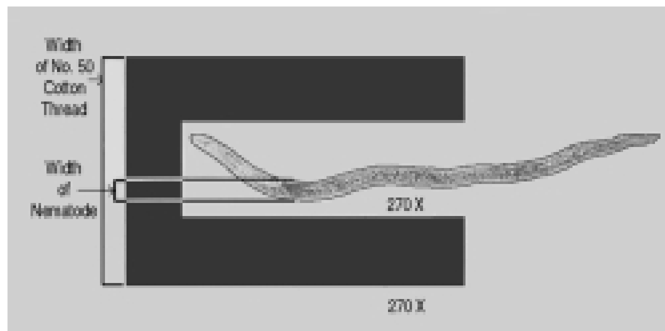
NEMATODE MANAGEMENT

CHAPTER 8

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand the basic biology of plant-parasitic nematodes.
- Be familiar with nematodes of importance in fruit crop production.
- Know the importance of monitoring nematode population densities.
- Understand the strategies and tactics used to manage plant-parasitic nematodes.



Nematodes are extremely small. Here a nematode is laid on top of a cotton thread to compare size.

INTRODUCTION

Nematodes are animals. More specifically, nematodes are non-segmented roundworms. They are closely related to segmented roundworms, more commonly known as earthworms. Adult nematodes can vary in length from 1/30 inch to nearly 9 feet. Nematodes are commonly found in soil or water, including oceans. They may be the most numerous multicellular organisms on earth. A shovelful of garden soil typically includes more than 1 million nematodes.

The majority of nematode species are regarded as beneficial. They feed on bacteria, fungi, and other soil-inhabiting or aquatic animals. Some feed on very specific foods; others are considered omnivores that can feed on a wide range of foods.

Some species of nematodes are parasites of plants and animals. The focus of this chapter will be plant-parasitic nematodes. Plant-parasitic nematodes share three common characteristics. First, they are all microscopic, with adults ranging in length from about 1/30 to ¼ inch in length. Second, they are obligate parasites of plants. This means they must have living plant tissue to feed on to grow and reproduce. Finally, they all possess stylets, which are structures similar to hypodermic needles that nematodes use to puncture plant cells and obtain the cells' contents. All plant-parasitic nematodes spend at least part of their life cycles in soil, although many are principally found in root or leaf tissue.

PLANT-PARASITIC NEMATODES

Plant-parasitic nematodes are microscopic animals that attack plants. Every species of plant has at least one species of nematode that parasitizes it. The majority of plant-parasitic nematodes (about 95 percent of the described species) feed on roots, either within the root tissue as endoparasites or outside as ectoparasites. Some nematodes feed within leaves. Plant-parasitic nematodes must have living host tissue to feed on to grow and reproduce. If the host dies, nematodes will disperse and search for other plants to invade.

Poor growth of replanted trees or plants is often the most obvious indication of a nematode problem. Aboveground symptoms may include stunting, short internodes and small leaves. Root systems are small and discolored and have poorly developed feeder roots.

Infected trees or plants often become non-productive earlier than normal. Plant-parasitic nematodes can also hinder the development of beneficial fungi necessary for normal plant growth. A few types of nematodes do produce characteristic symptoms or signs; these will be discussed when specific nematodes are described.

Nematodes, like insects, have exoskeletons. This outer covering must be shed or molted for a nematode to grow. A typical plant-parasitic nematode life cycle consists of an egg, four preadult stages (referred to as juveniles) and an adult. Females are often more destructive; males typically do not feed. In many species of plant-parasitic nematodes, males are rare or not known to exist. The life cycle of a plant-parasitic nematode may be completed in as little as two weeks or as long as two years, depending on the species and the temperature.

Because of their size, plant-parasitic nematodes do not move long distances on their own. They are usually transported over long distances on machinery, in nursery stock, on transplants or seed, or by animals. Anything that moves soil moves nematodes, including water and wind. Some nematodes are known to move a few feet vertically in the soil during a growing season when environmental conditions are adverse.

SAMPLING NEMATODE POPULATIONS

Plant-parasitic nematodes are microscopic organisms with concentrated distributions in a field. Since they tend to occur in clumps, symptoms usually occur in circular or elliptical patterns. If aboveground symptoms are uniformly distributed in any given field, the cause of the problem is typically not nematodes.

Points to remember when sampling for nematodes:

- Because of their microscopic size, the only way to diagnose a plant-parasitic nematode problem is to collect soil and/or plant tissue samples and send them to a nematode diagnostic lab for analysis.
- It is impossible to provide specific recommendations for the management of plant-parasitic nematodes unless they are properly identified.
- When collecting soil samples for plant-parasitic nematodes, the more soil cores gathered, the better the sample. However, it is necessary to submit only a pint to a quart of soil to a lab.
- For more complete instructions on sampling for nematodes, please refer to MSU bulletin E-2419, *Avoidance and Management of Nematode Problems in Tree Fruit Production in Michigan*.

MANAGEMENT OF PLANT-PARASITIC NEMATODES

The best defense against nematodes is to avoid them. Once fields or plant tissues are infected with nematodes, eradication is usually impossible. Nematodes are usually transported over long distances by machinery, in plant material, on animals, or by water or wind. Natural disasters such as floods are uncontrollable, but the patterns in which machinery is moved and the sanitation of this equipment can be controlled. These tactics should be considered when trying to avoid nematodes. The bottom line is that anything that moves soil moves nematodes.

Fields often become infested with nematodes. If samples indicate the presence of pest nematodes at action threshold levels, then steps should be taken to reduce their population densities. Many tactics can be utilized to accomplish this goal.

Biological controls: The majority of nematodes present in the soil are considered beneficial. They typically feed on bacteria, fungi or small animals, including other nematodes. Research results indicate that as the abundance of beneficial nematodes increases, the numbers of plant-parasitic nematodes decrease. Steps can be taken to increase the diversity and numbers of beneficial nematodes in fields. This type of approach is outlined in other MSU bulletins on crop ecology.

Many organisms are parasites or pathogens of nematodes. Most of these occur naturally in soils but often do not provide sufficient control of plant-parasitic nematodes. Some biological nematicide products are available, but their use has not resulted in consistent control of nematodes in Michigan.

Biotechnological controls: Plants have not been genetically modified at this time to control plant-parasitic nematodes.

Chemical controls: Nematicides are chemicals that kill nematodes. Nematicides are either **fumigants** or **non-fumigants**. Fumigants are typically compounds sold as liquids that react with water in the soil to produce gases that kill a wide variety of organisms, including beneficial and pest nematodes, fungi, plants and insects. They are usually applied to the soil in the fall or spring when soil temperatures are adequate. Fumigant nematicides are labeled for use in fruit production in Michigan. Please consult MSUE bulletin E-154, *Michigan Fruit Management Guide*, for specific recommendations.

Non-fumigant nematicides are also labeled for use in Michigan fruit production. Unlike fumigants, they do not volatilize in soil water. They can be applied before, at or even after planting in some situations. These compounds typically kill a narrower spectrum of organisms than fumigants but will typically kill both beneficial and pest nematodes. See MSUE bulletin E-154 for information on use of these materials.

Cultural controls: Cultural factors that affect nematode populations include the crop, length of time planted in the same crop, soil type and cover crop. Site selection and site preparation are very important components of nematode management in orchards and small fruit plantings. Plant only nematode-free trees or plants. Pay close attention to soil condition and fertility. Use cultivation and planting practices that allow unrestricted growth and development of root systems.

Site Selection and Preparation Guidelines

Before removing an orchard or small fruit planting:

- Examine the general vigor and root condition of the plants.
- Examine the soil structure for problems such as faulty drainage and hardpan.
- Do a complete chemical analysis of soil and foliage.
- Examine the soil and roots for plant-parasitic nematodes.

Immediately after plant/tree removal:

- Work the soil and remove as many of the remaining roots as possible.
- Plant a suitable cover crop. The choice of the cover crop depends largely on the nematode species present. Increasing organic matter and biological diversity in the soil decreases the risk of nematode problems.
- Do not replant with new trees or plants until at least one year after old ones are removed.

Soil preparation during the fall before planting:

- Cultivate, removing remaining tree roots and incorporating organic matter.
- Follow appropriate pH and soil fertility recommendations.
- If the nematode population is above the action threshold, a nematicide may be recommended.

Genetic controls: Some rootstocks are resistant to certain species of nematodes. Also, cultivars vary in their tolerances to nematodes.

Physical controls: These include the use of heat, steam or water (flooding) to reduce population densities of nematodes. In field situations, these types of controls are limited. In glasshouse or polyhouse plant production, heat or steam is typically used to sterilize growing media.

NEMATODES OF IMPORTANCE IN FRUIT PRODUCTION

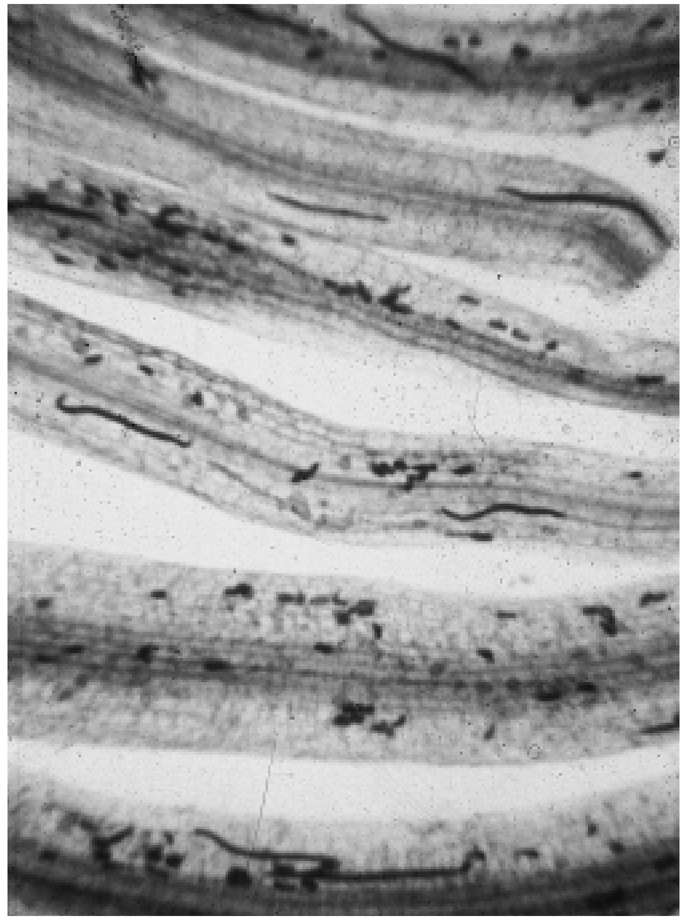
Lesion Nematode *(Pratylenchus penetrans)*

Type: Migratory endoparasite.

Host Plants: Virtually all species of cultivated plants.

Biology: Lesion nematodes overwinter as juveniles and adults within roots or in soil. These nematodes penetrate young roots. Once inside the root, they migrate between and through cells, often killing them.

Lesion nematode females lay eggs singly in root tissue or in soil. Females typically produce fewer than 100 eggs. Life cycles can be completed in three to four weeks, depending on soil temperatures. Lesion nematodes can complete multiple generations per growing season.



Lesion nematodes.

Symptoms: Penetration of roots by lesion nematodes results in very small lesions. These wounds create a point of entry for other soil pathogens, such as the fungi *Verticillium, Cylindrocarpon, Rhizoctonia, Colletotrichum* and possibly others.

Lesion nematode-infected plants typically have reduced root volumes and weights. Feeding and migration by these organisms kill cells. Feeder roots are usually destroyed.

MANAGEMENT

Avoidance:

Plant lesion nematode-free trees and plants. This is especially important in strawberry.

Population Reduction:

Cultural Controls: Lesion nematodes feed on virtually all species of cultivated plants, so they are difficult to manage with rotation. Utilizing sorghum or sudax as a rotational crop may help to reduce population densities of lesion nematode.

Chemical Controls: Nematicides may be necessary to maintain populations below the action threshold.

Dagger Nematode *(Xiphinema americanum)*

Type: Ectoparasite.

Host Plants: Most stone and small fruits.

Biology: Dagger nematodes are of concern to fruit producers because they are potential vectors of plant viruses known as nepo (**ne**matode-transmitted **po**lyhedral-shaped) viruses. Nepoviruses that are commonly vectored by *X. americanum* (the most common species of dagger nematode in Michigan) that affect small fruits and tree fruit are tomato ringspot virus (TmRSV), tobacco ringspot virus (TRSV) and peach rosette mosaic virus (PRMV). It requires only one dagger nematode to transmit a nepovirus to a host.

Dagger nematodes are large plant-parasitic nematodes that feed as ectoparasites on plant roots. All life stages overwinter, and adults can survive beyond one year. High population densities of these nematodes can injure the root systems of small fruit and tree fruit plants.

Symptoms: The feeding of this nematode often results in swollen root tips, prevents the root systems from functioning normally and often kills roots. Therefore, dagger nematodes can affect a plant's growth and yield even if they are not harboring viruses.

Tomato ringspot virus (TmRSV) causes stem pitting of peaches and cherries and brown ring union necrosis of apples and plums. Peach and cherry orchards affected by *Prunus* stem pitting exhibit an overall unthrifty appearance. Unfolding of leaf buds is delayed. The most characteristic symptom is spongy bark and pits in the trunk immediately above the soil line. Infected trees are severely stunted and die early. Prune trees infected with ring union necrosis exhibit a brown line at the scion-rootstock union. Trees are unthrifty and die early.

MANAGEMENT:

Late spring is usually a good time to check suspect trees or orchards for symptoms of these two diseases.

Avoidance:

Avoid contaminating sites with dagger nematode-infested soil. When possible, use bare-root nursery stock. Control of broadleaf weeds is imperative because these weeds often serve as hosts for nepoviruses.

Population Reduction:

Cultural Controls: Oilseed radish grown as a cover crop and incorporated into the soil will provide control.

Genetic Controls: Although apple is a host for *Xiphenema* spp., cultivars vary in their resistance or susceptibility to nepoviruses. Some rootstocks are tolerant to TmRSV (tomato ringspot virus), and some fruiting varieties are resistant, including Red Delicious and Jonathan.

Chemical Controls: Dagger nematodes are relatively easy to control with nematicides.

Ring Nematode *(Criconemella xenoplax)*

Type: Ectoparasite.

Host Plants: Hosts include stone, pome and small fruits. This species is more common on woody perennials than on annuals.

Biology: The life cycle of this species takes 25 to 34 days at 75° F under laboratory conditions. Females lay eight to 15 eggs over a two- to three-day period. Males are rare. Ring nematodes feed on cortical cells along roots as well as at the root tips. Once feeding is established, they do not move for extended periods of time.

Symptoms: Root systems fed on by this species generally lack feeder roots. In Michigan, ring nematodes have been implicated in increasing the susceptibility of sweet cherry trees on Mazzard rootstocks to a bacterium that causes bacterial canker (*Pseudomonas syringae* pv. *syringae*). Injured trees may become more susceptible to winter injury.

MANAGEMENT:

Avoidance:

Avoid contaminating sites with ring nematode-infested soil. When possible, use bare-root nursery stock.

Population Reduction:

Cultural Controls: Ring nematodes do not survive well in annual cropping systems, probably because of regular habitat disturbances. Tilling the soil will reduce population densities.

Using selected plants as ground covers may suppress *C. xenoplax* populations. Some marigold species (*Tagetes* spp.), for example, have demonstrated nematicidal properties against this nematode. Wheat also appears to have nematicidal properties against this species.

Genetic Controls: No resistance to this species has been identified in stone fruit. Partial tolerance in Lovell peach make it preferred over Nemaguard in locations infested with *C. xenoplax*.

Chemical Controls: Ring nematodes can be controlled with pre- and postplant nematicides.

Northern Root-knot Nematode *(Meloidogyne hapla)*

Type: Sedentary endoparasite.

Host Plants: Very wide host range includes virtually all vegetables and fruit crops.

Biology: The northern root-knot nematode (NRKN) overwinters in the soil as eggs. As soil temperatures increase in the spring, second-stage juveniles emerge, migrate through the soil and penetrate the roots of host plants. The nematodes establish feeding sites behind the root cap. As the infected root continues to grow, the vascular tissue differentiates in the area where the nematodes have fed. In otherwords, root-knot nematodes affect the plant's plumbing.

Shortly after successfully establishing a feeding site, the second-stage juvenile begins to swell and soon molts to a third-stage juvenile. Eventually, following two more molts, it matures to become an adult female or male nematode. Females are round and incapable of movement. Males are wormlike and generally exit the root because they do not feed. Female NRKN produce large numbers of eggs, up to 1,000, in a gelatinous matrix secreted by the anus.

The northern root-knot nematode can complete its life cycle in a month at optimal soil temperatures. Therefore, the nematode can complete multiple generations per growing season.

Symptoms: Northern root-knot nematodes restrict root growth by feeding directly within the vascular tissue of roots. This makes plants less efficient at taking up water and minerals from the soil. Typical symptoms are stunting, yellowing and reduced yields. Severely infested plants usually wilt during periods of hot, dry weather because the nematodes disrupt the xylem, the channels in a plant through which water moves.

NRKN invasion of roots causes small swellings on the roots called galls. Gall size depends on the number of nematodes feeding within them. On woody perennials, however, galls are not often evident.

MANAGEMENT

Avoidance:

Once established, root-knot nematodes are virtually impossible to eradicate. Therefore, attempts should be made to keep sites clean of northern root-knot nematode for as long as possible. This is accomplished primarily by using nematode-free plants and by not contaminating fields with northern root-knot nematode-infested soil.

Population Reduction:

Cultural Controls: Sites with histories of root-knot nematode problems should be kept out of fruit production for a period of two to four years. NRKN non-host crops such as corn or small grains should be grown to reduce population densities. Weed control is important because many weeds serve as hosts for the northern root-knot nematode.

Chemical Controls: Sites should be routinely sampled for plant-parasitic nematodes before establishing a new planting. If nematode population densities are recovered at action threshold levels, use of a nematicide may be advised. Root-knot nematodes are difficult to control with postplanting nematicides.

Genetic Controls: Root-knot nematode-resistant rootstocks may not necessarily be resistant to northern root-knot nematodes.

CHAPTER 8

Review Questions

Chapter 8: Nematode Management

Write the answers to the following questions and then check your answers with those in the back of the manual.

1. Nematodes are best described as:
   A. Animals.
   B. Bacteria.
   C. Earthworms.
   D. Fungi.

2. Plant-parasitic nematodes typically range in length from approximately:
   A. 1/3000 to 1/300 inch.
   B. 1/30 to 1/4 inch.
   C. 1/4 to 4 inches.
   D. 4 inches to 4 feet.

3. Which of the following is not a characteristic shared by all plant-parasitic nematodes?
   A. Complete their life cycles in usually 7 days.
   B. Microscopic.
   C. Obligate parasites of plants.
   D. Stylet-bearing.

4. How are nematodes similar to insects?
   A. They have compound eyes.
   B. They have three primary body segments.
   C. They possess an exoskeleton.
   D. They have legs and wings.

5. To reduce population densities of northern root-knot nematodes, you should:
   A. Encourage weed growth.
   B. Do nothing.
   C. Grow corn or small grains.
   D. Fertilize crops with nitrogen.

6. Which nematode would most effectively be controlled by disturbing soil?
   A. Dagger.
   B. Lesion.
   C. Northern root-knot.
   D. Ring.

7. If root-invading fungi such as Rhizoctonia or Verticillium are a concern, which type of nematode should be avoided?
   A. Dagger.
   B. Lesion.
   C. Northern root-knot.
   D. Ring.

8. Infection by which nematode causes severe damage to the plant's vascular system, often resulting in wilting and decreased water movement throughout the plant?
   A. Dagger.
   B. Lesion.
   C. Northern root-knot.
   D. Ring.

9. To diagnose a nematode problem, you should
   A. Collect a soil sample and place the soil in a paper cup on the windowsill and count the nematodes as they migrate to the top.
   B. Collect soil and plant tissue samples and send them to a nematode diagnostic lab for analysis.
   C. Ask an expert.
   D. Consult with a fortune teller.

10. Lesion nematodes would not be transported over long distances in which of these situations?
    A. By moving machinery from field to field.
    B. By planting plant material grown in contaminated soil.
    C. By applying leaf mulch.
    D. By soil erosion caused by flooding of the local river.

Match the following words with their definitions.

A. Juvenile
B. Stylet
C. Nematode
D. Root

11. ____ The part of the plant nematodes usually feed on.
12. ____ A young nematode.
13. ____ Piercing/sucking mouthparts that allow nematodes to puncture cells and suck out the contents.
14. ____ A small non-segmented roundworm.

15. The majority of nematodes are considered beneficial.
    A. True.
    B. False.