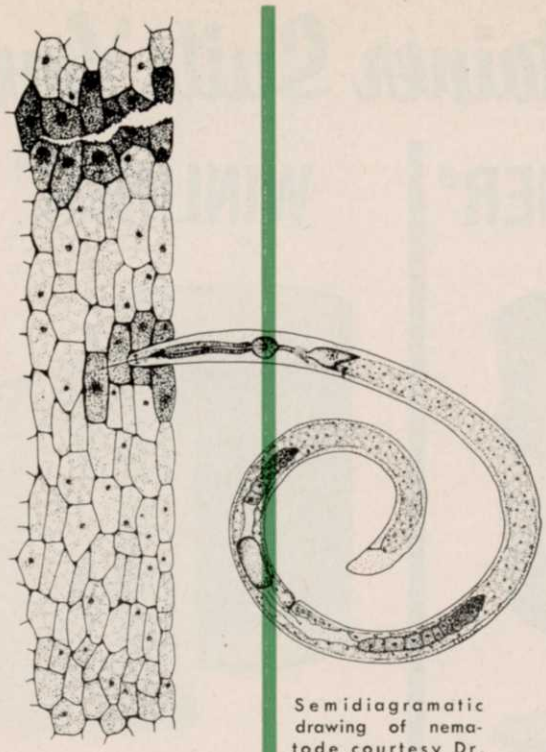


Semidiagramatic drawing of nematode courtesy Dr. Houston B. Couch (Pennsylvania State University) author of **Diseases of Turfgrasses.**

What Turf Managers Need to Know About Nematodes

Results of another **Weeds and Turf** field research project.

AWARENESS of nematode damage in turf has been steadily increasing. It is evident that homeowners and others concerned with decorative and useful grasses are going to call upon contract applicators for nematode control service as the demand for fine turf increases. To meet this anticipated demand, CAs will have to assimilate increasing amounts of diversified control information, both biological and chemical.

A quick examination of the nematode's place in the scheme of nature will help orient the reader to the subject of nematodes. These animals have such unusual characteristics that some experts have placed them in a grouping by themselves. Since no close relatives of nematodes can be found, they are placed in Phylum Nemata. *Phylum* is a primary grouping of plants and animals with similar characteristics, assumed to have descended from a common ancestor. For example, those animals with jointed legs and external skeletons (insects, spiders, crustacea) are placed in the Phylum Arthropoda.

Nematodes are suspected to be the most numerous form of animal life on earth. One acre is estimated to hold hundreds of millions of individuals. It has been said that they are second only to arthropods in the destruction they cause. A major importance stems from the fact that they are, as a group, parasites of man and animals in addition to plants.

Nematodes are causal organisms for "creeping eruption," a skin ailment familiar to termite operators. The eruption results when a cat or dog parasitic nematode called a hookworm burrows into a human, while he crawls in an area in which pets loaf. Certain nematode species also cause elephantiasis, entering man through a bite of an infected mosquito. Trichinosis in man is caused by eating improperly cooked pork infected with nematodes. Numerous self-descriptive plant ills (root-knot, wilting, stunting, yellowing, and decline) may be caused wholly or in part by plant parasitic nematode feeding. In this discussion, we will focus on those which parasitize or otherwise affect plants, specifically turfgrasses.

Plant parasitic nematodes have slender, unsegmented, translucent, colorless, legless, wormlike bodies which move in a whiplike fashion. Some mature female sedentary parasites, such as the root-knot nematode, and cyst-forming nematodes, lose their slender form and become lemon-shaped, pear-shaped or sometimes almost spherical. In general, adult plant parasitic nematodes measure 1/60 to 1/16 inch long. The nematode body is equipped with longitudinal muscles, a nervous system, a digestive system, and reproductive sys-

tem. They lack respiratory and circulatory systems.

The eyeless head portion of plant parasitic nematodes carries a specialized hollow stylet, similar to a hypodermic needle, through which nematodes inject digestive fluids into individual plant cells before they suck out the cell contents. Nematodes lacking stylets cannot injure plants and are called nonparasites.

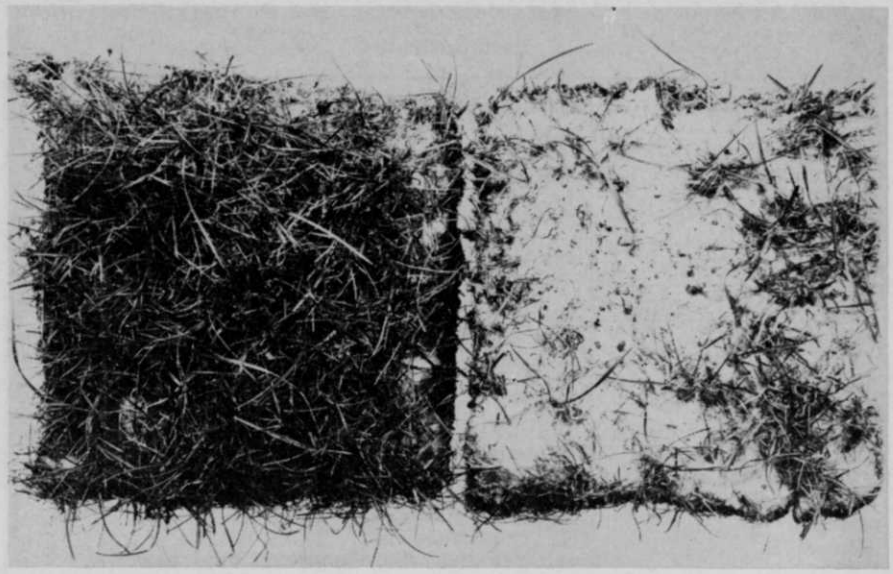
Plant nematodes can be grouped according to the plant area where they feed. There are foliar, seed, and root nematodes. Foliar and seed nematodes travel, under moist conditions, up plant stems and enter flower parts, leaf pores, or stems. Stunting, malformation, and discoloration results from nematode feeding in these areas.

Root nematodes can be divided into two types, ectoparasites and endoparasites. Ectoparasites feed on plant roots from outside the plant. Endoparasites burrow partially or totally into plant roots to feed; these may cause galls, or cysts in roots.

The name "nematode" is derived from Greek and literally means "threadlike." As a group nematodes are also called eelworms or threadworms. Other common names for individual species give the reader some idea about the function of the mouthparts, the way nematodes look in the soil, or the effect of feeding. Some ectoparasitic types are called spiral, sting, dagger, ring, lance, and stubby root nematodes. Others, which burrow to varying depths into roots and plant parts are called root-knot, burrowing, grass-seed, and meadow (lesion) nematodes. The most familiar is the root-knot because the nematode feeding causes roots to swell forming knots which are visible to the naked eye. Several experts advise use of technical names as listed in Tables 1A and 1B since common names vary and can confuse.

Determine Nematode Damage

Nematode damage to turf manifests itself in a generalized way, that is, there is no one symptom that one can chalk up to nematodes. Some authorities disagree on the importance, if any, of nematodes in turf. So far, they say, the proof has been only statistical that a plant may grow better for a while in treated soil versus untreated soil. The long-term effects of nematode predator destruction and making the soil devoid of both destructive and beneficial organisms have not been established, dissenters claim.



Kentucky bluegrass showing response to nematode control by V-C 13. Left treated with 20 gallons per acre; right untreated (after Perry, Darling, and Thorne, 1959).

Control proponents believe that nematodes do have a direct effect on plant vitality, though individual nematodes are much too small to test separately. They also believe that nematode feeding wounds plants and thereby predisposes them to infection by pathogenic soil bacteria, viruses, and fungi. Some nematodes are proven vectors of pathogens. By keeping plants free of wounds, they feel, a healthier "crop" results.

With this disagreement in mind, we can tally what is known so far about the effects nematodes "have been shown" to have on plants.

Symptoms generally include loss of plant vigor, chlorosis (loss of green color), and discoloration in some cases. Roots may be discolored or deformed. Many plants which are drought stressed by lack of moisture show results of nematode feeding. Affected plants show symptoms of nutrient deficiency; sometimes the ailment is indeed a nutrient lack, and sometimes nematode damage simulates this condition. Nematode feeding stunts and deforms new root growth so that nutrients are not absorbed efficiently.

Stems of parasitized grasses may show an obvious shortening between joints. Roots may begin to rot in advanced stages of decline, and sometimes may be covered with lesions or galls as a result of nematode feeding. Some nematode species even affect grass seedheads by feeding in flower parts causing galls to form instead of seed.

Nematode damage can be mistaken for turf ills such as fungus attack, lack of watering, soil compaction, and insect depredation. All these cause similar symptoms. The only way parasitic nematode presence may be determined with accuracy is for an experienced nematologist to analyze a well-prepared soil sample.

Contract applicators can use the process of elimination when diagnosing a suspected case of nematode damage. Many turf ills, such as those mentioned above, can be determined by simple tests and visual inspection. Eliminate the possibility of nutrient deficiency by a soil test for chemical elements. Examine soil to be certain it is not compacted. Culture a tuft of weakened turf with damp filter paper to see if there is any fungus dis-

Table 1A. Nematode Genera, Host Grasses, and Damage Observations
Endoparasites

Nematodes	Some Grasses Affected	Damage Remarks
Cyst Nematodes *Heteroda* spp.	creeping bentgrass Italian ryegrass perennial ryegrass red fescue rough bluegrass St. Augustinegrass	Females encyst in fibrous roots; cysts are visible and tan colored. Established stand contol not now possible.
Root-knot Nematodes *Meloidogyne* spp.	Bermudagrass dallisgrass Kentucky bluegrass St. Augustinegrass	Swellings on both fibrous and lateral roots. Swellings colored same as normal roo' tissue.
Root-lesion Nematodes *Pratylenchus* spp.	bentgrass Bermudagrass centipedegrass crested wheatgrass Kentucky bluegrass St. Augustinegrass tall fescue zoysia	Minute brown lesions visible. These lesions may enlarge and girdle root; this causes pruning. There is little new growth evident.
Burrowing Nematode *Radopholus* sp.	bahiagrass Bermudagrass carpetgrass large crabgrass St. Augustinegrass	Damage similar to root lesion nematode. Root spots become necrotic. Cavities form; girdling and root rot result.
Grass-seed Nematode *Anguina* sp.	bentgrass colonial bentgrass creeping bentgrass redtop velvet bentgrass	Galls are produced in grass flowers. Nematodes inside make purplish galls instead of grass seed.
Leaf-gall Nematodes *Anguina* sp. *Ditylenchus* sp.	colonial bentgrass fescue	Diseased leaves are short, but plants do not lack vigor. Single galls found at leaf bases. These are colored first greenish, then purple, then reddish purple, finally purplish black.

ease present. Search for beetle grubs under the sod. Discuss the history of maintenance with the client since damage can result from improper care. If any of these other troubles are present, they can be corrected before damage is blamed on nematodes. If no other problem is encountered, nematodes are then strong suspects.

Sample Soil to Confirm Diagnosis

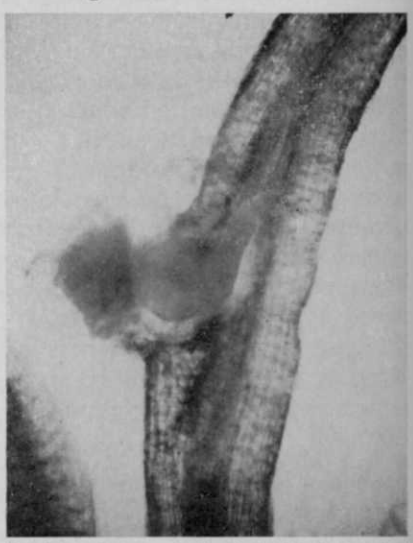
When all factors except nematodes have been considered and eliminated, take a soil sample and send it for analysis to a state extension service or experiment station nematologist with whom a cooperative understanding has been previously arranged.

Soil samples are not difficult to take, but care is needed to get an accurate sampling of overall conditions. With a small trowel take soil from the top six inches under the sod around the border of the affected area. Some diseased plant material may be collected also. Sample the soil in several places and mix the collected samples well. Then remove about a pint and place it into a plastic bag and seal tightly with a rubber band. A pint jar will also work. Avoid drying of the sample. Wrap the sample securely so that postal handling will not damage it. Be certain to label well, and include name, address and what information is desired about the sample. On the label state where the sample was taken, in case anyone wants to find the exact spot again. One can never tell when he will "dig up" an undiscovered species. This information would be very important to a nematologist.

Some CAs who already have their own microscopes may believe they can identify nematodes without sending them away. It is true that one can pick out a soil-inhabiting nematode from other soil organisms with only a little practice, but most soil nematodes are not plant parasitic. There may be an abundance of these wiggling organisms, but if no known pests are among them, one will have to look elsewhere for the cause of damage. An experienced nematologist can pick out the relatively few parasitic genera quickly and accurately.

In one instance, identification of root-knot nematodes, however, the microscope may be helpful and eliminate the need to send samples away for identification. With practice one may be able to observe the galled or knotted roots. Galls may be broken open (this is a delicate task) and examined with a low-power scope to find pear-shaped females. These are hardly visible to the naked eye and look much like small pearls. Galls on most grasses are very small and usually not readily discernible. Experts caution against confusion of any galls with the nitrogen nodules of legume plants such as clovers. These are caused by beneficial bacteria.

If the pearly female nematodes are found along with brownish egg masses which cling to the sides of roots, one can decide in relative safety that the plants are infected with parasitic nematodes, either root-knot, of the genus *Meloidogyne* or cyst, of the genus *Heterodera*. This is



Root-knot nematode imbedded in plant root is shown in this photomicrograph of a nematode gall. (Photo courtesy Shell Chemical Company.)

sufficient evidence to begin control measures.

For the most part, identification to the species level is not necessary. If one knows that parasitic nematodes are attacking a client's lawn, there is a nematocide or a soil fumigant which will reduce the numbers to a level below that which will be damaging to plants.

In tropical climates nematode damage may be seen all year, but in temperate regions damage is noted mostly from May to November. Nematodes do not usually provoke evident aboveground symptoms while grass is actively growing in spring and late fall. Of course soil temperatures must be about 65 degrees before nematodes hatch and begin feeding, but grass may not show symptoms until placed under stress of summer heat, lack of moisture, or additional wear. Then the absence of a good root system shows because the weakened turf begins to wilt and thin and becomes susceptible to pathological and physiological disorders caused by fungi and bacteria. Tables 1A and 1B show grasses affected by various types of nematodes and general remarks about specific damage observations.

Table 1B. Nematode Genera, Host Grasses, and Damage Observations

Ectoparasites

Nematodes	Some Grasses Affected	Damage Remarks
Spiral Nematodes *Helicotylenchus* spp.	Bentgrass Bermudagrass dallisgrass Kentucky bluegrass ryegrass St. Augustinegrass zoysia	Grass grows well until midsummer when shallow roots prevent absorption of deep water. Nematodes in soil attack most severely in spring; plants revive in late fall.
Sting Nematodes *Belonolaimus* spp.	Bermudagrass centipedegrass Italian ryegrass St. Augustinegrass zoysia	Root lesions restricted to tips where nematodes feed. Malformation of roots evident.
Stylet Nematodes *Tylenchorhynchus* spp.	annual bluegrass bentgrass Bermudagrass centipedegrass crabgrass grama grass Kentucky bluegrass ryegrass zoysia	No lesions evident on roots. Roots shriveled, shortened, and sparsely developed.
Ring Nematodes *Hemicycliophora* spp. *Criconemoides* spp.	Bermudagrass centipedegrass Kentucky bluegrass St. Augustinegrass zoysia	Lesions present at root tips and sides. Root rotting extensive.
Pin Nematodes *Paratylenchus* spp.	grama grass Kentucky bluegrass meadow fescue red fescue ryegrass	Noticeably stunted plant; shortened internodes. Root system larger, but lateral growth lacking proportionately.
Stubby root Nematodes *Trichodorus* spp.	Bermudagrass centipedegrass meadow fescue perennial ryegrass red fescue St. Augustinegrass	Short lateral root branches. Color darker than normal. No distinct lesions or galls.
Dagger Nematode *Xiphinema* sp.	bentgrass Bermudagrass carpetgrass dallisgrass grama grass rough bluegrass St. Augustinegrass zoysia	Chlorotic, sunken, reddish-brown lesions seen on roots. Roots stunted and rotting.
Lance Nematode *Hoplolaimus* sp.	annual bluegrass bentgrass carpetgrass dallisgrass Kentucky bluegrass St. Augustinegrass zoysia	Swelling on roots at feeding zones. Roots turn dark brown. Cortex falls away.

Pre-plant Controls

Two types of control are open to CAs for use against nematodes: pre-plant and post-plant. Pre-plant control involves cultivation, seedbed preparation, and use of one of several fumigant materials. Certain fumigants when properly applied destroy fungi, weeds, grass, and weed and grass seeds, in addition to nematodes. These are useful when one intends to reseed or resod.

Some of the more familiar of these all-purpose soil fumigants are methyl bromide, chloropicrin, Mylone, Vapam, and Vorlex. Labels of some of these fumigants state that tarping is optional, but most experts advise that better results will be obtained with all fumigants if tarps are used. Results are not as dependable, when a water seal is used to contain a drenched fumigant, as the results when a cover is used.

Depending upon the chemical, some labels state that seedbed or sodbed preparation may not be essential, but again experts suggest that good results are more predictable if an area to be fumigated is cultivated and raked before any chemical is applied. There have been cases where undisturbed dead grass serves as a good holding mechanism for new seed, but long-range results are unpredictable at this time.

Mylone, Vapam, chloropicrin, Vidden D, D-D, Telone, ethylene dibromide, dibromochloropropane, and Vorlex may be applied as a drench or rototilled into soil. This application followed by enough water to make an effective seal may do the job.

Methyl bromide is highly toxic and will always require a tarp

(Continued on page 26)

Nematode Control

(from page 14)

or polyethylene plastic cover. Chloropicrin is a tear gas and should be used with caution also.

Before any fumigation, operators should see that the area to be treated receives plenty of water so that all seeds in the soil will be in the process of germination. Fumigants are most effective on growing organisms.

Post-plant Control Methods

Post-plant or established stand control is a newer innovation, not previously possible until the development of specifically nematocidal chemicals which would not kill desirable turfgrasses.

Two chemicals have been developed to control nematodes in mature turf.

The first is V-C 13, chemically known as *O*-2,4-dichlorophenyl *O*,*O*-diethyl phosphorothioate. Virginia-Carolina Chemical Company is the producer.

V-C 13 is a contact nematocide; the manufacturer claims no fumigating action. It is applied as a drench to pre-sprinkled turf at a rate of 1 gallon of 75% active ingredient formulation to 3,000 sq. ft. in 80 gallons of water carrier. For use on bentgrasses, apply ½ gallon to 3,000 sq. ft. Two applications spaced 2 weeks apart are advised for best results. Virginia-Carolina suggests drenching soil with sufficient water to carry the chemical deeper into soil. Action of the nematocide can be expected to give 6 months' control, the manufacturer says.

Normal precautions should be taken with V-C 13, an organophosphorous compound. Use a respirator to avoid breathing mist, and employ a coarse spray to prevent mist formation. If chemical is spilled, wash it off immediately, and do not permit chemical to remain on clothing. One should always wash up after chemical application regardless of whether any chemical has been noticeably spilled.

The second chemical is 1,2-dibromo-3-chloropropane, DBCP, for short. It is marketed by Shell Chemical Company under the trade name "Nemagon," and by The Dow Chemical Company as "Fumazone."

Applicators can dilute 2 pints of 70% emulsifiable concentrate (one of several formulations) in 200 to 300 gallons of water and apply to 1,000 sq. ft. This application will be equal to 5 gallons technical material per acre.

Prior to treatment, it is recommended that the turf be watered and possibly spiked or aerated to aid penetration. Immediately apply enough water to the treated area to wash the nematocide down through the thatch and into the root zone where the nematodes are active.

To work with DBCP, operators should have natural rubber gloves and boots to wear when measuring, transferring, or spraying chemical, because DBCP will cause reddening or irritation of the skin. Manufacturers also suggest applicators do not breathe vapors when mixing and applying; wear an approved respirator to protect both lungs and eyes.

DBCP is only slightly more toxic to man than V-C 13. In all cases, with all products mentioned, the label of the product should be read and studied before any application.

Neither V-C 13 nor DBCP is said to be toxic to turfgrasses when used according to directions. DBCP should not, however, be used within the dripline of desirable plants such as dwarf palm or crysanthemums.

Nematode service by CAs will increase as more homeowners become aware of nematodes, and as more becomes known about the organisms and chemicals for their control. CAs who wish to offer nematode control should engage in a study program using texts, research reports, and promotional and technical literature from manufacturers. Extra knowledge will place the aggressive CA in a more competitive position as the demand for nematode control increases.

Next month:
The Bermudagrass Mite