Are Persistent Biocontrol Nematodes (Entomopathogenic) a fit for your organic farm?

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Organic growers looking for a way to reduce damage to crops from soil-based insects may want to consider entomopathogenic nematodes. Strains of biocontrol nematodes adapted to NY growing conditions with their persistent genes intact to persist across growing seasons (and winter) are available in NY and can be utilized as an integrated tool, along with good cultural practices to suppress the soil insect populations below economic levels throughout the growing season. Sources of Biocontrol Nematodes that are adapted to persist in NY soils

What are they?

Nematodes are microscopic round worms in the soil and are broken down into three different types. 1) Plant parasitic, 2) Insect parasitic and 3) free living (on organic matter). Insect parasitic nematodes only attack insects in the soil, they do not feed on plants and are known as entomopathogenic nematodes (EPN) or biocontrol nematodes. The infective stage of the EPN (called the Infective Juvenile or IJ) moves about in the soil in search of insect hosts, finding the insect using CO_2 gradients and other chemical attractants. When an insect host is located, the IJ enters the insect through a breathing opening called a spiracle and penetrates the insect body cavity. Once inside, the nematode releases a bacteria which kills the insect. The nematodes then molt to adults and produce offspring on the nutrition provided by the dead insect. When the insect resources are consumed, a new set of IJs are released into the soil to search additional insect hosts. An average sized insect larvae will produce between 100,000 and 200,000 new IJs.

Diakon radish sampled from EPN treated portion of field have significantly less insect damage.

What do they attack?

Biocontrol nematodes or entomopathogenic nematodes will attack most insects living in the soil. Some insect species have evolved defenses against nematodes and are difficult for the nematodes to kill. In general, the weevil larvae (black vine, strawberry root, carrot weevil) are easily killed by EPNs. Lepidoptera larvae (cutworms, sod worms, armyworms) are also easily killed by EPNs. Fly larvae (maggots) such as cabbage maggot, seed corn maggot, and onion maggot can be killed but require more nematodes to attack them before they die. Native white grub species (multiyear lifecycle) are very susceptible to attack by EPNs, but invasive annual white grubs (Japanese beetle, Asiatic Garden beetle, Chafers) are much more difficult to control with EPNs.

When applying persistent native nematodes, the number of nematodes applied are significantly less than the recommended rate for commercially available nematodes (41 million nematodes per acre vs 1 billion nematodes per acre). Persistent nematodes become part of the soil fauna and increase in number by recycling in available hosts. Often, it takes until the second growing season for full nematode activity by persistent strains. This delay in full activity is a result of the nematode persistence across growing seasons. The nematodes applied are composed of a genetic array of "time of activation" known as "phased infectivity" and it takes several months for full activation of the nematodes. These genetic traits allow the persistent biocontrol nematodes to persist in the soil for many years while suppressing pest insects from a single inoculation. In contrast, the commercial strains available from retailers are 100% infective at application and have lost their ability to persist across unfavorable conditions, requiring careful application timing and annual applications.

The expected level of insect control from persistent native nematodes is influenced by the intensity of the pest invasion, soil moisture conditions and the soil temperature during the timing of insect attack. For example, black vine weevil larvae start attacking strawberry roots when soil temperatures warm to 45 ^{0}F. NY persistent nematodes become active between 45-50 ^{0}F but are most effective when soil temperatures are at least 60 ^{0}F. As a result, spring feeding by BVW larvae often gets ahead of the control by biocontrol nematodes. However, when BVW eggs first hatch in late summer-early fall, the soil temperatures are above 60 ^{0}F and the biocontrol nematodes are very effective against the young larvae before the soils cool for winter. Therefore, the strategy for the BVW pest control is to establish persistent biocontrol nematodes in mid-late summer before damage occurs and allow the nematodes to reduce the BVW larval population before winter, resulting in less spring cold soil damage. When the soil warms, the presence of persistent biocontrol nematodes in the soil profile will then attack the remaining large BVW larvae. Research has shown that it takes two growing seasons for persistent biocontrol nematodes to bring a BVW outbreak under control when the application of biocontrol nematodes is delayed until serious plant damage is observed. In contrast, if the grower knows BVW is present on the farm, a nematode application before economic damage is observed, prevents economic damage by attacking the sub-economic BVW larval population.

<u>How are persistent biocontrol nematodes best used to manage soil insect pests?</u>

Persistent biocontrol nematodes are best utilized as an integrated tool with good cultural practices, not to "clean up" a pest problem after poor management. Persistent biocontrol nematodes require a single application to inoculate the soil profile and work throughout the growing season to suppress soil insects as long as the soil temperature is above 50 ^{0}F. Frequently, persistent biocontrol nematodes suppress the soil insect populations below economic levels throughout the growing season.

<u>Does the soil type influence the species of biocontrol nematode applied?</u>

NY research data indicates a mix of biocontrol nematode species gives better control of soil insects than a single species alone. Each nematode species has a preferred section of the soil profile where it is the most effective and mixing species provides better protection across the soil profile occupied by soil insects. For example, *Steinernema carpocapsae* prefers the top 2-3" of the soil profile and becomes the dominate species in this region. If *S. carpocapsae* is the only nematode used, insect larvae below the 2" level escape attack from *S. carpocapsae.* A second nematode species which prefers the low portions of the soil profile complements the presence of *S. carpocapsae* and gives more complete control of soil insects located below 2". In the lighter soils, the top 2" often become too dry for a biocontrol nematode to move and attack insect larvae. In these soils, a nematode species mix which include *S. carpocapsae* would be ineffective.

Our recommendations for biocontrol nematode species mixes for soil types:

Clay loam – silt loam soils: *S. carpocapsae* + *S. feltiae*

Sandy loams – sand soils: *S. feltiae* + *Heterorhabditis bacteriophora*.

What are the differences between the commercially available entomopathogenic (biocontrol) nematodes purchased on the web from the persistent NY strains?

Biocontrol nematodes purchased from commercial sources have lost the ability to persist in the soil for any significant length of time after application. Many commercial strains persist in the soil for only 7-30 days and require application timing to be closely matched with the presence of their target host and an annual reapplication is required. In contrast, the NY persistent strains of biocontrol nematodes are carefully cultured to maintain their evolutionary ability to persist across hostile conditions such as the lack of available hosts, temperature extremes (e.g. winter, dry soil conditions) and drought. NY persistent strains are applied a single time and persist in the field for many years following application; not surprising because they were isolated from NY soils where they have evolved for a few million years. If the NY persistent strains are cultured carelessly, they also quickly lose their ability to persist and are no better than the commercial strains purchased off the web.

The EPNs arrive in wax worm hosts and need to be rinsed out through a strainer into the tank water.

How are biocontrol nematodes applied?

Biocontrol nematodes are usually applied suspended in water and applied at a minimum of 50 gallons of water per acre. This can be accomplished in numerous ways but several factors need to be remembered. 1) Nematode-water solution needs to be applied within a few minutes if the water solution cannot be aeriated in some fashion. High concentrations of nematodes suspended in water quickly deplete the dissolved oxygen and suffocate. In addition, there needs to be some level of mixing or agitation because nematodes will settle in the water solution, resulting in an uneven application. 2) Mixing nematodes in with fertilizer solutions for application is not viable because interactions between the fertilizer and the nematodes cause nematode death. 3) Biocontrol nematodes are ultra violet (UV) sensitive so applications need to be made under conditions to protect them from UV. Applications should be made late in the day or on cloudy/rainy days or into fields where sufficient plant growth is present to give the soil surface adequate shading to protect the nematodes from UV until they have entered the soil.

Biocontrol nematodes can be applied with a wide array of equipment depending on the size of the area to be treated. If a commercial pesticide sprayer is used, all screens and filters need to be removed and the nozzles changed to a “stream type” nozzle to apply the nematodes in a concentrated stream. On smaller areas, a backpack sprayer or watering can will work. Several farmers have used a water tank on an ATV and made a boom from PVC pipe. Holes were drilled in the pipe for water streams and gravity flow was used. Whatever the application equipment, it needs to be calibrated so the applicator knows the water volume per acre and can adjust the nematode solution concentration for the appropriate application of 41 million nematodes per acre.

Application timing:

Biocontrol nematodes which are persistent, can be applied anytime during the growing season when soil temperatures are above 50 ^{0}F. Ideally, nematodes should be applied when there are host in the soil so they can immediately go to work and reproduce. However, the NY persistent strains have the ability to sit and wait for months before needing to attack hosts and reproduce. We request that no nematode applications be made after October 1st. Applications are made to the soil surface under conditions of low UV exposure (late in the day, rainy/overcast days, in cover crops where there is adequate ground shading). Field tillage has no impact on biocontrol nematodes. In addition, if nematodes are applied before field tillage, the movement of soil during tillage helps the nematodes redistribute throughout the field and help them fill in the gaps which may occur during application.

Where can I get Biocontrol Nematodes that are adapted to persist in NY soils across growing seasons?

Currently, there are two sources to purchase biocontrol nematodes adapted to NY growing conditions with their persistent genes intact to persist across growing seasons (and winter) in NY. If there is a member of the Organic Community who is interested in starting a business to provide these NY persistent nematodes to the NE Organic Agriculture community, the Shields' lab at Cornell can assist with the requirement to successful rear and produce the biocontrol nematodes for resale.

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