An Integrated Approach to Pest Management in Turfgrass: Nematodes

Fact Sheet FS1014

Cooperative Extension

Richard J. Buckley, Director, Plant Diagnostic Laboratory
Albrecht M. Koppenhöfer, Extension Specialist, Turfgrass Entomology
Sabrina Tirpak, Senior Lab Technician, Plant Diagnostic Laboratory

Introduction

Nematodes, also called roundworms or eelworms, are the second largest group of animals next to the insects with estimates of up to 500,000 species. Most species are free-living occupying all ecological niches feeding on decaying animal and plant matter, algae, and bacteria. Some species prey on small soil-borne animals including other nematodes.

Unfortunately, there are nematodes that parasitize animals and plants. Roughly 3,500 species are obligate parasites of plants. Most of these live in the soil and feed on plant roots. A total of 13 types of plant parasitic nematodes occur in New Jersey turfgrass (Table 1) but rarely cause direct injury on grass cut above ½″ (12.7 mm).

Morphology

Plant-parasitic nematodes (PPN) range in length from 1/64 to 1/8″ (40-320 µm), but are very thin and cannot be seen without magnification. Their bodies are translucent, so the internal organs show through the cuticle. They are unsegmented, but might have some segment-like or other ornamentation on the body. In some nematode genera there is sexual dimorphism–the male and female have different body shape.

A PPN is essentially a feeding machine that is much like a straw with a pump. At the front end there is a heavily sclerotized piercing-sucking mouthpart called a 'stylet'. The strongly muscled stylet moves in and out of the body to feed. It connects to a pump-like esophageal chamber called the median bulb, which aids the PPN in the withdrawal of plant fluids and serves as the transition to the intestine and excretory chambers.

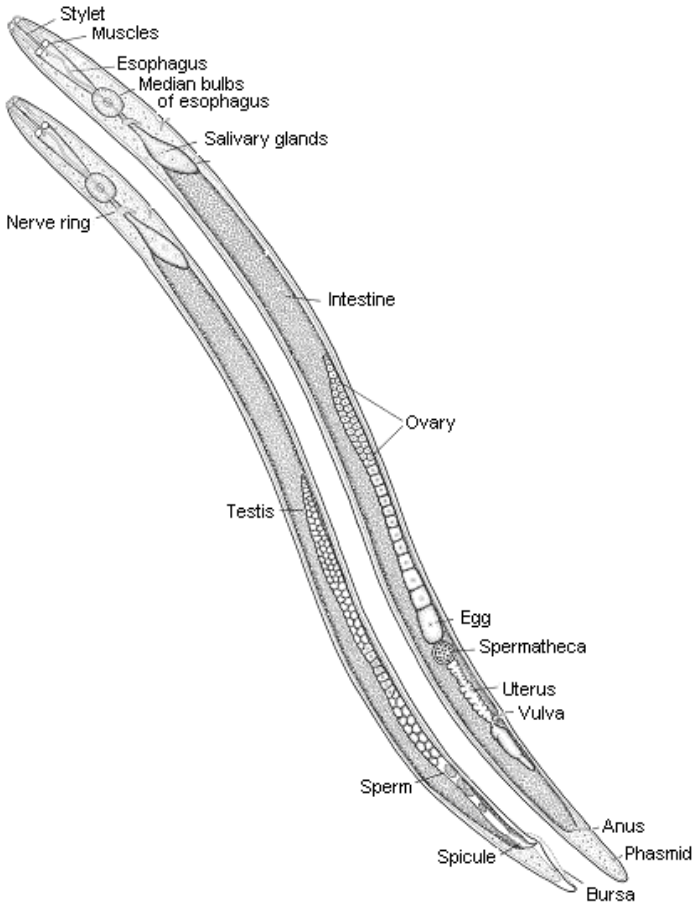


Figure 1. Male and female adults of a typical plant-parasitic nematode.

Life History

Most PPN life cycles have males and females and/or self-fertilizing hermaphrodites, but in some species only females may occur (parthenogenic). The females or hermaphrodites lay eggs (up to 1,000 over a two week time span in some species). Each nematode has five growth stages and molts four times, the first of which occurs in the egg, in a gradual transition to the reproductive adult. This process takes roughly four to eight weeks. In many species warmer soil temperatures speed the life cycle.

Conditions That Favor Nematodes

PPNs prefer warm soils but will be active anytime the soil temperature is above 40°F. They are semiaquatic and need soil moisture to avoid desiccation and allow movement. Soils at field capacity are ideal. PPNs prefer sandy soils with larger pore spaces. USGA recommended root zone mixes for golf greens are thought to be a perfect PPN habitat.

RUTGERS
New Jersey Agricultural Experiment Station

Rutgers, The State University of New Jersey
88 Lipman Drive, New Brunswick, NJ 08901-8525
Phone: 732.932.5000

Feeding Behavior

There are two types of feeding behavior in PPNs. Ectoparasites feed on the outside of the roots, endoparasites within the roots. Some ectoparasites migrate up and down the root and feed in many locations; others remain sedentary and continuously feed in roughly the same spot. Similarly, among endoparasites there are species that migrate up and down the roots between the cells and sedentary species that remain and feed in a single location. Migratory endoparasites are highly destructive to the root system.

Pathology of Infected Roots

PPN feeding causes different types of root injury. Most notable is the overall reduction in biomass. PPNs destroy cells directly by enzymes injected through the stylet. When there are enough feeding sites and enough cells destroyed, lesions may be present on the root. In some cases, the number of root hairs is reduced and apical growth is affected, so the roots appear stubby or stunted. Some of the endoparasites cause knot-like galls that distort the roots. The feeding sites can also act as infection courts either by mass cell destruction or when the endoparasites force their way into the plant, thus creating an opening for other pathogens to enter.

Symptoms

Plants respond to any root-dysfunction with symptoms related to nutrient or water deficiencies. Yellowing and thinning of the turf, reduced vigor, and premature wilt have all been attributed to PPN feeding. Turfgrass that is slow to recover from stress or does not respond to fertilization might indicate root damage from PPN.

PPN distribution in the soil is uneven with high populations clustered into "hot spots". Turf symptoms seen as non-uniform, poorly performing turf areas, correspond to these hot spots. PPN damage rarely is uniform or ends abruptly.

Since affected plants lack vigor, they have a reduced ability to handle periods of environmental stress or, in the case of sports turf, the rigors of turf management. These plants often die outright under the stressful conditions or are attacked by weak pathogens, like *Colletotrichum cereale*, the cause of anthracnose, or *Curvularia* spp., the cause of fading out.

Diagnosing Nematode Damage

Do not depend on above ground symptoms or root conditions alone to diagnose PPN problems. Analysis of soil samples by a competent laboratory is the best method for determining the types of PPNs present and the potential risks those PPNs pose for the turf. Sampling is inexpensive when compared to the cost of unnecessary or poorly chosen nematicide applications

Soil sampling for PPN analysis is much like sampling for nutrient levels. A 1" (2.5 cm) diameter soil corer is used to systematically sample the affected area. Take at least 25 cores to 4" (10 cm) depth and mix in a bucket. Remove a one-pint (0.5 Liter) subsample, place it in a plastic bag, and keep it out of direct sunlight and in a cool place until it is shipped to a nematode detection service. If turf damage exists, take the samples from throughout the affected area. If possible, sample a nearby healthy area for comparison. If there is no damage, sample the area in a systematic way such as a grid pattern.

If the intention is to set baselines and monitor the population over time, choose an area no larger than 500 square feet and return to the same area at a later date for additional samples. To get a clear picture of the nematode dynamics on your site, it may be prudent to sample repeatedly during the season and to repeat the process over several years.

Rutgers Nematode Resources

Nematode assay submission forms are available from County Rutgers Cooperative Extension Offices, the Rutgers Nematode Detection Service (p: 732-932-9140; f: 732-932-1270), or on the web at http://njaes.rutgers.edu/plantdiagnosticlab/.

Damage Thresholds

Injury thresholds signify the potential of a nematode population to cause damage. A number of thresholds have been established for most PPN species common in turfgrass. Some of the reported thresholds are research-based, others are simply based on a researcher's or practitioner's personal experience. Numbers may diverge greatly between sources. Some known thresholds for bentgrass and tall fescue are listed in Table 1.

Note that no thresholds are known for most PPN species on many of the major warm- and cool-season turfgrasses. Therefore, use caution when trying to extrapolate from one PPN-turfgrass combination to another. Furthermore, usually several species occur within the same turf stand. Damage thresholds only provide guidelines for control decisions and should be considered along with all other available factors

Cultural Management

Most turfgrasses can withstand some feeding by most kinds of PPNs if given sensible care. It is common to have the highest PPN populations in spring and fall, when the turf is actively growing due to the increased root biomass for food. Direct injury from high PPN populations in New Jersey on grass cut above ½ inch is rare.

Management practices that reduce plant stress and promote vigorous root growth will help the grass tolerate the feeding of very high PPN populations. Mowing the grass at the proper cutting height for the species, regular aerifications to prevent thatch and compaction, proper fertilizer inputs – based on soil test results – and judicious use of irrigation will all provide some relief by producing a healthier plant overall.

Raising mowing height will not reduce PPN densities but may increase the tolerance of the grass to PPN feeding. Because nematode-damaged roots are less efficient at nitrogen uptake, applications should be split into more frequent applications (spoon-feeding) without increasing seasonal nitrogen rates. While the effects of organic amendments such as composted sludge or manures on PPN populations in the field have been

Table 1. Accepted Damage Thresholds for Plant-Parasitic Nematodes on Selected Cool- and Warm-Season Turf

		Damage Threshold (Nematodes/100 cm^3 soil)			
		Cool season Grasses		Warm season Grasses	
Nematode	Genus	Bentgrass	Tall Fescue	Bermudagrass	St. Augustine
Awl	Dolichodorus	150	50	10	10
Cyst	*Heterodera*	Unknown	Unknown	Unknown	Unknown
Dagger	*Xiphenema*	200	150	300	200
Lance	*Hoplolaimus*	150	100	40	40
Lesion	*Pratylenchus*	150	150	150	150
Pin	*Paratylenchus*	Unknown	130	Unknown	Unknown
Ring	*Criconemella*	1500	150	1000	500
Root-Knot	*Meloidogyne*	100	2000	300	80
Sheat	*Hemicycliophora*	200	80	200	80
Spiral	*Helicotylenchus*	600	1000	1000	1000
Sting	*Belonolaimus*	20	12	20	Unknown
Stubby Root	*Paratrichodorus*	100	150	100	40
Stunt	*Tylenchorhynchus*	300	100	100	200

Adapted from Couch, 1995, Diseases of Turfgrass, 3rd edition.

variable, they may increase the turfs tolerance to PPN feeding by improving water and nutrient retention.

It is also important to monitor and control other diseases. Remember, it is often the cumulative effects of several stress factors, living and non-living, that cause the decline of the turf. To avoid spread of PPN infestations with equipment or repair plugs, infested putting greens should be core aerified last and nursery greens should be sampled periodically

Natural Enemies

Many microbes, including bacteria, fungi, and actinomycetes, are parasites of nematodes. *Pasteuria* species bacteria produce spores that stick to the nematode, germinate and penetrate the nematode body, to proliferate and produce more spores that are released when the nematode dies from the infection. Various species of nematode-trapping fungi produce sticky knobs or networks or constricting rings used to trap nematodes as a food source.

Biorational Control

The biorational products Ditera® (dried fermentation solids and solubles of the fungus *Myrothecium verrucaria*), No-Trol® (ground sesame plants), and Safe-T-Green® (linear secondary alcohols reacted with ethylene oxide) are labeled for PPN control in turf. There are many other plant-derived products that claim to suppress PPNs. Some of these are derived from herbs like mustard seed, pepper, clover, thyme, and wintergreen, or from various trees and shrubs. For most of these products there is no efficacy data provided from legitimate research. Some of these products may suppress PPNs in the laboratory, but few have maintained that performance in the field. Field trials in Florida, South Carolina, and Massachusetts suggest that these biorationals do not consistently suppress PPNs and perform poorly compared to traditional nematicides and fumigants.

Applications of the insect-parasitic nematode *Steinernema riobrave* (BioVector®) at high rates have reduced PPNs on golf greens in some research (Ohio State and Virginia Tech Universities) but not in other research (University of Florida). This nematode is currently not labeled for use in that manner.

More promising, at least against sting nematodes, seem to be the following biological products recently registered or to-be-registered for turfgrass use: BioNem is based on the spore-forming bacterium *Bacillus firmus;* EconNem™ on the sting nematode-specific *Pasteuria usgae;* and Melocon® on the egg- and juvenile-parasitic fungus *Paecilomyces lilicinus.* Generally, these products will work better as preventive applications before the turf is damaged.

While the performance of chemical nematicides can also be quite variable, it is likely that the efficacy of biorationals/biologicals is even more strongly affected by different PPN species and environmental conditions.

Chemical Control

The decision to use nematicides must be carefully evaluated. The simple presence of PPNs does not warrant applications. Furthermore, when high PPN populations occur in the absence of turf damage, it is difficult to justify the application. If PPN populations exceed reported damage thresholds, there is appreciable risk to the turf, and all other management issues and stress factors are considered, nematicide applications may be useful in reducing PPN populations and improving turf quality.

Fenamiphos (Nemacur® 3EC and 10G) was labeled for use on golf courses and in commercial sod and seed production. Due to its very high toxicity it has not been available for purchase since 2008. Fenamiphos is effective against many nematode pests in turf. Because it is systemic, it even has some activity against endoparasites. Take every precaution when using fenamiphos to avoid exposing birds and wildlife, as well as, yourself and other people to the toxic effects of the material. Read and follow the label specifications carefully.

Fumigation

Dazomet (Basamid®) is a granular product that is gaining popularity for turf managers as a tool for turfgrass renovations. The product, when used at the right temperature and soil moisture levels, releases methyl iso-thiocynate, which is the same active ingredient as in older general use fumigant products like Vapam®. This material can control many kinds of soil-borne pests including nematodes, fungal disease agents, insects, and weeds. It is labeled for a number of turf and landscape uses. In turf areas with chronic nematode problems, the renovation of the existing stand using a product containing dazomet might be prudent.

Another very effective fumigant, 1,3-dichloropropene (Curfew), is only labeled for use in eight coastal states of the southeast, not in New Jersey. It is slit-injected into established turf as a liquid that then moves through the soil as a gas. It is a very effective contact nematicide that kills nematodes in soil but has no systemic activity. Curfew is custom applied by a few approved applicators and labeling is sought on a state-by-state basis. It is unlikely that economics will justify registration beyond the eight states in which it is already registered.

Because fumigants have no lasting effect, nematode populations will begin to recover once the material dissipates. Furthermore, with no competition from other soil microbes that were killed by the fumigant, nematode populations may recover quickly.

Problems With Nematicide Use

No nematicide is equally effective against all nematode species. The endoparasitic species are particularly hard to control. Furthermore, there are always survivors, so nematode populations will recover over time.

Finally, there are reports of enhanced microbial degradation of fenamiphos on golf greens after repeated use of the product. Repeated use of any pesticide in the soil over a long period of time will encourage the buildup of bacteria and other microbes that can metabolize (eat) the particular chemical. The net effect is a reduction in the effectiveness of the material. In Florida, there are reports of Nemacur degradation at a rate 20 times faster than normal. It would not only be prudent to rotate all materials, but to keep their use to a minimum.

New Chemistries

There is currently a lot of effort going into the discovery of new nematicides that should be much safer to non-target organisms than organophosphates like Nemacur. Some new products may become available for turfgrass uses within a few years. However, none of the new chemistries presently being evaluated seem to have systemic properties, and they will probably be consistently more effective against ectoparasites than endoparasites.

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Rutgers, The State University of New Jersey
88 Lipman Drive, New Brunswick, NJ 08901-8525
Phone: 732.932.5000