Control of Fungus Gnats in Greenhouses with Vectobac (Bacillus thuringiensis var. israelensis)

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Fungus gnats have become a major pest of ornamental crops in recent years (3,4) and this has been of particular concern to greenhouse growers in North Carolina. Damage is caused by the larvae feeding on root, stem and leaf tissue of numerous plant species. Adult fungus gnats do not harm the plants but can be a nuisance to greenhouse workers and they are especially unattractive when they hatch out in retail stores and supermarkets.

The name fungus gnat is a general term that lumps insects in the order Diptera belonging to the families Sciaridae, Phoridae, and Mycetophilidae. One species in the Sciaridae commonly seen in greenhouses would be Bradysis coprophila (3). Adult fungus gnats are often found in mixed populations with Shore flies. Fungus gnat adults are distinguished from shore flies in that they are less than 1/8 inch long, are feeble fliers, have beaded antennae, and have a distinctive Y-shaped wing vein. The fungus gnat larvae have a white translucent body with a black head capsule (Fig. 1) compared to the wedged-shaped, maggot-like shore fly larvae (1,2).

The closed system of the greenhouse provides an ideal habitat for the fungus gnat. Mist propagation in the greenhouse or in outdoor nursery propagation beds provides the high humidity ideal for fungus gnat populations. Highly organic soils attract the females to lay their eggs (3). It is suspected that the peat in soiless potting mixtures may already be contaminated with eggs and the eggs hatch out after the cuttings or plantlets are watered-in. Algae on and under benches also provide a good food supply for the gnats (1).

Adult fungus gnats live for approximately one week (fig. 2) and then lay eggs on top of the soil in pots as well as on soil or algae under benches and on bench surfaces. Eggs hatch within 4 days. The larvae feed for approximately 2 weeks and then enter the pupae stage for 3 to 3.5 days (2).

Damage from the fungus gnat is apparent when plants show general wilting symptoms, which is not surprising since most of the root hairs are damaged by the larvae. Secondary root rots often occur after the roots are damaged. Grooves and tunneling can be seen under a microscope on roots collected after plants show leaf distortions (fig. 3) symptoms (P. Smith, personal communication).

By the time the leaf distortion symptoms become obvious, it may be too late to save the crop. Entire crops of poinsettias have been destroyed by fungus gnats. Another symptom of fungus gnat infestation, in zygocactus, is the color of the pads changing from emerald green to grey green. When the grey color appears you can dissect the pads and stem and frequently find the larvae have tunneled to the ends of the branches.

Key crops that are susceptible to fungus gnats are poinsettias, gerbera daisy, gloxinia, hybrid impatiens, New Guinea impatiens, salvia, geranium, ornamental peppers, candelabra cactus, Areca palm, pony tail palm, azalea, chrysanthemums, fuchsia, jade plant, peperomia, schefflera, cyclamen, violet, hydrangea, hibiscus, diffenbachia, kalanchoe, croton, lipstick plant, coleus, tradescantia, and begonia. Most lily-type bulbs, bedding plants, plugs, and tissue culture plugs are especially sensitive to the fungus gnats. Occasionally, when seeds do not germinate, upon examination fungus gnats have hollowed out the entire inside of the seed.

Standard treatments for control of fungus gnats have included Oxamyl, Dicarb, and Temik (3). Materials that are currently registered for this purpose are effective, but each causes phytotoxicity to certain plants (5). An alternative to the chemical treatments is Vectobac. Vectobac is a formulation of the bacteria Bacillus thuringiensis var israelensis or Bti.

Tests conducted in greenhouses in North Carolina comparing Diazinon, Dursban, Guthion, Lannate, Resmethrin and Vectobac indicate that Vectobac is equal to, or better than, these chemicals for controlling larvae at recommended rates, and Vectobac exhibited no toxicity to the applicators. One of the advantages of using a biological control agent in greenhouses is that there is no reentry restriction time. This is particularly important when watering times are critical (1).

Understanding the mode of action of Vectobac (Bti) is important for its usage. Bti is highly effective against certain Diptera including mosquitoes, black flies, and fungus gnats (5). Production of this spore-forming bacterium (fig. 4) is via fermentation; in the manner of the manufacture of many antibiotics. This naturally occurring organism is a soil bacterium found in most soils around the world. Susceptible larvae ingest the Bti, and the pH, salts and enzymes of the digestive system (different from humans' and animals' systems) breaks down and activates the insoluble Bti crystals. The protein crystal is known as an endotoxin (fig. 5,6) and is lethal to the larvae upon ingestion. The pH of the gut causes the dissolution of the crystals into toxic components. The crystal is broken down (digested) into smaller molecular weight subunits which attack the lining of the fungus gnat's mid-gut; the gut lining abrades, permitting leakage of the alkaline gut contents into the insect's body cavity. The spores escape into the body cavity and cause septicemia.

Damage to the larvae's digestive tract also causes it to stop feeding, and the combination of the gut leakage, lack of feeding and septicemia kills the insect. The timing of the sequence is that the crystals begin to dissolve the mid-gut in 1-4 hours, and death is in 24 hours (fig. 7).

Toxicological studies have shown that Bti will not harm humans, the environment, non-dipteran insects, or beneficial insects because unlike broad-spectrum pesticides, Bti is highly host specific.

The mode of action of the toxins and the host specific nature of the bacterium combine to permit little insect resistance. This host specificity is also important because of worker safety in greenhouses.

When Vectobac is applied to the plants, the larvae then feed on the bacterium in the soil. Bti does not kill the adult flies because of the nature of feeding. Death of the fungus gnat larvae will be noticed within 24 hours, although they will have ceased feeding. The pupae do not feed and after they hatch, the adults will be noticed for a few days and then disappear.

The best application method of Vectobac is by drench. The formulated Bti material of Vectobac AS contains 600 ITU's (International Toxic Units) per milligram. The drench can be by hand with rates of 1-2 teaspoons/gallon of water for a low rate, 4-8 teaspoons/gallon for a high rate. The material in bulk can be applied in large tanks at 8-16 oz/100 gal for the low rate and 32-64 oz/100 gal for the high rate. An easy method of application is via the injector system.

The injector set at 1:200 dilution gives you a 64oz/100 gal ratio. The higher rates should be used when there is a high population (use yellow sticky traps for monitoring). The material should be applied at 5-10 day intervals so as to treat the eggs that hatch out after the initial treatment.

Occasionally an infestation will be so severe that the high rate may need to be applied several times at 3 day intervals. If this is done an irrigation should be applied in between. Because of the biological nature of the material, Vectobac should not be tank mixed with other materials, particularly those containing copper or chlorine.

The best method of control is a weekly preventative treatment. Rates of 16 oz/100 gallon of water applied weekly keeps the fungus gnat population from exploding. This is very helpful for new plants that have just been watered-in and do not have well developed root systems.

Over-application is generally not a problem with Vectobac. In tests, phytotoxicity could only be induced by gross over-application on selected crops. Tip burn in ferns and leaf margin rolling in petunias was observed when the rates were raised to 11.25 pints/100 gallons of water, nearly 4 times the recommended rates. Symptoms disappeared within 28 days. Most plants are not nearly as sensitive as ferns and it may require an even higher rate to induce phytotoxicity in them. Since all ornamental plant species have not been evaluated, sensitivity to Vectobac should be checked on a few plants prior to wide scale usage.

Information and technical literature may be obtained from Abbott Laboratories at 14th and Sheridan Road, North Chicago, Ill. or call Customer Service at 1-800-642-1959.

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Figures on Pages 17 & 18

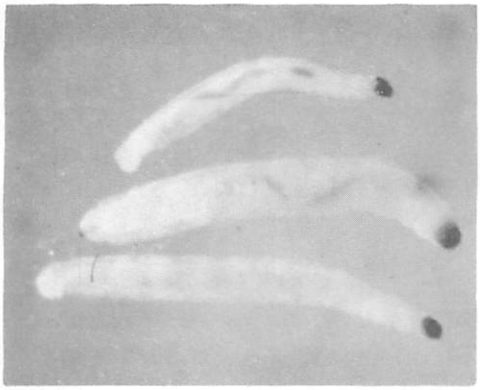


Fig. 1. Fungus gnat larvae
Photo by Jim Baker, NCSU.

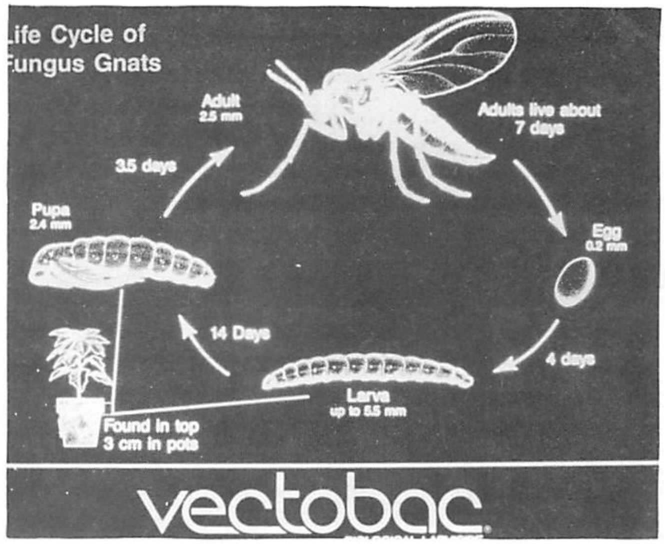


Fig. 2. Fungus gnat life cycle.
Drawing from Abbott Laboratories.

Fig. 3. Leaf distortion symptoms indicative of fungus gnat larvae.
Photo by the author.

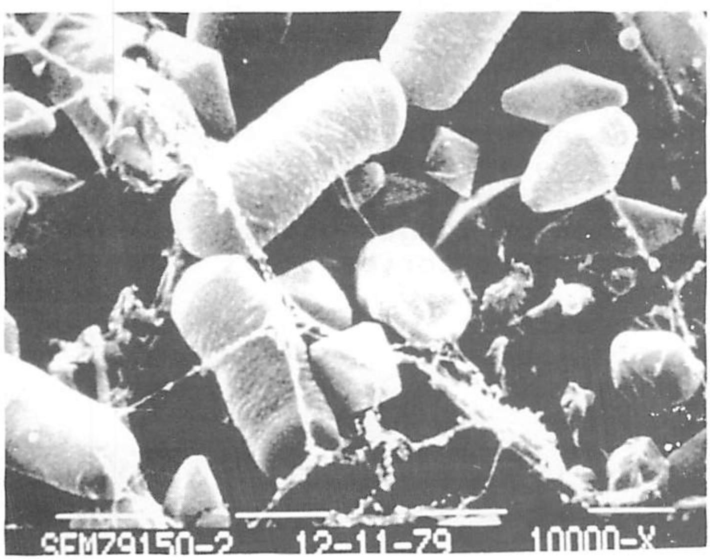


Fig. 4. Electron photomicrograph of <u>Bacillus</u> <u>thuringiensis</u> <u>israelensis</u> bacteria.
10,000 X. Photo by Abbott Laboratories.

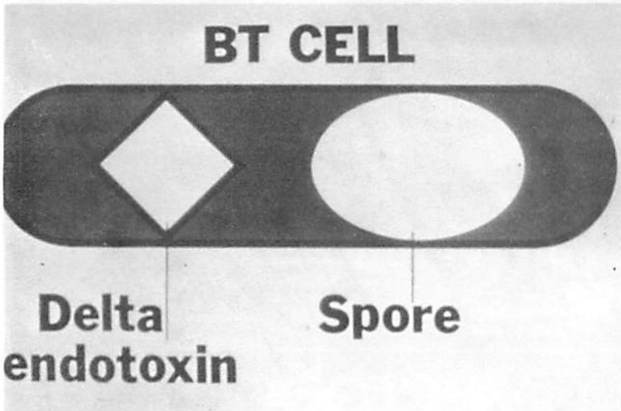


Fig. 5. Diagrammatic drawing of the Bacillus cell showing the delta-endotoxin crystal and the resting spore. Drawing by Abbott Laboratories.

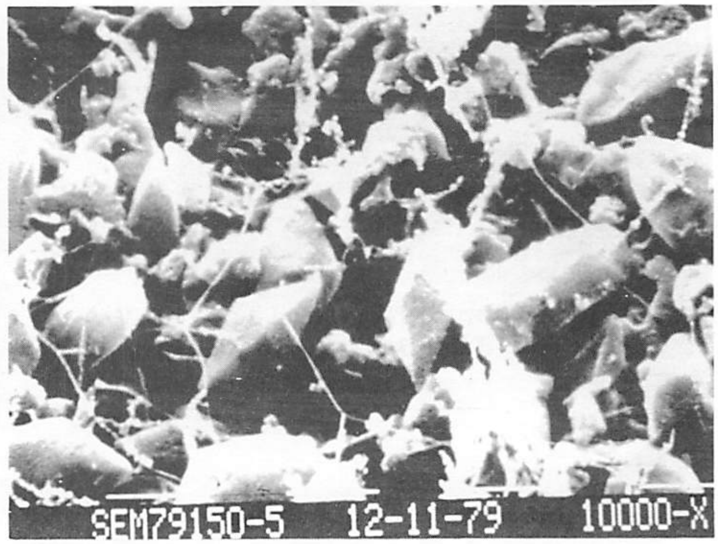
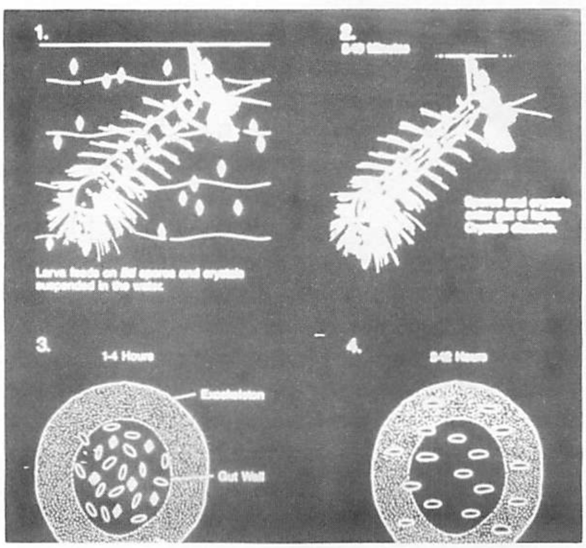


Fig. 6. Electron photomicrograph of the delta-endotoxin crystals. 10,000 X. Photo by Abbott Laboratories.



Cross-section larval mid-gut. Gut wall breaks down from action of crystals.

Crystals completely dissolve. Spores escape into body cavity. Larva dies.

Fig. 7. Sequence of events using Bacillus thuringiensis israelensis on mosquito larvae, which is similar to the mode of action on fungus gnats. Drawing from Abbott Laboratories.