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College of Agricultural, Consumer and Environmental Sciences

report on **PLANT DISEASE**

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NEMATODE PARASITES OF TURFGRASS

Figure 1. Turf showing lance nematode damage.

Parasitic nematodes feed on all species of turf grasses throughout the world and may be limiting factors in the production of high quality turf in Illinois. Although the damaging effects from nematodes are not as well established for turfgrasses as they are for many other crops, several species of nematodes are known to cause serious damage to bentgrass and bluegrass, especially when the turf is also stressed by other factors. Other species may feed on turfgrasses without causing noticeable damage. Often nematodes are overlooked when turfgrass problems are being diagnosed because (1) they are translucent and microscopic and virtually all live in the soil; (2) they generally reduce plant vigor but only cause severe symptoms during times of stress; and (3) most diagnoses are based on plant shoot growth rather than roots, soil, or both. Recognizing nematode problems and understanding the relationships of these parasites to turfgrasses are essential for growing high quality turf.

Plant parasitic nematodes are microscopic, translucent roundworms, generally 0.5 to 3 mm (2/50 to 1/10 inch) in length and 30 to 100µm (1/1000 to 1/250 inch) in diameter as adults. All are vermiform (worm-like) at least during the early stages of their life cycles. Females of root-knot (*Meloidogyne*) and cyst (*Heterodera punctodera*) nematodes grow to be pear and lemon shaped, respectively, at maturity. Most nematodes have well developed digestive and reproductive systems. The digestive system from anterior to posterior is composed of the oral opening, stylet, esophagus, intestine, and anal (female) or cloacal (male) opening.

Figure 2. Roots damaged by stunt nematodes (courtesy of George Powell).

Possession of a stylet separates plant parasitic from nonparasitic forms, although some stylet-bearing species feed on lower plants, such as the fungi associated with turfgrass roots. The stylet is a hollow, spear like structure in the head region that is used to probe and penetrate cells, egest digestive enzymes into plant tissues, and ingest cell contents.

For further information concerning nematodes on turfgrass, contact an Extension Specialist in the Department of Crop Sciences, University of Illinois at Urbana-Champaign.

Table 1. Nematode Genera Associated with Turfgrass Problems in the Midwest, Their Importance in Illinois, and Their Types of Root Damage

Genus name (common name)	Importance*	Root symptoms
Helicotylenchus (Spiral)	1—II—B	Roots shriveled, short and discolored; cortical tissue sloughs off
Tylenchorhynchus (Stunt)	1—II—B	Roots shriveled; short and sparse
Pratylenchus (Lesion)	2—I—B	Small, brown to black spots to large girdling lesions; severe root rot
Hoplolaimus (Lance)	2—III—B	Slight swellings and brown lesions; cortical tissue sloughs off
Xiphinema (Dagger)	2—I—B	Roots sparse and discolored; lack of feeder roots
Criconemoides (Ring)	2—II—C	Tiny lesions; roots discolored
Longidorus (Needle)	3—III—A	Short, stubby roots; small root—tip swellings
Meloidogyne (Root-knot)	3—I—A	General swellings and galls; roots distorted
Paratylenchus (Pin)	3—II—C	Roots shriveled; short and sparse
Paratrichodorus (Stubby-root)	3—III—A	Large brown lesions, mostly near tips; short, stubby roots with slightly swollen tips
Punctodera heterodera (Cyst)	4—II—A	Tiny, swollen, white females and brown cysts on roots; roots distorted and discolored
Belonolaimus (Sting)	3—III—A	Large, girdling lesions; short, stubby roots with knobby tips

* **Arabic numeral** indicates how commonly the genus occurs in Illinois: 1) very common; 2) common; 3) uncommon; and 4) not recorded but may occur rarely in some parts of the state.

* **Roman numeral** indicates soil preference: I) all soils; II) mainly heavy and amended soils; and III) mainly or only sandy soils.

* **Capital letter** indicates potential for damage: A) very damaging; B) moderately damaging; and C) damaging only at high populations.

SYMPTOMS AND DAMAGE

Above ground symptoms of nematode injury may include a slow green-up in the spring, chlorosis and dieback of the grass blades, sensitivity to stresses, reduction in vigor, stunting, and gradual thinning of the turf. Symptoms usually occur in gradually enlarging circular to irregular areas because of the clustered distribution of nematodes (Figure 1). Damage is most obvious during periods of moisture and temperature stress. Severely affected plants may wilt during the heat of midday and recover at night. These symptoms may be indicative but are **not** diagnostic of nematode problems. Nematode damage varies considerably with environmental conditions and is easily confused with insect injury, other diseases, nutrient and moisture stresses, pesticide injury, thick thatch, compaction, or other turfgrass problems. Nematode infested roots commonly are shallow, coarse (lack of fine feeder root), bushy, or stubby (Figure 2). Suspect a nematode problem if the turf does not respond normally to applications of fertilizer, water, a fungicide or to increased aeration in compacted or heavy soils.

Symptoms of root injury (Table 1) vary depending on the species and number of nematodes and the other stresses that are involved. Root-knot (*Meloidogyne*) and cyst (*Heterodera punctodera*) nematodes alter the grass physiology by egesting specific enzymes that induce giant cell formation within the root at the feeding site. Giant cells act as sinks by "attracting" energy rich plant metabolites, which are consumed by the nematode. The abnormal cells disrupt moisture and nutrient transport within the plant. Some nematodes inhibit root growth. For example, stubby-root nematodes (*Paratrichodorus*) feed at root tips. A combination of nematode enzymes and mechanical damage is thought to reduce cell multiplication, resulting in a "stubby root" appearance; swelling of the devitalized root tips is common. Other nematodes cause dark necrotic lesions (dead areas) in roots. Usually lesions are produced by nematodes that are actually entering, feeding, and multiplying within the roots. Some of the most obvious lesions are caused by lesion nematodes (*Pratylenchus*). Often lesions are enlarged by fungi and bacteria that invade and multiply in the wounds. Regardless of the type of root symptom, all nematodes reduce the size of the root system, and the damage is reflected in symptoms that are expressed above ground.

Nematodes have been shown to increase the severity of other diseases in certain plants. Disease complexes often produce synergistic effects that devastate the hosts. Soil fungi, such as species of *Fusarium, Phialophora, Leptosphaeria, Rhizoctonia,* and *Pythium,* are common pathogens of turfgrasses and are likely to form disease complexes with nematodes in turf. Nematode fungus interactions result from mechanical damage to roots and physiological changes that lower disease resistance in plants. The fungus may also affect nematode populations. For example, species of *Fusarium* may either increase or decrease reproduction of certain nematodes.

GENERALIZED LIFE CYCLES

Nematodes develop from eggs through four juvenile stages into adults (Figure 3). In most species, the nematode hatches from the egg as a second stage rather than as a first stage juvenile. The juvenile worm moves in a wave-like motion through the water that surrounds soil particles, searching for a suitable host plant on which to feed. Molting takes place between each life stage as the nematode increases in size. Most nematodes may feed at any stage once they hatch from the egg. In some species, adults mate and females lay fertilized eggs. In others, males are either unknown or very rare and are not needed for egg production. Nematodes usually complete their life cycles in about one month if they are within their optimum soil temperature range of 68°to 86°F (20° to 30°C). However, some species may take up to a year to complete the cycle.

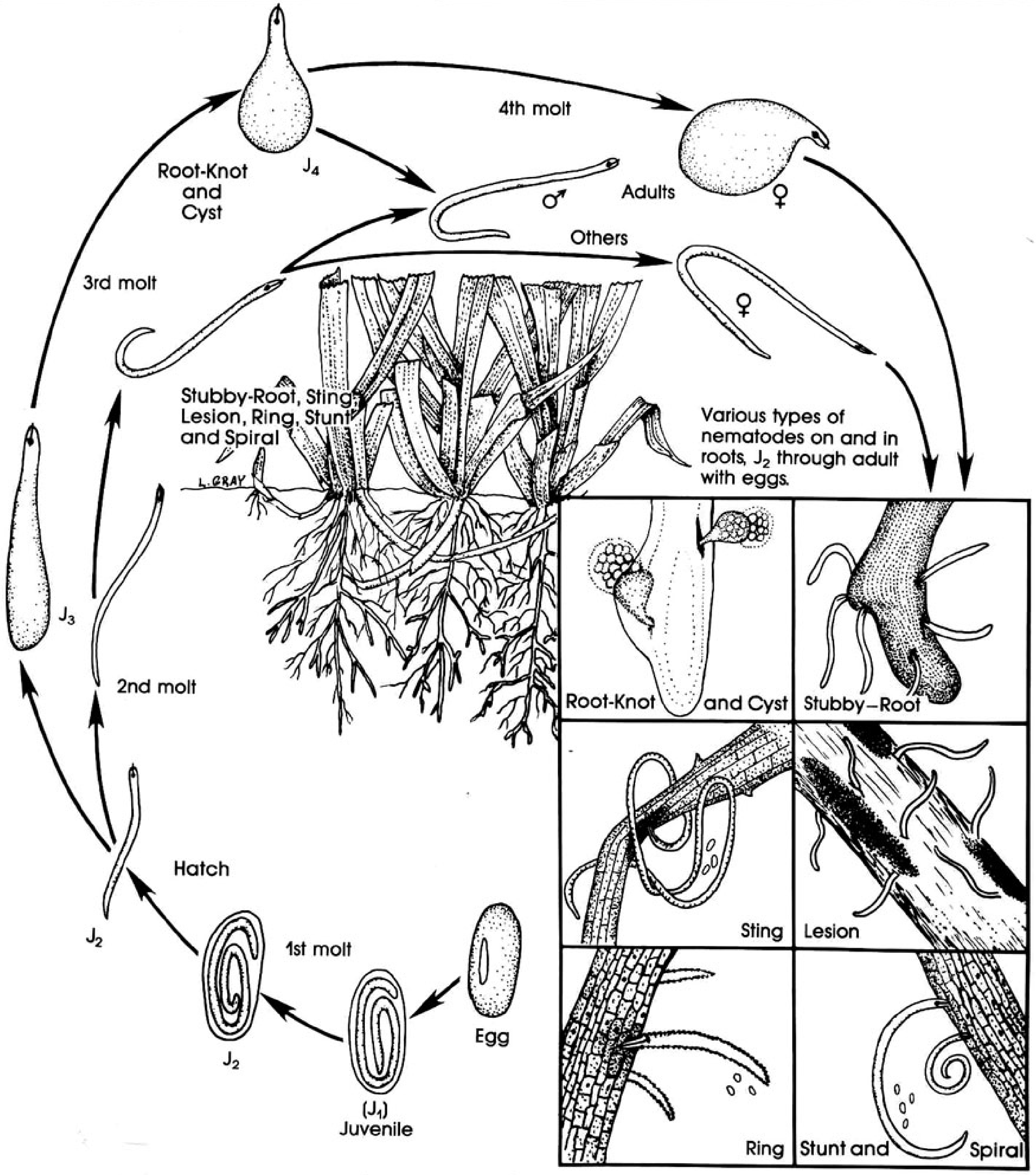

Figure 3. Generalized life cycles of some common turfgrass nematodes in the Midwest.

Nematodes feed primarily as ecto- or endoparasites. Ectoparasites, such as dagger (*Xiphinema*) and needle (*Longidorus*) nematodes feed by inserting their long stylets into roots, feeding only at or near the surface of roots. Endoparasites embed their entire bodies within plant tissue and feed within. Sedentary endoparasites, such as root-knot nematodes (*Meloidogyne*), never relocate after feeding sites are established. Migratory endoparasites, such as lesion nematodes (*Pratylenchus*) feed on cells until they are no longer attractive and then migrate to healthy cells. Semiendoparasites may feed externally or internally during parts of their life cycles or, more commonly, with their bodies partially embedded in roots. One uncommon form, the seed-gall nematode (*Anguina agrostis*), does not attack roots but feeds internally in flower heads where it causes formation of tiny galls, preventing the formation of seeds.

POPULATION DYNAMICS

Nematode populations fluctuate both seasonally and spatially. Changes vary according to the nematode species. Knowledge of the shifts in population sizes is necessary for properly diagnosing and managing nematode problems on turfgrasses. Populations of most species increase both during and immediately after periods that are favorable to turfgrass growth. Populations often peak in late spring and again in midfall. Although population levels generally increase when environmental conditions are favorable, above ground symptoms may not appear until later when the turfgrass is under some stress.

Nematode spatial distribution depends upon the nematode involved, root growth habit of the grass species, soil characteristics, and relative health of the root system. Populations of most nematode species tend to cluster in small areas and expand from those areas, which accounts for the frequent patchiness of the damage. Usually, nematodes are concentrated in the top 10 cm (4 inches) of turfgrass soil. Within a severely damaged area, the highest numbers of nematodes are found at the margins rather than in the center of the area because the healthier roots that have not been heavily fed upon provide a better food source. Nematodes move very slowly through the soil (rarely more than one foot per year) but are spread easily with infested soil, water, and plant material, primarily the result of man's activities.

DAMAGE THRESHOLDS

A **damage threshold** is either the number of nematodes in a given volume of soil or the weight of roots that will cause detectable plant damage. Damage thresholds are extremely complex and difficult to establish: they vary with the form of nematode, type of soil, season of the year, species, growth stage and vigor of the plant, and cultural practices. Moreover, nematodes almost always exist in communities of more than one species. One, several, or all of the species present may be contributing to the damage. Population thresholds for damage to turfgrasses are not well defined and are based largely upon personal experience rather than research.

General thresholds for damage to turfgrasses differ widely among nematodes (Table 2). For example, spiral, ring and pin nematodes cause little detectable damage until population increase to very high levels, whereas dagger, lesion and lance may cause damage at relatively low population levels. Combinations of nematodes, especially lance, lesion, stunt, and dagger may cause problems at below damage threshold levels.

Other factors may increase or decrease the damage threshold for each nematode form. Thresholds usually are lower in sandy soils than in heavy-textured soils that are more fertile and moisture-retentive. Additionally, turfgrasses are more tolerant of a given population level during the favorable growth periods in spring and fall than during summer when grass is exposed to numerous physical stresses. Also, shallow-rooted and nonrhizomatous grass species tend to be less tolerant than deeper-rooted and rhizomatous species. Seedlings are more sensitive than well-established plants. Furthermore, threshold levels are considerably higher on grass that is well fertilized and watered than on grass that is under nutrient or moisture stress. Close mowing practices place severe physiological stress on turfgrass, thus substantially lowering threshold levels.

Table 2. Damage thresholds for frequently encountered nematodes of turfgrasses in Illinois

Nematodes	Nematodes/100c soil[a]	Recommendation[b]
Lance	76+	Nematode numbers listed under column "Nematodes/100cc of soil" indicate that a nematicide may be profitable
Lesion	51+	
Stunt	100+	
Dagger	51+	
Spirals	300+	
Ring	300+	
Pin	501+	

[a] Combinations of nematodes, especially lance, lesion, and stunt, may cause problems at lower population densities.

[b] Eliminate pH, fertility, soil compaction, soil insects, diseases, etc., as possible factors limiting growth before using a nematicide.

DIAGNOSIS OF NEMATODE PROBLEMS

Soil Sampling

The principal concerns with turfgrasses are appearance, uniformity, and vigor. The collective symptoms of nematode injury usually produce a nonuniform appearance, exhibiting areas of both unthrifty and relatively healthy grass. Thus, a diagnosis of turf nematode problems requires paired sampling, which consists of both a sample from a suspect area and one from a "healthy" area. This procedure allows for the comparison between nematode populations of damaged and undamaged areas for both proper diagnosis and in order to provide data that helps to refine damage thresholds.

A nematode problem can be diagnosed only by a qualified nematologist in a laboratory equipped for such analyses. Although obtaining a "good sample" may be time-consuming, difficult, and appear costly, it is the most reliable method of diagnosis. The best time to sample is about one month after the grass resumes growth and greens up in the spring, or in midautumn. All samples should be taken from a depth equal to that of the root system, or about 10 cm (4 inches).

Sampling patterns depend on the size of the area to be sampled and the symptoms that have been observed. When only a gradual decline over an area is noticed, subsamples should be taken randomly in a zig-zag pattern throughout the area. A sample should consist of a minimum of twelve subsamples for an area that is up to an acre in size. A larger area should be subdivided into equal sectors, each being sampled separately If more severe symptoms occur in patches, subsamples should be taken just inside the perimeter of the patches. Six or more subsamples must be obtained to submit at least one pint of soil. Additionally, a sample from an affected area should be accompanied by a sample from an adjacent, healthy-appearing area. The best sampling tool for turf is a 2.5 cm (1-inch) diameter soil sampling tube. Subsamples also may be taken with a cup digger or narrow bladed trowel, a vertical section of the soil from each subsample should be saved for the composite sample.

Subsamples should be mixed together and placed in a sturdy plastic bag. Samples must be either shipped immediately or stored in a refrigerator until they can be submitted for analysis. Furthermore, samples should always be kept out of direct sunlight and never be exposed to high temperatures. Also, they must be accompanied by a completed Nematode Sample Form, which is available from your nearest Extension office, or by a description of the problem and a thorough history of soil fertility, irrigation, and pesticide practices on an attached sheet of paper. A check made payable to the University of Illinois in the amount of $18.75 should also be included. Samples must be labeled separately and should be submitted to the Plant Clinic, 1401 W. St. Mary's Road, Urbana, Illinois 61802.

Nematicide Strip Tests

Infinite combinations of nematode species and environmental conditions exist which may affect the amount of damage to turfgrasses. Thus, a nematode analysis alone may not confirm that these parasites are the primary cause of poor growth. For an additional means of confirmation, growers may want to conduct a nematicide strip test, using a registered nematicide. The response of treated plants, when compared with that of untreated plants, frequently confirms that nematodes are the causal agents and thus justify the expense of more extensive nematicide applications.

The strip test involves chemical treatment of a limited amount of turf and should be conducted within the problem area. A nonfumigant nematicide should be applied in a minimum of three 1- to 2-meter (about 3- by 6-foot) strips accompanied by a similar number of untreated strips. Both treated and untreated strips must be alternated because of the wide natural variation in soil nematode populations across an area of turfgrass. To determine the efficacy of the nematicide application and to correlate plant response with nematode control, either the grower or a professional consultant should take a soil sample from each treated and untreated strip, 5 to 6 weeks after application, and submit the labeled samples to the University of Illinois Plant Clinic or other reliable clinic for a follow-up nematode analysis. The sampling procedure is the same as that described above.

CONTROL PRACTICES

There are three basic methods for controlling turfgrass diseases caused by nematodes.

1. **Reduce the initial nematode population**. This procedure is applied prior to planting. Tactics include ensuring that sprigs, stolons, plugs, soil, and equipment are free of parasitic nematodes: sprigs and stolons can be freed of nematodes by hot water treatment (120° to 125°F, or 49° to 52°C, for 45 minutes). Plugs should be from grass grown in heat treated or fumigated soil. Soil mixes for golf greens and tees can be steamed or treated with a fumigant nematode/biocide. Grading and planting equipment should be thoroughly washed or steamed before use.

   An extensive area of unthrifty turfgrass with a history of nematode or nematode-fungus problems can be treated with a fumigant nematicide prior to reestablishment of the turf. Soil fumigation is expensive and requires specialized equipment but usually is highly effective in overcoming these problems. Soil fumigation cannot be used where roots of ornamental trees and shrubs are present within the areas to be fumigated.

Soil fumigation is best done in late summer or early autumn when soil temperatures are high enough for fumigant action and a new stand of grass can be established before winter or early spring. The area should be scalped of old turf, and the soil should be prepared for a seed bed condition to a depth of at least 15 cm (6 inches) prior to treatment. Soil temperatures at 10 cm (4 inches) must be 59° to 86°F (15° to 30°C) for at least a week after treatment. Fumigants are injected 10 to 15 cm (4 to 6 inches) beneath the soil surface, and the surface is partially sealed with a roller or drag bar. A post-fumigation waiting period of 3 to 4 weeks is required before seeding or sodding to allow the chemical to leave the soil without injuring new plants. The soil should be aerated several days before replanting if soil temperatures drop below 15°C (59°F) during the waiting period. **Fumigants are extremely hazardous chemicals, and all precautions for their safe use must be followed closely. Humans and animals must be kept off treated areas during the waiting period.** For more information on fumigation and other methods of soil disinfestation, check with nematologists, extension personnel, certified applicators, or manufacturers.

2. **Reduce the nematode population**. Chemical control of nematodes on established turfgrasses can be accomplished with nonvolatile nematicides formulated as either granular materials or liquids. However, nematicides should be applied on a broad scale **only** when the results from a laboratory analysis have shown that nematodes are part of the observed problem or when treated areas in a strip test return to normal. Nonvolatile nematicides can be applied from midspring to midautumn, but the soil temperature at 10 cm (4 inches) must be at least 15°C (59°F) to ensure that a high percentage of the nematodes are active and are not in the resistant egg stage. Grass will respond most rapidly to May or June treatment, when nematodes are feeding most intensively and before damage and summer stress become severe.

   Nonvalatile nematicides work best in light-textured, sandy soils and are less effective in soils that are high in silt, clay, and organic matter. They must be watered in with 1.2 to 2.5 cm (1/2 to 1 inch) of water **immediately** after application to avoid severe burning of the grass and to bring the chemicals into contact with the nematodes. **All nematicides are extremely toxic** and must be applied only by trained personnel who are licensed to handle restricted use pesticides. **Always read label directions and precautions** in their entirety before opening the container. For information on nematicides, see University of Illinois Commercial Landscape and Turfgrass Pest Management Handbook, revised annually.

3. **Increase the turfgrass tolerance to nematode parasitism**. This procedure utilizes cultural practices to reduce nematode damage. A deep, healthy root system achieved through good turfgrass management can withstand a much higher population of nematodes than a shallow, poorly developed one. The most important steps are using clean equipment and sterile soil amendments, keeping the thatch layer under 1.2 cm (1/2 inch), aerating compacted soils, and proper and timely application of fertilizers and irrigation. While underfertilizing decreases tolerance, overfertilizing can result in an increase in leaf and crown diseases caused by fungi, as well as in nematode-fungus disease complexes. Although frequent, light watering, especially at midday, may be necessary to minimize wilting when nematode populations are high, brief irrigation must be interspersed with deep, heavy watering to prevent roots from becoming concentrated near the soil surface.

   The most effective and practical means of controlling nematode diseases is through the use of resistant turfgrass cultivars. However, little research has been done in this area, and no cultivars that are now available are known to be nematode resistant.