Nurserymen face many decisions in their efforts to profitably produce healthy, quality trees and shrubs. For any given commodity, the grower must consider economic, environmental, and practical constraints when deciding what variety or cultivar to grow, what site to choose, and what management methods to employ throughout a production cycle.

No management scheme should overlook the potential of pests, including parasitic nematodes, to reduce nurserystock quality and profitability. Plant parasitic nematodes are roundworms (Phylum Nematoda) barely visible to the naked eye. They destroy or impair plant roots by direct feeding or by promoting fungal and bacterial decay. Infested plants may be stunted, off-color, lack vigor, or exhibit loss of drought and winter hardiness.

**Background** - In the past, a heavy emphasis was placed on nematicides for controlling parasitic nematodes. However, complete control may not be achieved with nematicides and is usually temporary.

*The philosophy of using chemicals as a sole management tool to "control" nematodes has become obsolete.*

Strategies to "manage" nematodes are now based on keeping nematode populations below levels where damage causes economic losses to the host crop. And, with recognition of the economic and environmental costs associated with using chemicals, nematode management should integrate cultural, biological, and chemical tactics.

Management with biocontrol organisms involves stimulation or introduction of natural predators and parasites.

*Predators include other nematodes, soil arthropods such as mites and collembola, and protozoa.*

Fungi and bacteria are the most important parasites. Biocontrol organisms account for much of the regulation of nematodes in nature but have been of limited success on an agricultural scale. Egg-colonizing fungi (e.g., *Paecilomyces* spp., *Verticillium* spp.) have promise in controlling
cyst and root-knot nematode infestations (13). This article will focus primarily on cultural practices for managing plant parasitic nematodes.

**Nematode Identification** - The most important information required before choosing and implementing a management practice is identifying the types of nematodes present, their population levels, and evaluating the damage potential for the specific crop to be planted. Late-season soil sampling is more informative than spring sampling and can easily be done by the grower. Identification of nematode populations requires a skilled nematologist usually located through a university, department of agriculture, or pest management consultant. Evaluation of damage potential for a specific crop/nematode population, which varies with soil temperature, soil type and moisture, and with the characteristics of different growing regions, is best done by a nematode advisory laboratory.

*Once the important nematode pests have been identified, cultural practices can be chosen that are tailored for a specific host/pest situation.*

Some of the major cultural methods include crop rotation, fallowing, weed control, use of resistant plant material when available, addition of soil amendments, and production practices that prevent the spread of infested plants and soil.

**Crop Rotation** - One of the oldest and most important methods for managing pests is crop rotation. By rotating a susceptible host crop with a nonhost crop, nematodes can be maintained below damaging levels. For example, corn is a good rotation crop for reducing populations of the northern root-knot nematode (*Meloidogyne hapla*) (11, 14), but population densities of other root-knot, stubby-root, lesion, lance, and ring nematodes may increase when corn is planted too long without rotation or when a rotation with nonhost or poor-host crop is too short (11). Wheat, barley, and other small grains are also good rotation choices to reduce northern root-knot nematode (*M. hapla*) and certain cyst nematodes (*Heterodera* spp., *Globodera* spp.) (12, 16).

An optimal rotation will also prevent buildup of other species that may damage future crops. Grasses and legumes affect nematode species differently; root-knot (*Meloidogyne* spp.) and lesion (*Pratylenchus* spp.) nematodes were suppressed, whereas ectoparasitic nematode levels such as stubby-root (*Paratrichodorus* spp.), spiral (*Helicotylenchus* spp.), and dagger (*Xiphinema* spp.) were increased under a number of grasses and legumes (7).

If lesion nematodes (*Pratylenchus* spp.) are present in damaging levels, rye has been shown to be significantly better than wheat or oats for reducing *P. penetrans* populations. However, whereas oats reduced *P. penetrans*, it promoted an increase in *P. crenatus*, another but less damaging species of lesion nematode (5). This highlights the importance of precise identification of the nematodes and the necessity of understanding what species are potentially damaging.

Unconventional rotation crops such as marigold (*Tagetes erecta, T. patula*) (10), crotalaria (*C. mucronata*) (3), and chrysanthemum (8) have also been tried with varying degrees of success.
One season of African marigolds (*Tagetes erecta*) followed by a rye winter cover crop resulted in lesion nematode (*Pratylenchus penetrans*) control equivalent to two granular nematicides and in significantly higher yield for the potato crop the subsequent year (1).

Marigold roots produce a chemical toxic to nematodes (6). The poor economic return of marigold reduces its desirability as an alternate crop, although the extracted yellow pigment is saleable for use in poultry feed and processing. Intercropping with marigold may suppress nematode populations without taking valuable land out of production (17).

Factors to consider in choosing a rotation cycle, in addition to the ability to reduce nematode populations, are the rotation effects on other soil organisms, including potential pathogens and insects, effects on soil fertility and structure, and the economic value of the rotation crops.

**Fallowing** - Most nematodes cannot survive periods without a host, so fallowing has often been suggested for reducing their populations. The best results are obtained when fallowing is timed to put maximum stress on the nematodes, i.e., during hot, dry weather, or when nematodes are in the most vulnerable stage of their life cycle (3). However, fallowing is unpopular for its negative effects on soil erosion, organic matter content and structure, and loss of production time.

*Short fallow periods may be as effective as seasonal fallowing.*

A six-week fallow in late spring in Georgia between the harvesting of tomato-transplants and planting of a cover crop was as effective as continuous fallow in preventing an increase in the population density of *Pratylenchus brachyurus* and *Trichodorus christiei* (3).

**Weed Control** - The principle of controlling weeds is similar to fallowing. Since nematodes may survive on weeds as well as on crops, weed control denies the nematode a food source. Weed control by plowing or disking also kills nematodes by exposure to drying on the soil surface.

**Resistant Plant Material** - Crop varieties and cultivars that are resistant to nematode damage or that do not allow nematode populations to increase are desirable as a nematode management tool. Under optimal conditions, target nematode species can be managed as well as or better than with nematicides (4).

*The biggest limitation on using resistant varieties is their availability.*

Development of resistant varieties is time consuming, and high value annual crops have received much of the attention. Varieties resistant to several root-knot nematodes and/or certain cyst nematodes have been developed for tomato, pepper, snap bean, sweet potato, sweet corn, and cowpea (4), potato, carrot, soybean, and tobacco.
Little research has been done in developing woody ornamentals resistant to nematodes. In only a few cases have nursery crops been evaluated for susceptibility to nematode injury. 'Blue Rug' juniper (*Junipers horizontalis*) and 'Spiny Greek' juniper (*J. excelsa stricta*) were severely stunted by the lesion nematode, *Pratylenchus vulnus*. 'Shore' juniper (*J. conferta*) was more tolerant. All three were resistant or tolerant to the stunt nematode, *Tylenchorhynchus claytoni* (2). Several different hollies have been tested (2). 'Dwarf Burfordi' Chinese holly (*Ilex cornuta*) was more tolerant than 'Rotunda'; and 'Compacta' Japanese holly (*Ilex crenata*) was more tolerant than 'Convexa', 'Helleri', or 'Rotundifolia' to ring (*Criconemella xenoplax*), lesion (*P. vulnus*), and stunt (*T. claytoni*) nematodes.

**Soil Amendments** - Soil amendments have reportedly reduced population densities of plant parasitic nematodes either by releasing substances toxic to nematodes or by stimulating soil-inhabiting microorganisms and antagonistic fungi. Ammoniacal nitrogen fertilizers have reduced some nematode populations, although the high rates of N required for nematode suppression can result in phytotoxic effects unless the formulation contains sufficient carbon to support metabolism of the added nitrogen (15). Organic amendments that release ammonia in the soil - for example chicken litter, composts, and green manure - have been effective due to their low carbon:nitrogen ratio (15).

**Sanitation** - Destroying infested plant material and preventing the spread of infested soil to uninfested land is always sound management. Lining out infested plant material will contaminate clean land.

Many cultural practices are available to nurserymen to manage damaging plant parasitic nematodes. No one tactic will be effective alone. By combining cultural, biological, and chemical methods in an integrated approach, the grower can design a management plan that is practical, environmentally sound, and economically feasible.

**Literature Cited**


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