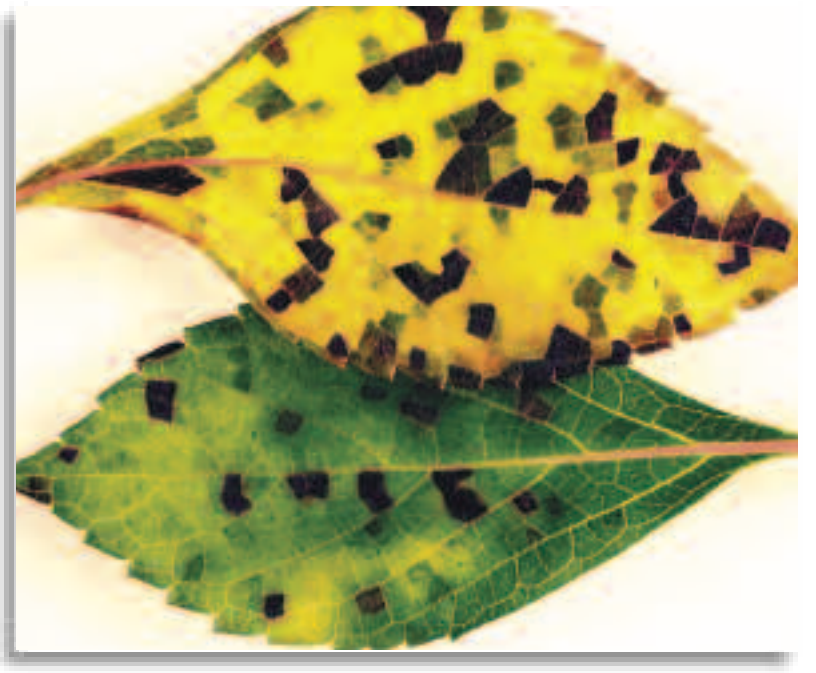
Plant Parasitic NEMATODES

Diagnosis and management of nematodes in herbaceous perennials.

By James LaMondia



Aphelenchoides symptoms on salvia. (Photos courtesy of James LaMondia)

Nematodes are some of the most numerous multi-cellular animals on earth. They exist in a vast array of ecologic relationships and may be found in almost every kind of ecologic niche available, from the arctic to deserts or the depths of the oceans. A handful of soil may contain many thousands of these microscopic worms. Most are free-living species that feed on bacteria, fungi, algae or other nematodes. Many are parasites of insects, plants or animals. Most nematodes cannot be seen without a microscope, but some animal parasites may be measured in meters.

The nematodes that growers and gardeners are most familiar with and concerned about are the plant parasitic nematodes. They are simple, consisting of only about 1,000 somatic cells in a "tube within a tube" body form. The exterior tube is the outside body wall or cuticle, and the interior tube is the digestive tract that extends from the anterior mouth to the anus near the tail. Plant parasitic nematodes have a stylet, a spear-like mouthpart used to cut into or pierce plant cells. They possess digestive, nervous, excretory and reproductive systems but do not have circulatory or respiratory systems. They cannot see, so they find their way through soil to hosts by means of physical cues and chemical receptors.

Top left: *Root galls and egg masses resulting from northern root-knot nematode,* Meloidogyne hapla *infection and reproduction.* ***Top right:*** *Symptoms of root-knot infection include variously sized galls which may have secondary decay.* ***Bottom left:*** *Excessive root branching resulting from root-knot infection.* ***Bottom right:.*** *Root-knot juvenile infection may result in swollen root tips.*

Plant parasitic nematodes live in water films in soil or in and around plant parts such as roots, stems and leaves. They may be general feeders or have very specific host-parasite relationships with a limited number of host plants. Management of plant parasitic nematodes is challenging in many cropping systems but can be especially challenging in ornamentals for a number of reasons. Herbaceous perennials are a diverse group of about 2,500 species in about 500 different genera. This diverse group of plants can be quite valuable, with annual gross receipts of approximately $1 billion in 1994 in the United States alone. In addition, perennials are propagated by a number of techniques, including seed, division and cuttings. The use of vegetative methods of propagation such as division are often preferred, as they are easier and may produce better, more uniform plants as well as reduce variation within cultivars. Unfortunately, vegetative propagation may result in the unintended propagation of low populations of plant parasitic nematodes in non-symptomatic plants, increasing the spread and distribution of these nematodes and the extent of nematode problems.

NEMATODE PESTS

The northern root-knot nematode, *Meloidogyne hapla*, is the most important nematode pathogen affecting a wide range of flowering herbaceous perennials in the Northern United States and Canada. Root-knot nematodes are sedentary endoparasites, meaning that they stay in one place, feeding on nutrient-rich cells in which they initiate inside the root. Juveniles hatch from eggs; infect roots, usually near root tips; establish feeding cells that result in root galls; and develop into swollen females. These females produce a large number of eggs in egg masses that are produced outside the female body. Symptoms of root-knot infection include variously sized galls, excessive root branching and swollen root tips. Above ground, plants are often stunted, off-color and exhibit symptoms of poor root function. *Meloidogyne hapla* is of particular concern for the Northern United States and Canada, as this species can readily over-winter and over time, increase in number on perennials in these areas.

Plant parasitic foliar nematodes can also cause severe damage to a large number of flowering ornamentals in nurseries and landscape plantings. The range of symptoms observed on flowering ornamentals can vary considerably with plant and nematode species, but leaves, stems, flowers or buds are commonly distorted, dwarfed and killed. There are two different plant parasitic nematodes that can attack aboveground plant parts. The most common foliar nematode, *Aphelenchoides fragariae*, was listed as able to attack more than 250 plants in 47 families, including many flowering ornamentals. *Ditylenchus dipsaci*, the stem and bulb nematode, has been found in more than 450 host plants, including both monocots and dicots. Both of these nematodes are widely distributed and can quickly ruin foliage and flowers.

Aphelenchoides spp., common name foliar nematodes, are microscopic, worm-like nematodes 0.018-0.047 inches in length. These migratory nematodes usually feed inside foliage. Depending on the host plant, nematode feeding may cause necrotic lesions delimited by veins in crops such as hosta or salvia, or bronzing and discoloration of the foliage in crops such as begonia and anemone. Injured leaves will eventually desiccate, all or in part. Foliar nematodes can survive desiccation for years and may survive without the host or be dispersed in dry, dead tissue. When rehydrated, plant infection occurs after nematode movement in water films or water splash. Nematodes in water films on surfaces that dry quickly are killed; so long periods of leaf moisture increase dispersal and nematode survival during movement. Once inside new leaves, reproduction occurs rapidly. Females lay 25-32 eggs each that can hatch within 3-4 days and mature in 6-12 days, completing the entire life cycle in about two weeks.

Ditylenchus dipsaci, the stem and bulb nematodes, are vermiform, and adults are 0.031-0.055 inches long. These nematodes can infect stem, leaf and bud tissues, causing swellings, distortion and necrosis. Stem and bulb nematode infection is often masked by infection as a result of secondary pathogens such as Botrytis, a common secondary fungus on *Phlox subulata*. These nematodes can live at a wide temperature range, 41-86° F, although optimum temperature is 59-68° F. Ditylenchus females produce 8-10 eggs per day with a total of 200-500 per female. The juvenile goes through one molt in the egg, hatches and molts three more times before becoming an adult. The entire life cycle can be completed in 19-23 days.

Numerous surveys have detected foliar nematodes on annual and perennial flower species worldwide. We have recently recovered the foliar nematodes Aphelenchoides and Ditylenchus from field-grown and potted nursery plants in Connecticut, Massachusetts and New York. Aphelenchoides has been a recurring problem on several plant species, and a number of new hosts have been recently identified. Ditylenchus is a particular problem on the flowering perennial *Phlox subulata*. Both nematodes can increase populations rapidly to tremendous numbers per leaf, and detached or dried leaves can disperse populations. Infection can quickly become widespread and damaging. Both nematodes can survive for long periods of time in dried plant debris.

***Top:** Aphelenchoides symptoms on hosta. **Bottom:** Aphelenchoides symptoms include bronzing and discoloration of the foliage of anemone.*

TREATMENT

The concept of initial damage threshold levels, namely that the amount of damage to plant growth is a result of the number of nematodes present at planting, may not apply to nematodes infecting perennials. Low initial nematode densities may greatly increase on susceptible perennial hosts after the planting year and may cause damage over time.

Because of this, control of root-knot nematodes in perennials presents a particular challenge. Managing nematodes in high-value ornamentals previously meant using systemic nematicides such as aldicarb or oxamyl. The current lack of labeled nematicide management options requires nursery and landscape nematode management programs based on sanitation and rotation. Sanitation, accomplished by identifying and eliminating *M. hapla*-infested planting stock and rotating with non-host species, can be effective, especially for field-grown perennials, although the successful use of rotation requires knowledge about the host status of a large number of plant species. The host suitability of *M. hapla* to nearly 100 common perennials grown in the Northeast has been investigated and published. In addition, we determined that root pruning of bareroot planting stock can greatly reduce or eliminate *M. hapla* infection and reduce the potential spread of the nematode. Planting resistant plants, such as *Rudbeckia fulgida* or aster, into *M. hapla*-infested soils may also reduce or eventually eliminate populations of this nematode.

Control of nematodes in foliar plant parts can be extremely difficult. Diagnosis of plants with foliar nematodes is often confounded by additional infection with fungal pathogens such as *Botrytis cinerea*. Nursery and greenhouse crops have little or no tolerance, as any nematode-infested material usually results in the establishment and spread of the nematode. Sanitation, avoidance and irrigation water management may help slow the spread of foliar nematodes, but there are no chemical nematicides registered for post-plant nematode control. This lack of control options may be responsible for the recent increased frequency of diagnosed foliar nematode infestations in the Northeast.

INSECTICIDES

In a series of experiments over several years, we determined that certain foliar-applied insecticides have limited activity against foliar nematodes. Avid (Syngenta Professional Products) is labeled for use on ornamentals to control mites and leafminers and had previously shown some activity against both root-knot and foliar nematodes. Avermectins have been shown to be nematicidal, reducing nematode infectivity, hatch, oxygen uptake and motility. Diazinon (Gowan Company) is listed as a means of foliar nematode control in the Cornell Recommendations for Integrated Management of Greenhouse Florists Crops, but little information on efficacy is available. Pylon (Olympic Horticultural Products), clorfenapyr, is labeled for foliar nematode control in the greenhouse. ➧

Top: Ditylenchus dipsaci *symptoms on phlox.*
Right: Ditylenchus dipsaci, *stem and bulb nematode, stem gall symptoms.*

In our experiments, Avid application to foliage at two rates (5.6 or 11.2 ppm ai) in one or two applications of each rate reduced the number of nematodes recovered from *Lamium maculatum* foliage, but it did not eliminate them. There were no differences in effects of the two rates, labeled for spider mites or leafminers, respectively, and no phytotoxicity was observed. There were no differences in efficacy between one or two Avid applications one week apart. *Ditylenchus dipsaci* in *Phlox subulata* were partially controlled by up to four weekly applications of Avid or Diazinon. Neither Avid nor Diazinon completely controlled the Ditylenchus stem and bulb nematodes, even after four applications. There were no significant differences between Avid and Diazinon. In additional greenhouse experiments, Pylon and Avid, at label rates, had some activity against foliar nematodes, but control was incomplete and results were inconsistent between experiments.

Management of large nematode populations by insecticide application would be extremely difficult, especially in light of the high reproductive potential and low tolerance of these pathogens in commercial production. Control of low populations would be easier to achieve and maintain. Therefore, the integration of nematode-suppressive chemicals such as Avid, Pylon or Diazinon on foliage combined with cultural control tactics such as sanitation, the removal of diseased plants or tissues from a crop or between plantings, and the exclusion of infected plant parts from compost piles; environmental modification such as the management of leaf wetness by reducing overhead irrigation frequency; and increasing air flow through a crop will be necessary to manage foliar nematode infection.

Management of root-knot on herbaceous perennials must also be multifaceted and may include: the selection of pathogen-free propagation stock, the reduction of non-symptomatic low level infections by root tip pruning at propagation, and rotation to non-host or root-knot resistant plants. Any suspect plants should be examined by a nematode diagnostic lab prior to placement in the nursery or landscape. GPN

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