Introduction to Biological Pest Control in Greenhouses

J.D. DeAngelis

The past decade saw a dramatic increase in research and commercial use of biological pest control, particularly in greenhouse crops. This came about mainly because of concerns over the use of pesticides in enclosed spaces and consumers' concerns about possible pesticide residues on food.

The Europeans and Canadians have largely taken the lead in research and commercial applications of biological control in greenhouse crop production.

Biological pest control is simply the use of "good bugs" to control "bad bugs." The "good bugs" aren't necessarily insects; beneficial bacteria, fungi, nematodes, and mites are included as well.

The vast amount of research and practical experience gained over the past 10 years convinces many people that biological pest control is a realistic alternative to chemical pest control. In fact, some commercial vegetable greenhouses in Canada, and elsewhere, use no pesticides at all. They rely instead on biological control.

Some words of caution are appropriate at this point, however:

- No single pest control method is 100% effective. This applies to biological as well as chemical pest control. Don't expect miracles.
- Biological pest control often involves more work at first than chemical control, and it may require changes to your production methods.
- Biological control agents (predators and parasites) are susceptible to pesticides, often more susceptible than the target pests, so you must regulate chemical applications carefully.
- Finally, many biological control agents work slowly to express the pest population, so they're best used when pest numbers are fairly low.

Most predators and parasites perform best at moderate temperatures (65 to 85°F) and humidities (60 to 90%). Light level is also important. For these reasons, biological control may not be workable during cold winter months or hot, dry summer months.

In addition, during the spring and summer, make your releases of predators and parasites in the mornings or, better yet, in the evenings so that the "good bugs" can settle down into protected areas before temperatures rise.

The compatibility of traditional pesticides with predator and parasite is an important issue in biological pest control. Pesticides differ widely in their impact on biological control agents. In general, pesticides are incompatible with biological control when used in conventional ways.

Much research is now underway to determine the best ways of integrating chemical and biological control methods; some success has been attained.

Here's a general rule of thumb: When you must use chemical pesticides, use those that have the shortest residual life and the highest specificity. Discuss these requirements with your Extension agent or pest control advisor.

This publication has three parts:

First, "Biological control agents," page 2, organizes the predators and parasites according to the major pests they control. Many of the organisms discussed have no common names, so I use scientific names.

Release rates and costs are rough estimates; use them as guides only. The rates are calculated for a house measuring 30 x 100 feet (3,000 ft²); adjust them appropriately for a larger or smaller house.

Second, "Tips for starting your program" begins on page 4.

Jack D. DeAngelis, Extension entomologist, Oregon State University.
Third, because *Amblyseius cucumeris* is the one predator that's easy to rear yourself, methods for doing so begin on page 5.

**Types of biological control**

Scientists recognize three (the second and third are related and apply more often in greenhouse situations):

1. **Classical biological control** is the oldest, and it's attempted when a foreign pest has been introduced without its natural enemies. To attempt control of the pest, natural enemies, often collected from the pest's native habitat, are imported and released.

2. **Inundative biological control** involves the release of large numbers of predators and/or parasites to achieve rapid, short-term control. This is much like chemical control; we replace the chemical pesticide with a predator or parasite.

3. **Augmentative biological control** is most often used in field crops and tree fruit production. Predators and parasites that naturally occur in the system, but perhaps at lower than the desired numbers, are released at certain times to "augment" the natural agents.

Because greenhouses have no natural predator/parasite complex, the second and inundative biological control is most often enjoyed. With careful management, however, it's possible to establish a predator and parasitic in your greenhouse so that it's only necessary to make augmentations periodically.

**Sticky card traps**

*Every greenhouse pest management program, whether chemical or biological, should include the use of sticky card traps. Yellow sticky card traps are useful for monitoring, and to some extent trapping out, a variety of small flying (adult) insects including thrips, whiteflies, aphids, and fungus gnats.*

Yellow is the best all-round color, but some shades of blue seem to work better for Western flower thrips.

As a rule, hang three cards per 100 feet of bench, just above plants. Replace traps when they become covered with insects or dirt and after pesticide applications. Cost: about 25¢ each.

**Biological control agents**

Table 1 summarizes the key characteristics of the control agents described here. Remember, the release rates listed for each agent is for a house measuring 30' x 100 feet (3,000 ft²); adjust this rate as necessary for a larger or smaller house.

**Pest: Aphids**

*Aphidoletes (pronounced "a-fido-le-teez").* Aphidoletes is a small mite resembling a fungus gnat, whose young feed exclusively on aphids. Adult *Aphidoletes* live for only a few days; the female's only purpose is to lay eggs near aphid colonies. When the eggs hatch, the small, orange larvae immediately begin to search for and consume aphids.

When you purchase *Aphidoletes*, they arrive as pupae, mixed in peat or vermiculite.

Release rate: 500; cost: $40. Release *Aphidoletes* early, when aphids are present but before significant damage has been done. Some growers report a single early summer release is enough to suppress aphids all season long, but you should plan two releases about 2 weeks apart to ensure overlapping generations.

**Ladybird beetles (or ladybugs)** are the familiar orange or red beetles with black spots. The species most commonly called "ladybug" is *Hippodamia convergens*. Both adult and young feed on aphids, spider mites, and other small insects and mites. The young are males with yellow or orange markings, sometimes described as "baby alligators." Adult ladybird beetles are purchased.

Release rate: 18,000; cost: $15 to $20. On released, they immediately begin feeding and laying eggs. *Ladybird beetles* are strong fliers and will leave the area if the weather is too hot.

Ladybirds are best used to quickly check an outbreak, with no expectation of long-term control. They don't do well at temperatures above 90°F.

**Pest: Spider mites**

The two-spotted spider mite, found universally in greenhouses, can be effectively controlled by several predatory mites, called phytoseids ("fi-TOE-see-ids"). The most common predator mite used in greenhouses worldwide is *Phytoseius persimilis*.

Several new forms of this mite are available, some with tolerance to higher temperatures and lower humidities. Follow your supplier's advice about selecting strain or species.

Release rates are difficult to estimate for phytoseids, but try 1 to 3 per plant; cost: $25 to $40.

**Pest: Thrips**

Until recently, thrips (mainly the Western flower thrips and onion thrips) weren't important greenhouse pests. Two things happened to promote thrips to major pest status.

The first relates to the use of pesticides. Long-term use of insecticides in greenhouses has resulted in...
Table 1.—Common pests and characteristics of biological agents to control them

<table>
<thead>
<tr>
<th>Pest/agent</th>
<th>Cost</th>
<th>Control</th>
<th>When to release</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphids</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Aphidoletes</em></td>
<td>Moderate</td>
<td>Excellent, slow</td>
<td>Spring, when aphids are present</td>
<td>May provide season-long control.</td>
</tr>
<tr>
<td>Ladybird beetles</td>
<td>Low</td>
<td>Fair to good, rapid</td>
<td>Time greenhouse temperatures are moderate (60-90°F)</td>
<td>Release in evening; useful for “knocking down” an infestation.</td>
</tr>
<tr>
<td>Spider mites</td>
<td>Moderate</td>
<td>Good to excellent, rapid</td>
<td>When spider mites first appear</td>
<td>Select strain or species best adapted to your conditions.</td>
</tr>
<tr>
<td>Predator mites</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ladybird beetles</td>
<td>Low</td>
<td>Fair to good, rapid</td>
<td>Time greenhouse temperatures are moderate (60-90°F)</td>
<td>Release in evening; useful for “knocking down” an infestation.</td>
</tr>
<tr>
<td>Thrips</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Amblyseius cucumeris</em></td>
<td>Very low to moderate</td>
<td>Good to excellent, slow</td>
<td>Early season, when thrips first appear</td>
<td>May be reared onsite. Prey on spider mites when thrips are scarce.</td>
</tr>
<tr>
<td>Ladybird beetles</td>
<td>Low</td>
<td>Fair to good, rapid</td>
<td>Time greenhouse temperatures are moderate (60-90°F)</td>
<td>Release in evening; useful for “knocking down” an infestation.</td>
</tr>
<tr>
<td>Whiteflies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Encarsia</em></td>
<td>Moderate</td>
<td>Excellent, slow</td>
<td>When whiteflies first appear</td>
<td>Several releases may be needed.</td>
</tr>
<tr>
<td>Ladybird beetles</td>
<td>Low</td>
<td>Fair to good, rapid</td>
<td>Time greenhouse temperatures are moderate (60-90°F)</td>
<td>Release in evening; useful for “knocking down” an infestation.</td>
</tr>
<tr>
<td>Fungus gnats</td>
<td>Moderate</td>
<td>Good, rapid</td>
<td>When sticky card traps show an infestation</td>
<td>Applied as a soil drench.</td>
</tr>
<tr>
<td><em>Beauveria thuringensis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mealybugs and scales</td>
<td>High</td>
<td>Good to excellent</td>
<td>Whenever mealybugs or scales appear</td>
<td>Release in morning or evening.</td>
</tr>
</tbody>
</table>

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For most current information: 
http://extension.oregonstate.edu/catalog
strains of Western flower thrips that are resistant to insecticides in many parts of the country. Some populations can no longer be effectively controlled with chemicals alone.

Secondly, in operations where insecticide use has been replaced by biological control of spider mites, aphids, and whiteflies, thrips can become the dominant pest.

The phytoseiid mite Amblyseius cucumeris ("am-BLEE-see-us coo-coo-MER-us") is a specialist thrips predator. This mite feeds on young thrips but will consume spider mites as well. Control will be slower than with phytoseiid control of spider mites because they consume only immature thrips. You can buy the mite or rear it yourself (page 5).

**Pest: Whiteflies**

The most widely used biological control agent is the greenhouse whitefly parasite Encarsia ("n-CAR-see-a"). The Encarsia wasp lays its eggs inside the body of young whiteflies. As the larvae develop, they devour the whitefly and emerge as adults to repeat the process. Encarsia will survive and multiply only when whiteflies are present. As long as you have whiteflies present, several releases a year may be necessary to maintain control.

Encarsia alone won't solve severe whitefly infestation. The parasite works best when you have a large, steady supply of whiteflies. If you have the Encarsia wasp in abundance, they will arrive damaged; therefore, always inspect them carefully.

**Pest: Fungus gnats**

Fungus gnats are best suppressed by combining yellow sticky card traps (to monitor for adult flies) with a bacterium called Bacillus thuringiensis (Bt; common brand name, Gnatrol) to control larvae in the soil.

Direct your control at the larvae, while you monitor the adults. Use the label instructions for rates and timing. Work is currently underway to determine if beneficial nematodes will work; early results are promising.

**Pest: Mealybugs and scales**

The most commonly used mealybug predator is Cryptocephus, called "the mealybug destroyer." Both adults and larvae of the small ladybird beetle attack mealybugs and scales.

Release rate: 100 to 500 depending on severity of infestation, cost: $35 to $100.

Mealybugs and scales are most often pests of woody and other perennial plants. Because of the relatively high cost, release this predator only after you've confirmed an infection.

**Tips for starting your program**

**Pick suppliers carefully**

Like any other business, there are good and not-so-good suppliers of biological control agents. While the vast majority are excellent, it still pays to be cautious, just as you would with any other supplier with which you have not had much experience. Even with the best suppliers, shipments will occasionally arrive damaged; therefore, always inspect them carefully.

Try several suppliers and be cautious of supplier claims and quality. Also, good suppliers can be important sources of information—use them.

**Be realistic**

Be realistic in your pest control expectations. Remember that the objective is to manage pest populations, not to eliminate them. Biological control should be just another tool or option in your pest control arsenal.

**Start small**

Start small and gain the experience with biological control before you convert your whole operation. You may find that biological control will work only for certain parts of your operation or only during certain times of the year.

**Monitor pests and agents**

Carefully monitor the pest and biological control agents to determine effectiveness. Monitoring procedures will differ with pest, crop and biological control agent.

A starting point, however, is to use sticky card traps (see page 2) for flying pests and get a hand lens (10X to 20X magnification) for checking leaves and stems. Scout your house at least once a week. Walk through the house and check plants with your hand lens.

**Keep good records**

Keep a notebook and carefully record your progress. Record when you release biological control agents, how you released them, how many you released, etc. Also record how the release seems to be working over the short and long term.
Get good advice

Seek advice from your Extension agent and your biological control supplier about release rates, timing, and availability of other agents. This field of pest control is changing extremely rapidly, so current information is critical. Visit your library to get additional information.

Rearing a thrips predator

In most cases, it’s impractical to rear predators and parasites yourself because of the amount of space needed.

One exception is Amblyseius cucumeris, the phytoseiid mite predator of thrips and spider mites. You can mass-produce this predator mite cheaply and in a minimum of space. By keeping a small culture going, you’ll have predator mites available whenever you need them.

You rear the predator mites on grain mites, which are reared on a wheat bran diet—this sounds complicated, but it really isn’t.

Supplies
1. wide-mouth pint Mason jars and lids;
2. wheat bran, brewer’s yeast; wheat germ from the bulk section of your supermarket;
3. plastic storage box with lid (deep enough to hold jars; see figure 1);
4. paper towels; and
5. 16-oz measuring cup.

Mixing the diet
Mix together 9 oz wheat bran, 1 oz wheat germ, and ½ oz yeast. This will yield enough diet for 2½ jars. Add about 4 oz of this mixture to each Mason jar. Cut a paper towel sheet into quarters and place one piece over the mouth of the jar and secure with a lid (don’t use the metal lid insert).

You must heat the diet to about 120°F overnight to kill any contaminating insects and mites. The lowest setting on a kitchen oven is about right; but check with a kitchen thermometer to allow the jars to cool. Put about ½ inch of water in the plastic storage box, put in the diet jars, cover and allow to stand overnight.

Growing the mites
Put about ½ teaspoon of a predator/grain mite culture into each jar and mix. To get started, you’ll need to purchase some mites from a supplier. Put the jars back into the storage box, cover and hold at room temperature or slightly warmer. Under a greenhouse bench will work, but keep out of direct sunlight.

Once a week, gently mix the culture by tumbling the jars to keep the diet loose. In about 3 to 4 weeks, there’ll be enough predators to release. The bran diet will swell during this period.

Release predators by sprinkling the diet-grain mite-predator mixture over the plants. The best release rates will vary with crop and infestation, but try about ¼ teaspoon per square foot of plants; each jar will produce enough for about a 6 x 12 foot bench.

Be sure to save enough culture to start a new set of jars. You’ll need about a half teaspoon per jar.

Cautions
1. Some people may experience an allergic reaction to the mite culture. The grain mites are particularly noted for causing this reaction. Use a dust mask when you work with the culture and when you apply it to plants.
2. In rare cases, the predator mites will completely eliminate the grain mites from the culture. If this happens, the predators will die also, and the bran will become covered with what looks like bread mold. Discard the cultures and start over.
3. If a culture becomes too old, it will turn a chocolate brown and look...
wet. Again, discard the culture if this happens. To avoid this, don’t let the cultures get more than 3 to 4 weeks old.

4. If the room temperature is too high, the cultures will turn brown and all the predator mites will die. Discard the culture. Maintain your culture temperatures below 80°F.

5. The predator cultures require long day length. Under natural light, your cultures will decline during winter months (when day length drops below 12 hours) unless you provide artificial light during these months.

For further reading

OSU publications

Dreves, Amy, and Glenn C. Fisher, Biological Control Agents and Where to Find Them, Oregon State University Extension Service Circular 1328 (Corvallis, 1989). 75¢

This publication (and the one you’re holding, EC 1376, Introduction to Biological Pest Control in Greenhouses, 75¢) are available from:

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