults are weak fliers and are normally found flying or running over the substrate.

Attracted by the smell of compost.
Sciarid fly control

Nemasys®

Sciarid fly life cycle

- Sciarid fly go through complete metamorphosis, passing through distinct egg, larvae (L1-L4 instars), pupae and adult stages
- Time to complete lifecycle is temperature dependent
  - Match nematode application with presence of sciarid larvae (L2-L4 instars are susceptible)
  - Sciarid larvae normally die 3-5 days after nematode application

Total development time (days) vs. Temperature (°C)

The sciarid fly life cycle is approximately 28 days at 18°C


Total length of development (egg to adult) of sciarid flies at a range of temperatures (Lee et al, 1998)
Sciarid fly control

Damage

- Sciarid larva feed on young roots of ornamentals and can tunnel into base of cuttings

- Sciarid populations generally reach damaging levels during spring and summer, however they can remain in the glasshouse all year round
  - Continuous use of the same pesticide (particularly of single-site compounds of long persistence and at sub-optimal rate), or pesticides of the same chemical group or mode of action, can contribute to the development of resistance.

- Adults may carry spores of fungal diseases (e.g. Verticillium)
## Recommendations

<table>
<thead>
<tr>
<th>Target pest</th>
<th>Application method</th>
<th>Application volume</th>
<th>Application</th>
<th>Dose</th>
<th>Pack size 50 million</th>
<th>Pack size 250 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sciarids/Fungus gnats</td>
<td>Soil drench</td>
<td>1 litre/m²</td>
<td>Propagation</td>
<td>500,000/m²</td>
<td>100 m²</td>
<td>500 m²</td>
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<tr>
<td></td>
<td></td>
<td>2 litres/m²</td>
<td>Preventative</td>
<td>500,000/m²</td>
<td>100 m²</td>
<td>500 m²</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Curative</td>
<td>1,000,000/m²</td>
<td>50 m²</td>
<td>250 m²</td>
</tr>
</tbody>
</table>

- Treat entire house or plant inventory as soon as pests are seen. In propagation areas, treat new plants as they are introduced.
- If product is applied over foliage, irrigate immediately with plain water to wash nematodes onto compost.
- Repeat applications every 2-6 weeks depending on pest pressure.
**Western flower thrips control**

**Nemasys®**

**WFT** (*Franklinella occidentalis*)

- Numerous overlapping generations per year
- Toward the end of the 2nd larval stage, it usually drops into the soil/substrate to pupate
- Rate of development influenced by temperature; 7 to 13 days to maturity from egg to adult between 26 to 29°C
- Larva, pupa and adult are susceptible to nematodes
Western flower thrips control
Nemasys®

WFT damage

- Larvae and adults feed on plant tissues causing deformed growth, leaf veining and discoloration. They also consume pollen and spend much of their time in flower heads.

- Vector of viruses such as impatiens necrotic spot virus (INSV) and tomato spotted wilt virus (TSWV).

Susceptible plant species

- WFT is a polyphagous insect attacking a wide range of plants:
  - Soft fruit including strawberries
  - Ornamentals including chrysanthemums, carnations, gerbera, roses, and hardy nursery stock species
  - Protected edibles including cucumbers, herbs and peppers
Western flower thrips control
Nemasys®

Thrips flight activity on chrysanthemum

Keele University and ADAS (DEFRA-funded project HH3102 TPC, 2002-2006)
Western flower thrips control

Nemasys®

Boom application of nematodes under blackouts
## Recommendations

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<th>Application</th>
<th>Dose</th>
<th>Pack size 50 million</th>
<th>Pack size 250 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFT pupae</td>
<td>Soil drench</td>
<td>2 litres/m²</td>
<td>Preventative</td>
<td>125,000/m²</td>
<td>400 m²</td>
<td>2,000 m²</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Curative</td>
<td>250,000/m²</td>
<td>200 m²</td>
<td>1,000 m²</td>
</tr>
<tr>
<td>WFT adults</td>
<td>Foliar contact</td>
<td>0.1 litre/m² (+/- to ensure leaf coverage without runoff)</td>
<td>Preventative</td>
<td>125,000/m²</td>
<td>400 m²</td>
<td>2,000 m²</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Curative</td>
<td>250,000/m²</td>
<td>200 m²</td>
<td>1,000 m²</td>
</tr>
</tbody>
</table>

- Apply early morning/ late evening, close vents/ screens, use blackouts and switch off artificial lighting and fans during and for at least 2 hours after application.

- Repeat foliar sprays as necessary. **Ensure the canopy remains wet for at least 2 hours after application.**

- Repeat soil drenches every 2-6 weeks depending on pest pressure.
Use of adjuvants for control of WFT

- Some debate around whether longer survival on the leaf surface equates to higher efficacy or whether creating the most optimal conditions in the first hour is sufficient (Biological Control 33 (2005) 81–86)

- Most adjuvants are designed to speed up the drying process and to be used with conventional chemistry
  - Adjuvants that accelerate the drying process are not suitable, this includes spreaders and wetters
  - Some compatible adjuvants showed promise in the lab but this effect could not be repeated/demonstrated in field trials
  - Good application practice should be main focus

- Do humectants provide the most promising conditions for foliar applications of nematodes?
Shore fly control
Nemasys® C – Product overview

- Entomopathogenic nematode *Steinernema carpocapsae*
- Infective juveniles penetrate larvae through natural openings (mouth, anus)
- Soil temperature should be between **12°C** and **30°C**
- Mainly an aesthetic problem with the resultant droppings spotting the foliage and consequently decreasing product quality

Shore fly (Scatella spp.)

- Adult shore flies are small black flies with short antennae and slightly longer (3.5 mm) and broader (1.25 mm) than sciarids
- Larvae are small translucent-white maggots without a distinct head capsule and feed on algae
- Pupae are dark brown, spindle-shaped, with a distinctive forked structure at one end of the puparium
- Shore flies breed very quickly in warm temperatures, and can occur in vast numbers
Shore fly control
Nemasys® C

Shore fly lifecycle

Both pests have relatively short life cycles and their duration depends directly on temperature.
Shore fly control
Nemasys® C

Recommendations

<table>
<thead>
<tr>
<th>Application method</th>
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<th>Dose</th>
<th>Pack size treats</th>
<th>Pack size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil drench</td>
<td>2 litres/m²</td>
<td>500,000/m²</td>
<td>100 m²</td>
<td>50 million</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>500 m²</td>
<td>250 million</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2500 m²</td>
<td>5 x 250 million</td>
</tr>
</tbody>
</table>

- Treat entire house or plant inventory as soon as pests are seen
- In propagation areas, treat new plants as they are introduced and continue application every 7 days. When tender plants are being hardened off at lower temperatures, apply every 2-4 weeks depending on pest pressure
- If product is applied over foliage, irrigate immediately with plain water to wash nematodes onto compost
150 years

- BASF

We create chemistry
Integrated pest management for pest and disease control in ornamental crops
Time For a Break
IPM Study Day:
The secrets of successfully combining plant protection products within an IPM programme

David Hide and Joshua Burnstone
Compatibility databases: Bioline, Biobest and Koppert

Side Effect Manual

Active ingredient | Commercial product
---|---

Beneficial organism:
- Amblyseius californicus
- Amblyseius cucumeris
- Amblyseius dognieranus
- Amblyseius swirskii
- Anthocoris nemoralis
- Aphidius spp.
- Aphidoletes aphidimyza
- Bembus spp.
- Chrysopa carnea
- Coleoptera
- Dacus sittica
- Dicyphus hesperus
- Encarsia formosa

Legend

Toxicity on natural enemies
- Class 1: Non-toxic
  - Values ranging between class 1 & 2
  - Mortality < 25%
- Class 2: Slightly toxic
  - Values ranging between class 2 & 3
  - Mortality 25-50%
- Class 3: Moderately toxic
  - Values ranging between class 3 & 4
  - Mortality 50-75%
- Class 4: Toxic
  - Values ranging between class 4 & 5
  - Mortality > 75%

Toxicity on bumblebees
- Method of application
- Persist code
- Greenlab
Sourcing information

* Product label
* Environmental Information Sheet
* MSDS
* Manufacturers recommendations
* Agronomist / distributor recommendations
**IPM compatibility**

* “Soft options”: non disruptive products that can be used alongside biological controls

* Biopesticides: mostly highly compatible products for use in IPM systems

* Conventional chemicals: products that can vary greatly in their IPM compatibility
“Soft options”

* These products are contact acting and may be harmful to biological controls if they are hit.

* However, in most cases they are highly compatible as they are more efficacious against slow/immobile pests than fast/mobile natural enemies.

* No resistance issues.
* Eradicoat / Majestik
* Potassium bicarbonate
* SB Plant Invigorator
* Sodium bicarbonate
A fast acting contact pesticide for spider mites and whitefly (maltodextrin)

- Acts via suffocation

- Apply as a fine spray to ensure effective coverage
  - Use a flat fan nozzle

- Safe to biologicals once dry
Potassium bicarbonate

* A fast acting contact/eradicant fungicide for the control of powdery mildew containing the commodity substance potassium hydrogen carbonate

* Acts via amending leaf pH, dehydrating fungal spores and collapsing cell walls of fungal hyphae

* Multiple MOAs makes resistance unlikely

* Apply as foliar spray and ensure even leaf coverage (5 - 20g/L). Be aware of scorch
* Natural product with no harvest intervals
* Non hazardous – safe to environment and humans
* Improved with addition of adjuvant such as Silwet/Slither (0 HI) – but check adjuvant database for crop specific harvest intervals
* Incorporate into IPM plan, reducing use of conventional fungicides
* Once dry, unlikely to be harmful to beneficials
SB Plant Invigorator

* A product for the control of whitefly, aphid, spider mite, mealybug, scale and psyllid

* No chemical toxicity and no persistence

* Will damage some bios when sprayed directly on them

* Has less effect on mobile/fast moving biocontrols
• Wax particles on their wings mix with SBPI to form a sticky paste

This ‘Sticking Effect’ was confirmed in the lab using both *Trialeurodes & Bemisia tabaci*

• 1st instar larvae are killed but later instar larvae, eggs and pupae are not affected. Therefore multiple applications are necessary.

Trial data: Dr. Ian Bedford, John Innes Centre
A fast acting herbicide for the control of liverwort

Contains the approved basic substance sodium hydrogen carbonate (EU level approval)
* Can be an efficient method of delivering multiple A.I.s to the crop
* Check manufacturers recommendations for all products
* Some products may be physically incompatible
* Some product mixtures may increase the risk of scorch
* Special care must be taken with biopesticides and recommendations may include leaving gaps between applications of incompatible products
- AQ-10
- T34 / Trianum G&P
- Serenade ASO
- Botanigard WP / Naturalis-L
- Met52 Granular and OD
- Prestop
- FLiPPER
- DiPel / Lepinox Plus
- Mycotal
### AQ10® within a programme

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>A.I.</th>
<th>Fungicide</th>
<th>A.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serenade ASO</td>
<td><em>Bacillus subtilis</em></td>
<td>Fortress</td>
<td>quinoxyfen</td>
</tr>
<tr>
<td>Various products</td>
<td>cymoxanil</td>
<td>Cuprokylt</td>
<td>Copper oxchloride</td>
</tr>
<tr>
<td>Aliette</td>
<td>fosetyl-aluminium</td>
<td>Cercobin</td>
<td>thiophanate-methyl</td>
</tr>
<tr>
<td>Rovral</td>
<td>iprodione</td>
<td>Topas</td>
<td>penconazole</td>
</tr>
<tr>
<td>Frupica</td>
<td>mepanipyrim</td>
<td>Bumper</td>
<td>propiconazole</td>
</tr>
<tr>
<td>Systhane</td>
<td>myclobutanil</td>
<td>Scala</td>
<td>pyrimethanil</td>
</tr>
<tr>
<td>Various products</td>
<td>tebuconazole</td>
<td>Various products</td>
<td>metalaxyl-M</td>
</tr>
</tbody>
</table>

- AQ10 can be tank mixed with the fungicides listed in this Table
- No loss in spore viability occurs

See technical notes for complete list
<table>
<thead>
<tr>
<th>Fungicide</th>
<th>A.I.</th>
<th>Fungicide</th>
<th>A.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captan</td>
<td>captan</td>
<td>Amistar</td>
<td>azoxystrobin</td>
</tr>
<tr>
<td>Repulse</td>
<td>chlorothalonil</td>
<td>Dithane</td>
<td>mancozeb</td>
</tr>
<tr>
<td>Switch</td>
<td>cypromidinil + fludioxonil</td>
<td>Folicur</td>
<td>tebuconazole</td>
</tr>
<tr>
<td>Teldor</td>
<td>fenhexamid</td>
<td>Thianosan</td>
<td>thiram</td>
</tr>
<tr>
<td>Stroby</td>
<td>kresoxim methyl</td>
<td>Flint</td>
<td>trifloxystrobin</td>
</tr>
<tr>
<td>Various products</td>
<td>sulphur</td>
<td>Signum</td>
<td>boscalid + pyroxystrobin</td>
</tr>
<tr>
<td>Dithianon</td>
<td>dithianon</td>
<td>SB Plant Invigorator</td>
<td>physically acting</td>
</tr>
</tbody>
</table>

- AQ10 can **NOT** be tank mixed with the fungicides in this Table
- Allow 5 days between these fungicides and applications of AQ10

See technical notes for complete list
- T34 and Trianum (G&P)
- Biopesticides for the control of a range of diseases
- Substrate incorporated products are remote from most biocontrols and are not harmful
- Flexible application
- When drenching do not tank mix with other products
- Be careful of conventional fungicides applied to the crop – see manufacturer’s recommendations
Beauveria products

* Botanigard WP and Naturalis-L
* Whitefly and a range of other pests depending on the label
* Generally very safe with beneficials
* Consider environmental conditions: these products work better within temperature and humidity optimaums
* No knock down effect
* High pest populations – consider partnering with other products
* Each product will have different recommendations on compatibility, tank mixing and application equipment
<table>
<thead>
<tr>
<th>Biopesticide</th>
<th>Target</th>
<th>Control method</th>
<th>Storage temperature</th>
<th>Shelf life</th>
<th>Temperature activity range</th>
<th>Humidity requirement</th>
<th>Preparation</th>
<th>Adjuvant</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ 10</td>
<td>Powdery mildew</td>
<td>Preventative</td>
<td>4-8 °C</td>
<td>2 years 1 year @ room temp</td>
<td>12-30°C</td>
<td>High best applied morning/evening</td>
<td>Pre-soak for 30 mins</td>
<td>Improves performance Nu Film P</td>
</tr>
<tr>
<td>Prestop</td>
<td>Botrytis, Pythium, Phytophthora, Rhizoctonia, Fusarium</td>
<td>Preventative</td>
<td>Below 8°C 25°C</td>
<td>1 year 6 months</td>
<td>5-34°C Best 15-25°C</td>
<td>60-80%</td>
<td>Pre-cream in small amount of water and leave for 30 mins</td>
<td>None specified</td>
</tr>
<tr>
<td>Serenade ASO</td>
<td>Botrytis Some activity on powdery mildew</td>
<td>Preventative</td>
<td>Chemical store</td>
<td>2 years</td>
<td>Above 5°C</td>
<td>No pre-treatments required</td>
<td>None specified In HDC trials the addition of Silwet or similar adjuvant improved control</td>
<td></td>
</tr>
<tr>
<td>T34</td>
<td>Fusarium plus a range of soil borne diseases and botrytis</td>
<td>Preventative</td>
<td>4°C</td>
<td>2 ½ years unopened 6 months once opened</td>
<td>15-35°C</td>
<td>No pre-treatments required</td>
<td>None specified</td>
<td></td>
</tr>
<tr>
<td>Biopesticide</td>
<td>Target</td>
<td>Control method</td>
<td>Storage temperature</td>
<td>Shelf life</td>
<td>Temperature activity range</td>
<td>Humidity requirement</td>
<td>Preparation</td>
<td>Adjuvant</td>
</tr>
<tr>
<td>----------------</td>
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<td>---------------------------</td>
<td>---------------------</td>
<td>---------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Trianum P and G</td>
<td>Fusarium plus a range of soil borne diseases</td>
<td>Preventative</td>
<td>8-10°C</td>
<td>1 year from production date</td>
<td>10-34°C</td>
<td>No pre-treatments required</td>
<td>None specified</td>
<td></td>
</tr>
<tr>
<td>Botaniguard</td>
<td>Whitefly</td>
<td>Contact</td>
<td>4-30°C</td>
<td></td>
<td>20-30°C</td>
<td>70%</td>
<td>No pre-treatments required</td>
<td>None specified</td>
</tr>
<tr>
<td>Dipel DF</td>
<td>Caterpillar</td>
<td>Contact</td>
<td>Chemical store</td>
<td>3 years</td>
<td>10-20°C optimum</td>
<td>No pre-treatments required</td>
<td>Attractor</td>
<td></td>
</tr>
<tr>
<td>Lepinox Plus</td>
<td>Caterpillar</td>
<td>Contact</td>
<td>Chemical store</td>
<td>3 years</td>
<td>10-20°C optimum</td>
<td>No pre-treatments required</td>
<td>Attractor</td>
<td></td>
</tr>
<tr>
<td>Met 52 Granular Insecticide</td>
<td>Vine weevil larvae</td>
<td>Contact</td>
<td>4-5°C Chemical store</td>
<td>1 year from production date</td>
<td>15-30 °C optimum</td>
<td>NA</td>
<td>Growing media incorporation</td>
<td>NA</td>
</tr>
<tr>
<td>Biopesticide</td>
<td>Target</td>
<td>Control Method</td>
<td>Storage Temperature</td>
<td>Shelf Life</td>
<td>Temperature Activity Range</td>
<td>Humidity Requirement</td>
<td>Preparation</td>
<td>Adjuvant</td>
</tr>
<tr>
<td>--------------</td>
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<td>----------------</td>
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<td>----------------------------</td>
<td>----------------------</td>
<td>---------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Mycotal</td>
<td>Whitefly</td>
<td>Contact</td>
<td>2-6°C</td>
<td>Comes with expiry date</td>
<td>18-28°C</td>
<td>Maintain 70% for several days post application</td>
<td>Mix with water @ 15-20°C</td>
<td>Addit</td>
</tr>
<tr>
<td>Naturalis-L</td>
<td>Whitefly, thrips, spider mite, aphid</td>
<td>Contact</td>
<td>4-5°C</td>
<td>1 year from production date at chemical store temperature</td>
<td>10-37°C 20-30°C optimum</td>
<td>60%</td>
<td>Rotate container to ensure spores evenly mixed within concentrate</td>
<td>None specified</td>
</tr>
</tbody>
</table>
Conventional chemicals

* Movento for aphid and whitefly control
* Chess for aphid and whitefly
* Dynamec for spider mite, leaf miner and thrips
* Pyrethrum 5EC for a wide range of pests
* Signum for a wide range of fungal diseases
* Switch for botrytis
* Two way systemic insecticide (spirotetramat) for the control of aphid and whitefly
* EAMU 2011/1987 ornamental plant production
* IRAC code 23 – two applications max
* Slow but thorough control best applied when plant actively growing and pests feeding
* All stages of pests are killed and adults inhibited from producing offspring

* Good coverage using medium quality spray

* IPM compatible
* A systemic insecticide (pymetrozine) for the control of aphid and whitefly

* IRAC Code 9B - four applications per crop max

* Inhibits feeding so no knockdown effect

* IPM compatible with most bios

* Tank mix with Dipel/Lepinox
A contact and translaminar insecticide and acaricide (abamectin) for the control of spider mite, leaf miner and thrips

- IRAC Code 6
- Maximum control 2-5 days post application
- Thorough coverage of all plant surfaces
* Breaks down in sunlight, so for best control apply at end of day as humidity levels rise to maximise leaf wetness

* Use as end of season clean-up or for hotspots

* Tank mix with Chess
IPM compatible? In summer reintroduction of bios can take place after 7 days

<table>
<thead>
<tr>
<th></th>
<th>abamectin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amblyseius cucumeris</td>
<td>s</td>
</tr>
<tr>
<td>nymph/adult</td>
<td></td>
</tr>
<tr>
<td>persist</td>
<td></td>
</tr>
<tr>
<td>2 w</td>
<td></td>
</tr>
<tr>
<td>Aphidius spp.</td>
<td></td>
</tr>
<tr>
<td>larva</td>
<td>1</td>
</tr>
<tr>
<td>adult</td>
<td>4</td>
</tr>
<tr>
<td>persist</td>
<td>1 w</td>
</tr>
<tr>
<td>Encarsia formosa</td>
<td></td>
</tr>
<tr>
<td>larva</td>
<td>1</td>
</tr>
<tr>
<td>adult</td>
<td>4</td>
</tr>
<tr>
<td>persist</td>
<td>2 w</td>
</tr>
<tr>
<td>Phytoseiulus persimilis</td>
<td>4</td>
</tr>
<tr>
<td>nymph/adult</td>
<td></td>
</tr>
<tr>
<td>persist</td>
<td>2 w</td>
</tr>
</tbody>
</table>
* A contact acting broad spectrum insecticide (pyrethrins)
* IRAC Code 3A
* High volume spray ensuring full leaf coverage
* Risk of scorch in bright sunshine or if applied on days
* Short persistence making it ideal companion to biocontrol

* Use to control hotspots, reintroduce bios next day

* Used by organic growers
* A protectant and systemic fungicide (boscalid and pyraclostrobin) for the control of a wide range of fungal diseases

* FRAC Code 7 + 11

* EAMU 2012/2141 – two application per year

* Ensure good foliage cover

* Limited info suggests IPM compatibility
* Environmental Information Sheet

**NON TARGET INSECTS AND OTHER ARTHROPODS**

No risk management is necessary. Signum poses a low risk to a range of arthropod species commonly found in and around treated fields, e.g. ground beetles, predatory mites, lacewings and aphid parasitoids.

* Effect on biopesticides - limited information available leave 10 days between application and most biofungicides. (Prestop four Serenade zero)
* A protectant and systemic fungicide (cyprodinil and fludioxonil) for the control of a wide range of fungal diseases

* FRAC Code 9 + 12

* Apply using a medium quality spray and a minimum of two bar

* Maximum of three applications per year

* Limited info suggests IPM compatibility

* Effect on biofungicides as for Signum
* Read the label and Environmental Information Sheet
* Check side effect data
* Contact distributor / discuss with agronomist
* Observe application intervals and tank mixing compatibilities
* Target hot spots
* Apply the least harmful product to the environment and the operator
* COSHH and Environment Risk Assessment
* Plan
Integrated pest management for pest and disease control in ornamental crops
Creating IPM programmes (bringing it all together)

Pot plants (cyclamen)

Poinsettia

Protected HNS

Neil Helyer, IPM Specialist

Fargro Ltd

Majority of images copyright Nigel Cattlin
The major (predictable) pests and diseases

- Aphids: parasitoid wasps, predatory insects.
- Caterpillars: parasitoid wasp for moth eggs.
- Spider mite: predatory mites.
- Thrips: predatory mites and insects.
- Whitefly: parasitoid wasps, predatory insects.
- Vine weevil: entomopathogenic nematodes.
- Botrytis, Fusarium, Pythium, Phytophthora, powdery mildew: biofungicides.
Biocontrol for cyclamen

- **Pests:** cyclamen mite *(Tarsonemid)*, caterpillar, sciarid fly, aphids, thrips, vine weevil. Diseases: Botrytis, Fusarium, Pythium.

- *Amblyseius cucumeris*: predatory mite feeds on tarsonemid mites and thrips.

- Rate of 100 to 150 *A. cucumeris* per m$^2$ per week for first 4 weeks or 1 CRS sachet per m$^2$ of crop area. Depending on crop monitoring and previous history predatory mites may be required weekly, if pest numbers remain low, introduce further *A. cucumeris* when flowers open.
Biocontrol for cyclamen

• Pests: cyclamen mite (Tarsonemid), **caterpillar (moth eggs)**, sciarid fly, aphids, thrips, vine weevil. Diseases: Botrytis, Fusarium, Pythium.

• *Trichogramma*: parasitoid wasp of moth eggs.

• Rate of 200 to 500 wasps per m$^2$ weekly when moths are active, depending on crop susceptibility.

• *Bacillus thuringiensis*: applied as a spray to control caterpillar (larval) stage.
Amblyseius release pot system
Biocontrol for cyclamen


- *Hypoaspis miles*: predatory mite feeds on sciarid larvae and thrips.

- Rate of 100 mites per m² once during first 2 to 3 weeks of production, further *Hypoaspis* may be required if thrips found on plants or traps.

- *Atheta coriaria*: predatory beetles, 2 to 3 per m².
Sciarid fly control

Hypoaspis miles
• Good in all growing media, preventive.
• Live just below surface, dislike direct light.

Atheta coriaria
• Predatory beetle.
• Feeds on sciarid larvae and pupae as well as scatella larvae.
Biocontrol for cyclamen

- Pests: cyclamen mite (Tarsonemid), caterpillar, sciarid fly, **aphids**, thrips, vine weevil. Diseases: Botrytis, Fusarium, Pythium.

- *Aphidius* species: CE mix parasitoid wasps.
- Rate of 1 wasp per m² fortnightly.

- *Aphidoletes aphidimyza*: predatory midge.
- Rate of 1 per m² per fortnight.
Aphid control
Biocontrol for cyclamen

- Pests: cyclamen mite (Tarsonemid), caterpillar, sciarid fly, aphids, **thrips**, vine weevil. Diseases: Botrytis, Fusarium, Pythium.

- *Amblyseius cucumeris*: predatory mite feeds on tarsonemid mites and thrips.

- Rate of 100 to 150 *A. cucumeris* per m$^2$ per week for first 4 weeks or 1 CRS sachet per m$^2$ of crop area. Depending on crop monitoring and previous history predatory mites may be required weekly, if pest numbers remain low, introduce further *A. cucumeris* when flowers open.
Biocontrol for cyclamen


- Serenade applied as preventive spray against Botrytis.
- T34 and Trianum applied as drench to newly potted plants.
- Switch spray.
Biocontrol for poinsettia


- *Hypoaspis*: predatory mite.

- Rate of 100 mites per m$^2$ just after potting.

- *Steinernema feltiae*: entomopathogenic nematodes.
Biocontrol for poinsettia


- *Encarsia / Eretmocerus*: mix parasitoid wasps.

- Rate of 1 wasp per plant weekly for first 6 to 8 weeks, if no *Bemisia* or other whitefly species found on traps or plants, change to pure *Encarsia*. If whitefly numbers remain low reduce *Encarsia* to 1 per 2 or even 3 plants weekly up to 1 week before dispatch.
Biocontrol release methods
Biocontrol for poinsettia


• Usually a migration of cereal / grass thrips in late August to early September.

• Sticky traps to kill adults, rarely any reproduction and usually no control needed.
Biocontrol for poinsettia

- Pests: sciarid fly, whitefly, thrips, **aphids**. Diseases: Pythium, Rhizoctonia.

- Sporadic in crop but increasing occurrences.

- *Aphidius* species: CE mix parasitoid wasps.

- Rate of 1 wasp per m$^2$ fortnightly.
Biocontrol for poinsettia

• Pests: sciarid fly, whitefly, thrips, aphids. Diseases: 
  
  *Pythium*, *Rhizoctonia*.

• *Trichoderma asperellum* (T34 Biocontrol), *T. harzianum* (Trianum).

• Applied as drench to newly potted plants and repeat after 6 weeks, fully compatible with nematodes.
Biocontrol for hardy nursery stock

- **Pests:** *sciarid fly*, aphids, caterpillar, spider mites, thrips, vine weevil, whitefly.

- *Hypoaspis*: predatory mites at 100 per $m^2$ either per batch of plants or monthly to prop unit.

- *Atheta coriaria*: predatory beetles 2 to 3 per $m^2$ per batch or monthly. Rearing release system widely used.
Grower system for rearing the predatory beetle *Atheta coriaria*

Jude Bennison, ADAS

This factsheet provides grower guidelines for rearing the predatory beetle *Atheta coriaria* on the nursery for reduced cost biological control of sciarid and shore flies, and for potential contribution to western flower thrips (WFT) control. The factsheet refers to results in HDC projects PC 239, PC 239a and PC 261.
Biocontrol for hardy nursery stock

• Pests: sciarid fly, **aphids**, caterpillar, spider mites, thrips, vine weevil, whitefly.

• Aphid parasitoid wasps, ACE / CE mix or single species.

• Rate of 1 wasp per m$^2$ fortnightly.

• *Aphidoletes aphidimyza*: predatory midge.

• Rate of 1 per m$^2$ per fortnight.
Aphid parasitoid wasps

• Prevents aphid populations from developing and reduces moderate populations to non-damaging levels.
• Adults begin to emerge in transit, ready for immediate release.
• Not light sensitive – no diapause stage.
• Ventilation and food source available in packaging ensures adult survival in transit and storage.
• Suitable for all greenhouse crops.
Biocontrol for hardy nursery stock

- Pests: sciarid fly, aphids, **caterpillar**, spider mites, thrips, vine weevil, whitefly.
- *Trichogramma*: parasitoid wasps.
- Rate of 200 to 500 wasps per m$^2$ weekly when moths are active, depending on crop susceptibility.
- *Bacillus thuringiensis*: applied as spray to control caterpillar (larval) stage.
- Conserve / Steward for Tortrix caterpillar.
Biocontrol for hardy nursery stock

- Pests: sciarid fly, aphids, caterpillar, **spider mites**, thrips, vine weevil, whitefly.

- *Amblyseius andersoni*: predatory mites, preventive for all spider mites, good control of citrus mite.

- Rate of 50 to 100 per m$^2$ per fortnight for mite control or 2 introductions at 2 to 3 weeks apart in late spring.

Spider mite control predators
Biocontrol for hardy nursery stock

- **Pests**: sciarid fly, aphids, caterpillar, spider mites, **thrips**, vine weevil, whitefly.

- **Amblyseius cucumeris**: predatory mites, preventive to early stage curative.

- Rate of 100 to 150 A. *cucumeris* per m$^2$ per week or 1 CRS sachet per m$^2$ of crop area. Depending on crop monitoring and previous history, may need to introduce further A. *cucumeris* when flowers open.

- **Hypoaspis**: predatory mites, use in conjunction with Amblyseius if thrips numbers start to increase.
Biocontrol for hardy nursery stock

- Pests: sciarid fly, aphids, caterpillar, spider mites, thrips, vine weevil, whitefly.

- *Encarsia* (pure) or *Encarsia / Eretmocerus* mix parasitoid wasps.

- For glasshouse whitefly; rate of 1 to 3 *Encarsia* per m$^2$ weekly or 3 to 5 wasps per m$^2$ fortnightly.

- For other species use mix of parasitoids at same rate.

- If site has history of whitefly, use aubergine banker / trap plants.
IPM standard techniques

- Start clean and stay clean, crop specific substrates, correct nutrition.
- Monitoring with sticky traps and plant inspection.
- Environmental management for pathogens: includes watering, heating / venting, spray applications.
- Prevention better than trying to cure: beneficial organisms, protective fungicide sprays.
How to build a schedule

Know your site history and crop susceptibility. Talk to a BASIS qualified advisor and communicate regularly.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>WEEK NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal box Card box for hanging on plants to aid release of parasitoids and predators. Water resistant card, unit of 50 boxes</td>
<td>FGBOX = 50 boxes FGADB = 25 adults FGADC = 250 larvae</td>
</tr>
<tr>
<td>Adalline b Adalia bipunctata</td>
<td>FGAPK = 500 FGAPL = 1,000 FGAPN = 5,000</td>
</tr>
<tr>
<td>Adalline a, c, e or m Aphis colemani</td>
<td>FGAPD = 500 CE FGAPC = 500 ACE</td>
</tr>
<tr>
<td>A. colemani unit of 500 and 1,000 &amp; 5,000 for small spp. A. ervi unit of 250 A. matricariae unit of 500 for herb aphis A. ervi unit of 250 or Aphis abdominalis both for larger aphid species. Use all at 1 to 2 per m² per fortnight.</td>
<td>FGAPJ = 1,000 bottle FGAPR = 1,000 blister</td>
</tr>
<tr>
<td>Aphidlines mixes CE mix: 500 wasps A. colemani + A. ervi ACE mix as above + Aphelelinus abdominalis Berry mix 240 wasps of 5 species including 100 Praon volucre. Flower mix = 6 species each of Aphiinus A. colemani, A. ervi A. matricariae, Praon &amp; Ephedrus : 1 per m².</td>
<td>FGWIM = 500 larvae FGWIN = 1,000 tube</td>
</tr>
<tr>
<td>Aphidoline aa Aphidoletes</td>
<td>FGWIR = 2,500 bag</td>
</tr>
<tr>
<td>Chrysoline c Chrysoperla larvae aphidimyzos cocoons in blister pack, use at 1 cocoon per m² per fortnight for aphid colonies. Unit of 1,000 in bottle with vermiculite carrier or 4 x 250 in blister pack.</td>
<td></td>
</tr>
<tr>
<td>Digline i Diglyphus isaea unit of 250 wasps for leaf miner larvae within the leaf. Good activity all year round. Use at 1 to 2 per m² depending on level of infestation.</td>
<td></td>
</tr>
</tbody>
</table>
Integrated pest management for pest and disease control in ornamental crops
How research is improving IPM performance

Jude Bennison, ADAS
Summary

• Problems with aphid hyperparasitism
• Aphid trials - new IPM-friendly aphicides and biopesticides
• WFT trial – integrating new pesticides and biopesticides with biocontrol
• Vine weevil trial control of larvae
• Nematode control of vine weevil adults
• Improving vine weevil control in HNS
Aphid parasitoids can be very effective.....
However, watch out for hyperparasitoids!
Monitoring hyperparasitism in protected HNS (ADAS IPM Fellowship CP 089)

Up to 70% hyperparasitism by August 2012 and 95% by August 2013 on protected HNS nursery
Until a solution is found:

- Use parasitoid mixes rather than rely on one species (Pope et al 2015, PE 027 review of aphid control on peppers)
- Start them early to avoid large numbers of ‘mummies’
- Include aphid predators in IPM
- Use IPM-compatible aphicides if needed e.g. Chess WG, Mainman
- Be aware of future role of new aphicides & biopesticides
MOPS Objectives

• Develop options for the control of priority pests and diseases on ornamental plants
• Evaluate novel conventional pesticides and biopesticides
• Products tested have a clear route to market for their potential use in sustainable integrated pest and disease management programmes
• Jan 2014 - Jan 2017
Aphids - 2014 MOPS trial

• Peach-potato aphid (*Myzus persicae*) with carbamate and pyrethroid resistance typical of those found on commercial nurseries
• Host plant pansy
• Glasshouse compartment at Harper Adams University – Tom Pope and Grace Smith
Trial design and treatments

- 8 treatments:
  - Movento (+ve control)
  - Water (-ve control)
  - Teppeki (= Mainman)
  - 2 new conventional pesticides
  - 3 new botanical biopesticides

- 4 weekly sprays
- 9 pansy plants per plot (6 reps)
- Insect-proof screens between plots
Results

• Movento gave good control from 6 days after 1\textsuperscript{st} spray

• Teppeki (=Mainman) and one botanical biopesticide gave good control from 3 days after 1\textsuperscript{st} spray

• Teppeki (= Mainman) and one conventional treatment eradicated aphids 3 weeks after 1\textsuperscript{st} spray

• All treatments except for one conventional product gave good control by the end of the trial
Aphids - 2015 MOPS trial

- Melon & cotton aphid (*Aphis gossypii*) collected from commercial nursery then cultured for trial
- Host plant *Hebe* ‘Purple Pixie’
- Poly tunnel at Harper Adams University – Tom Pope and Grace Smith
Trial design and treatments

- 8 treatments:
  - Movento (+ve control)
  - Water (-ve control)
  - Mainman
  - 2 new conventional pesticides
  - 3 new biopesticides

- 4 weekly sprays
- 9 *Hebe* plants per plot (6 reps)
Results

• Aphids built up to very high numbers in controls
• Movento gave 80% control after 3<sup>rd</sup> spray
• Teppeki (=Mainman) and one conventional insecticide gave 99% control after 3<sup>rd</sup> and 2<sup>nd</sup> spray respectively
• The 3 botanical biopesticides gave significant control by the end of the trial and have potential in an IPM programme
• 2016 trial – using same treatments but applied at suppliers’ recommended frequency: results available soon
WFT - 2016 MOPS trial

• WFT with spinosad (Conserve) resistance typical on commercial nurseries
• Host plant verbena
• Glasshouse compartments at ADAS Boxworth

© Nigel Cattlin / FLPA
Trial design and treatments used in IPM programme with *Neoseiulus cucumeris*

- 8 treatments, 6 reps:
  - Water (-ve control)
  - *N. cucumeris* (+ve control)
  - *N. cucumeris* + Attracker
  - *N. cucumeris* + Actara (+ve control)
  - *N. cucumeris* + new conventional pesticide
  - *N. cucumeris* + new conventional pesticide + Attracker
  - *N. cucumeris* + Botanigard WP + Majestik
  - *N. cucumeris* + Botanigard WP + Majestik + Attracker

Sprays applied x3 at 5 day intervals or x2 at 7-day intervals

WFT numbers and damage assessed over 14 days
Snapshot of results at end of trial

• Data currently being analysed

Water controls  Neoseiulus cucumeris
MOPS – more details:

• AHDB Horticulture website
• [http://hdcmopsblog.wordpress.com/](http://hdcmopsblog.wordpress.com/)
Vine weevil

• Number 1 pest of containerised HNS, can also affect some pot plants
• Adults feed on leaves and larvae damage roots
• One larva around roots can cause ornamental crop rejection
Life cycle

• Adults usually active from May/June
• Eggs usually laid June – September
  (but overwintered adults can lay eggs from April)
• Larvae usually present August – following March
• Pupation usually April/May
Vine weevil control challenges

• Demand for high quality, pest-free plants
• Limited choice and restrictions on use of substrate-incorporated insecticides
• Neonicotinoid (imidacloprid) restrictions on flowering plants
• Exemptor (thiacloprid) only in peat-based substrates
• Lack of confidence in Met52 – when to use?
• Drenches of entomopathogenic nematodes time-consuming – and which species to use?
• Adult control? What to use and when in IPM?
Biological control of larvae - nematodes applied as drench

- *Steinernema kraussei* (e.g. Nemasys L) active down to 5°C
- *Heterorhabditis bacteriophora* (Nemasys H, Nematop, Larvanem) active 12-33°C depending on product
- Mix of 3 species (SuperNemos) active above 10°C
Biological control of larvae - Met52 (substrate incorporation)

Entomopathogenic fungus, *Metarhizium anisopliae (brunneum)*. Needs 15-30°C when vine weevil larvae present

©Fargro
Research to test current IPM methods and to develop future options

- MOPS trial 2014 – control of larvae
- AHDB, HTA and EMT– funded work in ADAS IPM Fellowship project – control of adults
- AHDB-funded project HNS 195 – Improving control of vine weevil in HNS
MOPS trial 2014 (control of larvae)

Fuchsia erecta infested with 15 vine weevil eggs/pot 1 Aug
10 Treatments

Preventive substrate incorporated:
• Exemptor (thiacloprid) +ve control in plugs and pots
• Met52 granular in plugs and pots

Curative drenches 16 Sep
• Water (-ve control)
• Calypso (thiacloprid - EAMU)
• Nemasys L (*Steinernema kraussei*)
• Larvanem (*Heterorhabditis bacteriophora*)
• SuperNemos (mix of 3 nematode species)

Preventive biopesticide drenches 31 July
• Met52 OD 1 day before vine weevil eggs 31 July
• Azadirachtin 1 day before vine weevil eggs 31 July
• Code 179 1 day before vine weevil eggs 31 July
Results

Mean number of live vine weevil per pot

Treatment

Water control  Exemptor  Calypso  Nemasys L  Larvarem  SuperNemas  Met52 OD  Met52 Granular  Code 179  Azadirachtin

0  1  2  3  4  5  6  7

d  a  a  ab  abc  abc  abc  a  c  e  bc
E-nema ‘weevil stop’ traps with nematodes for adult control

• *Steinernema carpocapsae*

• Available on home garden market in Germany and UK
Efficacy and speed of kill? (Horticultural Fellowship CP 89)

- Cages for traps with or without nematodes
- 5 marked weevils per cage
- Live and dead weevils recorded over 30 days
Dead weevils removed and dissected for nematodes
92% kill in treated cages over 30 days

- Current traps uneconomic for commercial use
- Further development justified together with weevil attractant for ‘lure and kill’ approach
Improving vine weevil control in HNS (HNS 195, 2016-2019)

Aim: Develop practical ‘blueprint’ for vine weevil IPM

Control of larvae

• Alternative ‘little and often’ application technique for nematodes through overhead irrigation

• Predict Met52 granular kill of larvae at nursery temperatures

• Timing and persistence of Met 52 OD drench

Control of adults

• Identify adult attractant and traps for monitoring and timing of control measures

• Lethal and sub-lethal effects of IPM-compatible pesticides and biopesticides on adults
Little and often control with nematodes (Nemasys L)

2016 – pilot experiment ADAS Boxworth
2017 – trial on commercial HNS nursery

2016 treatments:
1. Full rate as drench x2 (Sep and Oct)
2. Full rate through overhead x2 (Sep and Oct)
3. 20% rate through overhead x5 (June-Oct)
4. 40% rate through overhead x5 (June-Oct)
5. Water control drench x2 (Sep and Oct)
6. Water control through overhead x5 (June – Oct)
Little and often control with nematodes: Testing water and nematode application rates using AHDB irrigation calculator
Checking nematode application rates through sprinkler
Vine weevil eggs added to growing media every month June-Sep
Nematode application one rate at a time to replicate pots of Fuchsia
Checking nematode delivery to growing medium and floor
Destructive assessment Nov –
numbers live larvae per pot
Developing monitoring methods for early detection of adults (to help time adult control)

- Compare trap designs and indicator plants
- Identify novel attractants for improved monitoring and potential ‘lure and kill’ approach
Current monitoring techniques (using adult nocturnal and aggregation behaviour)

Night time assessments of adults on crop

Leaf notching of crop or indicator plant

Use of grooved boards or corrugated material
Vine weevil traps tested

<table>
<thead>
<tr>
<th>Trap Type</th>
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</thead>
<tbody>
<tr>
<td>Corrugated cardboard roll</td>
</tr>
<tr>
<td>Grooved board</td>
</tr>
<tr>
<td>Pitfall ‘trap’</td>
</tr>
<tr>
<td>Roguard (cockroach bait station)</td>
</tr>
<tr>
<td>Modified red palm weevil ‘trap’</td>
</tr>
<tr>
<td>Commercial vine weevil ‘trap’</td>
</tr>
</tbody>
</table>

[Images of traps]
Trapping experiment

Replicated experiment: (40 weevils per cage, 17 weevils/m$^2$)
Results – mean number of weevils caught

- Cardboard roll
- Grooved board
- Pitfall trap
- Roguard
- Modified red palm weevil ‘trap’
- Commercial vine weevil ‘trap’
Results – trap reliability (% traps with weevils)
Summary of trapping work so far

- Commercial vine weevil trap was the best
- Traditional trapping methods comparatively ineffective and unreliable
- Potential to further improve adult monitoring through use of vine weevil lure
- Recent results – surface hydrocarbons identified on weevil cuticles may have a role in aggregation
- Next step – are weevils attracted to the scent?
Effect of fluctuating temperature on Met52 granular performance

Aim: Provide growers with practical information to improve control with Met52

• Lab test

• Nursery experiments
Current lab test – temperature threshold for larval infection and day degrees for kill?

• Larvae added to treated or untreated growing media in plastic boxes with carrot as food
• Incubated at constant temperatures (10-30°C) or fluctuating temperatures consistent with nursery conditions
• Weevil death assessed every 2-3 days over 4 weeks
Nursery experiment 2016

Aim – validate predictive model from lab test

• Sedums planted in growing media treated / untreated with Met52 granular
• Vine weevil eggs added
• Plants kept in poly tunnel or under protection then moved outside, growing media temperatures recorded
• Current destructive assessments of larvae and plant vigour, larvae kept to assess Met52 infection
Summary of IPM gaps being filled by current research

• Growers alerted to risk of aphid hyperparasitoids in IPM on ornamentals

• Knowledge on potential of new aphicides and biopesticides for aphid and WFT control in IPM

• Knowledge on best-practice use of biological controls and biopesticides for vine weevil IPM

• New trapping techniques for adult vine weevil

• IPM blueprint for vine weevil control being developed 2016-2019
Thanks to funders and industry partners:

• AHDB Horticulture (MOPS & HNS 195)
• AHDB Horticulture, HTA and EMT (Fellowship Project CP 89)
• BASF and e-nema for providing nematodes
• Fargro for providing Met52 and nursery temperature data
Thanks to ADAS colleagues and research collaborators
Integrated pest management for pest and disease control in ornamental crops