Greenhouse Tomatoes: Guidelines for Biological Control

Biological controls are widely used in commercial greenhouse tomatoes in North America. As growers shift from using chemicals to using biological controls for pests, conditions have become favourable for using bumble bees for pollination. Biological control are most effective when used in an Integrated Pest Management (IPM) program (see Sheet 160). As in any IPM program, success depends upon correct identification of pest problems, regular monitoring, careful timing and integration of complementary control measures. It also depends on good clean-up, sanitation and other measures that remove breeding sites for pests and prevent them from entering the greenhouse.

The primary pests of greenhouse tomatoes grown in rockwool or hydroponic systems are greenhouse whiteflies (*Trialeurodes vaporariorum*), fungus gnats (*Bradysia* spp.) and two-spotted mites (*Tetranychus urticae*). Where ornamental crops are grown nearby, or were grown in the preceding crop, sweet potato whitefly (*Bemesia tabaci*) and western flower thrips (*Frankliniella occidentalis*) may be a problem; the latter is more likely to occur in soil cultures. Aphids can be an occasional problem.

Most biological controls are used after the target pest is found to be present, but some can be established ahead of time. The two main ways to use biological controls in tomatoes are:

- early, inoculative releases to establish them before pests are detected.
- inundative releases, after monitoring shows that the target pests are present. Start with early releases as much as possible because this increases the chance of achieving successful control. This is especially important on tomatoes, because the toxic, glandular hairs on leaves and stems hinder the movement of some biological controls.

The following guidelines contain practical tips for achieving good results against pests in greenhouse tomatoes. Recommended release rates for each biological control are shown in Table 1. More detailed information on pests and biological controls can be found in the separate information sheets for each species.

General Monitoring

There are two main ways to monitor for common tomato pests:

- Trapping pests on yellow sticky cards or ribbons. These are used to monitor for whitefly, thrips and fungus gnats; blue traps are also used for thrips but yellow traps are usually preferred because they can be used for whitefly as well. Inspect traps weekly; replace every 3-4 weeks as glue becomes less effective. Place traps at the top of the plant canopy for whiteflies and thrips; place them about 25 cm (1 foot) above the growing media for fungus gnats.
- Visual inspection of plant leaves. This should be done (using 10-15X magnifying lens) weekly, for signs of two-spotted mites, aphid infestations and other problems.

SHEET 410- TOMATO

WHITEFLIES

The main pest in greenhouse tomatoes is the greenhouse whitefly (for more on whiteflies, see Sheet 310). Sweet potato whitefly is occasionally a problem, but usually only in tomatoes grown near ornamentals, such as poinsettias. Whiteflies damage greenhouse tomatoes by covering fruit and leaves with the sticky honeydew as they feed. High populations also reduce the vigour of plants. The sweet potato whitefly can cause a net-vein symptom in fruit. Both species of whiteflies can be controlled on tomato by the parasitic wasp, 'Encarsia', by following steps described below.

Monitoring Tips

- Begin in the empty greenhouse, before seedlings are planted out.
- Hang up yellow sticky cards or tapes at the rate of 1 trap/200 m^2 (2,000 ft^2).
- Check traps weekly for adult whiteflies.
- Early in the season under low light levels whitefly may remain on the plant and not be detected on traps. Examine the underside of leaves on about 1% of the plants.
- Use the leaf or trap counts to determine rates of introduction of Encarsia and other biological controls.

Identify Whiteflies

Correct identification is important because treatment recommendations differ for each species. It is difficult to identify whiteflies trapped on sticky cards, therefore it is advisable to examine adults and immature whiteflies on leaves (for descriptions, see Sheet 310).

Release Biological Controls

'Encarsia': *Encarsia formosa* is a tiny, 1 mm (1/20 inch) long, wasp that parasitizes immature stages of whitefly. It is sold as parasitized scales glued to cards, from which the adult wasps emerge. As the wasp develops inside, greenhouse whitefly scales gradually turn black; parasitized sweet potato whitefly scales turn a tan colour.

Best results are achieved when Encarsia are introduced at low rates before whiteflies are found on monitoring traps. Releases continue, usually weekly and are maintained until 80% of whitefly pupae appear parasitized. (For more on Encarsia, see Sheet 210).

'Dicyphus': The predatory bug *Dicyphus hesperus* is a new and experimental addition to the list of commercial biological controls (for more on Dicyphus, see Sheet 280). It is best used along with other biological controls in greenhouse crops that have—or because of past history, are expected to have—whitefly, spider mite, or thrips problems.

- Dicyphus needs large numbers of prey so releases them only in areas where pests have been detected.
- Release Dicyphus as soon as whiteflies are established, early in the season, and again in 2-3 weeks.
- These predators also feed on plants, but damage on tomato is slight unless population levels exceed 100 Dicyphus/plant.

Other Measures

- It is essential to start with a clean crop at the beginning of the season, therefore destroy all crop residues.
- If the previous crop was infested with whiteflies, leave the greenhouse entirely empty of plants for 5 days, with heat, to starve whiteflies or kill them with cold by allowing the greenhouse to freeze for a week (must be below -10 C to kill adults)
- If a plant-free period is not possible between crops, use a short-residual fumigant such as naled (Dibrom®). Apply at the end of the crop, before removing plant debris, and again to the empty greenhouse.
- Keep the greenhouse weed-free, and maintain a 3-m (10-ft) wide, weed-free border around the greenhouse.
- Do not keep ornamental plants in a tomato greenhouse as these are also whitefly hosts.
- If greenhouse whitefly numbers are high, hang yellow sticky tapes (up to 1 tape per plant) at the top of the plant canopy to trap adult whiteflies. If sweet potato whitefly is present, hang traps about 1 m (3 ft) below the top of the plants.

FUNGUS GNATS

Fungus gnats can cause significant damage in soil-less cultures. In tomatoes, most damage is caused by the larvae feeding on tender roots. As root area is lost, tomato plants become more susceptible to drought stress and less tolerant of root infections. Adult fungus gnats can transmit root rot and other diseases (for more on fungus gnats, see Sheet 320).

Monitoring Tips

- Use yellow sticky cards at a rate of 1 trap/500-1,000 m^2 (5,000-10,000 ft^2).
- Place cards about 25 cm (1 ft) above the soil or rockwool surface.
- Check traps weekly for adult fungus gnats; replace traps every 3-4 weeks as the glue dries out.

Identify

It is important to distinguish between fungus gnats and shore flies because biological controls for fungus gnats do not work on shore flies (for descriptions, see Sheet 310).

Release Biological Controls

The following three species of biological controls are compatible and may be used together.

'Hypoaspis'. This soil-dwelling predatory mite feeds on fungus gnat larvae. The best way to use Hypoaspis is to establish it in the greenhouse before fungus gnats appear. Apply to tomato seedlings in flats or cubes at the start of the growing season, and then again when planting out. By feeding on other soil organisms, Hypoaspis populations can build up to high numbers that are effective in keep fungus gnat populations low (for more on Hypoaspis, see Sheet 230). Supplement Hypoaspis with other biocontrols (below) if fungus gnat populations are high.

Insect Parasitic Nematodes. *Steinernema carpocapsae, S. feltiae,* and *Heterorhabditis* spp. are beneficial nematodes sold to control fungus gnats and other insects. They can be applied to the soil through conventional sprayers or through the irrigation system. They are effective against high populations of fungus gnats.

- Apply nematodes when yellow sticky traps average over 50-75 fungus gnat adults per trap, weekly, or while fungus gnat populations are increasing.
- If root diseases are a problem in the crop, apply nematodes sooner to reduce the risk of disease transmission by fungus gnat larvae.
- Three applications, 7-10 days apart, are usually required. Nematode products vary, so always follow product recommendations for rates.

Note: The actual growing area for rockwool cultures with plant densities of 2-3 plants/m² (10 ft²), is typically 1/3 to 1/4 of the total floor space.

***Bacillus thuringiensis israelensis* (Bti):** A strain of this bacteria that infects fungus gnat larvae is available (Vectobac®). It is applied in water to the soil or growing media after fungus gnats are established (follow instructions on the product label).

Other Measures

- It is essential to eliminate wet spots in the greenhouse where fungus gnats can breed by improving drainage, repairing leaks, adjusting automatic irrigation equipment, etc.
- Control is usually better in greenhouses with white plastic floors because fewer breeding sites are available for fungus gnats.
- Control fungus gnats in other crops in adjacent greenhouses.

TWO-SPOTTED MITES (TSM)

Two-spotted mites are increasingly important pests of greenhouse tomatoes. They are difficult to control with biological controls or with chemicals (for more on two-spotted mite and the carmine mite, see Sheet 300). Strains of TSM adapted to tomatoes survive well despite the toxic, glandular hairs on tomato leaves and stems, and strains such as the carmine mite can cause severe damage.

Controls should be used at the first sign of TSM infestation, even if it is minimal. An early sign of a TSM infestation is speckled leaves. Later, infested tomato plants become yellowish, stressed and may develop only 3-4 flowers per truss.

Monitoring Tips

- Inspect leaves under 10-15 X magnification for TSM infestation.
- Some growers use climbing bean plants (var. Scarlet Runner) as trap plants trained up support posts to detect the first appearance of TSM in tomato greenhouses. TSM damage is easy to see on beans, which alerts growers that there may be mites on tomato plants as well as acts as a nursery plant for the production of predators.

Release Biological Controls

'Persimilis': The predatory mite, *Phytoseiulus persimilis*, can be used to control TSM in tomatoes. The predators develop twice as fast as the pest at moderate greenhouse temperatures. Unfortunately, biological control using Persimilis is not as reliable on

tomato as in other crops because:

- Predatory mites have difficulty moving on tomato plants because they are caught in the glandular hairs on the stems.
- Spider mites on tomatoes are not easy to see, so populations may be quite high before they are detected.

For best results:

- When TSM are first seen, spray affected plants (usually only the top 1/4 of the plants) with fenbutatin oxide (Vendex®).
- Introduce Persimilis one week later (for more on Persimilis, see Sheet 200).
- Use the Persimilis shipped on bean leaves. This gives better results on tomato than the vermiculite product, which is difficult to apply to tomato leaves. Place one bean leaf with Persimilis on each tomato plant, weekly, until predators are present on all plants.

'Feltiella': Where humidity above 60% RH can be maintained, the predator *Feltiella acarisuga* can also be used with Persimilis. This predator is does best at high mite densities and in high humidity (for more on Feltiella, see Sheet 280).

Other Measures

- Integrating chemical controls with biological controls is preferred if mites are detected in a tomato crop. Sprays of fenbutatin oxide (Vendex®), water or insecticidal soap will help reduce mite numbers and cause minimal harm to predatory mites.
- It is important to finish each crop with low populations of TSM. High numbers at the end of the year result in the survival of many diapausing (overwintering stage) spider mites that will re-infest the next crop early in the season. If mites are still a problem in late July, a miticide should be applied (contact biological control supplier) in August to prevent diapausing mites from over wintering. Pesticides are less effective against the diapausing form of TSM present in the fall.

WESTERN FLOWER THRIPS

Western flower thrips (WFT) is more likely to be a problem in soil cultures, in greenhouses recently converted to rockwool culture, or in greenhouse complexes with ornamental plants on site. WFT cause "ghost rings" on fruit, some feeding damage to leaves, and can transmit Tomato Spotted Wilt Virus, which is lethal to tomatoes. Biological control of thrips in tomatoes using predatory mites is difficult because the toxic, glandular hairs on the plants impede the mites, but other measures described below can sufficiently suppress thrips on tomato.

Monitoring Tips

- Use yellow sticky cards (using the same yellow cards for whitefly monitoring saves time) at a rate of 1 trap/50-100 m^2 (500-1000 ft^2). Place traps at the top of the plant canopy.

SHEET 410- TOMATO

Release Biological Controls
'Dicyphus': The predatory bugs will feed on thrips and can survive on tomato if there are other pests present as well (for more on Dicyphus, see Sheet 280).

'Cucumeris': The predatory mites can be used on tomato to control flower thrips (for more on Cucumeris, see Sheet 220). Because the hairs on the plant impede the movement of mites, use the bulk Cucumeris product in bran and sprinkle it on to the top of each infested plant.

Other Measures:
- Avoid thrips infestations by thoroughly cleaning up the crop at the end of the season: apply naled (Dibrom®) before removing tomato plants, and again after the greenhouse is empty.
- To starve thrips between crops, maintain a heated greenhouse, empty of plants, which forces adult thrips to emerge from the soil-borne pupal stages.
- Do not keep any ornamental plants in the greenhouse, and maintain a weed-free border, 3-m (10-ft) wide, around the outside perimeter of the greenhouse.

APHIDS
Aphids (such as the green peach aphid, *Myzus persicae*) may appear during the spring or summer. They are relatively easy to control on tomatoes using biological controls so seldom cause major problems. New infestations are usually detected first on the lower stem of tomato plants in the course of routine crop management. Aphid populations can build-up rapidly, however, so do not delay treatment (for more on aphids, see Sheet 340) The potato aphid, *Macrosiphum euphorbiae*, can be a more serious problem because its toxic saliva causes leaf distortions and stunted growth. It is larger than the green peach aphid, has long slender cornicles pointing back from the abdomen (see Figure 1, Sheet 242), and tends to drop quickly from the plant when disturbed.

'Aphidoletes': When aphids are found, release aphid midges *Aphidoletes aphidimyza* (see Sheet 240), twice, 1-2 weeks apart.

'Aphidius': As soon as green peach aphids are detected, apply the parasite *Aphidius matricariae* , (see Sheet 242) weekly until established.
If the potato aphid is detected, use *Aphidius ervi* as well as Aphidoletes for control.

RUSSET MITES
This microscopic mite (*Aculops lycopersici*) infests tomato stems and spreads slowly through the greenhouse. There are currently no adequate biological controls available. Most growers spot spray affected and nearby plants with dicofol (Kelthane®).
- Mark infested plants and rows; pick and handle these plants separately to avoid moving the russet mites to adjacent plants and throughout the greenhouse.

Summary of IPM Guidelines Greenhouse Tomatoes
Between crops:

SHEET 410- TOMATO

- Treat with naled (Dibrom®) after last picking; wash greenhouse structure.
- Remove crop debris, heat empty greenhouse for 3-5 days.
- Cover floors with white plastic.
- Improve drainage to eliminate wet spots,
- Remove all weeds inside and around greenhouse perimeter.

At start of crop:

- Whitefly: Release Encarsia at low rates.
- Fungus gnats: Introduce Hypoaspis at the start of the crop.

When pests are detected:

- Fungus gnats: Apply insect parasitic nematodes, BTI.
- Whitefly: Release Encarsia until 80% of whitefly pupae are parasitized.
- Where there is a history of high pest numbers, release Dicyphus.
- Two-spotted mites: Spot treat fenbutatin oxide (Vendex®); apply Persimilis and Feltiella as needed.
- Russet mites: Spot treat with dicofol (Kelthane®) as needed.
- Aphids: Release Aphidoletes and Aphidius.