

Applying parasitic nematodes to control carpenterworms in fig orchards

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The carpenterworm (CW) is a native wood-boring insect pest found in commercial fig varieties in the San Joaquin Valley and in several native, ornamental and agriculturally important trees throughout the United States and Canada. Other trees infested in the San Joaquin Valley include almond, walnut, pecan, loquat, oak, elm, willow, cottonwood, and poplar.

Carpenterworms, *Prionoxystus robiniae* (Peck), overwinter as partially to fully developed larvae deep in the heartwood of the tree. Larval activity may begin as early as mid-March if the spring is unusually warm. Moth emergence usually extends from mid-April to June. Adults emerge in the evening, leaving behind a residual pupal skin protruding from the gallery opening. The females release a sex pheromone, which attracts the strong-flying males. Mating occurs soon after emergence, and the heavy-bodied female deposits most of her 300-plus eggs on the tree from which she emerges. Eggs hatch 10 days later, and the larvae begin new galleries.

Signs of carpenterworm activity in fig orchards (*California Agriculture*, January-February 1981) are: gallery openings plugged with sawdust-like frass and, often, reddish brown stains below the openings; frass accumulations on the ground around the base of the trees; broken limbs with dark galleries at the breaks; stunted trees missing large branches; in the spring, residual pupal skins protruding from gallery openings.

Parasitic nematode

The "codling moth nematode," also referred to as "caterpillar nematode," *Neoaplectana carpocapsae* Weiser, is beneficial because it only parasitizes insects. It is harmless to plants and other animals. The nematode has been found throughout the world, originally in parasitized codling moth larvae associated with apple trees. This mobile biological control agent, which is easily reared on insects or artificial media, can actively search for and parasitize the CW larva inside its gallery. Consequently, the nematode provides a new approach for the control of such

insects inhabiting hidden environments that are difficult to reach with conventional insecticides.

The most effective temperatures for the nematode's searching activity range between 15.5° and 32°C (60° and 90°F). Temperatures exceeding 32°C are lethal to the nematode. Those below 15.5°C and above freezing, although not harmful, restrict its searching activity and therefore its effectiveness.

Nematode suspensions can be applied to the galleries with backpack sprayers or oil cans. The applicators in a 1981 field trial preferred oil cans, because they were lighter and easier to manipulate inside the tree canopy. The oil can was also more efficient, using about half the nematode suspension required with a backpack sprayer. An oil can with a 20-ounce (600-ml) capacity contains enough nematodes to treat about 25 acres of fig trees at a 10 percent CW infestation level.

Timing

Nematodes can be successfully applied to the galleries anytime during larval activity, from mid-April to early November, but fall treatment is preferred, after figs have been harvested. A problem with early spring applications is that cold weather reduces larval activity, interfering with the identification of infested trees. CW pupae are susceptible to this nematode, but the gallery dries up during pupation. Dry, inactive galleries are difficult to locate and treat. A continuously emerging adult population is also hard to control.

Mid-May applications may be useful in reducing the late-maturing portion of the CW population. These small galleries may be overlooked in fall treatment but are large and easily found the following spring. Spring foliage is also less dense, so that applicators can move under the tree canopy and see the active galleries more easily.

If applications are made in July and August, the CW population is stable without emerging adults, but new galleries are small and hard to distinguish. Also, proper timing is necessary to avoid high afternoon temperatures and irrigation and harvest operations.

The advantages of fall applications are:

moderate temperatures; availability of the total CW larval population for treatment; and easy identification of infested trees, because frass accumulations are undisturbed by harvest machinery. Since one surviving CW female can reinfest the same tree, the goal is to eliminate all CW larvae from each infested tree.

The following procedure is recommended for the control of CW larvae in fig orchards.

Application by oil can

Nematodes are applied with a 20-ounce (600-ml) oil can at a concentration of 25,000 invasive-stage nematodes per ml of thickened deionized (DI) or distilled water. The thickening agent (SGP 104 absorbent polymer, sold by Henkel Corporation, Minneapolis, Minnesota) is used at a rate of 1 gram (about ¼ level teaspoon) per 400 ml (about 1 ½ cups) DI water to prevent the nematodes from settling. Tap water is not recommended, because its mineral content may reduce the thickening agent's effectiveness. Nematode applications can be monitored for percentage of galleries actually treated by adding 1 to 2 percent red or orange latex pigment (4 to 8 ml, or about ½ to 1 level teaspoonful, to 400 ml DI water).

Galleries vary in size and will accept as little as 0.3 ml to as much as 8.3 ml or more per application. Applicators should be instructed to apply the nematode suspension until it starts to run out and to apply no more than two plungers full (about 4 ml) of nematode suspension per gallery. This method prevents over-application of the nematode concentrate and compensates for possible incomplete delivery of the suspension as the oil can becomes empty. This procedure yields an average application rate of 2 ml per gallery. The oil-can nozzle should be inserted into the gallery opening before application to inject the nematodes as far as possible into the gallery system.

Application effectiveness can be monitored by spraying the frass-plugged opening of each treated gallery (identified by residual latex pigment) one week after application with a yellow or other bright-colored spray



Blue paint marks frass plug of treated galleries. If this plug remains intact a week later, the CW larva is presumed dead; if plug is not intact, gallery must be re-treated.



Nematodes are applied to a carpenterworm gallery at a concentration of 25,000 per ml with a 20-ounce oil can. Red latex dye identifies treated galleries for later monitoring.

paint. Larval activity can then be determined a week later by checking to see if the previously sprayed frass plug is still intact. If the gallery has not been reopened (the frass plug still covered with paint), the larva is presumed dead. If the painted frass plug has been replaced with new frass, the larva is still active, and the gallery must be re-treated.

Re-treatment

The percentage of infested trees identified and treated depends on the ability and training of the applicator. Two or more applications may be necessary. Subsequent applications to previously identified infested trees

should require less time and fewer nematodes. Estimated cost of treating an acre of a Black Mission fig orchard, 48 trees per acre, at a 10 percent infestation rate, would be about \$10 for labor and materials, with re-treatment at about half the cost.

In a cooperative test conducted in the fall of 1981, the relatively untrained applicators provided by the grower identified 93 percent of the infested trees but identified and treated only 45 percent of the galleries. Their applications inactivated 85 percent of the treated galleries.

At least one reapplication should be made two to three weeks after the first application.

Previously treated trees will be easier to identify for nematode reapplications and monitoring of CW larval activity if the base of the trunk is marked with paint during the first application.

Rope caulking putty may be used to seal the galleries after the nematodes are applied, preventing the loss of nematode suspension and thereby increasing the effectiveness of the application. This technique, although time-consuming, may be used in a cleanup third application or in ongoing spot treatments either for CW eradication from the orchard or for continuous population suppression.

CW larvae often open plugged galleries before succumbing to the nematode. These galleries can be monitored, without the use of the paint spray, by smoothing the putty from the active galleries back over the openings one week after the application and reexamining the plugged galleries for activity a week later.

Other management concerns

Dead trees and prunings should be removed from the fig orchard each year before March to prevent CW emergence from dead wood. If possible, susceptible trees in residential sites bordering treated orchards should be examined for CW and treated if they are infested. Treatment of such trees may help prevent CW reintroduction into the treated orchard.

Application of the codling moth nematode for controlling CW larvae in San Joaquin Valley fig orchards represents the first commercially feasible use of this biological control agent in the United States. The nematode, through the cooperative efforts of federal and state agencies and industry, has been exempted from EPA registration and is now available commercially. Fig growers can rear the nematodes, and have done so, on readily available bait crickets for orchard applications.

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