Strategies to Control Insects in Successive Plantings in High Tunnels

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The various types of season extension materials and strategies can be valuable tools in managing insect pests. Extending the season allows farmers to avoid pests that are common in the field by growing the crop (or at least starting the crop and getting it well established) when the field pests are not active. In addition, covering the plants may act as a barrier to some pests. Floating row covers are often used in the field, particularly by organic growers, as barriers to exclude pests such as flea beetles and striped cucumber beetles. High tunnels where the sides are closed at night can be used to exclude some of the night-flying moths, such as tomato hornworm or tomato fruitworm.

However, some insect pests are likely to be more severe in successive plantings in high tunnels because:

- The natural enemies present in the field are not likely to occur naturally in the tunnel during the extended season
- Conditions in the protected environment are ideal for these pests
- Successive plantings provide an opportunity for these pests to build up
- Pests are easily moved from one protected environment to another
- In an isolated population, pesticide resistance can develop in the pest if the grower is using the same pesticide repeatedly.

Among the pests likely to occur in protected cultivation are: aphids, whiteflies, thrips, spider mites, and fungus gnats.

Some strategies to avoid introducing pests at the beginning of the crop cycle:

- Clean out all the weeds and leftover plant debris from the tunnel between crops. Remove debris far from the greenhouse or compost it actively to prevent survival of pathogens and pests.
- Keep the areas adjacent to the tunnels free of herbaceous weeds and mowed as much as possible.
- If and when you can, close up the cleaned tunnel between crop cycles and allow it to heat up. Under hot and dry conditions, in the absence of host plants, many of the adult thrips and other above-ground pests will die in a few days. The soil-dwelling stages of pests (such as thrips pupae) may survive this treatment, but overall survival of pests will be reduced.
- If you use transplants, inspect them carefully for pests before planting. Don't forget to check the soil for fungus gnat larvae.

The next step is to set up a scouting program to know what pests are present, so that action can be taken to control the pests before they become a serious problem. Yellow sticky cards are attractive to many pest insects, including winged aphids, adult whiteflies, adult fungus gnats, and

adult leafminers. Blue sticky cards are more attractive to adult thrips. In all cases, sticky cards sample only the flying stage of the insect, so sticky cards should be supplemented with a regular routine of plant inspection.

Sticky cards should be set up before planting in order to detect any lingering pest population from the previous crop. As plants are introduced, keep the sticky cards 1-2 inches above the plant canopy. Change the cards every 1-2 weeks as needed. As the plants grow up over head height, sticky cards are less effective and plant inspection should be emphasized. Also, if any parasitic wasps or flying predators such as lacewings are present, yellow sticky cards should be removed because the cards are also very attractive to these beneficial insects and will trap and kill them.

Successive crops in high tunnels provide an excellent environment for using biological control. Often the options for using pesticides in an enclosed environment on a food crop are very limited, and many of the pests that thrive in a protected environment, such as whiteflies and thrips, are resistant to a wide array of pesticides. There is a considerable body of research on biological control of pests of protected cultivation, particularly in greenhouse tomatoes. One of the best sources of information is a greenhouse IPM manual from Pennsylvania Integrated Pest Management Program: *Greenhouse IPM with an Emphasis on Biocontrols.* This manual is available from PSU Agricultural Publications Distribution Center for $12 or sections can be downloaded for free at: http://paipm.cas.psu.edu/63.htm. Much of the following information comes from this manual.

The types of biological control agents:

- Parasitoids (parasites that kill their hosts): These are typically very tiny wasps (stingless). They lay their eggs inside the immature stages of the pest, and their larvae feed on host tissues and kill it. They are often very host-specific, so you will need to identify the host carefully and choose the parasitoid to match the pest.
- Predators: These insects or mites kill and eat their prey. They reproduce outside the bodies of their prey.
- Insect pathogens: These bacteria (such as *Bacillus thuringiensis*) or fungi (such as *Beauveria bassiana*) cause diseases in their host insects, killing or weakening them.
- Insect pathogenic nematodes: These tiny roundworms are applied in water to soil. They find insect hosts, invade their bodies, and kill them.

There are also biological control agents used against plant pathogens, such as PlantShield or Mycostop. These have different modes of action, but are generally compatible with insect biological control.

If you intend to use insects for biological control, you need to plan ahead by avoiding the use of insecticides with long residual periods. (This is also true if you expect to bring in pollinators such as bumble bees to supplement natural pollination in the crop.) If you buy transplants, you should also find out whether they have been treated with insecticides with long residual periods. In general, synthetic pyrethroids and organophosphates are broad spectrum insecticides with long residual periods, and you might not be able to introduce beneficial parasitoids, predators, or pollinators for up to 3 months after using them. Natural pyrethrin or insect growth regulators are broad spectrum insecticides, but have a short residual. They can be used to knock down a pest

population before introducing beneficial insects a few days later. Insecticides that are most compatible with beneficial insects are: horticultural oils, insecticidal soaps, and biological pesticides such as *Bacillus thuringiensis* (such as Gnatrol for controlling fungus gnats), *Beauveria bassiana* (BotaniGard or Naturalis) or nematodes (such as *Steinernema feltiae*, used to control fungus gnat larvae and thrips pupae in soil).

Here are some of the insect biological control agents effective against the major pests of protected cultivation. Some suppliers of natural enemies are listed at the end. They can give you good advice about the specific needs of particular species and about rates and timing of use.

Against aphids:

- Parasitic wasps: Different species of wasps are used against different species of aphids, especially those that are different in size. *Aphelinus abdominalis* and *Aphidius ervi* are used against larger aphid species such as potato aphid. *Aphidius colemani* is used against green peach aphids and melon aphids. Some suppliers sell a mix of parasitoid wasp species for use against aphids.
- Predators: The aphid midge *Aphidoletes aphidimyza* lays its eggs in clumps of aphids, and its orange larvae kill and feed on aphids in the clump. It drops down into soil to pupate. It can be combined with parasitoids. The aphid midge goes into dormancy in late September. Other predators are also available, such as lady beetles and lacewings, but aphid midges are generally thought to be most effective in an enclosed environment.
- Insect pathogens and biorationals: The fungus *Beauveria bassiana* (BotaniGard or Naturalis) is also effective against aphids. Horticultural oils and insecticidal soaps are also effective to knock down aphid numbers.

Against whiteflies:

- Parasitic wasps: *Encarsia formosa* is effective against greenhouse whitefly and banded-wing whitefly, the two most common whiteflies of vegetable crops at temperatures between 64 F and 86 F. At temperatures above 80 F, or if you have silverleaf whitefly, which is more common on ornamental plants, then *Eretmocerus eremicus* will be more effective.

Against thrips:

- Biological control is only effective on relatively light infestations of thrips, and when thrips-vectored viruses such as tomato spotted wilt virus are not present. Otherwise, you may need to use short residual pesticides to get thrips under control.
- Predators: These predators are best used in combination. *Amblyseius cucumeris* feeds on immature thrips in foliage and flowers, and *Hypoaspis miles* feeds on thrips pupae in the soil.
- More predators: The predatory minute pirate bug, *Orius insidiosus*, will attack both immature and adult thrips, and it will also feed on aphids and spider mites. It can be combined with *Hypoaspis* mites. *Orius* is most effective between 70 F and 90 F.

Against spider mites:

- Biological control agents are also best used in combination against spider mites.
- Predatory mites: *Amblyseius californicus* or *Amblyseius fallaces* are relatively effective under high temperature conditions.
- Predatory midge: *Feltiella acarisuga* females lay eggs in areas of high mite density and the larvae feed on mites. They need high humidity and presence of a source of sugars for the adults.

Against fungus gnats:

- Pathogens: Gnatrol, *Bacillus thuringiensis israelensis*, can be applied to the soil for control of fungus gnat larvae.
- Nematodes: *Steinernema feltiae* can also be applied in water to soil against fungus gnat larvae and thrips pupae.

Some sources of biological control agents:

IPM Laboratories: www.ipmlabs.com phone: 315-497-2063
Koppert Biological Systems: www.koppert.com phone: 800-928-8827
Syngentia Bioline: http://www.syngenta-bioline.co.uk/america.htm phone: 805-986 8265

References:

Ferguson, G. 2003. Predators for spider mites on greenhouse veggies. http://www.omafra.gov.on.ca/english/crops/facts/info_spidermite.htm

Thomas, C. 2005. Greenhouse IPM with an Emphasis on Biocontrols. Pennsylvania IPM Program. http://paipm.cas.psu.edu/63.htm