



NEMATODES FOR INSECT PEST CONTROL

by Vern Grubinger
Vegetable and Berry Specialist
University of Vermont Extension

Nematodes are small worms; they're microscopic, in fact. They're sometimes referred to as roundworms or eelworms. Some nematodes are friends, some are foes, and some could be considered neutral. It all depends on their eating habits. Of the thousands of kinds of nematodes, some feed on insects, some eat plant roots, while others consume bacteria or are parasites of animals.

Nematodes are found all over the world in many kinds of habitats. For farmers, the nematodes of interest are soil-dwellers that either attack crop roots (bad nematodes) or feed on insect pests (good nematodes).

Bad nematodes. These are called plant parasitic nematodes. They either attack plants from the outside (ectoparasitic) or they live inside the host plant for part of their lives (endoparasitic). Both these nematodes inject saliva into their host plants that results in damage, either by killing tissue or causing the creation of many giant cells that form galls. There are many kinds of plant parasitic nematodes, and most have a relatively narrow host range. A few nematodes, such as the root-knot nematode and the root-lesion nematode, attack many kinds of crops. Damage from nematodes includes stunting, chlorosis, and root distortion.

Good nematodes. Enough bad news; let's focus on beneficial nematodes, how they work, and how to best use them. The following information comes from the fact sheet "Insect-Parasitic Nematodes for the Management of Soil-Dwelling Insects" by Dr. Mary Barbercheck, Department of Entomology at Penn State University.

Insect-parasitic nematodes help farmers by providing 'biological control' of soil-dwelling insect pests. These nematodes occur naturally in the soil, or they can be purchased and introduced. They are relatively easy to mass produce and are available from several commercial labs as 'biological insecticides' which are exempt from EPA registration. These nematodes can infect many kinds of insects, but they don't infect birds or mammals.

Big names worth knowing. The nematodes commonly used as biological control agents for soil pests belong to the families Steinernematidae and Heterorhabditidae. Some commercially available nematode species are: *Steinernema carpocapsae*, *S. feltiae*, *S. riobrave*, *Heterorhabditis bacteriophora*, *H. marelatus*, and *H. megidis*. These nematodes are generally used for management of soil insect pests in high value crops.



Close up photos of beneficial nematodes

How they kill insects. These nematodes carry bacteria in their bodies that are toxic to insects. That's why they are called 'entomopathogenic' (insect-killing) nematodes. The nematodes and bacteria are always found together because they depend on each other. The bacteria need the nematodes to deliver them into the insects, and the nematodes need the bacteria for food and to create conditions in the insect that allow it to reproduce. The bacteria are safe to animals and have only been found in association with these nematodes and infected insects, never living freely in soil.

What Goes Around, Comes Around. Nematodes are only deadly to insects at one stage in their life cycle, called the infective juvenile, or IJ. This is the only time that the insect-pathogenic nematode exists outside of the host insect. Infective juvenile nematodes in the soil seek out insects then enter them through their natural body openings. Once inside the insect body, the nematodes release their bacteria, which multiply and eventually kill the host. But not before the nematodes develop into adults, reproduce, and produce offspring.

A few weeks after the initial infection, the new generation of nematodes develops into infective juveniles, and thousands of them emerge from the dead insect and search for new insect hosts in the soil.

Applying Insect-Parasitic Nematodes. Because these are living organisms special attention needs to be paid to their handling, application, and selection of species to match the crop. Nematodes need adequate moisture, moderate temperatures, and protection from direct sunlight during application. Their natural home is in the film of water around particles of soil, so commercial formulations of beneficial nematodes are usually soil-applied. They should not be sprayed on plant foliage unless specifically formulated for that use.

Nematodes are typically applied in water at a rate of about 1 billion per acre, depending on the crop. They can be applied with conventional chemical application equipment, but nozzle filters or screens smaller than 50-mesh will clog and it is best to remove screens in nozzles when applying nematodes with a back-pack sprayer or spray rig. Care should be taken when using hydraulic pumps that have high internal pressure and high shear force as these will shred the nematodes.

Nematodes tend to settle in the tank, so agitation must be provided for uniform application. Nematodes can be killed by excessive tank agitation through sparging (recirculation of a portion of spray mix) or excessive mechanical stirring that is used to keep the nematodes in suspension. Pump pressure above 300 pounds per square inch or temperatures above 85°F will kill nematodes.

It is best to apply nematodes to moist soil in the early morning or late evening when air temperatures are between 60 and 85°F. A pre-application irrigation can be applied to moisten the soil and a post-application irrigation can be applied to wash any nematodes on plant surfaces to the soil surface. The post-application irrigation should be applied before spray droplets dry and must provide a tenth to a quarter inch of water to allow the nematodes to move into the upper soil layers, out of sun or drying air exposure. Applications can be made before or even during a rainfall to wash nematodes to the soil surface.

Successful application of nematodes is influenced by spray volume. Most nematode labels suggest volumes of two to six gallons of spray per 1000 square feet (87-260 gallons per acre). This is achievable for many boom sprayers and lawn shower nozzle sprayers that are equipped with sufficiently large nozzles. Some turf applicators use shower nozzles that deliver 1 to 1.5 gallons of spray per 1000 square feet. When lower spray volumes are used, pre- and post-application irrigation can be adjusted to counteract the problem of low volume sprays and to assist in moving the nematodes to the soil and off exposed surfaces.

Nematodes can also be applied with irrigation. However, some irrigation systems, especially low volume trickle systems, may not move water fast enough to keep nematodes suspended. When in doubt, check periodically by taking a sample at the emitters to determine if live nematodes are being moved through the system.

When Do They Work, and Why? Success using nematodes for insect control has been mixed. Their effectiveness has been highest in highly controlled systems such as nursery containers and mushroom houses where environmental conditions highly suitable for the nematodes can be maintained. Besides improper conditions, most failures with field applications are due to a poor match between the nematode species and target insect pest. Using the right kind of nematode for the insect pest you wish to control is critical because nematode species vary in their host range and in their host-finding behavior.

Some nematodes are very active in the soil ('cruisers') and search around for a host insect, while some tend to sit and wait for a host insect to pass by ('ambushers'). Cruiser nematodes will be more effective than ambushers at finding a sedentary insect host, like white grubs. The ambushers are effective at infecting active insect hosts, such as cutworms or mole crickets. Some known appropriate pathogen-host targets are *S. glaseri* against the Japanese beetle; *S. scapterisci* against mole crickets; *S. riobrave* against cutworms and citrus weevils; and *S. feltiae* against sawfly larvae and fungus gnat larvae.

As with any purchased natural enemy, quality of the product can affect efficacy. Quality of the product can be affected by batch, and shipping, storage, and application conditions. Nematodes are living organisms and are subject to destruction by excessive cold or heat, and lack of moisture or oxygen. A small sample of the mixed product should be checked with a hand lens or magnifying glass to observe living, moving nematodes. Nematodes that are very straight and motionless may be dead, and therefore, ineffective.