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DISEASE CONTROL

Root-knot nematodes on turf in the northeastern United States

By Nathaniel Mitkowski, Ph.D.

For many years, nematodes were not considered to cause significant disease on golf courses, particularly in the Northeast. While there are many reasons for this, management techniques, the subtle nature of most nematode damage (especially in northern climates) and the difficulty in researching nematode problems on a perennial host claim most of the responsibility for this gap in understanding (Nelson, 1995).

It is now known that nematodes can cause significant damage on many turf grasses. However, the diagnosis of nematode symptoms is still difficult and control of these plant pathogens can be time consuming, expensive and inconvenient.

While there are many species of nematodes that attack grasses, I have a particular interest in Meloidogyne graminis, a root-knot nematode. While seen infrequently in the past, it seems to be increasing in its incidence, an observation based on turf samples submitted to the University of Rhode Island Turf Diagnostic Lab and the Plant Disease Clinic at the University of Massachusetts .

ABSTRACT

Root-knot nematodes (*Meloidogyne graminis*) are gradually becoming more prevalent on golf courses throughout New England. These nematodes can be particularly damaging to turf, as a result of their intimate relationship with plant hosts. Symptomology is general in nature and difficult to diagnose. Typically, these and other nematodes are considered stress related diseases. Only through soil sampling and extractions can identification be made conclusively. Many grass species have been reported as being susceptible and no genetic resistance effective against *Meloidogyne graminis* has been identified. Control of these organisms can be a perennial problem and Nemacur is the only chemical registered for use on golf courses with nematode problems. Timing of application is also critical for efficacy against root-knot nematodes.

Unlike fungi, many nematode populations develop relatively slowly and damage may only be observed during periods of high stress. In Rhode Island, levels of Meloidogyne graminis are still relatively low and this particular nematode is only found sporadically. However, these unique organisms can be difficult to manage when encountered and can develop very high populations in turf. For these reasons, it is worth examining the management and control of these organisms.

Biology

Root-knot nematodes (Meloidogyne spp.) are distributed widely throughout the United States and can cause significant damage on a wide variety

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of plant species (Goodey et al., 1965; Walters and Barker, 1994). They are generally recognized as one of the most destructive of the plant-parasitic nematodes because of the intimate relationship they establish with their plant hosts.

While the great majority of plant-parasitic nematodes spend their lives in the soil, probing into plant roots with their stylet and moving about multiple feeding sites, root-knot nematodes enter into plant roots and permanently set up camp. They inject molecules into plant cells which cause dramatic changes in plant physiology, effectively hijacking the roots (Dropkin, 1989; de Guiran and Ritter, 1979; McClure, 1977).

To feed the nematode continuously, plants respond by forming "giant cells" (Endo, 1971). Acting as large sinks, these cells draw in nutrients from the surrounding area and funnel them to the nematode. The nematode continues to develop as the plant roots are altered and eventually the swollen female and the giant cells form the characteristic gall or knot, which gives the nematode its name.

Symptoms of a highly virulent isolate of Meloidogyne hapla infecting lettuce.

Eggs are produced throughout the lifespan of the female and are either deposited into the surrounding soil or remain embedded in the root tissue. Often they can be seen appearing to adhere to the gall as egg masses.

In terms of reproductive capacity, no other nematode comes close. While the number of eggs produced by a single root-knot nematode can vary widely, populations of nematodes can often average anywhere from 500 to 2,000 eggs per female. Millions of nematodes can be produced on a single plant. The lifecycle of root-knot nematodes is highly dependent upon soil temperatures, but in the Northeast, the lifecycle can be as short as three weeks. Thus, there is a significant potential for large numbers of nematodes to be produced in a single season.

Distribution

Although there are over fifty recognized species of Meloidogyne, only two are regularly found in the Northeast: Meloidogyne hapla and Meloidogyne graminis. For the most part, root-knot nematodes are tropical to subtropical organisms.

While growers, horticulturalists and superintendents in warmer climates have to contend with numerous root-knot nematodes, temperate winters are an impedance to most Meloidogyne species and a large number of other nematodes (Van Gundy, 1985). In addition, southern root-knot nematodes tend to be more aggressive and have a shorter lifecycle (and thus more generations) than northern root-knot nematodes.

Root-knot nematodes generally have very wide host ranges, making it difficult to identify non-host crops or resistant germplasm. However, the presence of only these two root-knot nematodes in the Northeast does provide some reprieve. Golf course superintendents also have an additional advantage: Meloidogyne hapla (which causes significant losses on onions, carrots and other vegetables) will not reproduce on grasses (Widmer et al., 1999). Conversely, however, Meloidogyne graminis will reproduce on nothing but grasses (MacGowan, 1984).

Damage and symptoms

In order to understand the type of damage root-knot nematodes can cause, it is necessary to consider their mode of parasitism. When manipulating plant roots into generating giant cells, the stele or vascular system of the plant is being usurped. Nematode feeding is focused upon the xylem parenchyma (Dropkin, 1989). The ultimate result is a considerable disruption in the water and nutrient uptake of infected plants.

Symptoms are generally consistent with this type of damage. On very hot days, especially when minimal amounts of water

have been applied, plants will wilt easily. Symptoms can also be very general, such as a reduction in vigor, chlorosis and plant stunting. Because of reduced nutrient uptake, nematode damage may mimic nutrient deficiencies which will not respond to fertilizer applications.

In southern states, however, Meloidogyne graminis can cause very dramatic symptoms. On St. Augustine grass, the nematode may outright kill grass in large patches (MacGowan, 1984).

The majority of nematodes can only be diagnosed through soil sampling. Nematodes are microscopic organisms and in order to confirm their presence they must be extracted from the soil and observed under the microscope. Because root-knot nematodes cause such dramatic symptoms on host plants, however, root galling can sometimes be used to diagnose them. The disadvantage to identifying root-knot nematodes solely on the basis of root galling is that galling occurs three to four weeks after infection. If a visual inspection of the roots is made prior to this time, galls will not be observed and the nematodes will escape detection.

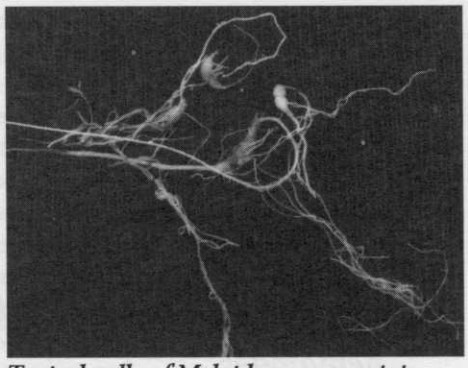
In addition, galls on grass roots are commonly very small and difficult to see. For these reasons, it is best to sample for root-knot nematodes as if they were any other nematode, by taking a minimum of five to ten one-inch cores per green (spread across each green) and forwarding them to your local turf diagnostic lab or nematode diagnostic lab. Processing of soil samples for nematode diagnosis is a relatively time consuming effort however, so be cognizant of the costs involved in having many greens diagnosed.

Control

Controlling Meloidogyne graminis can be very difficult. Nematode eggs will remain in plant roots or in the soil throughout the winter. When spring arrives, nematodes will hatch and penetrate plant roots near the area of cell elongation.

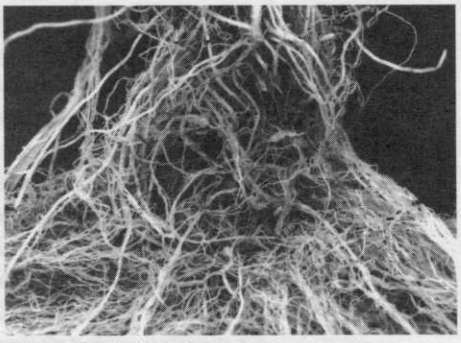
Once feeding has been initiated, chemical controls will have very little effect. Therefore, the critical time for application of nematicides is in the spring, before nematodes have entered the roots.

There is currently only one nematicide registered for use on golf course greens which will work against root-knot nematodes, Nemacur. While Nemacur can be extremely effective, it is highly toxic to people and has a 24 REI. Consequently, greens to which it has been applied must be temporarily shut down. And unfortunately, Nemacur will not eliminate the problem, only reduce the number of nematodes in the soil.



Typical galls of Meloidogyne graminis, produced on wheat. Galls produced by this nematode are more delicate and relatively cyclindrical, as compared to those caused by M. hapla.

Areas with chronic problems will require multiple applications of the pesticide. While it has yet to be reported in the Northeast, in the South, increased biodegradation of Nemacur has been observed under high application rates. Soils repeatedly treated with the pesticide will develop populations of microorganisms capable of degrading the pesticide and thus limiting its usefulness. This type of "resistance" to a chemical is biologically very different from typical fungal resistance to pesticides, but is functionally similar.



A low level of Meloidogyne graminis infection on wheat, indicated by sparse galling. Galls are commonly observed as slight swellings on turfgrass roots and frequently are not even observed.

Another option exercised by superintendents is fumigation. While only practical during renovations, this option may have severe consequences in the future. When fumigation is utilized, the majority of soil-borne organisms are killed, not only plant-parasitic nematodes.

From a short-term perspective, this will remedy the problem. However, if plant-parasitic nematodes are reintroduced (which is not uncommon), they may cause more problems than before fumigation. This is because the act of fumigating the soil has removed all of the native antagonists of the plant-parasitic nematodes. While it is unclear how much control antagonists exercise over plant-parasitic nematodes, it is possible that

Cultural practices can alleviate some of the damage caused by root-knot nematodes, but generally these practices are inconsistent with the demands of players.

they may be able to keep populations below damage threshold levels in some instances.

When fields are fumigated in preparation for high value annual crops, the same cycle will occur. However, because these crops are harvested every year, fumigation can be undertaken every few years, a luxury golf course superintendents do not have.

Cultural practices can alleviate some of the damage caused by root-knot nematodes, but generally these practices are inconsistent with the demands of players. Simply put, grass that is under minimal stress will still support populations of plant-parasitic nematodes but will be less likely to show symptoms. This means raising the height of cut and limiting the amount of play, options which are generally not feasible.

Hopes for the future

One of the research aspects I hope to focus on in the future will be to examine the genetics and pathogenicity of Meloidogyne graminis. The ultimate goal of this research will be to identify techniques to manage this and other plant-parasitic nematodes on turf using strategies other than chemical controls.

One method that may show promise is the use of resistant germplasm, which could be developed into commercial varieties and be easily over seeded into established turf stands. In addition, there are many golf courses where the levels of plant-parasitic nematodes remain well below damage thresholds. The reason for this is not well understood.

Investigations into the effect of golf course management and microbial communities on plant-parasitic nematodes may lend some insight into useful management practices.

Nathaniel Mitkowski received his B.S. from the Department of Plant Pathology at the University of Massachusetts in 1997. It was here that he got his first exposure to turf pathology, as a student of Dr. Gail Schumann. He received his Ph.D. from the Department of Plant Pathology at Cornell University in 2001. There, his research focused on nematode diseases of vegetable crops, particularly Meloidogyne hapla. He was recently hired by the University of Rhode Island as an Assistant Professor to fulfill the role of Turf and Ornamentals Pathologist. Beginning in 2002 he will oversee the direction of the URI Turf Diagnostic Laboratory.

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