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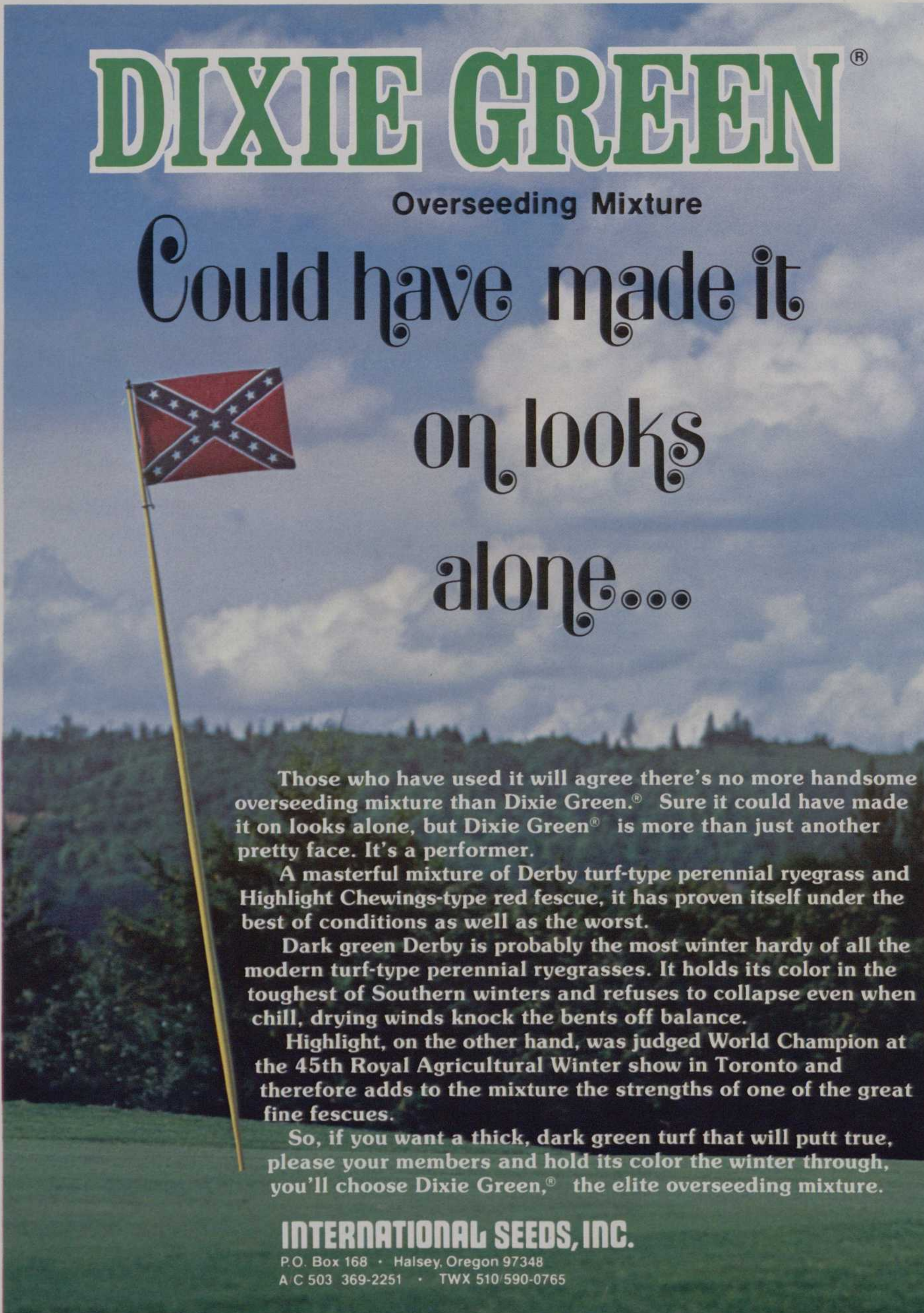
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be phenomenally inexpensive. "I bet I've spent no more than $200 per year in maintenance costs to keep the sprinklers in top working condition," says Flaherty.

Total cost of the system was approximately $300,000 in 1969, including installation by Wilpat Associates, Inc. of Springfield. Initial design work for the project, which took six months to complete was provided by Richard J. Jeske, Inc., a consulting engineering and design firm.

Prior to the automatic system, Flaherty relied on a traveling watering system. "My master satellite controllers provide much better accuracy than I got from the system," he explains. "And I've got a much better handle on the amount of water and money I spend to water the property."

Flaherty's very accurate records show that he spent $12,400 in 1979 for electrical power and water from the city. Fewer crewmen are needed to operate the automatic irrigation system than to drag around the old system, too.

Why automatic irrigation for this part of the nation where average rainfall can top 44 inches in a single year? Though the average rainfall is high, it tends to come during a relatively short period of time. Then, it's more rain than the grass can use. A few dry weeks and the grass will brown out.

Flaherty indicated that his watering cycle runs from approximately the third week in June until mid-September, depending upon natural rainfall. Though no week's schedule is the same as the previous week's, each of the 600 stations on his irrigation system receives one-half hour of watering per day during the irrigation season.

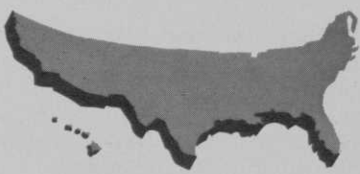
During tournament week, however, depending upon weather conditions, Flaherty will refrain from irrigating the greens. Should the weather be particularly dry, he may hand water carefully at rates which are sufficient to keep the grass alive. Normally, Flaherty waters all greens for approximately 10 minutes each morning following cutting.

Baltusrol's famous hillsides call for separate watering treatment. Sprinklers topside are allowed to run longer than those at the bottom in order to compensate for run-off.

During the winter months, the irrigation system lies dormat, the pipes cleared of water by compressed air. The official golf season runs from mid-April through mid-October, though Flaherty points out that some of the Club's 500 golf members will play anytime when snow isn't on the ground.

This Irishman is rightly proud of his golf courses. He was prepared for the onslaught of visitors the U.S. Open always brings but was just as glad to see them go and operations around Baltusrol return to normal. Like Baltusrol Golf Club, Flaherty is a traditionalist dedicated to keeping the grounds in tip-top condition so that the grand old game of golf can be played here the way it has for nearly 100 years — "the way it's meant to be played".

Determining the role of nematodes when plant growth is unsatisfactory is the most common problem



Diagnosis of nematode problems

By R. A. Dunn, Extension Nematologist,
Florida Cooperative Extension Service

It can be very difficult to decide if nematodes are causing, or are likely to cause, a plant growth problem. If you know from previous experience that a particular nematode pest was found in a site, plan to continue to take steps to avoid damage by the species. It is probably still present. In a location for which a complete history is lacking, the population density of nematode pests can usually be estimated by laboratory assay of soil and/or root samples.

The most common diagnositic problem is to determine the role of nematodes when established plants are making unsatisfactory growth. This task is often especially difficult because few nematodes cause distinctive diagnostic symptoms or signs. Therefore, a diagnosis may be based on any or all of these: symptoms above and below ground, field history, diagnostic namaticide tests and laboratory assay of soil and/or root samples.

Above ground symptoms are rarely, if ever, sufficient evidence to diagnose a root nematode problem. However, they are important because possible nematode problems are almost always first noticed because of abnormal top growth. Certain kinds of symptoms are typical of nematode injury to roots, and should always make one consider nematodes as possible cause for the inferior performance. They can also be used to help locate the most severly affected areas in the planting after the problem is diagnosed.

Since most plant nematodes affect root functions, most symptoms associated with them are the result of inadequate water supply or mineral nutrition to the tops: chlorosis (yellowing) or other abnormal coloration of foliage, stunted top growth, failure to respond normally to fertilizers, small or sparse foliage, a tendancy to wilt under less stress than healthy plants, and slower recovery from wilting. Woody plants in advanced stages of decline incited by nematodes will have little or no new foliage when healthy plants have substantial flushes, and eventually exhibit dieback of progressively larger branches. "Melting out" or gradual decline is typical of nematode-injured turf. Invasion by weeds that should not be able to compete with healthy turf is another common sign of nematode damage. The distribution of nematodes within any site is very irregular. Therefore the shape, size, and distribution of areas showing the most severe effects of nematodes will be highly irregular within the field. Nematodes move very few feet per year on their own. In undisturbed turf, visible symptoms of nematode injury normally appear as round, oval, or irregularly lobed areas which gradually increase in size year by year. Nematode damage is often seen first and most pronounced in areas under special stress, such as heavy traffic, excessive drainage because of slope or soil structure, and outside regular irrigation patterns.

Below ground symptoms are more useful than top symptoms for diagnosis of many nematode problems. Galls, abbreviated roots, necrotic lesions in the root cortex, and root-rotting may all be used to help diagnose nematode problems. Short roots are the most frequently recognized symptom of nematode injury to turf. Abbreviated root systems may be caused by several kinds of nematodes.

Feeding by many ectoparasites (living on the outer surface) such as sting, awl and stubby-root nematodes, causes root elongation to stop. The root tips sometimes swell when they stop growing in length, and often become much darker in color than uninjured root tips. Lateral roots often emerge from the root a short distance behind the injured root tip; if a series of lateral roots are injured as they emerge, the end of the root acquires a bunchy or bushy arrangement of very short roots that is very characteristic of sting or awl nematode injury.

Abbreviated roots can also be caused by migratory endoparasites (inhabiting the internal tissues). When lesion or lance nematodes cause extensive physical wounds in the fleshy cortex of host roots, fungi which could not ordinarily penetrate the intact root are often able to colonize the injured tissues and, from there, rot through the entire root. Rotted mature tissues at the tip of the root are a clue that endoparasitic nematodes and/or root-rot fungi rather than octoparasitic nematodes may have shortened the roots.

Root-knot nematodes injure and reproduce in many grasses, including improved bermudagrasses and St. Augustine grass, but may not cause growth of obvious galls on the roots. Absence of large galls does not rule out root-knot nematodes as possible primary cause of turf decline. Distortion of root growth and slight fusiform (broadest in the middle and tapering toward each end) swellings sometimes result from rootknot infection of turf grasses.

The only turf nematode which can be seen without magnification on its host root is the St. Augustine grass cyst nematode *(Heteroda leuceilyma)*. The adult females are visible as tiny white beads attached to the roots of its host. About the size of the period at the end of this sentence, each is a small, lemon shaped capsule full of eggs which will become tan, then deep brown, after the female has died. Once one becomes familiar with their appearance, he can diagnose cyst nematodes on St. Augustine grass without further aid.

Field history can provide valuable clues to the identity of nematode and other pest problems. A nematode which has been present in recent years is probably there yet, and is likely to cause injury to susceptible plants again. Prolonged rotation to non-host plants may sharply reduce the population by starving them, but rarely eliminates them entirely.

Nematicides may be used to help diagnose the role of nematodes in some situations. Application of a nematicide which is known to be effective against the pest species present can sometimes help to determine their importance. In such trials, it is best so apply the treatment to no fewer than four areas of the suspect field, leaving adequate untreated areas for comparison.

Laboratory Nematode Assay is usually necessary to complete a diagnosis. A variety of methods may be used to extract nematodes from soil and plant tissues representative of their areas in question. When the kinds that are present and their relative population densities (concentration, numbers) are known, those data can be compared with experimental data and field observations to estimate injury to that crop by that population under those conditions.

As a result of many years' experience, the relative importance of many nematodes to the various turf grasses has been established, and a scale of approximate threshold levels has evolved. However, these action levels often vary because of the effects of cultural conditions and turf vigor on turf grass's sensitivity to a specific level of injury. There is also wide variation in how much injury is acceptable, depending on use of the grass, personal aesthetic standards, and maintenance budget. You must also realize that the specific numbers used as thresholds for one laboratory may not be the same as those for another laboratory which uses different nematode assay techniques.

Nematode Sample Collection and Handling. The objective is to take a sample or samples which are representative of a specific area and to get them to the laboratory in as nearly as possible the same condition in which they existed in the field. Following are instructions for collecting a nematode sample, adopted from the Florida Nematode Sample Kit. The kit is a package available at county extension offices for anyone who wishes to use the services of the Florida Nematode Assay Laboratory. (Ed. note: Those in other states should contact their local extension agent for specifics on available kits.)

1. The sample should be prepared from a mixture of 10 to 20 "cores" of soil. Cores are most easily taken with a soil-sampling tube, auger, or trowel. A shovel may be used by cutting a 1-inch thick slice of soil through the soil profile and discarding all but a 1 to 2-inch vertical band from the slice. It is often best to discard the top 1 inch from each core, since nematode numbers may be very low there.

2. Where to sample. When diagnosing a problem of growing plants, always sample near living roots of the plants for which diagnosis is needed. It may be helpful to submit an additional sample from an adjacent area of good growth for comparison. Sample only when soil moisture is appropriate for working the field; avoid extremely dry or wet soil conditions for best results. Specific directions for different crops are as follows:

A. Annual crops (most vegetables, annual ornamentals, and field crops) - take soil from root zones of 10 - 20 affected plants that are not yet dead. Include "feeder" or fine roots from several of them. Remove the surface inch of soil before taking each core 6 - 8 inches deep.

B. Fruit and nut trees, perennial shrubs and trees - if many plants are affected, include cores or subsamples from several of them in the sample. If only one or a few are affected, take several cores from around each plant. Use a spade or shovel to dig down within the "drip-line" (the area covered by the branches) to find fine feeder roots. Each subsample or "core" should consist of a few fine roots and soil from immediately around them. Discard roots and soil from the surface inch. For burrowing nematode of citrus, collect roots and soil from below 12 inches.

C. Turf grasses and forage crops - collect 10 to 20 cores from declining, but not yet dead, areas. Collect cores 3 - 4 inches deep in the root zone of the desired plant species, avoiding bare spots and weeds.

The above article was excerpted from the Florida Turf Grass Pest Control Manual, Nematode Diagnosis section.

Abstracts continue on page 31

Table 1.

Approximate threshold levels (number/100cc soil) for the most common nematodes which injure turfgrasses, used in the Florida Cooperative Extension Service Nematode Laboratory. Control is usually recommended when numbers of a particular nematode exceed the level shown in the table. Control may be suggested at lower population levels if more than one serious nematode pest species is present, or if other stresses such as diseases or insects are also excessive. Other nematodes which cause problems on turf less frequently are not included in this table.

Common name	Scientific name	Bermuda	St. Augustine	Centipede	Bahia	Zoysia
Sting	*Belonolaimus longicaudatus*	10	10	10	10	10
Lance	*Hoplolaimus* spp.	40	40	40	40	40
Stubby root	*Trichodorus* spp.	40	40	40	40	40
Stunt	*Tylenchorhynchus* spp.	80	80	80	80	80
Ring	*Criconemoides* spp.	*	*	150	*	80
Root-knot	*Meloidogyne* spp.	80	80	*	??	??
St. Augustine grass cyst	*Heterodera leuceilyma*	*	10	*	*	*
Spiral	*Helicotylenchus* spp.	150	150	150	150	150

*Research data do not indicate a need to control this nematode on this grass species, regardless of population level, in most circumstances.

Table qualifications

1. Threshold levels of these same nematodes may be very different for different species of turfgrasses.
2. Other nematodes may be damaging to turf in other states; this table reflects the most common Florida situations.
3. Cultural problems and environmental stresses can alter the damage levels.
4. These are based on sandy soils (generally over 90% sand); thresholds for many species would be higher on heavier soils. Sting nematode is not a problem in soils with less than about 85% sand.
5. If more than one serious nematode pest is present, there may be serious damage without numbers of any species exceeding the normal threshold, because of additive or complementary effects of the damage from all species present.
6. Different lab techniques may produce very different numbers from the same sample. Each lab should develop its own thresholds, based on local conditions and its own procedures.

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