Greenhouse Cucumbers: Guidelines for Biological Control

Biological controls have been used in commercial greenhouse cucumber production in Canada since the early 1980's. Biological control is 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 in greenhouse cucumbers are fungus gnats (*Bradysia* spp.), western flower thrips (*Frankliniella occidentalis*), greenhouse whitefly (*Trialeurodes vaporariorum)* and two-spotted mites (*Tetranychus urticae*). Melon aphid (*Aphis gossypii*) can be a serious problem in some situations, while other species of aphids, caterpillars and Lygus bugs may also occur.

Challenges for using biological controls successfully on cucumbers are:

- Controlling pests during winter months. When the natural daylength is short it induces many biological controls to go into diapause.
- Lack of pollen in cucumber crop flowers. This means there is no alternative food source for biological controls, making them more difficult to establish.
- Chemicals used to control plant diseases. Fungicides to control Pythium root rot and powdery mildew can interfere with development of biological controls.

The following guidelines contain practical tips for achieving good results against pests in greenhouse cucumbers. 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.

Start Right with Cucumber Seedlings

IPM for cucumber begins with seedling production. It is important that propagators establish the fungus gnat predator, 'Hypoaspis' (see Sheet 230) at the seedling stage. Propagators must also supply information about all pesticides that have been used on seedlings. This is important to know as some pesticides can interfere with the later use of biological controls.

If powdery mildew is a chronic problem, consider choosing a mildew tolerant cultivar to reduce the need for fungicide applications that can interfere with biological control.

General Monitoring

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

- Trapping pests on yellow sticky cards. 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 weekly for signs of two-spotted mites, aphid infestations and other problems.

WHITEFLIES

The main pest in greenhouse cucumbers is the greenhouse whitefly (for more on whiteflies, see Sheet 310). Whiteflies damage greenhouse cucumbers by covering fruit and leaves with the sticky honeydew as they feed. High whitefly populations also reduce the vigour of plants. Whiteflies can be controlled by the parasitic wasp, 'Encarsia', and the predatory beetle, 'Delphastus', 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/50-100 m^2 (500-1000 ft^2).
- Check traps weekly for adult whiteflies.

Release Biological Controls

Both biological controls for whiteflies described below can be used together.

Encarsia*:* *Encarsia formosa* is a tiny, 1 mm (1/20 inch) long, wasp that parasitizes immature stages of whitefly. It is sold as loose parasitized scales or 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.

If there is a history of whitefly problems best results are achieved when Encarsia are introduced preventively, 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).

In warm regions or areas where a large number of greenhouses have whitefly infestations, the whiteflies may move onto outdoor plants. This makes them more difficult to control as whiteflies continually re-infest the crop plants. Encarsia are less effective during cool weather and overcast periods, therefore whitefly populations must be monitored closely.

Delphastus: *Delphastus catalinae* is a small, black, 1.4 mm (1/15 inch) long, lady beetle. Both adults and larvae feed on whitefly eggs and immature stages. Delphastus is sold as adults and should be applied as soon as whitefly are detected. Delphastus works well with Encarsia because it avoids feeding on parasitized whitefly scale (for more on Delphastus, see Sheet 244).

Other Measures

- It is essential to start with a clean crop at the beginning of the season, therefore destroy all crop residues and dispose of them at a site remote from the greenhouse

- 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 below -10C for a week.
- 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. Sprays such as bleach and Virkon used for disease control will not kill whitefly. Add insecticidal soap or dormant oil to the spray used to wash down the greenhouse structure and floor between crops to kill whitefly and other pests that often move to the walls or ceiling or hide in protected areas.
- 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 cucumber 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 meter below the top of the plants.
- If whiteflies are present on outdoor plants, screen all entry points.

FUNGUS GNATS

Fungus gnats can cause significant damage in soil-less or sawdust bag cultures. In cucumbers, most damage is caused by the larvae feeding on tender roots and on the lower part of the stems. As root area is lost, cucumber plants become more susceptible to drought stress and root rot infections. Adult fungus gnats can also transmit root rot and other diseases. If the humidity in the greenhouse is very high, fungus gnat larvae may feed on and destroy the growing points of the cucumber laterals. (For more on fungus gnats, see Sheet 320).

Monitoring Tips

- Use yellow sticky cards at a rate of 1 trap/500 m² (5,000 ft²).
- Place cards about 25 cm (1 foot) above the soil or rockwool surface.
- Check traps weekly and record the number of 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 with each other and can 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 cucumber 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. Nematodes are effective against high populations of fungus gnats but, unlike Hypoaspis, will not reproduce or remain in the growing media and must be reapplied.

- Apply nematodes when yellow sticky traps average over 50-75 fungus gnat adults per trap, weekly, or while fungus gnat populations appear to be 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 follow product recommendations for rates. Calculate application on the actual growing area, not the greenhouse area.

Note: The actual growing area for rockwool cultures with plant densities of 1.2-1.4 plants/m^2 (10 ft^2), 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 in plumbing, 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.

WESTERN FLOWER THRIPS (WFT) & ONION THRIPS

Western flower thrips is more likely to be a problem in greenhouses with ornamental plants on site. Thrips damage leaves and distort the fruit of English cucumbers by feeding and laying eggs in leaf and flower tissues and young developing fruit. When WFT populations are high the adults are found in high numbers in the cucumber flowers. Onion thrips will also attack cucumbers but the damage is usually confined to older leaves and is less severe. Adult onion thrips are not as attracted to cucumber flowers and fruit as WFT are (for more on thrips, see Sheet 320).

Monitoring Tips

- Use yellow or blue 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 plant canopy.

- Count the number of thrips on traps weekly; replace traps every 3-4 weeks as the glue dries out.
- Examine a minimum of 20 leaves from mid-plant level in each infested area. Look for presence or absence of both thrips and Cucumeris predatory mites. When each leaf with thrips also has predators present, it is an indicator that the thrips population should begin to decline.

Release Biological Controls
The following three species of biological controls are compatible and can be used together**.**

'Hypoaspis': This soil-dwelling predatory mite feeds on the immature stages of thrips in the soil or growing media. Hypoaspis alone cannot control thrips infestations, but it contributes to the effectiveness of biological control when used with other predators (for more on Hypoaspis, see Sheet 230).

'Cucumeris': The predatory mite *Amblyseius cucumeris* feeds on immature stages of thrips. It is available in slow release bags, which are placed among plants as soon as plants begin to climb the trellis wire. Cucumeris is also available in a loose bran carrier, which is sprinkled onto leaves. Releases should continue until there is a 1:1 ratio of thrips to Cucumeris on leaves as determined by monitoring (see monitoring above)(for more on Cucumeris, see Sheet 220.

It usually takes 4-6 weeks to see a drop in the number of thrips caught on traps as a result of releasing Cucumeris.

'Orius': The tiny pirate bug (*Orius* spp.), is attracted to cucumber flowers and feeds on all stages of thrips. Orius are only effective from March to September because they do not reproduce if daylength is less than 16 hours. Orius should be released once thrips are established, on plants where thrips numbers are the highest in the greenhouse. Release at least 500 Orius at one time to establish a breeding population (for more on Orius, see Sheet 222).

Other Measures
- Avoid thrips infestations by thoroughly cleaning up the crop at the end of the season. Treat the greenhouse with naled (Dibrom®) after the last pick, before removing cucumber 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.
- If thrips populations were high in the preceding crop, it may be advisable to apply lime to the ground before covering the greenhouse floor with plastic. Care should be taken to overlap and tape, or glue, the floor covering together.
- Do not maintain any ornamental plants in the greenhouse, and maintain a weed-free border, 3-m (10-ft) wide, around the outside perimeter of the greenhouse.

TWO-SPOTTED MITES (TSM)

Two-spotted mites are common, important pests of greenhouse cucumbers (for more on two-spotted mite, see Sheet 300). During warm weather, TSM populations reproduce very quickly and cause economic damage to cucumber plants.

Controls should be applied at the first sign of TSM infestation, even if the infestation is minimal.

Monitoring Tips

- Inspect leaves under 10-15 X magnification for TSM infestation.
- Some growers use bean seedlings or climbing runner beans as trap plants to detect the first appearance of TSM on new crops. TSM damage is easy to see on bean leaves, which alerts growers that there may be mites on cucumber plants.

Release Biological Controls

TSM can reproduce very rapidly on greenhouse cucumber so it is important to apply biological control agents as soon as mite damage is detected. A combined attack using the three biological controls listed below will provide the best results.

'Persimilis': The predatory mite, *Phytoseiulus persimilis*, is a very effective control for TSM in cucumbers. The predators develop twice as fast as the pest at moderate greenhouse temperatures (for more on Persimilis, see Sheet 200).

- When TSM are first seen, introduce Persimilis onto all infested leaves using at least 2000-3000 Persimilis per introduction. If treating a "hot spot", where TSM numbers are high, plan to continue releases until predator mites are present on all infested leaves.
- Use the Persimilis shipped on bean leaves, rather than vermiculite, because predators survive shipping in better condition and are easier to apply. Place bean leaves with Persimilis on cucumber leaves near TSM infestations or on the growing points of plants. Alternatively, apply the 'HOT SPOT' Persimilis product (which contains high numbers of Persimilis in vermiculite) to each infested site.
- Once Persimilis are established, thousands will be produced on each cucumber leaf. To speed distribution, pick some of these Persimilis "nursery" leaves and move them to other plants all around the infested sites and throughout the crop.
- If TSM populations are high (i.e., there are large numbers of mites clustered on webs, stringing or dropping down from the plants), spray once or twice with fenbutatin oxide (Vendex®), then release Persimilis when the last spray has dried. Vendex does not kill the egg stage of the spider mites and will not harm predatory mites.

'Stethorus': The tiny, black lady beetle, *Stethorus punctillum,* is effective at controlling TSM populations and can be used with other biocontrol agents. Stethorus is active over a wide temperature and humidity range, feeds on all stages of TSM and adult beetles fly and are good at finding small colonies of TSM. Stethorus adults are available from suppliers. They should be released in infested sites as soon as TSM are detected (for more on Stethorus, see Sheet 207).

'Feltiella': The predatory midge, *Feltiella acarisuga*, may also be used to control TSM on cucumber. Feltiella larvae feeds on all stages of TSM. Feltiella do best when humidity is

over 50%RH and at high mite densities. They should be released early in the season once TSM becomes established (for more on Feltiella, see Sheet 280).

Other Measures

- Chemical control in conjunction with biological control is recommended if mites are clustering in balls or "stringing" down from the plant or detected in high numbers without predators present. Fenbutatin oxide (Vendex®) is safe for use with Persimilis, but check compatibility list (Sheet 180) before using other pesticides with biological controls.
- Once Persimilis has been released, maintain warm temperatures (optimum 25°C) and high humidity (optimum 80-90% RH) to encourage the predators. Mist the crop if necessary.
- 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 red colored 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 such as Avid should be applied in August to prevent diapausing mites from over-wintering. Pesticides are less effective against the diapausing form of TSM present in the fall.

APHIDS

Aphids (such as the melon aphid, *Aphis gossypii*) can be a serious problem in greenhouse cucumbers. New infestations are usually detected first on cucumber leaves and stems. The melon aphid reproduces very rapidly on cucumber and all three biological control agents listed below should be released as soon as possible.

- Release 'Aphidius' parasitic wasp (*Aphidius matricariae*) (see Sheet 242) to parasitize the melon aphid.
- Release 'Aphidoletes' aphid midges *(Aphidoletes aphidimyza*) (see Sheet 240) between March 15 and August 15, at a high rate, weekly, until aphids are controlled.
- Release the lady beetle, *Harmonia axyridis*, to control all species of aphids. If the aphid infestation is widespread, also release field-collected *Hippodamia convergens* as well (for more on both lady beetles, see Sheet 244).

CATERPILLARS (CABBAGE LOOPERS, ETC.)

The caterpillars of several species of moths and butterflies may become serious pests in if their numbers are allowed to build up and should not be ignored.

- Hand pick and destroy any larvae found on young plants; use an ultraviolet (UV) light trap to catch adult moths (for instructions on making a light trap, see Sheet 500).
- If intake fans are used, screen with 5 mm (¼ inch) mesh screen. This will also stop Lygus and other flying pests.

Release Biological Controls

- Spray *Bacillus thuringiensis* (Dipel® or Foray®) at label rates every 3 days, for several weeks, as soon as caterpillars are first detected. Ensure good coverage of both upper and lower leaf surfaces.
- *Trichogramma* spp. parasitic wasps (see Sheet 270) attack moth eggs and can assist in control. Apply weekly for at least 4 weeks or until looper populations are controlled.

- Predatory bugs, such as 'Podisus' (see Sheet 280) and 'Orius' (see Sheet 222) attack eggs and small stages of caterpillar larvae.
- The parasitic wasp 'Cotesia' (see Sheet 280) attacks caterpillars and may be available for release.

LYGUS BUGS

Several species of Lygus bugs attack cucumber plants. Their toxic feeding causes abortion or death of the affected growing point.

- Hand pick and destroy any adults or larvae found on the plants.
- Screen intake vents and other large openings with 5 mm (¼ inch) mesh screen.

Summary of IPM Guidelines Greenhouse Cucumbers

Between crops:

- 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.
- Screen vents where caterpillars or Lygus bugs are problems.

At start of crop:

- Whitefly: Release Encarsia at low rates.
- Fungus gnats and thrips: 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; release Delphastus.
- Two-spotted mites: Apply Persimilis, Stethorus, Feltiella as needed.
- Western flower thrips: Apply Cucumeris as needed; add Orius if thrips numbers high.
- Aphids: Release Aphidius, Aphidoletes and, if aphid numbers are high, Harmonia and Hippodamia lady beetles.
- Caterpillars: Spray BT, release Trichogramma, use UV light traps for adults
- Lygus: Hand-pick all stages.