TURFGRASS TRENDS

INSECT THRESHOLDS

Consider Nematode Thresholds Before Treatment

By Nathaniel Mitkowski

Plant parasitic nematodes on golf courses present special problems for both disease diagnosticians and superintendents. In contrast to fungal diseases, which are unacceptable at any level, low to moderate levels of plant parasitic nematodes should be expected in any stand of turf.

The difficult part of managing a potential nematode problem is determining when the nematode population is actually a cause for concern. The point at which nematode populations become a problem is called the population, disease or damage *threshold*. The threshold concept is used widely in plant pathology and is often the underlying mechanism of an integrated pest management strategy.

Many factors contribute to nematode thresholds. While some of these factors are obvious, others are not. Additionally, interactions between these factors have the potential to dramatically influence a threshold. In short, thresholds are not as absolute as they may seem.

Nematodes are aquatic organisms — even terrestrial nematodes live in films of water.

Pathogens: A nematode population's species is commonly recognized as the most important consideration in determining a nematode threshold. However, it is extremely difficult to identify the majority of individual nematodes to species in any soil sample. As a result, identifications are usually made to the genus level even though management recommendations are made using numbers published for an explicit species.

While this would seem to be a major problem, it is generally considered an acceptable practice. The biological differences between species within most genera of turf pathogenic nematodes are considered to be slight. For instance, few morphological differences exist between most turf pathogenic species of the lance nematode, *Hoplolaimus*, and the assumption is usually made that pathological differences are also few.

Whether this assumption is true is debatable, and it points to a potential source of significant uncertainty. Is a published threshold for another species valid for the species of nematode found on your putting green? If experimental data doesn't exist, a guess may be in order. Such a situation rarely occurs in most other agricultural systems because the diversity of serious plant parasitic nematodes is much lower than that in turf stands.

A cyst nematode on soybean is most likely to be *Heterodera gylcines*, and a positive identification is a relatively straightforward procedure. A root-knot nematode on lettuce in New York is almost certainly *Meloidogyne hapla*. In both of these cases, the thresholds are well-established for the identified species, and that species is the only one likely to be encountered. A stunt nematode on bentgrass, on the other hand, could easily be one of half-a-dozen different *Tylenchorhynchus* species, but it is unclear whether this fact is important in using established thresholds. *Heterodera* and *Meloidogyne* are unique examples on turf because, at least in the Northern states, no generally recognized thresholds are available for these two genera. While *Heterodera* is encountered sporadically, its damage poten-

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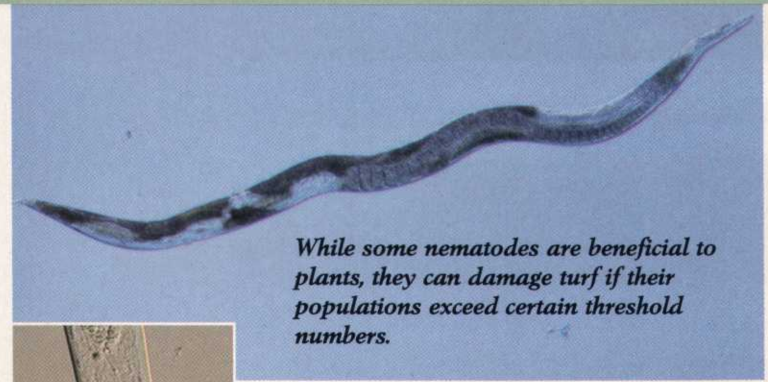
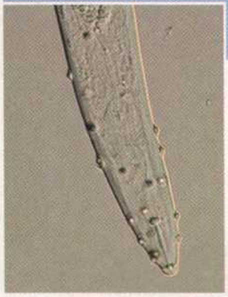


While some nematodes are beneficial to plants, they can damage turf if their populations exceed certain threshold numbers.



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tial is usually low. *Meloidogyne*, however, can be extremely damaging even when population numbers are low.

Host: Grass species is probably the next most important consideration in determining a nematode threshold. Most nematode thresholds are determined on a commercially produced grass species such as creeping bentgrass. Across the United States, however, one is also likely to encounter putting greens comprised of annual bluegrass or mixtures of the two.

It is well-established that plant parasitic nematodes often (but not always) have very discrete host ranges. Even if a nematode species can cross over to another host, it is probable that its virulence on the new host will be different (and likely reduced) from its virulence on the original host.

While pathogenicity is the ability to cause disease (a qualitative character), virulence is often regarded as severity (a quantitative character). Turf parasitic nematodes are exceptional, however, because they often have wide host ranges, affecting creeping bentgrass, velvet bentgrass, annual bluegrass, Kentucky bluegrass and others. As a result, it is often not always necessary to consider the turfgrass species when applying a nematode threshold.

There are a few notable exceptions, however, that do have discrete host ranges including the root-gall nematode, *Subanguina radicicola*. Although this nematode is not frequently observed, it is common in the coastal areas of Rhode Island and New Jersey. Recently, we have observed it from as far north as New Brunswick, Canada (Mitkowski and Jackson, 2003). This nematode has a very discrete host range.

Work by Jatala *et al.* (1973) clearly demonstrated that it could only parasitize annual bluegrass, while bentgrass in mixed stands will be unaffected. Discrete pathogenicity is often the rule in other agronomic crops but exceptions do also exist. Cultivar also plays a role in susceptibility to nematodes, as it does with most plant pathogens. Work by Townshend *et al.* (1973) has demonstrated different levels of varietial resistance within turfgrasses of many different species. A more recent study by Settle *et al.* (2002) showed that Penncross creeping bentgrass supported much higher populations of *Hoplolaimus* than Crenshaw, L93 or Providence. Such relationships can potentially affect the reliability of a nematode threshold.

Soil type: Soil type is another factor that may affect nematode thresholds. Nematodes are aquatic organisms. Even terrestrial nematodes live in films of water. The available water, the size of pores and level of soluble inorganic molecules will all be affected by soil characteristics.

Most turf parasitic nematodes are ectoparasitic; that is, they spend their lives in the soil and only their stylets ever enter into the plant. Even migratory endoparasites (those that move around side of plants) will spend some time in the soil. Soil characteristics are critical to nematode success. Nematode thresholds are determined under precise experimental conditions, including specific soil parameters. If these parameters are changed, as is likely to occur when a threshold is taken into a field situation, nematode viability, reproduction and pathogenicity may be affected. The same number of nematodes may be found in multiple soil types, but the nematodes may be more pathogenic in one soil type than another.

It is difficult to determine exactly which parameter is exerting the most influence on nematode populations because water-holding capacity, bulk density, organic matter and many other factors are inherent characteristics of each soil. Even when thresholds are not directly affected by soil type, whether a nematode population can increase to the threshold level is clearly a function of soil type (Walker & Martin, 2002).

Vigor: Plant health and vigor have a major impact on nematode thresholds. Nematodes are often considered stress-related pathogens. They usually do not cause significant damage but can cause visible disease symptoms when plants are under excessive stress. The same population of nematodes that can kill stressed turf may go unnoticed on a vigorously growing stand. Turf parasitic nematodes feed on plant roots.

When fewer roots are produced, nematode populations are concentrated on less root sur-

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face. This can further stress turf and exacerbate a decline problem. When turf is cut at a lower height, it produces shallower roots and nematode populations are quickly concentrated. As a consequence, nematode problems are most often seen on putting greens.

Rarely do even extremely high numbers of turf-parasitic nematodes have an effect on grasses cut at fairway or lawn heights, although plenty of parasitic nematodes can be found in these systems.

Antagonism: Microbial antagonists surely play a role in limiting nematode populations and may affect threshold values.

Many species of fungi live off plant-parasitic nematodes and can reduce total nematode numbers. While this may not affect a nematode threshold, antagonists like the bacterium *Pasteuria penetrans* certainly do. *Pasteuria* attach to the cuticle of nematodes and slowly invade and reproduce inside the host. During this process, the nematode continues to survive but its pathogenicity, vigor and fecundity will decline.

An uninfected nematode can produce more damage and more offspring than an infected nematode. If half a population of turf parasitic nematodes is infected with *Pasteuria*, the pathogenicity of that population will be greatly diminished and the actual threshold value is likely to rise. Unfortunately, quantifying the degree to which *Pasteuria* affects any one population is difficult to measure and will change as the proportion of infected individuals changes.

Temperature: While climate and temperature are often overlooked, they may dramatically affect a threshold in the context of nematode vigor.

Nematodes are invertebrates, and as such their life cycle is entirely dependent upon the environmental temperature. Nematode reproductive rates and metabolism are directly proportional and respond to fluctuations in temperature. Some nematode species have the ability to become dormant in colder climates and survive in frozen soils while others die. Some become quiescent at high soil temperatures while others thrive.

To a certain point, nematodes that experience warmer temperatures will be more active and cause more damage. Thus, thresholds for the same nematode may vary from Florida to Maine.

In the South, 150 nematodes per 3 cubic inches of soil is considered the threshold for *Hoplolaimus* (Couch, 1995). In the Northeast, *Hoplolaimus* does not start to produce damage symptoms until its population reaches about 400 nematodes per 3 cubic inches of soil. An unanswered question is whether this difference in threshold is attributable to altered nematode metabolism, the presence of different *Hoplolaimus* species in different climates or both.

Population dynamics: Although nematode thresholds are absolute values, thresholds also implicitly take into consideration the population's ability to reproduce and cause additional damage. Thus, sampling timing has an effect on how a threshold is used.

Even though populations of specific nematodes are above a threshold at sampling, there may be no need to control the population, depending upon the climatic location and the time of the year. Indeed, the population may actually be declining. Population dynamics are critical to understanding whether a population is above a threshold. Nematode population levels begin at low levels in the spring and increase throughout the season.

Some nematode populations crash in the summer and rebound in the fall. Others peak in the summer and decline in the fall. Unfortunately for the diagnostician, the dynamics of a population occur throughout time and space. A single absolute number provides only limited information. This highlights the point that appropriate use of nematode thresholds can only occur in context, incorporating a thorough case history.

Synergy: While interactions between nematode species can dramatically increase nematode damage, these interactions are rarely incorporated into predicted nematode damage on turf.

While stunt nematodes have a practical threshold of 800 nematodes per 3 cubic inches of soil, and lance nematodes have a threshold of 400 nematodes per 3 cubic inches of soil in the Northeast, an algorithm does not exist that can predict whether a combination of 600 stunt nematodes and 300 lance nematodes per cubic inches of soil will cause observable damage.

Nematode thresholds currently used for turf systems are extremely simple models. While this makes them easy to use, it ignores much of the inherent complexity of the soil microcosm. Diagnosticians, however, need to be cognizant of these potential interactions.

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Sampling: Sampling location, specifically within a green, has a significant impact on nematode counts and thus the applicability of nematode thresholds.

There are two general philosophies towards nematode sampling in turf. The first philosophy is to take two composite samples, one from affected areas and the other from unaffected areas, a process that we will call spot sampling. The other philosophy is to take a single composite sample from across an entire green, which we will call holistic sampling. While they are both valid, they serve two entirely different purposes and cannot be used interchangeably.

Spot sampling can only be used when there is observable damage. The intent of spot sampling is to determine whether observable damage is caused by high populations of nematodes.

Holistic sampling should not be used to make such a determination because a holistic sample actually dilutes the highest nematode population clusters with areas of low nematode density. While holistic sampling gives an estimation of nematode density across a green, it does not account for hot spots.

The holistic approach is most useful in monitoring population density over multiple seasons or throughout a single season. Sampling methodologies can be complex, and these two methods can be modified in numerous ways but are generally the most useful for superintendents and other turfgrass managers.

Extraction: In order to count nematodes in soil, they must first be extracted from soil, which is an inherently error-prone process.

Nematode extraction is largely performed by people, although some very expensive automatic and semiautomatic elutriators do exist. Technique and equipment vary from lab to lab, and this has a direct impact on the average extraction efficiency of each lab. Additionally, differences between each individual lab employee may have an effect on extraction efficiency.

As a result, two labs that process exactly the same sample may generate different nematode counts. While these counts will often be close enough that they do not affect the final management recommendation, sometimes the management recommendation may vary based on a particular extraction, especially when counts hover close to threshold values.

Superintendents often look at threshold values as absolutes. They treat for nematodes when levels are above the threshold for a particular nematode. In the Northeast, where nematode damage and symptomology is subtle, this approach is ill-conceived. The cost, availability and environmental impact of nematicides should be seriously weighed before making such an application. But assembling the proper information to make an educated decision about control entails a significant amount of work with uncertain results.

Type of nematode, species of grass, soil composition, plant health, time of year and a number of other factors will all influence management decisions. While we often treat preventatively for fungal diseases, it is unclear whether preventative nematicides are warranted in the Northeast.

Courses in the South that deal with sting nematodes certainly do rely on perennial nematicide applications, but this situation is very different from what occurs in Northern states. The best recommendation that can be made to superintendents is to carefully monitor nematode populations annually. When numbers approach thresholds, treatment may be necessary. But populations can sometimes exceed threshold without disease symptoms ever being observed, given the variability discussed previously. Correlating nematode populations with observed damage is critical for making informed decisions about nematode management.

Rarely do even extremely high numbers of turf-parasitic nematodes have an effect on grasses cut at fairway or lawn heights.

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