Biological Control of Plant Parasitic Nematodes Affecting Turfgrasses

by Eric B. Nelson

The biological control of turfgrass pests is an exciting new area of research and commercialization. However, the biological control of parasitic nematodes on turfgrasses has not kept pace with that of other turfgrass pests. This is partly due to general ignorance of the nematodes' role as pests in turfgrass plantings. Currently there are no commercially-available biological products for the control of turfgrass nematodes. A great number of recent studies, however, have focused on the biological control of many different plant parasitic nematodes that affect crops. Many of the same species studied are also parasitic on turfgrasses. It is very likely that our understanding of biological control of nematodes in other crops can be applied directly to turfgrasses. Other current studies are directed specifically toward the biological control of turfgrass nematodes. My intent, therefore, is to review some of the research being done in this area and to present a prognosis for the future development of biological controls for parasitic nematodes in turfgrasses.

Soil Environment and Biological Control

It has often been observed, in agricultural soils, that when certain pesticides are applied or when soils are partially-fumigated prior to planting, certain species of nematodes frequently increase. These types of observations tend to support the notion that other microbes in soils naturally limit the population increases of plant parasitic nematodes. Soil is one of the more biologically-complex environments known. It is now well accepted that nearly all soils exist in a state of biological balance, in which a variety of living organisms exist in stable communities or assemblages of organisms. This biological stability provides numerous checks and balances on developing populations in soils. This means, for example, that nematodes parasitic on plants have parasites and predators of their own. Likewise, the predators and parasites of nematodes also have their own set of predators and parasites. It is this type of association that keeps populations of nematodes from increasing astronomically in many soils. When something is done to disturb that balance, such as the application of a pesticide or the imposition of a plant stress, population growth is generally a direct consequence. It is, therefore, important to gain a better understanding of the types of organisms in turfgrass soils that could very well be playing significant roles in limiting the population growth of parasitic nematodes.

Microarthropods Affect Nematode Populations

Over the years we have learned a great deal about the types of organisms affecting nematode populations. In general, the organisms involved in the biological control of plant parasitic nematodes are either parasites or predators of nematode eggs, juveniles, or adults. They may be either microscopic animals such as other nematodes, mites, and collembola, or commonly recognized biological control microorganisms such as viruses, bacteria, fungi, actinomycetes, and protozoa.

Of the former group, mites and collembola have been the most studied. These are perhaps the most abundant microarthropods associated with plant roots. Collembola are known for their ability to perforate the cysts of *Heterodera* species and devour the eggs and developing juveniles within. Mites are also known predators of *Heterodera* species. As populations of mites increase in the soil, populations of cyst nematodes decrease. However, if populations of the nematode become too low, then the population of the mite also declines.

As it stands, we currently know little about how these kinds of organisms interact with plant para-

sitic nematodes and how they might be handled and commercialized for effective biological control. As far as I know, these organisms are not being realistically considered for the biological control of turfgrass nematodes.

Nematode-Trapping Fungi: A Marvel of Nature

Of all of the microorganisms that have been studied for their biological control potential, nematode-trapping fungi tops the list. The existence of these organisms has been known for over 100 years and, during that time, they have been studied in exhaustive detail. Despite that fact, however, there are only a couple of commercially-available biological control products based on preparations of nematode-trapping fungi.

Nematode-trapping fungi are rather remarkable organisms that have evolved a range of strategies for attracting, capturing, and devouring nematodes. These fungi can be separated into two groups based on the complexity of their capturing mechanisms. Some of these fungi are quite happy living in the soil on dead and decaying organic matter without being particularly interested in nematodes. Others, however, have a strong preference for nematodes as a source of food, with little selectivity for plant-parasitic types. There are over 100 species of fungi that are known to either actively or passively capture nematodes.

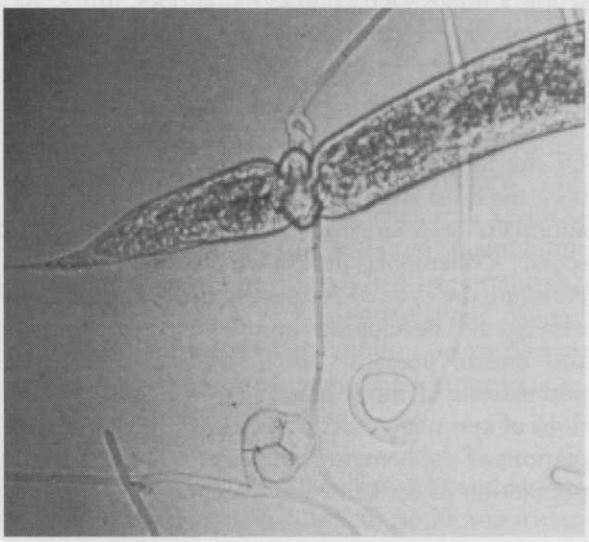

Figure 1. Nematode caughti in constricting hyphal ring.

Although passive nematode-trapping fungi prefer sources of food other than nematodes, these fungi develop hyphal networks that are sticky to nematodes. Nematodes swimming by get stuck in these networks and the fungi then penetrate and devour the nematodes through the production of numerous enzymes.

Active nematode-trapping fungi are more predacious. Generally, the more attractive these fungi are to nematodes, the more aggressive are the trapping mechanisms. Some fungi both attract and capture nematodes with the aid of adhesive knobs and hyphal branches with sticky ends. Still others, such as *Arthrobotrys oligospora*, produce hyphal rings that constrict nematodes as they pass through and touch them (Figure 1). For the greater part of their life, these latter types of nematode-trapping fungi live in soil as saprophytes without producing constrictive rings. However, as these rings are invariably present in conjunction with nematodes, it appears that the presence of nematodes actually induces the formation of these traps. In addition to the trapping mechanisms, many nematode-trapping fungi produce toxins that paralyze the nematode prior to digesting its body.

Many Microbes are Parasites of Nematodes

There are numerous species of bacteria, fungi, and actinomycetes that have been shown to be antagonistic towards plant parasitic nematodes. Nearly all of the important turfgrass nematodes have been the subject of at least one of these studies. There are numerous root-associated bacteria that are capable of protecting roots from nematode feeding. These bacteria, however, usually prefer very specific host genotypes.

Many of the species of microbes found associated with nematodes are endoparasitic fungi and bacteria that enter the nematode through natural openings as spores or cells. Inside the body of the nematode, these organisms digest the nematode only to release a new "crop" of spores on the nema-

tode cadaver. Many other organisms, particularly fungi, produce enzymes that both digest nematode eggs and, by destroying the cuticle, reduce nematode motility.

One of the best studied organisms that affect various species of nematodes is the spore-producing bacterium *Pasteuria penetrans.* Spores of *P. penetrans* are sticky and adhere to the cuticle of the nematode, usually around the head and mouth parts. Upon germination of the spores, the germ tube penetrates the cuticle. Inside, the bacterium is free to proliferate, liberating more infective spores. Once the host dies from the infection, the spores are released into the soil where they can attach to another nearby nematode. A number of turfgrass nematode genera are susceptible to infection by *P. penetrans.*

Organic Amendments Enhance Natural Biological Control

Years ago, nematode control relied almost exclusively on the addition of organic matter to soils. We have come to learn the reasons for many of the beneficial properties of soil organic matter and recognize that these effects are largely realized due to the increased level of microbial activity that follows the use of organic amendments. In some cases, specific microbial antagonists such as trapping fungi are stimulated, reducing populations of plant parasitic nematodes.

Organic amendments induce dramatic changes in soil microbial communities and their effects on nematode behavior. For example, chitin amendments have been shown to increase the populations of chitinolytic bacteria in amended soils and, at the same time, to reduce the populations of several nematodes, particularly root knot, cyst, and stunt nematodes. Furthermore, applications of composted sewage sludge to golf course putting greens significantly reduces the populations of lance, ring, and sting nematodes in the soil.

Organic amendments may also affect nematode populations by releasing toxic compounds during degradation in soil. For example, many different organic acids toxic to plant parasitic nematodes are released during tissue decomposition in soil. These compounds are generally non-toxic to free-living nematodes.

A Future for Nematode-Suppressive Plants?

A number of plants are found throughout nature that produce naturally-occurring nematicides. One of the more common such plants is marigold (*Tagetes* spp.). The roots of marigold plants apparently release compounds that repel plant parasitic nematodes. Additionally, extracts and oil cakes of

some oilseed crops such as neem, mahua, castor oil plant, and peanut have also been shown to have nematicidal properties. Although the compounds derived from these plants are not available,, it is important to recognize that such interactions can be found in nature and that one day, we may have a battery of natural plant products available for use on turf.

Future of Biological Control Products Uncertain

Although there are no nematode biological control agents commercially available in the United States, there are several that may be developed in the near future. Only a couple of such products are available internationally and, despite the current research efforts world-wide, it is unlikely that specific biological control products will be available for turfgrass applications in the foreseeable future. This is due primarily to the small market size for such a product coupled with the lack of recognition of nematodes as important turfgrass pests. However, since currently available nematicides for turfgrass applications are being steadily eliminated, either directly or due to their not being re-registered, it is likely that their loss will be the impetus to move the biological control of turfgrass nematodes forward. In the meantime, it is important to utilize as many of the turfgrass cultural manipulations as possible in an attempt to enhance natural levels of biological control in turfgrass plantings.

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