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Nematodes - Little Known Pests Of Plants

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We are asked so often by greenhouse operators and nurserymen about nematodes, the symptoms of nematode injury, how nematodes are brought into an area, and the control of nematodes that two articles on this subject are being prepared.

Nematodes are unsegmented round worms, not closely related to any other form of animal life. This group of animals is made up of several thousand species that live in soil, fresh water, and salt water as well as several hundred kinds that live on, and in, animals and plants This means that most nematodes—like most fungi and bacteria—are harmless, saprophytic sorts that live on decaying organic matter, while only a few, relatively speaking, attack animals and plants. In this parasitic group is included pinworms, ascarids, and hookworms of man, and foliar, root-knot, cyst and lesion nematodes of plants. Nematodes were first demonstrated as the cause of a disease of wheat in 1775, while root-knot, the best known nematode disease, was first discovered in 1855.

Plant parasitic nematodes often may be a problem and cause serious losses in perennial as well as annual crops in all parts of the United States. The expansion of research in nematology in the last 20 years brought recognition of the widespread occurrence of plant parasitic nematodes, discovery of many new kinds, increased information as to host plants, and further knowledge on the distribution of nematodes that had been known for a long time. The information accumulated in the last 50 years indicates that almost all crop and ornamental plants can be attacked by one nematode or another. Although several kinds of parasitic nematodes must have been present in greenhouses and fields for a number of years, we are just now becoming aware of the damage they cause. That growers have failed to see nematodes and connect them with the visible crop injury is understandable when we realize that plant parasitic nematodes range in size from less than one sixty-fourth to approximately one eighth inch. Equally important, most nematodes do not cause characteristic and distinctive symptoms that clearly distinguish their damage from all other injuries.

The life-cycle of only a few nematodes have been studied and much remains to be learned. Some kinds of nematodes progress from egg to adult in 25-30 days, others may take 75 days. In general, the higher the soil temperature (up to 85-90°F), the shorter the time necessary to complete a life-cycle. When the soil temperature drops below 50°F, nematodes become almost inactive. Of course, the active adult life span varies too—a root-knot female may live only 20 to 30 days, while dagger, ring and some other nematodes may live 12 to 18 months or even longer. As to reproduction, a root-knot female may lay from 500 to 1000 eggs, while a female meadow nematode will lay only one egg per day. An increase in nematode population is favored by light, well-drained soil, soil moistures that are favorable for good root growth, fairly high soil temperatures and repeated cropping to susceptible plants. With a combination of favorable environment and suitable host plants, the nematode population can increase very rapidly. Many of these nematodes survive the winter. The unprotected stages in the life-cycle, however, are killed by exposure to temperatures too low to kill most fungi (110°F for 2 hours, 120°F for 10 minutes, 140°F almost instantly) and by relatively low dosages of a number of soil fumigants.

The presence of a spear or stylet is a structure common to all plant-attacking nematodes. This stylet is a hollow, hypodermic needle-like structure that is used to withdraw food from the plant cells. In certain kinds of nematodes the spear also is used to inject fluids which aid in breaking down the cell contents. The nematode can then easily assimilate the cell contents with little further digestive breakdown.

Nematodes may be internal parasites (endo-parasitic) or external parasites (ecto-parasitic). Each group can be further sub-divided into sedentary (settled or stationary) and migratory (wandering or roving) types. Although a few kinds do not fit perfectly into any single category, most forms are readily classified. These terms are generally accepted and will come into common usage.

Symptoms of Nematode Attack

Plants affected by root-attacking nematodes may have root galling, general root browning or lesions, short, stubby roots, swollen root tips, or may have excessive root branching. The *majority* of root-attacking nematodes *do not* cause root galls or root-knots. Such galls or knots are produced by nematodes of the genus *Meloidogyne* (root-knot nematodes), although a swollen root tip condition caused by *Xiphinema* species (dagger nematodes) may sometimes be confused with root-knot. The feeding of nematodes on roots not only reduces the effectiveness of the root system, but also provides entry for root rotting micro-organisms. Consequently, above-ground, an attacked plant may show dwarfing, yellowing, a tendency to wilt, and frequently the appearance of a nutritional deficiency. As pointed out earlier the above-ground symp-

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toms are not specifically characteristic of nematode injury. The same symptoms may, and can, be caused by fungus root rot or wilt organisms, by insects attacking the roots, and occasionally by mineral deficiencies. This lack of distinctive and characteristic symptoms is doubtless a principal reason for the failure for so many years to recognize the damage caused by nematodes.

Plants attacked by leaf and bud nematodes (*Aphelenchoides sp.*) may show dwarfing, browning, distortion, crinkling of leaves and leaf drop.

Plants affected by stem and bulb nematodes (*Ditylenchus sp.*) may have galls on the leaf or stem, swollen, hard chlorotic spots, or stem and flower distortion. In bulbs such as narcissus, iris, hyacinths, these nematodes attack and digest the intercellular lamellae causing the parenchyma cells to become loose and spongy. These loose cells die and a brownish ring develops.

Diagnosis

A positive diagnosis requires that a number of individuals of the same parasitic nematode be found either in tissue or in soil in the root zone. If bulb and stem, or leaf and bud nematode is suspected, only the affected tissue is necessary to determine the presence of these nematodes. This infected plant tissue is teased apart in water under a microscope and the worms observed. Nematodes attacking the roots are somewhat more difficult to determine. In some cases they may be within the roots, in others in the soil surrounding the roots, and in still others they may have moved to other plants especially if the root system has decayed. To recover root-attacking forms the roots and surrounding soil must be processed by some method and the nematodes recovered and examined microscopically. In most instances the symptoms shown by the plant are a definite help in diagnosing nematodes as the cause of the trouble.

Dissemination of Plant Parasitic Nematodes

Movement of nematodes from one part of the globe to another or from one region of a country to another occurs most commonly in and on plants and plant parts, especially on plants in soil or on moist roots. Movement within localized areas can be accomplished through movement of soil or water, on animals including man, and even by wind. Although seed may carry nematodes into new areas, this is not important to greenhouse or nursery crops.

Present day quarantine regulations hinder the introduction and spread of many kinds of pests but cannot prevent entry of all pests indefinitely.

Can Nematodes be Controlled?

As a basis for this discussion of control we need to define certain terms that are used frequently. "Eradication" of parasitic nematodes means the complete destruction or extermination of all such organisms whether in seed, root, leaf, or in soil in a greenhouse bench or field. "Control" of parasitic nematodes means diminishing and maintaining the population at such a level that damage is negligible.

For the grower the principal question in setting up a control program is that of possible profit to be obtained —whether the increase in salable product will pay all expenses of the control program and a reasonable profit. We know that a good pre-planting treatment program pays real dividends; we do not have sufficient experience with post-planting treatments to say one way or the other.

Nematodes can be controlled—but not necessarily eradicated—by certain treatments of infected plant material, by chemical or steam treatment of soil *before* planting, by chemical treatment of plants *after* planting, or by a combination of such treatments. As in any control program, sanitation, crop rotation, fallowing, selection of planting stock, and certain other cultural practices aid and contribute in varying degrees to the control of nematodes.

Plant Treatments

Hot water-formalin treatment is an effective eradicant of nematodes in dormant narcissus, iris, and lily bulbs. A hot water treatment alone is effective in eradicating certain kinds of nematodes in strawberry, chrysanthemum, peony, tuberose, lily-of-the-valley, fern, begonia, etc. Some plants will not tolerate formalin, but if formalin can be used it helps to kill nematodes as well as control secondary fungus rots. The maximum temperature and duration of exposure that plants will tolerate varies considerably from one kind of plant to another. Plant tolerance as well as the minimum temperature and duration of exposure that will kill the nematode involved must be determined by small scale trials.

Certain chemical treatments are effective in preventing or eradicating nematode infection in some plants. Sodium selenate applied as a drench to the soil is effective in controlling leaf nematode (*Aphelenchoides ritzema-bosi*) on chrysanthemum. Parathion included in the spray schedule is likewise an effective control for leaf nematode on chrysanthemum. Systox applied as a spray to narcissus is reported to eradicate the bulb nematode (*Ditylenchus dipsaci*). Sodium selenate is extremely poisonous to man and animal and should never be applied to soil that may be used to grow food for either man or animal.

Soil Treatments

Pre-planting treatments with steam (180°F for 30 minutes) or a chemical fumigant (Vapan, methyl bromide, chloropicrin, D-D, ethylene dibromide, Telone, etc.) if done properly will give good commercial control under field conditions or complete eradication in raised benches or water-tight ground beds. A grower must realize that complete eradication of nematodes in field soil is literally impossible; therefore, pre-planting treatment of field soil may be required each year or every two to three years. Although pre-planting treatments are less than perfect, their use permits one or more good crops before the nematode population increases sufficiently to limit plant growth.

Post-planting treatments (treating established plant in place) are a comparatively recent innovation. About 4 years ago Nemagon and VC-13 became available through the Shell Chemical Corporation and the Virginia-Carolina Chemical Corporation, respectively. Fumazone (same active ingredient as Nemagon) was marketed by the Dow Chemical Company in 1956. Although these

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materials are effective as pre-planting treatments, they are most interesting and worthwhile for post-planting application. These chemicals effectively reduce the nematode population *in the soil* and are safe to established plants. However, nematodes *inside* the root tissue (*Pratylenchus sp.* and *Medidogyne* sp.) are not killed. For post-planting application simply dilute and apply the material in sufficient water to distribute the chemical evenly over the area to be treated, then apply additional water to carry the chemical throughout the root zone. Fumazone, Nemagon, and VC-13 are relatively slow acting, but have long residual toxicity to nematodes.

The discovery of safe, effective post-planting treatments is a major development in control of plant parasitic nematodes. This type of treatment may well be an answer to keeping perennial crops free of nematodes.