

Nematode Management in Lawns

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Nematodes are pests of lawns in Arkansas, particularly in sandy soils. Nematodes are microscopic, unsegmented roundworms, 1/300 to 1/3 inch in length (8) (Figure 1), that live in the soil and can parasitize turfgrasses.

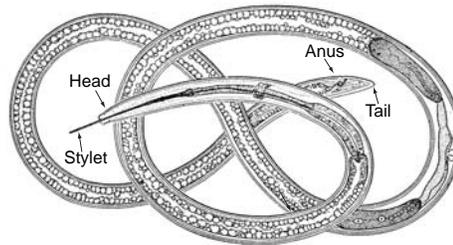


Figure 1. Schematic drawing of a plant parasitic nematode (Adapted from N.A. Cobb, *Nemapix* Vol. 2)

Although most nematodes are beneficial and feed on fungi, bacteria and insects or help in breaking down organic matter, there are a few species that parasitize turfgrasses and cause damage, especially in sandy soils. All parasitic nematodes have a stylet (Figure 1), a protruding, needle-like mouthpart, which is used to puncture the turfgrass root and feed (Figure 2). Nematodes feed on turfgrass roots and are most abundant when the turfgrass is actively growing in the spring and fall for cool-season grasses and the summer months for warm-season grasses.



Figure 2. Parasitic nematode feeding on a plant root (Photo by U. Zunke, *Nemapix* Vol. 2)

There are six stages in the nematode life cycle including an egg stage and the adult. There are four juvenile stages that allow the nematode to increase in size and in some species to change shape. These juvenile stages are similar to the larval stages found in insects. Nematodes are aquatic animals and, therefore, require water to survive. Nematodes live and move in the water film that surrounds soil particles. Soil type, particularly sand content, has a major impact on the ability of nematodes to move, infect roots and reproduce. For most nematodes that are a problem in turf, well-drained sandy soils with soil moisture at or near field capacity are optimum for nematodes to flourish. For this reason, nematodes are most problematic on high-maintenance lawn areas that receive frequent irrigation and on lawns with sandy soils.

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Symptoms and Signs

In turfgrasses, there are few definitive symptoms or signs for consistent diagnosis of a nematode problem. Generally, the symptoms of nematode damage are similar to those of other pest problems, nutritional deficiencies or environmental stresses (Figures 3 and 4). However, lawns with irregular areas of turf without distinct borders; areas of yellow, stunted plants; wilting; and thin, weedy turf would be extremely good candidates for suspecting a nematode problem. Sometimes, actual signs of nematode infection such as root galls due to the root-knot nematode or the presence of cysts attached to roots may be evident. An additional symptom of nematode damage is lack of response to irrigation, fungicides, insecticides



Figure 3. Typical nematode damage: Irregular areas without distinct border including yellow stunted turf that is thin and not responsive to fertilizer or irrigation (Photo courtesy N. Walker)



Figure 4. Mild symptoms from nematode infection can appear similar to many other plant stresses including drought, nutrient deficiencies, pH problems and other common symptoms seen in damaged turf.

and fertilizers. Aboveground symptoms do not typically occur until injury to the turfgrass root system is well advanced. Additionally, turf may be unresponsive to applications of fungicides and insecticides since these products will not control nematodes. Once nematode populations reach a critical threshold, turfgrass death can occur (Figure 5).



Figure 5. Once nematode populations reach a critical threshold, turfgrass death can occur, as seen in this Meyer zoysiagrass lawn.

Important Nematodes in Turfgrass

Sting Nematodes

Sting nematodes are more damaging to turfgrass than any other nematode species (5). Sting nematodes require sandy soils to be active. Therefore, sting nematodes will not commonly be found in Arkansas, except for sandy home lawn soils and on golf courses. Symptoms of sting nematode damage can include wilt, stunted growth, nutrient deficiency, irregular patches and added growth of weeds (such as prostrate spurge). Unlike many other nematode species, turf areas with heavy sting nematode infestations can be completely killed.

Lance Nematodes

Lance nematodes are the most common nematode problem nationwide because they are adapted to many soil environments. Generally, damage thresholds are higher than for sting nematodes, but since lance nematodes can feed and reproduce on a wider variety of soil types, damage could be found in more areas. Lance nematodes generally affect warm-season grasses. Since lance nematodes feed inside the root, damage throughout the root system may occur.

Aboveground symptoms of lance nematode damage to turfgrasses include patches of yellowing, dying and poorly rooted turf (Figures 6 and 7). It is hard to diagnose lance nematode damage just by observing symptoms, since the symptoms are similar to other stresses including insect damage, disease, drought and nutrient deficiency.



Figure 6. Lance nematode damage to bermudagrass rough (Photo courtesy N. Walker)



Figure 7. Decrease in bermudagrass rooting (right) caused by lance nematodes (Photo courtesy N. Walker)

Root-Knot Nematodes

Root-knot nematodes penetrate the root with their entire body and then form a permanent feeding site where they remain for life. A sign of root-knot nematodes is root gall formation in response to their infection. Although galls can be easily observed on the roots of most crops, they can be difficult to see on turfgrass roots. Symptoms of root-knot nematodes can include darkened, rotted roots, chlorotic areas of turf and limited response to fertilizer, fungicide or irrigation.

Spiral, Stunt, Sheath and Pin Nematodes

The symptoms of spiral, stunt, sheath and pin nematode feeding include shriveled roots that are short and sparse. Spiral nematodes, named for the shape of the inactive nematodes, do not typically cause major damage to lawn grasses in Arkansas.

Dagger and Awl Nematodes

Dagger nematode symptoms are sparse, discolored root systems lacking feeder roots. Generally, dagger nematodes are not considered to be a significant threat to turf in Arkansas. Awl nematodes can cause severe damage to turfgrasses and are similar to sting nematodes in their damage potential. Fortunately, awl nematodes are rarely found in Arkansas.

Ring and Stubby-Root Nematodes

Both ring and stubby-root nematodes can cause significant damage to turf if population densities are high enough. With both nematode species, feeding results in tiny lesions on the roots, and under high nematode pressure, roots can become discolored and stubby. Centipedegrass is highly susceptible to ring nematodes, but bermudagrass and St. Augustinegrass can also be damaged.

Cyst and Lesion Nematodes

Other nematodes known to parasitize turfgrasses are lesion and cyst nematodes. Lesion nematodes can cause roots to have black spots (lesions) or even severe root rot. Neither lesion nor cyst nematodes are thought to be very damaging in Arkansas.

Diagnosing Nematode Problems

Nematode problems in turf are often misdiagnosed as being the result of poor cultural practices, diseases, insect damage, soil compaction, nutrient deficiencies, poor drainage, drought or other environmental stresses. To accurately diagnose a nematode problem, a soil sample must be collected from the affected area and be assayed by a nematology laboratory where trained professionals can determine if there are parasitic nematodes present at levels that could cause the observed damage.

The process of taking a soil sample for nematode assay includes collecting random subsamples in a zigzag pattern (Figure 8) from the area in question similar to the procedure that would be used for a soil sample for nutrient analysis. Soil samples for nematode analysis should be taken to a depth of 4 inches – since this is where the majority of the roots are located – with 12 or more subsamples making up a representative sample of the area. It is important to submit separate samples of both healthy and unhealthy turf to accurately reflect the population density of the area. Never sample only dead or severely damaged areas. Samples collected in areas with severe damage (dead turf) may not contain many nematodes, since there are few roots available for nematode feeding. Collect unhealthy turf samples in areas bordering the damaged area and a separate sample from a healthy-looking area. This information will help in implementing sanitary maintenance practices as well as control options that are discussed further in the “Control” section.

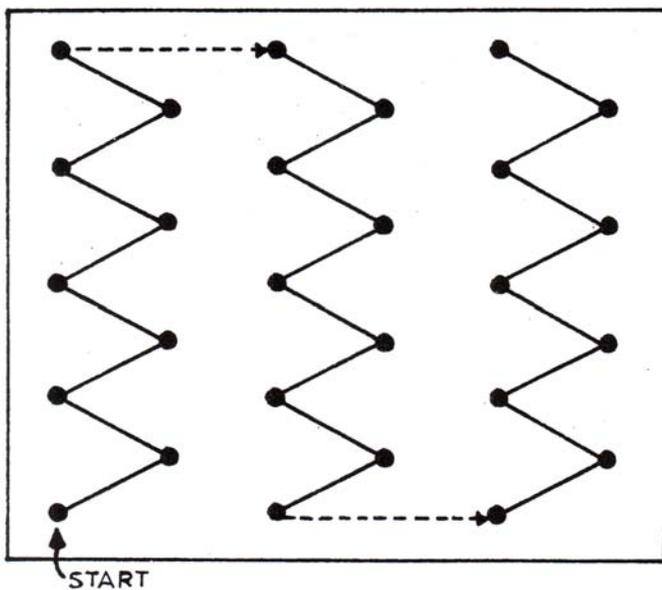


Figure 8. Sampling pattern for turfgrass area with suspected nematode problems. In a similar pattern, also collect a sample from a healthy-looking area.

Combine the subsamples for a particular sample as they are collected. A convenient method is to use a small bucket or other container that is easy to carry. When 8-12 subsamples have been collected, mix the soil thoroughly and place approximately 1 pint into a quart size plastic bag. Bags should be sealed to retain soil moisture and kept out of direct sunlight – placing samples into a small insulated cooler (without ice) is

a safe and convenient method for protecting the sample until it can be sent to the nematology laboratory. Label each sample on the outside of the plastic bag with your name, address, short sample identifier and county. Ziplock storage bags are ideal for this use because they generally have a labeling space on the outside.

Deliver the sample to your county Extension agent as soon after it is collected as possible. If samples must be stored for a few days (up to one week), keep them in an insulated cooler at cool (air-conditioned) room temperature. NEVER store the samples in the refrigerator or on ice in the insulated cooler. The county agent will help you complete a Nematode Sampling Submission Form (AGRI-483), which must accompany your sample.

These forms may also be obtained from the Arkansas Nematode Diagnostic Laboratory web site <<http://www.aragriculture.org/nematodes/>>. The Arkansas Nematode Diagnostic Laboratory is located in Hope, Arkansas, at the University of Arkansas Southwest Research and Extension Center, 362 Highway 174 N., Hope, AR 71801 (phone: 870-777-9702). A \$10 cost-recovery fee is charged for each sample that is assayed. More information about nematodes and the diagnostic lab can be found at the University of Arkansas Cooperative Extension Service web site <<http://www.uaex.edu>>.

Interpreting the Results

Once assay results are complete, the next step is to interpret the results. Note that the results are reported in a standardized fashion as nematodes per 100 cm³. Table 1 lists the most common parasitic nematodes for turfgrass and their estimated threshold levels needed to cause moderate or high levels of damage. While these threshold values may be used as a general guide, it is important to remember that damage due to the nematode is strongly related to overall turf health and turf species (Table 2). Healthy turf can withstand higher nematode levels than stressed turf. Visible damage may be likely once any one nematode species surpasses the medium threshold limit.

Table 1. Nematode common name and genus, threshold level, damage potential and root symptoms. Modified from Tables 1 and 2 from Anonymous (1), Table 1 from Crow (3) and from Davis et al. (7).

Common Name (Genus Name)	Threshold ^a		Damage Potential ^b	Root Symptoms
	Medium	High		
	-----#/100 cc (cm ³)-----			
Sting (<i>Belonolaimus</i>)	10 (25 ^c)	25 (50 ^c)	1	Cropped, stubby roots; large lesions
Lance (<i>Hoplolaimus</i>)	40	120	1	Roots sloughing away; slight swellings and brown lesions
Root-knot (<i>Meloidogyne</i>)	80	300	1	General swellings and galls; no reaction to applications of irrigation, fertilizer or pesticides
Spiral (<i>Helicotylenchus</i>)	700	1500	2	Roots wilted, cropped off, discolored
Spiral (<i>Peltamigratus</i>)	150	300	2	Roots wilted, cropped off, discolored
Stunt (<i>Tylenchorhynchus</i>)	100 ⁺		2	Roots wilted, cropped off, discolored
Dagger (<i>Xiphinema</i>)	51 ⁺		2	Roots wilted, cropped off, discolored
Stubby-root (<i>Paratrichodorus</i>)	150	300	2	Stubby roots, attacks root tips, lesions may be present
Stubby-root (<i>trichonosus</i>)	40 ^{cd}	120 ^{cd}	2	Stubby roots, attacks root tips, lesions may be present
Lesion (<i>Pratylenchus</i>)	51 ⁺		2	Black spots, root rot
Sheath (<i>Hemicycliophora</i>)	200	400	2	Stubby roots, attacks root tips, lesions may be present
Cyst (<i>Punctodera heterodera</i>)	10 ^c	40 ^c	2	Swollen, white females or brown cyst on roots
Ring (<i>Criconemoides</i>)	500 (150 ^e)	1,000 (300 ^e)	3	Discolored roots, tiny lesions
Pin (<i>Paratylenchus</i>)	500 ⁺		3	Roots wilted, thin

^aThese thresholds were developed based on observations in other states and may be adjusted occasionally as more data is collected in Arkansas on nematode pathogenicity to turfgrasses. If nematode assays indicate that you have more than the medium threshold for a given nematode species, damage may become evident if turf incurs additional environmental stress. If nematode assays indicate that you have more than the high threshold for a given nematode species, root systems are likely damaged and turf quality is likely declining. Threshold levels are determined under otherwise normal conditions. It should be noted that in the presence of other stresses (drought, disease, insects), the threshold is effectively lowered. Additionally, the combination of multiple nematode species may cause damage even when present at populations below the threshold level.

^bDamage potential: 1 = very damaging or moderately damaging to turf and very common or common occurrence in Arkansas; 2 = moderately damaging to turf and uncommon in Arkansas; 3 = damaging to turf only at high populations and uncommon or rare in Arkansas.

^cIndicates threshold numbers for St. Augustinegrass.

^dIndicates numbers for genus *trichonosus*.

^eIndicates threshold level for Ring nematode in centipedegrass.

⁺Indicates baseline threshold number based on counts per 100 cc (cm³) soil.

Control Options Before Planting

Very little nematode resistance or tolerance is known in turfgrasses, but there are key differences between species in their susceptibility to certain nematodes (Table 2). Notably, cyst nematode only parasitizes St. Augustinegrass, and bahiagrass is generally more tolerant to nematodes than other turf

species (6). Bermudagrass is typically more tolerant to nematode feeding than zoysiagrass because of the deeper root system of bermudagrass (Figure 9). Susceptibility is known to differ among cultivars within certain species, but there are few definitive reports on these differences. There are no known turfgrass species or cultivars resistant to nematodes.

Table 2. Nematodes and the turfgrasses most affected by each (9).

Turfgrass	Sting	Lance	Root-knot	Spiral	Stunt	Dagger	Stubby-root	Lesion	Cyst	Ring	Pin
Warm-Season Grasses											
Bahiagrass	X	X		X							
Centipedegrass	X			X			X			X	
St. Augustinegrass	X	X	X	X			X		X		X
Bermudagrass	X	X	X	X			X				
Zoysiagrass	X	X	X				X				
Cool-Season Grasses											
Kentucky bluegrass	X			X			X				
Perennial ryegrass	X			X			X				
Tall fescue	X			X			X				



Figure 9. A large patch of bermudagrass appears (right of mailbox next to curb) symptom free in this Meyer zoysiagrass lawn weakened by nematodes.

Nematodes are often found as problems in established turf. In some situations, nematodes may already be present in the native soil at the time the lawn was established, while in some cases, the nematodes are transported to the site in the sand or soil that is used during construction. In either case, it is best to avoid or eliminate the problem if at all possible.

Solarization and Soil Amendments

Soil fumigation is an option used in crops to reduce or eliminate nematode populations prior to planting. However, these products are used commercially and are not labeled for residential use. Although lawns cannot be fumigated, nematode populations can be reduced prior to planting with a process called solarization. Solarization is the process of sterilizing soil by placing clear plastic covers over the soil for a period of two months in the summer. This process will cause the soil temperature to increase, and nematodes will be killed when soil temperatures climb above 140° F. For additional information and assistance, contact your local county agent.

If planting a lawn on a sandy soil, incorporate compost or other similar soil amendments into the soil prior to planting to help make the environment less favorable for nematode activity. This will not only help reduce nematode populations by encouraging nematode-antagonistic microorganisms but will also improve turfgrass health by improving the water- and nutrient-holding capacity of the soil as well as overall turf health.

Sanitation

Sanitation practices are extremely important in preventing the spread of nematodes. Nematodes can be imported or spread with contaminated equipment and with new sod, sand or soil. Therefore, when you are planting your lawn, check the sod or soil for nematodes when appropriate and especially avoid buying sod or soil containing nematodes. You can check your own soil by submitting a sample for analysis. Ask sod producers if they have a recent nematode assay test or if they have ever had problems with nematodes.

Also, when borrowing tilling equipment, be sure to wash the equipment clean of soil before use to avoid introducing nematodes into your lawn.

Control Options in Established Turf

Cultural Practices

Cultural practices are fundamental in the prevention of severe nematode damage. Appropriate cultural practices are vital since chemical control options are limited. Well-managed turf can withstand some nematode infection with little apparent damage. Generally, cultural practices that promote root health and vigorous growth will aid in damage prevention. A few notable cultural practices include increasing the mowing height, properly balanced fertility applications and anything that promotes root growth [for example, aerification (coring)] and incorporation of certain soil amendments like compost in sandy soils. Water deeply and infrequently to promote deep rooting. Appropriate cultural practices are vital since chemical control options are limited.

Avoid applying more than 1.0 lb/1,000 ft² of nitrogen in any one application, as this will promote shoot growth while promoting little root growth. Under-fertilization should also be avoided since damaged plants need some fertility to encourage recovery and new root growth (4). When granular fertilizers are applied, there is limited research suggesting that organic fertilizers may help reduce nematode population densities in sandy areas by increasing soil organic matter, which may encourage

nematode-antagonistic microorganisms. Although deep and infrequent irrigation is ideal for enhancing root growth, light and frequent irrigations applied to the depth of rooting may be necessary on nematode-infested areas to keep these areas from wilting.

Biological

Certain biological and organic products can help minimize nematode damage, but limited efficacy has generally been reported under severe infestations (2). Many of these products are known nematode, bacterial and fungal antagonists or naturally occurring plant compounds that are nematicidal. A few examples include ClandoSan[®], Neo-Tec[®], DiTera[®], mustard seed meal and mustard bran. Mustard bran as well as extracts from *Euphorbia* spp. have been reported to work in the laboratory, and testing is currently ongoing in the field. The environmental and human safety attributes of these biological products make them extremely attractive potential nematode control methods for home lawns as well as for golf courses, athletic fields, parks and commercial landscapes.

Chemical

No chemicals are currently registered for nematode control in residential areas. Chemicals that control nematodes are generally highly toxic to mammals and, therefore, can be extremely problematic in applying. Many of the effective nematicides used in the past are no longer available on the market because of their environmental toxicity (4). Research is ongoing to identify new nematicides that are effective and safe to apply.

Conclusions

Nematode control in turf is challenging due to limited control options. Nematodes generally do not move more than a few feet during their entire life cycle, but they can be moved long distances on equipment, turf or soil. Consequently, sanitation practices are vital to ensuring nematode-free turf. Cultural practices are also extremely important in controlling nematodes and the damage they cause. Preventing other turf stresses through good management practices for fertility, irrigation and pest management will promote turf health in general.

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Additional Information

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Additional information about nematodes is available at <http://www.aragriculture.org/nematodes/>.

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