Biological Control
Starting in Propagation

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Bio-control at Propagation:

Bio-control developments at a global level:

• Changing to biological control in Propagation
• Starting ‘clean’ propagation….what does this mean
• Starting early→ why is it so critical
• Main pest problems in propagation and their control options
• Changes with pest management at young plant production
• Questions and discussion
Changing to Bio-Control

When we want to do less of this ..........
Changing to Bio-Control – *Amblyseius cucumeris* and *Amblyseius swirskii* in propagation (Amblyline Stick and Swirskiline Stick)

...or this.........
Changing to Bio-Control – *Amblyseius cucumeris* in propagation (Amblyline Stick)

…or this……….
Changing to Bio-Control – Bio-control on Stock plants

...and do more of this........
Biological Control & IPM at poinsettia stock plant site:
Changing to Bio-Control - Dipping

..... or this.....
Changing to Bio-Control – applying nematodes (in combination with Botanigard WP)

..... or this.....
Changing to Bio-Control: Banker plants to support BCA’s
What is a ‘clean’ plant or cutting?
**A ‘clean’ plant or cutting?**

- Insect, mite and disease → what is acceptable?
- What about Pesticide residues? → what is acceptable?
- Leaf tissue sampling for residues → affordable
- Zero tolerance.....is it possible?
- Producers of cuttings/Breeders → their actions can affect your program → ‘Clean’ plugs / plants are important for any pest management program
- Grower to breeders and propagators → growers reaction can trigger propagators actions.
- Positive and constructive communication between breeder, propagator, and grower is very important!
- Growers requesting information
- Greenhouse vegetable industry as an example
- Start as early as possible = in propagation
Pest management and residues:

- More growers requesting information, especially those who are implementing BCA’s
- European regulations – residues (changed Jan 2015)
- Better future for ‘cleaner’ cuttings
- Bio-control and IPM at cutting production locations
- Bio-control / IPM at rooting stations
- Greater chance of success for end product growers

Abamectin (Avid®)
Buprofezin (Talus®)
Fenazaquin (miticide)
Pyridaben (Sanmite®)
Pyriproxifen (Distance®)
Spinosad (Conserve®)
Spiromesifen (Judo®)
Thiacloprid (neonic)
Thiamethoxam (Flagship®)
Novaluron (Pedestal®)

Acephate (Orthene®)
Acetamiprid (Tristar®)
Bifenthrin (Talstar®)
Clothianidin
Cyfluthrin (neonic)
Imidacloprid (Marathon®)
Lambda-cyhalothrin
Methamidiphos (Monitor®)
Methomyl (Lannate®)
Omethoate
Oxamyl (Vydate®)
Starting early → Why is it so critical to start early?
Development of thrips in 60 days (at 68°F)
(at 20°C/68°F on cucumbers)

One female thrips

30 days

± 90 thrips

30 days

± 5800 thrips
Development of thrips in 60 days (at 68°F)
(at 20°C/68°F on cucumbers)

- 30 days: 1 female thrips → ± 90 thrips
- 30 days: ± 90 thrips → ± 5800 thrips

Start here = Success
Too late = Disappointment
STARTING POINT → Development of Whitefly in 64 Days
(at 20°C/68°F on Tomato)

32 days

± 125 whiteflies

32 days

± 8000 whiteflies
STARTING POINT → Development of Whitefly in 64 Days
(at 20°C/68°F on Tomato)

32 days

± 125 whiteflies

Start here = Success

Too late = Disappointment

32 days

± 8000 whiteflies
Reasons for biological control to fail:

- Starting too late!
- ‘Trying’ biological control (commitment)
- Not starting ‘Clean’ → pest and residues
- Scouting and monitoring!
- Reactive vs proactive
- Not taking all pest and disease problem into consideration
- Poor planning → Supply of BCAs (forecasting)
- Poor management → Application
- No technical support
- Check quality at point of arrival
- Fear of loss → bailing at tipping point → Trust
- Expectations vs threshold
- Compatibility with traditional crop protection products
- Cost -> Reducing input
What are the most common pest problems during propagation and what are the bio-control solutions?
Ornamental Propagation – ‘a pro active approach’:

Seed and RC plug trays at rooting stations:
• Typical potential pest problems that are experienced later in the production cycle → Fungus Gnats, Thrips, Aphids, Whitefly and TSSM are most common
• Crop specific preferences.

BCA’s used during propagation:
• *Amblyseius cucumeris* or *Amblyseius swirski* depending on climate/pest/crop (sachet on stick)
• *Hypoaspis miles* / *Stratiolaelaps scimitus* (Hypoline™)
• *Atheta coriaria* / *Dalotia coriaria* (Staphyline™)
• *Steinernema feltiae* (Exhibitline™ sf)
• *Aphidius colemani* (with banker plants)
• Botanigard WP (*Beauvaria bassianna*)
Bio control in propagation....what are the tools we have to be successful
Understanding Thrips life cycle and BCA target!

- **Egg** (in leaf tissue)
- **Larva 1 & 2** (on plant → exposed)
- **Pupa** (in soil)
- **Adult** (on plant → exposed)

Temperatures and Durations:
- 68°F
- 6 days
- 3 + 3 days
- 6 days
- up to 60 days
Thrips life cycle and BCA target!

**Egg**  (In cell tissue)

**Larva 1 & 2**  (on plant ➔ exposed)

**Pupa**  (in soil)

**Adult**  (on plant ➔ exposed)

68°F  6 days  3 + 3 days  6 days  up to 60 days

86°F  3 days  1.5 + 1.5 days  3 days  20 - 40 days
Thrips life cycle and BCA target!

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Larva 1 & 2 (on plant → exposed)
Pupa (in soil)
Adult (on plant → exposed)

68°F  6 days  3 + 3 days  6 days  up to 60 days
86°F  3 days  1.5 + 1.5 days  3 days  20 - 40 days

Amblyseius spp (L1 only)
Orius insidiosus
Steinernemafeltiae

Bioline AgroSciences
Thrips life cycle and BCA target!

- Egg (In cell tissue)
- Larva 1 & 2 (on plant → exposed)
- Pupa (in soil)
- Adult (on plant → exposed)

68°F  6 days
86°F  3 days
3 + 3 days
1.5 + 1.5 days
6 days
up to 60 days
3 days
20 - 40 days

- Amblyseius spp
- Orius insidiosus
- S. feltiae
- Stratiolaelaps scimitus
- Dalotia coriaria
- Orius insidiosus
- S. feltiae

- Fecundity in vegetative stage vs when pollen is available
- Fecundity in different crops
What about Thrips and vectoring virus?

- **Adult**
  - Oviposition
  - Transmits TSWV

- **Egg**
  - Eclosion

- **1st instar**
  - Acquires TSWV
  - Moulting
  - Under the ground

- **2nd instar**
  - Moulting

- **Pupa**
  - Emergence
  - Pre-pupa

- **Pre-pupa**
  - Moulting

- **TSWV**
**Amblyseius cucumeris – Amblyline**

- Predatory mite *Amblyseius cucumeris*
- Prey on L1 larvae of thrips (3 to 4 / day)
- Strong side effect on tarsonemid / broad mites
- Can be used in wide range of crops
- Active from 58-86°F (15-30°C)
- No diapause → active at low light levels
- Can establish and sustain in some crops where pollen is available
- breeding system and carrier material
- Release rates → Crop and technique depending:
  - mites per sq. foot WEEKLY as broadcast
  - 1 sachet/plant, plug tray, shuttle tray
  - Sachet last 4 – 8 weeks
Amblyseius swirskii – Swirskiline

- Predatory mite *Amblyseius swirskii*
- Prey on L1 larvae of thrips, whitefly eggs and pollen
- Strong side effect on broad mites
- Can be used in wide range of crops (not tomatoes)
- Active from 68-105°F (20-41°C), prefers warm/hot
- Sensitive to low temperatures (< 18°C/66°F)
- Breeding system vs carrier material
- Can establish / sustain in crops with pollen
- Active at higher temperatures and crops where both thrips and whitefly are present
- Release rates:
  - Crop and technique depending
  - 10 mites per sq. foot WEEKLY as broadcast
  - Or 1 sachet/plant, plug tray, shuttle tray
  - Sachet last at least 4 weeks
Predatory mite application and rates
What to remember with all predatory mites:

- Predatory mites do not fly → mobility is limited
- Distribution IS really important.
- All *Amblyseius* species are very hard (impossible) to ID in the crop. One exception is *Amblyseius degenerans* because of its color
- Experience shows that breeding systems (sachets) in general result in more consistent results → constant production of mites in the crop EARLY
- Eggs of *Amblyseius* *spp* often can be found on leaf hairs
- *Phytoseiulus persimilis* ONLY feeds on TSSM → specialist and very aggressive
- *Amblyseius* *spp* are more generalists and many can feed on pollen

Development: Alternative food sources to increase mite levels in the crop → Predafix, Typha pollen
Introducing *Amblyseius spp* predatory mites: choosing the best method for your situation?

- Broadcasting vs breeding systems
- Before 1989 → broadcast only
- Mites do not sustain or establish in crops without pollen or prey
- Result → weekly application needed to get population high enough at all times
- Release rates:
  - 10 – 25 mites per sq. ft.
  - Weekly
  - Broadcast or blowing
  - Cost (labor and material)
Introducing *Amblyseius spp* predatory mites: choosing the best method for your situation?

- Blowing applications → Black and Decker and other battery operated devices:
Introducing *Amblyseius spp* predatory mites: choosing the best method for your situation?

- Breeder piles
- Same product that goes in sachets but packed in bulk
- Longevity shorter compared to sachets
- Cost for smaller pot sizes or plugs
- Rate:
  - 2.5 ml – 5 ml per plug/pot
  - 50 – 100 mites per pile
Breeding sachets

- What’s in a sachet?
  - Bran
  - Prey mites
  - Food for the prey mites
  - Predatory mites
  - Culture

Amblyline™ mini
Product development → Solution/Strategy driven

- Finding solution for pest problems → listening to industry
- Different crops, different strategies (formulations)

- Development of breeding systems for predatory mites for all crop settings
- Consistently more mites = better results
- 6 to 8 weeks reproduction & release of mites
- Consistently more mites with CRS vs Broadcasting
New Product development:

Average cumulative number of mites emerging per week

Week 1 to Week 6
Sachets on Stick

1. Fits easily in every seed tray by narrow stick
2. No fungal growth as stick doesn’t absorb water
3. Easy to recognize by specific paper color and clear description of mite species
4. Waterproof by seals and paper
5. Hole is protected from water by fold
6. No closure of the hole as stick is not central
7. Sachet can’t fall off the stick by fold
8. Transparency of product information by QR code for consumer and customer
9. Consumer information: “Contents non harmful/ecofriendly!”
10. Easy handling as there are strips of 6 sachets

Other benefits:
Crops in trays can be mown as sachet is just 6 cm high
Available with A. cucumeris and A. swirskii
**Hypoaspis miles (Stratiolaelaps) - Hypoline**

- Soil dwelling mite *Hypoaspis miles*
- Eats Fungus Gnat larva and eggs, pupae of thrips
- Active from 15°C/ 59°F
- Also feeds on other soil pest, e.g., *Duponchelia* (European pepper moth) larvae
- Available in carrier (peat and vemiculite)
- Pest control in soil
- Active in the top layer of the soil.
- Can be mixed with *Atheta* just prior to introduction
- Rates:
  - 10 – 25 mites per sq foot, once
  - If used in propagation stage at 10 mites per sq foot, use half rate (5 mites/sq ft) after transplanting
**Atheta coriaria (Dalotia coriaria) - Staphyline**

- Soil dwelling insect (rove beetle)
- Eats pupae of thrips, Fungus Gnat larva and eggs, Shorefly larva, Duponchelia eggs
- Active from 10°C / 50°F
- Available in carrier (peat and vemiculite)
- Active in the top layer of the soil
- Adults do fly and are nocturnal
- Often van be found underneath pots and trays
- Rate:
  - 0.2 beetles/sq.ft. once
  - If used in propagation stage at 0.2 beetles per sq foot, use half rate (0.1/sq ft) after transplanting
**Orius insidiosus – Oriline**

- Predatory bug *Orius insidiosus* (adult, 5 nymphs)
- Eats larvae and adults of thrips
- Also feeds on other small pest, e.g. TSSM, moth eggs
- Can kill up to 80 adult thrips per day!!
- Can feed and establish on pollen
- To enhance establishment, can be fed with Bugfood™ (*Ephestia* eggs) → increase fecundity
- Long establishment time (2 generations).
- Active from 15°C/59°F
- Diapause sensitive → less active at low light levels
- Recommended use with banker plants (purple flash pepper)
- Release rates:
  - 4 introductions of 0.25 – 0.5/m²(10 sq feet)
  - In hotspots → 2 – 5 / sq. feet – 2 to 3 introductions
Aphids:
Biological Control Release Rates - Aphids:

Aphids:
- Very explosive population development
- Fast becoming the #1 pest problem worldwide
- Know your aphid species: 4 major greenhouse species → choice of BCA
- Crop specific and preferences.
- Almost impossible to ‘repair’ an out of hand situation with BCA’s, especially in ornamental production
- Compatibility with traditional pesticides
- **Preventive approach important**
- Timing
- Wings or no wings…..
- Parasites & Predators
- Banker plants vs weekly releases:
  - Weekly releases 0.025 – 0.1 /sq. feet
  - Banker plant system = 1/sq.ft/week
- Other BCA’s on bankers
Biological Control Release Rates - Aphids:

Aphid BCA wasps:
- Much better searchers
- Specific to aphid species
- > 300 eggs per female
- Higher fecundity as younger adults
- Deposit egg inside the aphid
- Develops into mummified aphids
- Preventive releases or banker plants for best results
- Release rates:
  - 0.025 – 1 wasp per sq. foot
  - Available in mixes/pure

Aphid BCA predators:
- Perform better in aphid colonies
- Not picky about dinner 😊
- Kill aphids by consuming their fluids or eating the aphid completely
- Need large amount of aphids to reproduce
- Excellent tool for when aphids have been found
- Release rates:
  - 0.1 – 1 per sq. foot
  - 20 – 50 per plant/hanging basket

Aphid species:
- Potato aphid
- Foxglove aphid
- Green Peach aphid
- Black Melon Aphid

*Note: Bioline AgroSciences logo at the bottom.*
Biological Control Release Rates - Aphids:

Aphid BCA wasps:
- *Aphidius ervi*
- *Aphelinus abdominalis*
- *Aphidius colemani*

Aphid BCA predators:
- *Aphidoletes aphidmyza*
- *Chrysoperla spp*

Aphid species:
- Potato aphid
- Foxglove aphid
- Green Peach aphid
- Black Melon Aphid
Aphid banker plants
Aphid banker plants

- Important to know about Aphid banker plants:
- Understand the technique (it is not just a matter of seeding some pots with barley or wheat!!!) Growers who do their own, protect the bankers!
- Apply properly → use the correct rate of banker plants → start with 2 per acre and maintain with a minimum of 1 per acre bi-weekly (1 wasp per sq. ft weekly)
- It is a system that needs continuity
- Release *Aphidius colemani* – Aphiline c - weekly for the first 4 to 5 weeks until *Aphidius* population is established.
- Maintain system properly (watering etc.)
- Many growers hang bankers along main walk way. Hanging baskets seems to be working best.
- Monitor system → watch for other BCAs showing up (usually spring time) and hyper parasites (late summer)
- Watch aphid species showing up in greenhouse (*Aphidius colemani* only effective against green peach and black melon aphid)!
Whitefly:
Plan of attached for whitefly: What is important to know?

• Most common whitefly species
  • *Trialeurodes vaporariorum* → greenhouse whitefly
  • *Bemisia tabaci* → silverleaf / sweet potato whitefly

• 8 stages of development: egg, 4 larvae, pre-pupae, pupae and adult

• Adult whitefly often in top of the plant, on bottom side of the leaves

• Fecundity depending on crop
  • Pepper plants = 25 – 40 eggs / female in life time
  • Tomato plants = 100 – 125 eggs / female in life time
  • Cucumber, Gerbera daisy, Poinsettia = 200 eggs / female
  • Tobacco, Egg plants = 800 eggs / female

• Switching host plants and fecundity

• Cold tolerance

• **Damage done by larvae NOT adults**
  • Honeydew on leaves and fruits
Greenhouse Whitefly vs Sweet Potato Whitefly?
Different species of whitefly:

**Greenhouse whitefly**
- *Trialeurodes vaporariorum*
- Adult: bigger than B.t.
- View from top: more triangle shape
- Colour is whiter due to more wax excrement
- Egg: first days white, later brown – black (purple)
- Pupae: oval white casket with ring of wax strings
- Parasitized by *Encarsia formosa* and *Eretmocerus eremicus*

**Silver leaf whitefly**
- *Bemisia tabaci*
- Smaller than T.v.
- View from top: elongated
- More yellow due to less wax excrement
- Egg: light yellow-green, later light brown
- Pupae: flat, transparant / yellowish of colour (adult is visible → red eyes)
- Parasitized by *Eretmocerus eremicus*
## Development Time of Greenhouse Whitefly on Tomato Plants:

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Egg</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>Pre pupae</th>
<th>Pupae</th>
<th>Adult</th>
<th>Development time (egg – egg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50°F</td>
<td>15.8</td>
<td>12.7</td>
<td>8.1</td>
<td>7.1</td>
<td>17.3</td>
<td>9.8</td>
<td>10</td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>59°F</td>
<td>10.9</td>
<td>8.0</td>
<td>9.3</td>
<td>6.3</td>
<td>8.6</td>
<td>7.5</td>
<td>50.5</td>
<td>50.5</td>
<td>53</td>
</tr>
<tr>
<td>68°F</td>
<td>10.4</td>
<td>4.5</td>
<td>4.7</td>
<td>3.5</td>
<td>3.0</td>
<td>4</td>
<td>3.6</td>
<td>53</td>
<td>33</td>
</tr>
<tr>
<td>77°F</td>
<td>7.7</td>
<td>3.6</td>
<td>4.4</td>
<td>3.0</td>
<td>2.2</td>
<td>3</td>
<td>2.7</td>
<td>21.9</td>
<td>25</td>
</tr>
<tr>
<td>86°F</td>
<td>6.6</td>
<td>4.3</td>
<td>4.9</td>
<td>4.2</td>
<td>4.2</td>
<td>3.6</td>
<td>5.4</td>
<td>27</td>
<td></td>
</tr>
</tbody>
</table>
Biological Control of Whitefly:

- Egg: 9.9 days
- L1: 4.4 days
- L2: 3.5 days
- L3: 4.3 days
- L4: 2.6 days
- Pupa: 7.3 days
- Adult: from egg to adult: 32 days

- Black coloured: 14 days
- Adult: from egg to adult: 27 days
Encarsia formosa - Encarline Card/Mix

- Parasitic wasp Encarsia formosa
- Parasitizes larvae of whitefly
- Some host feeding (3 – 4 L1/day)
- No effect on Bemisia (parasitism)
- Can be used in wide range of crops
- Active from >59°F - <85°F
- 99% females
- Very sensitive for sulphur and traditional pesticides
- Available on cards and in blisters (mixed product)
- preventative approach recommended
- Release rates depending on crop
  - Ornamental crops \(\rightarrow 0.6 – 1\) wasp/sq. ft (hostfeeding)
  - Vegetable crops \(\rightarrow 0.015 – 0.6\) wasp/sq. ft (establishing)
**Eretmocerus eremicus** – Eretline Blister/Card

- Parasitic wasp *Eretmocerus eremicus*
- Parasitizes larvae of whitefly
- **Aggressive host feeding** (20 – 30 L1/day)
- Bemisia and Greenhouse whitefly parasitism
- Can be used in wide range of crops
- Active from >20°C/68°F
- Less active at low light levels in winter
- Available in blisters (and cards, **not** preferred method)
- preventative approach
- Release rate depending on the crop and whitefly species
- Release rates depending on crop
  - Ornamental crops → 0.6 – 1 wasp/ sq. ft (hostfeeding)
  - Vegetable crops → 0.015 – 0.6 wasp/ sq. ft (establishing)
**Amblyseius swirskii – Swirskiline**

- Predatory mite *Amblyseius swirskii*
- Prey on L1 larvae of thrips, whitefly eggs and pollen
- Strong side effect on broad mites
- Can be used in wide range of crops (not tomatoes)
- Active from 68-105°F (20-41°C), prefers warm/hot
- Sensitive for low light levels and low temperatures (< 18°C/66°F) Be careful with temp below 15°C/59°F
- breeding system vs loose material
- Active at higher temperatures and crops where both thrips and whitefly are present
- Release rates:
  - Crop and technique depending
  - 10 mites per sq. foot WEEKLY as broadcast
  - Or 1 sachet/plant, plug tray, shuttle tray
  - Sachet last at least 4 weeks
**Dicyphus Hesperus – Hesperusline**

- Predatory bug *Dicyphus hesperus*
- Prey on eggs, larvae and pupae of whitefly, but also Thrips, Moth eggs and Mites (generalist)
- Mainly used in greenhouse vegetables – Tomatoes, but also opportunities in ornamentals
- Active from >65°F
- Slow development → planning ahead.
- Best establishment using mullein plants (*Verbascum thapsus*) as banker plants
- Feeding with Ephestia – Bugfood → fecundity
- Introduction rates:
  - Minimum 40 mullein per acre
  - 8 weekly introductions at 3 – 4 Dicyphus per mullein plant
  - Feed with 4 grams Ephestia eggs per week
Release methods...how does it impact?

- Blister packs vs cards, what is the difference?:
  - *Eretmocerus eremicus* can only hatch on top side of pupa!
  - *Encarsia formosa* can hatch from both sides
  - Pupa stuck on card vs pupa loose in blister pack
  - Protection with blisters from ants or other environmental conditions such as watering with loose pupa → *Aphidius colemani* and *Aphidoletes aphidimyza* also available in blisters
  - Blisters preferred method for protection and better hatch
Release methods...how does it impact success or failure?

However, what to keep in mind........:
Release methods…how does it impact?

However, what to keep in mind.........:
What is changing in young plant production?
Amblyseius spp (Amblyline Stick, Swirskiline Stick) in plant propagation:

• Young vegetable plants experience.
• Water resistant and exit hole protected from overhead irrigation/misting
• ‘Signature’ for ICM/IPM ready plant material from propagators to growers
• Timing of introduction for especially thrips and broad mites is critical → early establishment of predatory mites
• *Amblyseius cucumeris* (Amblyline™) Stick most suitable for spring propagation → Climate/Temperature and most cost effective.
• *Amblyseius swirskii* (Swirskiline™) stick → Warmer climate and whitefly susceptible crops
Applying sachets in young vegetable propagation
Amblyline & Swirskiline Stick on young pepper plants:
Importance of ‘clean’ propagation when using banker systems:
Amblyseius spp (Amblyline Stick) starting in propagation
(Syngenta FHG site Gilroy, California)
Amblyseius spp (Amblyline Stick) starting in propagation
(Syngenta FHG site Gilroy, California)
Releasing *Amblyseius swirskii* (Bugline) on Chrysanthemum stock plants for thrips and broad mite control
Releasing *Phytoseiulus persimilis* for Two Spotted Spider Mite control: *(Syngenta FHG site, Alva, Florida)*
Amblyline & Swirskiline Stick in Dracena Plug Trays:
Biological Control & IPM at poinsettia stock plant site:
Biological Control in Spring Plugs / Propagation:

More locations this spring:
Where can you find more information about releases rates and not to forget timing of introductions?
Bioline App:

- Information on Bioline App:
- Apple, Android and Microsoft compatible
- Compatibility data
- Trade name and A.I.
- Technical information per pest, BCA and strategies
- Free download from app store
Bioline App:
User guidelines for Biological Control Release Rates:

- General release rates
- Crop specific
- Rates per m², sq.ft., per plant, pot, plug tray.
- Guideline only
- Release instructions
- Storage/holding BCA’s??
- Timing of introduction
- More to consider when talking about release rates!!
Biological Control Release Rates → Crop Specific:

**Biological Control Strategy for Poinsettia Production**

Using biological control agents (BCAs) to control pests in poinsettia has been successful for years. There are few pests that affect poinsettia; however, the discovery of the Q bio-type silver leaf whitely has increased the use of BCAs because it is more resistant to traditional control products. Working with BCAs improves resistance management and can help increase plant quality. For more information, download the Bioline App from [www.biolineapp.com](http://www.biolineapp.com).

### Bioline Biological Control Agents for Poinsettia

<table>
<thead>
<tr>
<th>Pest</th>
<th>BCA</th>
<th>Product</th>
<th>Application Rate m³ sq. ft</th>
<th>Timing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Whitefly</strong> (&lt;i&gt;Diaspidiotyrum brassicae&lt;/i&gt;)</td>
<td>Euscelidius coccinellida</td>
<td><strong>Red</strong></td>
<td>10 1</td>
<td>Start around week after sticking cuttings or immediately after planting. Repeat weekly.</td>
<td>Optimal introduction method for Euscelidius coccinellida on susceptible hosts. Euscelidius is also available on other hosts. Keep whitefly packs available out of direct sunlight.</td>
</tr>
<tr>
<td><strong>Anthocoris nabida</strong></td>
<td>Euscelidius coccinellida</td>
<td><strong>Black</strong></td>
<td>10 1</td>
<td>Free introduction on several cuttings just before transplant.</td>
<td>Introduction of Euscelidius coccinellida is timed to coincide with the maximum feeding of the pests to ensure the greatest number of insects are released on the plants.</td>
</tr>
<tr>
<td><strong>Fusarium graminearum</strong> (&lt;i&gt;Fusarium solani&lt;/i&gt;)</td>
<td>Blastocladia constricta (Myzostoma solani)</td>
<td><strong>Hydroporina</strong></td>
<td>100 10</td>
<td>Place at sticking/setting and again during transplanting into larger pots.</td>
<td>Larger pots that are individually placed need one Blastocladia stick per pot.</td>
</tr>
<tr>
<td><strong>Debaryosporum solani</strong></td>
<td>Blastocladia constricta (Myzostoma solani)</td>
<td><strong>Hydroporina</strong></td>
<td>10 1</td>
<td>Apply at sticking and at transplanting.</td>
<td>If applied at rooting stage, second application should be half rate at transplanting.</td>
</tr>
<tr>
<td><strong>Ceratocystis fimbriata</strong></td>
<td>Blastocladia constricta (Myzostoma solani)</td>
<td><strong>Hydroporina</strong></td>
<td>10 1</td>
<td>Apply at sticking and repeat twice during rooting stage.</td>
<td>Correct application is critical for efficacy. Make sure solution is applied; then filters are removed and pot is left bare.</td>
</tr>
<tr>
<td><strong>Thrips</strong> (&lt;i&gt;Frankliniella occidentalis&lt;/i&gt;)</td>
<td>Euscelidius coccinellida</td>
<td><strong>Red</strong></td>
<td>10 1</td>
<td>Start when first mines are detected. Repeat weekly for 3 to 4 weeks until mines are controlled.</td>
<td>If applied at rooting stage, second application should be half rate at transplanting.</td>
</tr>
<tr>
<td><strong>Thrips</strong> (&lt;i&gt;Frankliniella occidentalis&lt;/i&gt;)</td>
<td>Blastocladia constricta (Myzostoma solani)</td>
<td><strong>Hydroporina</strong></td>
<td>100 10</td>
<td>Place at sticking/setting and again during transplanting into larger pots.</td>
<td>Larger pots that are individually placed need one Blastocladia stick per pot.</td>
</tr>
</tbody>
</table>

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Biological Control Release Rates → Crop Specific:

### Biological Control Strategy for Chrysanthemum Production

#### Bioline Biological Control Agents for Potted Chrysanthemum

<table>
<thead>
<tr>
<th>Pest</th>
<th>BCA</th>
<th>Product</th>
<th>Application Rate</th>
<th>Timing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thrips (Frankliniella occidentalis)</strong></td>
<td>Anthracnose cinerea</td>
<td>Anthracnose Liner</td>
<td>100 10</td>
<td>apply weekly during propagation.</td>
<td>Broadcast every 10 days or use a battery-powered blower.</td>
</tr>
<tr>
<td><strong>Leafminers (Lepidoptera spp)</strong></td>
<td>Diptera</td>
<td>Digitec</td>
<td>0.5 to 1 0.5 to 0.1</td>
<td>weekly for 3 to 4 weeks until sufficient parasites have been established.</td>
<td>Start releasing at first signs of infestation (feeding and repositioning).</td>
</tr>
<tr>
<td><strong>Aphids (Aphis gossypii, Macrosiphum rosae, Myzus persicae)</strong></td>
<td>Apidacine</td>
<td>Apidacine</td>
<td>0.25 to 1 0.25 to 0.1</td>
<td>weekly and use in combination with aphid banker plants.</td>
<td>Aphidacine is more aggressive towards Myzus persicae and grass aphids.</td>
</tr>
<tr>
<td><strong>Caterpillars/Looper (Pseudoiscola spp)</strong></td>
<td>Chrysodeixis</td>
<td>Chrysodeixis</td>
<td>0 to 30</td>
<td>1 to 2</td>
<td>Use as larvae controllers only for quick knock down.</td>
</tr>
</tbody>
</table>

**Dipping at sticking and/or planting:**

- Thrips, fungicide, and others: Use WPF biological inoculator. Follow label. Keep solution in agitation. Rebatch dipping solution as often as needed.
Biological Control Release Rates → Crop Specific:

<table>
<thead>
<tr>
<th>Pest</th>
<th>BCA / Product</th>
<th>Application Rate</th>
<th>Timing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Western Flower Thrips, Chilo suppressalis</strong>&lt;br&gt;and other &lt;br&gt;small thrips&lt;br&gt;and whiteflies</td>
<td>Anthophora 300 - mini sachets</td>
<td>1 sachet per propagation tray, should only be used in propagation.</td>
<td>Apply early during sprout stage.</td>
<td>Transplant into soil or hanging baskets.</td>
</tr>
<tr>
<td><strong>Orange thrips</strong></td>
<td>Orhidecine</td>
<td>5 to 10</td>
<td>0.5 to 1</td>
<td>Place sachets at planting time.</td>
</tr>
<tr>
<td><strong>Small thrips</strong>&lt;br&gt; **and whiteflies</td>
<td>Hypepeline</td>
<td>100</td>
<td>10</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Dactyloidea carnea</strong>&lt;br&gt; *<em>(Doritos)</em></td>
<td>Sunflyline</td>
<td>3</td>
<td>0.3</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Punja gnat and shore flies</strong>&lt;br&gt; <strong>(Lipaphis sp., Lipaphis sp.)</strong></td>
<td>Hypepeline</td>
<td>100</td>
<td>10</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Aphids</strong>&lt;br&gt; <strong>(small aphids)</strong>&lt;br&gt; <strong>- Green peach, black currant, tobacco aphids, potato aphids</strong></td>
<td>Apholine</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Rhopalosiphum padi</strong>&lt;br&gt; <strong>- green peach</strong></td>
<td>Apholine</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Aphidius riebschlagii</strong>&lt;br&gt; <strong>- aphid</strong></td>
<td>Apholine</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Mycocentrus sp.</strong>&lt;br&gt; <strong>- aphid</strong></td>
<td>Apholine</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Aphideiphagus sp.</strong>&lt;br&gt; <strong>- aphid</strong></td>
<td>Apholine</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Chrysoperla sp.</strong>&lt;br&gt; <strong>- Coccinellidae</strong>&lt;br&gt; <strong>- aphid</strong></td>
<td>Chrysaline</td>
<td>10 to 50</td>
<td>1 to 5</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Aphidoletes</strong>&lt;br&gt; <strong>- aphid</strong></td>
<td>Ecoline</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Aphis gossypii</strong>&lt;br&gt; <strong>- aphid</strong></td>
<td>Aphidine</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Aphididae</strong>&lt;br&gt; <strong>- green peach</strong></td>
<td>Apholine</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Aphididae</strong>&lt;br&gt; <strong>- green peach</strong></td>
<td>Apholine</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Aphididae</strong>&lt;br&gt; <strong>- green peach</strong></td>
<td>Apholine</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Two-spotted shield bug (Philaenus spumarius)</strong>&lt;br&gt; <strong>- aphid</strong></td>
<td>Anthophora 300 - mini sachets</td>
<td>1 sachet per propagation tray, should only be used in propagation.</td>
<td>Apply as needed.</td>
<td>Transplant into soil or hanging baskets.</td>
</tr>
<tr>
<td><strong>Philaenus spumarius</strong>&lt;br&gt; <strong>- aphid</strong></td>
<td>Physiolin</td>
<td>5 to 8</td>
<td>3.6 to 8</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Leptosiphon luteus</strong>&lt;br&gt; <strong>- aphid</strong></td>
<td>Physiolin</td>
<td>0.25 to 1</td>
<td>0.025 to 0.1</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><strong>Broad mites</strong>&lt;br&gt; <strong>(Polyphagotarsonemus latus)</strong>&lt;br&gt; <strong>- aphid</strong></td>
<td>Anthophora 300 - mini sachets</td>
<td>1 sachet per propagation tray, should only be used in propagation.</td>
<td>Apply as needed.</td>
<td>Transplant into soil or hanging baskets.</td>
</tr>
<tr>
<td><strong>Sweatpants</strong>&lt;br&gt; <strong>(Eriophyes chrysanthemi)</strong>&lt;br&gt; <strong>- mite</strong></td>
<td>Anthophora 300 - mini sachets</td>
<td>1 sachet per propagation tray, should only be used in propagation.</td>
<td>Apply as needed.</td>
<td>Transplant into soil or hanging baskets.</td>
</tr>
<tr>
<td><strong>Chlorinea</strong>&lt;br&gt; <strong>- mite</strong></td>
<td>Anthophora 300 - mini sachets</td>
<td>1 sachet per propagation tray, should only be used in propagation.</td>
<td>Apply as needed.</td>
<td>Transplant into soil or hanging baskets.</td>
</tr>
<tr>
<td><strong>Mites</strong>&lt;br&gt; <strong>(Graphocephalum destructor)</strong>&lt;br&gt; <strong>- mite</strong></td>
<td>Eucarote</td>
<td>3 to 5</td>
<td>0.3 to 5</td>
<td>Apply as needed.</td>
</tr>
<tr>
<td><em><em>Caripari</em> / Mites</em>*&lt;br&gt; <strong>(Eriophyes sp.)</strong>&lt;br&gt; <strong>- mite</strong></td>
<td>Anthophora 300 - mini sachets</td>
<td>1 sachet per propagation tray, should only be used in propagation.</td>
<td>Apply as needed.</td>
<td>Transplant into soil or hanging baskets.</td>
</tr>
</tbody>
</table>
What does it take to be successful?
Implementing Bio-control → Important messages for success:

- On-going education, knowledge, communication and networking
- Start as early as possible, even before the crop has started → Planning!
- Use resources → follow introduction rate recommendations
- Pro-active approach → insurance = success rate
- Understand life cycle of both pest and BCA
- Systems approach → don’t let efforts on one pest to be torpedoed by another
- Check compatibility if/when a traditional product is considered
- **Communicate → with young plant material suppliers**
- Communicate → with specialists and other growers who are successful
- Communicate with producer/supplier of BCAs
- Consider banker plants as part of your strategy
Biological control is preventing problems, not fixing them!

Bio-control works!

It is people (managing) that makes bio-control an effective strategy!
Thank You!

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