Plant Parasitic Nematodes

PLANT NEMATODES ATTACK ALL PLANTS grown in Florida. They cause farmers and nurserymen millions of dollars in crop loss annually, but also can cause problems in the urban world by damaging turfgrasses, ornamentals and home gardens. We are often unaware of losses caused by nematodes because much of the damage caused by them is so subtle that it goes unnoticed or is attributed to other causes.

Some scientists estimate that there are over 1 million kinds of nematodes, making them second only to the insects in numbers. However, few people are aware of nematodes or have seen any, because: Most nematodes are very small, even microscopic, and colorless; most live hidden in soil, under water, or in the plants or animals they parasitize; and relatively few have obvious direct effects on humans or their activities.

Of all of the nematodes known, about 50 percent are small animals living in marine environments, and 25 percent live in the soil or fresh water and feed on bacteria, fungi, other decomposer organisms, small invertebrates or organic matter. About 15 percent are parasites of animals, ranging from small insects and other invertebrates up to domestic and wild animals and man. Some of the parasites of animals are the largest nematodes known: some from grasshoppers can be several inches long, and one from whales can reach lengths of more than 20 feet! Only about 10 percent of known nematodes are parasites of plants.

Morphology and Anatomy. Plant nematodes are tiny worms usually 0.25 mm to 3 mm long (1 / 100 " to 1 / 8 ") and cylindrical, tapering toward the head and tail. Females of a few species lose their worm shape as they mature, becoming pear-, lemon- or kidney- shaped. Plant parasitic nematodes possess all of the major organ systems of higher animals except respiratory and circulatory systems. The body is covered by a transparent cuticle, which bears surface marks helpful for identifying nematode species.

Life Cycle and Reproduction. The life cycle of a plant-parasitic nematode has six stages: egg, four juvenile stages and adult. Male and female nematodes occur in most species, but reproduction without males is common, and some species are hermaphroditic (Afemales@ produce both sperm and eggs). Egg production by the individual completes the cycle. Most species produce between 50 and 500 eggs per female, depending on the nematode species and their environment, but some can produce more than 1,000 eggs. The length of the life cycle varies considerably, depending on nematode species, host plant, and the temperature of the habitat. During summer months when soil temperatures are 80 to 90?F, many plant nematodes complete their life cycle in about four weeks.

Nematode Feeding and Host-Parasite Relationships.
Plant parasitic nematodes feed on living plant tissues, using an oral stylet, a spearing device somewhat like a hypodermic needle, to puncture host cells. Many, probably all, plant nematodes inject enzymes into a host cell before feeding to partially digest the cell contents before they are sucked into the gut. Most of the injury that nematodes cause plants is related in some way to the feeding process.

Ectoparasitic nematodes feed on plant tissues from outside the plant; endoparasitic nematodes feed inside the tissues. If the adult female moves freely through the 61 soil or plant tissues, the species is said to be Amigratory.@ Species in which the adult females become swollen and permanently immobile in one place in or on a root are termed Asedentary.@ Migratory endoparasitic and ectoparasitic nematodes generally deposit their eggs singly as they are produced, wherever the female happens to be in the soil or plant. Sedentary nematodes such as root-knot (*Meliodogyne* spp.), cyst (*Heterodera* spp.), reniform (*Rotylenchulus* spp.), and citrus (*Tylenchulus semipenetrans*) nematodes produce large numbers of eggs, which remain in their bodies or accumulate in masses attached to their bodies.

The feeding/living relationships that nematodes have with their hosts affect sampling methods and the success of management practices. Ectoparasitic nematodes, which never enter roots, may be recovered only from soil samples. Endoparasitic nematodes often are detected most easily in samples of the tissues in which they feed and live (burrowing and lesion nematodes), but some occur more commonly as migratory stages in the soil (root-knot and reinform nematodes).

Endoparasitic nematodes inside root tissues may be protected from those kinds of pesticides that do not penetrate into roots. Root tissues may also shield them from many microorganisms that attack nematodes in the soil. Ectoparasites are more exposed to pesticides and natural control agents in the soil.

Foliar nematodes (*Aphelenchoides* spp.) are migratory nematodes that feed on or inside the leaves and buds of ferns, strawberries, chrysanthemums and many other ornamentals. They cause distortion or death of buds, leaf distortion, or yellow to dark-brown lesions between major veins of leaves. Other nematodes that attack plants above ground, but are not common in Florida, cause leaf or seed galls. Still others cause deterioration of the bulbs and necks of onions and their relatives.

Diagnosing Nematode Problems

Determining if nematodes are involved in a plant growth problem is difficult because few nematodes cause distinctive diagnostic symptoms. A sound diagnosis should be based on as many as possible of: symptoms above and below ground, field history, and laboratory assay of soil and/or plant samples.

Above-ground symptoms. It is rare that above-ground symptoms give sufficient evidence to diagnose a nematode problem in the roots. However, they are important because they are almost always the reason that nematode problems are first noticed. 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 tendency to **wilt more readily** than healthy plants, and slower recovery from wilting. Woody plants in advanced stages of decline caused by nematodes may exhibit **dieback** of progressively larger branches. A**Melting out,**@ or gradual decline, is typical of nematode- injured turf and pasture. Plantings stunted by nematodes often have **worse weed problems** than areas without them because the crop is less able than it should be to compete with weeds.

Distribution. The distribution of nematodes within any site is **very irregular,** so the shape, size and distribution of areas with the most severe effects of nematodes will be erratic within the field. Nematodes move very few feet per year on their own. In the undisturbed soil of groves, turf and pastures, visible symptoms of nematode injury normally appear as **round, oval or irregular** areas that gradually increase in size year by year. In cultivated land, nematode-injured spots are often **elongated in the direction of cultivation** because nematodes are moved by machinery. Erosion, land leveling, and any other force that moves masses of soil or plant parts can also spread a nematode infestation much more rapidly than it will go by itself. Nematode damage is often **seen first** and most pronounced **in areas under special stresses**, such as heavy traffic, excessive drainage because of slope or soil and dry areas outside regular irrigation patterns.

Below-ground symptoms may be more useful than top symptoms for diagnosing nematode problems. **Galls** caused on roots by root-knot nematodes, **abbreviated** 62 **roots** or **stunted root growth,** necrotic **lesions** in the root cortex, and **root rotting** may all be symptoms of nematode problems. An experienced observer can often see cyst nematodes (*Heterodera*, *Globodera* and *Cactodera* spp.) on the roots of their hosts without magnification. The young adult females are visible as tiny white beads, about the size of a period on this page. After a female cyst nematode dies, her white body wall is tanned to a tough brown capsule containing several hundred eggs. Important cyst nematodes found in Florida include soybean cyst nematode (*H. glycines*) on soybeans and a few leguminous weeds, beet cyst nematode (*H. schachtii*) on cabbage and related plants, St. Augustine grass cyst nematode (*H. leuceilyma*) on St. Augustine grass and cactus cyst nematode (*C. cacti)* on Christmas cactus and related plants. *H. cyperi* is a cyst nematode occasionally found infesting nutsedges (*Cyperus* spp).

Field history. Accurate field history can provide valuable clues to the identity of nematode and other pest problems. A nematode that has been present in the field in recent years is probably there yet, and is likely to injure susceptible crops if environmental conditions are favorable. Production records that show a gradual decline in yields over a period of years despite no change in cultural practices may indicate progressive development of a nematode problem. A nematode infestation in a new field usually begins in a small area. It gradually intensifies in the original spot and is spread through the field by cultivation, harvest, erosion and other factors that spread infested soil or plant parts. Therefore, the total effect of a recently introduced nematode is a gradual production decline for the field, as the percentage of the field that is involved and the severity of damage at any given area in the field increase over the years.

Laboratory assay. Laboratory analysis of soil and/or plant tissue samples is often necessary to complete a diagnosis. In the lab, nematodes are extracted from soil and plant tissues, identified, and counted. Those results can be compared with research and field observations to determine whether or not the crop is likely to be injured by the population under those conditions. In some cases, specific steps to reduce the numbers and/or effects of a particular nematode species are recommended only if the population density exceeds some predetermined level felt to represent the threshold for economic loss of that crop. Such thresholds are determined through longterm experience of nematologists with that pest and crop in growers= operations and in controlled experiments.

Principles of Nematode Management

For many reasons, nematode management is not and should not be a matter of simply identifying a specific pest and then applying a chemical nematicide that is effective against it. There are many situations for which no safe, effective chemical nematicide is available. Most chemical nematicides are relatively toxic, so they are hazardous to people, pets, and other animals if handled carelessly. Most nematicides are environmentally risky because of their toxicity. Unfavorable environmental conditions and/or events can make all nematicides less effective than expected. Nematicides are expensive. Many cultural practices can affect how seriously nematodes affect a planting and how effective nematicides are if they must be used.

Carefully combining many of the following practices into an **integrated nematode**

management program often will help keep nematodes below damaging levels, and improve effectiveness of nematicides if they are available and must be used.

Preventing a nematode problem is far better than trying to treat one after it is established. Many serious nematode pests are widespread, but some are quite limited in distribution, either from one region to another or from field to field. One can avoid carrying serious nematode problems into uninfested land by knowing that nematodes are spread in contaminated soil and plant parts. Good sense dictates working in areas that are not infested with nematodes before moving to those that are infested, to avoid carrying contaminated soil or plants to the uninfested field. Ornamental cuttings to be rooted should be taken only from uninfested plants or portions of plants from above ground that have never been rooted in potentially 63 contaminated soil. This prevents propagating populations of nematodes that might seriously reduce growth and might cause the plants to be unfit for shipment to many potential markets because of quarantines. Quarantine is governmental action taken to prevent importing a pest into a previously uninfested area, usually by controlling movement of contaminated soil and plant material.

Crop rotation is a very old practice for reducing soil-borne problems. Many nematodes, soil-borne disease organisms and insects can reproduce and survive on only a few plants. Repeatedly planting a field with the same crop without interruption will enable any organisms that reproduce successfully on that crop to continue to increase. Rotation to non-host crops may interrupt nematode reproduction and allow natural mortality factors to reduce their numbers. By carefully planning the sequence of crops to be planted in a particular field it may be possible to avoid excessive build-up of pests of all of the major cash crops in the cycle.

In a few instances, it is even possible to include a crop in the rotation that will help control pests that have built up in preceding crops in the cycle. For instance, hairy indigo can be planted as a summer cover crop to reduce numbers of sting and rootknot nematodes, and pangola digitgrass is used to control burrowing and root-knot nematodes in vegetable lands in Florida and in the West Indies. The many kinds of plant nematodes in Florida complicate selection of rotation crops, because crops that reduce some species of nematodes may favor the increase of others. Despite the difficulty, a good rotation program should be a basic component of land/crop management plans because of the multiple benefits that can be derived from it.

Crop root destruction gets far less credit than it deserves as a nematode management practice. Nematodes, soil-borne diseases and many soil-borne insects will continue to feed and multiply on crop root systems as long as they remain alive. When soil temperatures are high, each month that a root system continues to live represents an additional generation and potential increase of about 10-fold for many nematodes. Even when soil temperatures are gradually declining, a two-month period may support at least one additional generation. Therefore, destroying root systems as soon as a crop is finished can stop nematode reproduction and should encourage their decline through normal mortality.

Flooding may sometimes be used to help reduce numbers of nematode pests. It is practical only where the water level can be controlled easily and maintained at a high level for several weeks. Where flooding can be practiced, alternating periods of about two or three weeks of flooding, drying and flooding again are apparently much more effective than a continuous period of flooding. The soil should be worked during the periods of drying to increase aeration and drying of soil and to prevent weed growth while the soil is exposed. Flooding probably kills nematodes by providing a long period without host plants rather than by some direct physical effect on the nematodes. It is also important to consider the possibility that flooding with contaminated water may actually spread some soil-borne pests such as nematodes.

Fallowing is leaving a field with no plants on it for a prolonged period to starve nematodes or other pests. Most nematodes will decrease after a period of time without plants on which to feed. For fallowing to be effective, the field should be cultivated regularly to prevent growth of weeds and to expose new portions of the soil to the effects of drying and heating. If weeds are allowed to grow in fallow land, many kinds of nematodes may be able to survive and reproduce on the weeds, making the practice ineffective.

Resistance of plants to a specific pest is usually the least expensive and most effective means of minimizing losses to that pest. However, successful use of varietal resistance requires knowing the extent and limitations of the resistance and which pests are present in a particular situation. There are Anematode resistant@ varieties of tomatoes, soybeans, southern peas, sweet potatoes, cotton and tobacco available for use in Florida, but each of these varieties has resistance that is effective against only one, two or at most three species of nematodes; none are Anematode proof.@ It is necessary to know the pest species present in a field to select a variety with the appropriate resistance. In addition, varieties with the appropriate resistance must 64 be adapted to cultural conditions and requirements of your area. Another limitation to using nematode resistance as a major management practice is that high temperatures often weaken or destroy the resistant effect. Tomatoes Aresistant@ to root-knot nematodes may not be able to limit nematode reproduction or effects if soil temperature is hotter than 81?F. It also is still necessary to use other methods to control any other nematodes that are present, because the resistance against one or two species is not going to affect the ability of any other nematodes to injure the crop.

Biological Control

Many different bacteria and fungi that are nematodes= natural enemies have been isolated from nematode populations apparently being kept at low levels by the bacteria and fungi. Nematologists have been able to use some bacteria and fungi to reduce populations of some kinds of nematodes under laboratory conditions, but successes at the full-scale field level have been few.

Most organisms recognized as promising for biological control of one or more nematode pests are quite specific in which nematodes they will attack, have been very difficult to culture in sufficient quantities to be useful for field application, or both. The conditions under which each is most effective are often quite specific and limited. Commercially effective biological control as a means to reduce the effects of nematodes on any cultivated crops may still be many years away. Nematicides sometimes can be very profitable when used correctly in appropriate situations. However, their effects are almost universally short-lived, so they should be used in conjunction with other practices that minimize nematode re-infestation of a planting and reproduction.