

Nematodes and the Home Garden

Northern version

Introduction

Plant-parasitic nematodes are probably the least understood of all the organisms that cause disease of plants. However, they are the most numerous animals on our planet. It is estimated there are up to a million nematodes or more in a shovel-full of garden soil. The majority of these nematodes are beneficial, indirectly aiding in plant growth. However, some of the nematodes, the plant parasites, can have negative impacts on plant growth. The purpose of this publication is to provide information on the role of nematodes in home gardens and landscapes.

Nematodes are non-segmented roundworms. This separates them from the segmented roundworms, which are earthworms and their relatives. Nematodes are aquatic animals occurring anywhere water is found including oceans. Adult nematodes range in size from about 1/10th of an inch in length to around 100 inches. They are all typically long and thin which is important so that the tissues of their bodies can receive oxygen as it diffuses in through their skins (cuticles). The majority of the nematodes found in soil are microscopic, typically less than ½ inch in length. The longer nematodes tend to be parasites of animals including man. For example, dog heartworm adults are roughly 12 inches in length.

Because the majority of nematodes are microscopic and are never seen by home gardeners, their presence usually goes undetected. The symptoms of their feeding, however, are often observed when growing and harvesting plants. One very important consideration when trying to manage nematodes is that it is impossible, in general, to control them unless they are properly identified. To accomplish this, it is necessary to collect samples and send them to a laboratory where nematodes can be extracted from the soil and/or plant tissues, identified and enumerated. Many land grant universities have diagnostic laboratories capable of performing these tasks. There will typically be a fee associated with a nematode test, so it is best to contact an area laboratory for a price list.

Vegetable Gardens

All vegetable crops are susceptible to root-knot nematodes, *Meloidogyne sp.* In temperate areas, the northern root-knot nematode, *Meloidogyne hapla*, is most common. Root-knot nematodes get their name from the primary symptom caused by their feeding which are swellings on the roots of their hosts called galls or knots. Feeding by northern root-knot nematodes typically results in very small galls when compared to those caused by southern species. However, on most vegetables, even these small galls are fairly conspicuous. These galls function as little protective houses for the root-knot nematodes.

Northern root-knot nematodes overwinter as eggs in the soil. When host plants are sown or transplanted in the spring, their roots quickly come under attack by these nematodes. Young nematodes are attracted to a certain region of the root and often congregate there.

This region is an area where the vascular system (the plumbing of the plant) has not yet formed. The nematodes begin feeding in this area and as the root continues to grow and the vascular tissue develops, the nematodes are there to steal the plant's carbohydrates and disrupt water flow. It is often said that root-knot nematode-infested plants often seem starved for water.

Female root-knot nematodes are prolific egg producers. A single female may produce up to 1,000 eggs and these nematodes will complete multiple generations (egg to adult) over the course of a growing season. Small gardens can quickly become overrun by root-knot nematodes.

Typically, nematodes by themselves do not kill their hosts. If the host dies, the nematodes often die with it. This is especially true for root-knot nematodes because once they start feeding they are incapable of movement. Root-knot nematodes can regulate their numbers and impacts on their hosts by reversing sex. Male root-knot nematodes do not require nearly as many calories as females and obviously do not produce eggs. If a host is weakened significantly, the nematodes communicate chemically so that females sex-reverse and become males. This eases the burden on the host allowing it to survive which, of course, is beneficial to the nematodes. Usually, if plants die, nematodes are not the sole cause.

Like all species of nematodes in gardens and fields, root-knot nematodes are virtually impossible to eradicate from these environments once introduced. Therefore, steps must be taken to minimize their impacts. If numbers are high, reducing their population densities is necessary to maximize yields in the garden.

The best management strategy against root-knot nematodes is to avoid them. Of course, this is often easier said than done. Root-knot nematodes will usually be introduced into new habitats in infested plants, so transplants should be inspected for galls and if observed these plants discarded. Typically, if new garden sites were previously in sod, northern root-knot nematodes will probably not be present. However, many weeds are hosts to these nematodes, so areas where native plants are growing may be infested. To diagnose their presence, collection of a soil sample(s) is required.

To reduce population densities of northern root-knot nematodes, rotation to grasses for 2-4 years is recommended. Since many vegetables, especially carrots, are highly susceptible to these pathogens, the longer the rotation, the better.

Some cultivars of tomato have resistance to certain species of root-knot nematodes. However, most vegetables do not have resistant varieties. Another impact of these nematodes is they may render plants susceptible to other pathogens for which they are bred to be resistant. This is termed resistance-breaking and the role of nematodes is well documented.

Try to keep root-knot nematode-infested plants as healthy as possible. Be sure to fertilize with ample potassium as this element seems to play a key role in a plant's ability to

withstand stress. Keep plants watered. Try to maintain a healthy soil, one with a high organic matter. The numbers of beneficial nematodes are often higher in soils with high organic matter (healthy) with lower numbers of plant-parasitic nematodes. Try to keep weeds under control.

Another control tactic that can be used against northern root-knot nematodes is growing radish as a trap crop. Radish functions as a trap crop as long as they are harvested or killed before the nematodes produce eggs. Because the nematode swell and become immobile after entering the roots of the host, removing the host will eliminate the nematodes. Successful use of a trap crop requires close monitoring of the nematodes because it is important to destroy the crop prior to egg production. If the nematodes are allowed to produce eggs, the benefit of the trap crop is lost. Don't worry about consuming these radishes if infested with root-knot nematodes. Think of it as a little protein boost with your carbohydrates.

Vegetables are also susceptible to other types of plant-parasitic nematode especially lesion nematodes. Please read the information under small fruit gardens for information on lesion nematodes.

Small Fruit Plantings

This section will include the impacts of nematodes on blueberry, raspberry and strawberry. All these plants are susceptible to at least one species of plant-parasitic nematode. In fact, all described plant species have at least one documented nematode parasite.

Strawberry and raspberry are susceptible to lesion nematodes, *Pratylenchus sp.* In most temperate growing regions, the most common species is *P. penetrans*. In many locations, lesion nematodes are the most frequently detected of all the plant-parasitic nematodes.

Lesion nematodes get their name from to the fact they produce very minute wounds (lesions) on the surfaces of the roots they penetrate. Unlike root-knot nematodes, these nematodes do not swell upon entering the host. They continue to migrate throughout the root feeding and killing cells in the root cortex. They are typically attracted to the smallest feeder roots and in the case of severe infestations, these roots are often killed resulting in root systems of reduced volumes and weights. Lesion nematode-infested plants often do not compete well for soil nutrients and water.

The wounds produced by lesion nematodes are often utilized by other plant pathogens to invade plants. Bacteria and fungi need wounds to enter hosts, so lesion nematodes are said to predispose plants to other plant pathogens. Lesion nematodes interact with many soil fungi such as *Colletotrichum*, *Rhizoctonia* and *Verticillium*, the latter two which are important pathogens of particularly strawberry. With these interactions, the combined impacts of the two pathogens can significantly reduce plant growth and yields.

Lesion nematodes overwinter as juveniles (pre adult life stages) and adults. They prefer to overwinter in roots but also will in the soil. They penetrate young roots in the spring and females lay eggs within root tissue. Lesion nematodes females do not produce nearly as many eggs as root-knot nematodes. However, similar to root-knots, lesion nematodes can complete multiple generations per growing season with a generation time of roughly a month.

Lesion nematodes can be found in all soil types although similar to other types of plant-parasitic nematodes, sandy soils tend to be nematode-loving soils. They can be found in soils with wide ranges of pH.

Strawberries are extremely sensitive to lesion nematodes. They often interact with *Rhizoctonia* to cause black root rot of strawberry. If strawberries are purchased from a nursery infested with *Rhizoctonia* and planted into a lesion nematode-infested site, these plants will probably be a productive for only a year or two.

Raspberry is also susceptible to lesion nematodes. Steps should be taken to avoid planting raspberries in a location where *Verticillium* may be present as lesion nematodes can predispose plants to this fungus. The interaction of these two organisms will shorten the life of raspberry plantings.

Blueberries are grown in low pH, high organic soils and appear to tolerate lesion nematode feeding fairly well. However, lesion nematodes can stunt the growth of blueberry if present in high population densities.

Lesion nematodes are very difficult to control using crop rotation as most plants grown in gardens are hosts. Clean fallow will reduce population densities. Pearl millet is a very poor host.

Because lesion nematodes are so common, avoiding them is virtually impossible. The purchase of pathogen-free planting stock is important. Most plants will tolerate some feeding from lesion nematodes, so minimizing the impacts of other pathogens is an important management tactic.

Perennial plants are susceptible to dagger nematodes, *Xiphinema sp.* Dagger nematodes are nematodes that feed with their bodies outside of the root and they use their stylets (similar to hypodermic needles, all plant-parasitic nematodes possess stylets) to puncture cells. Dagger nematodes are pathogens of plants but the primary concern is their abilities to vector certain plant viruses. Only one dagger nematode is required to acquire a virus from an unhealthy plant and transmit it to a healthy one.

All fruit, small and tree, are susceptible to at least one virus transmitted by the American dagger nematode, *X. americanum*. Two of the most common viruses transmitted by these nematodes are tobacco and tomato ringspot viruses. Blueberry and raspberry are susceptible. Infected plants will be severely stunted and produce very low yields. Typically, these viruses are only spread by dagger nematodes.

Dagger nematodes are more frequently encountered in perennial cropping systems than annual ones because they are sensitive to soil disturbance. Regular cultivation will reduce population densities of these nematodes. They do not like dry, hot soils, so frequent cultivation should provide good control.

Positive detection of viruses is critical to minimize the impacts of these nematodes. Rogue out and destroy virus-infected plants. Efforts should be made to remove as many roots as possible. Soil in these areas should be churned regularly. If this is not feasible, plant a grass for two years and be sure to control weeds. Many broad-leafed weeds, especially dandelion will harbor these viruses, so good weed control is critical. Grasses can host dagger nematodes but viruses are not passed onto their offspring through eggs. The viruses must be acquired through feeding and grasses are not hosts. Rape can also be used to control dagger nematodes but it can become a weed if allowed to go to seed. If rape is grown, plow it down as a green manure prior to flowering.

Dagger nematodes have fairly long life cycles and adults can survive for over a year. They do not produce large numbers of eggs. They prefer sandy soils.

Herbaceous Perennials, Annual Beddings Plants and Flower Gardens

This section encompasses many plants species and cultivars thus providing a tremendous amount of genetic diversity. Plants in this section are susceptible to northern root-knot and lesion nematodes and information on those two parasites has already been provided. Lesion and root-knot nematodes are typical of most plant-parasitic nematodes in that they feed on cells located within the roots. However, there are a small number of nematodes that occur in the foliage and they will be covered here.

Two species of foliar (leaf) nematodes, *Aphelenchoides fragariae* and *A. ritzema-bosi* are often detected in temperate growing regions. Both these species have wide host ranges but *A. fragariae* is often associated with *Begonia*, ferns, *Lilium*, strawberry and violets whereas, *A. ritzema-bosi* is more common on other plants. In general, foliar nematodes are a more significant problem in green or poly houses than outdoors mainly because they don't survive readily over the winter unless host foliage or weed hosts are available.

Feeding by foliar nematodes results in death of plant tissues resulting in leaf blotches. The form and pattern of these blotches varies from plant species to species and is closely correlated to leaf anatomy and venation. In most dicotyledonous hosts, leaves are rather thin, so the main veins subdivide them into areas with little or no continuity of intercellular spaces between them. The veins act as barriers to nematode movement. The nematodes reach other sections of a leaf by emerging from stomata and migrating over the surface in water film. The result is a leaf with discrete areas showing different stages of discoloration. In some plants with thicker, fleshier leaves such as *Begonia* or *Cyclamen*, the veins do not act as barriers resulting in irregular areas of discoloration with poorly defined margins. Because foliar nematodes typically crawl from the soil onto

stems, lower leaves are the first to exhibit symptoms. Often these leaves, when they die, will cling to the stems.

Foliar nematodes have relatively short life cycles going from egg to adult in approximately 2 weeks. Females can produce large numbers of eggs, so symptoms can occur and spread fairly rapidly.

Try to purchase plants free of foliar nematodes symptoms. There are no post-plant chemical control options, so infested plants should be removed from the garden and destroyed. To reduce the spread of foliar nematodes, try to minimize leaf to leaf contact of susceptible plant species like *Anemone* and *Hosta* and reduce over head irrigation which can spread the nematodes in splashing water. Good air flow around plants is advantageous as this will result in faster drying of leaf surfaces. Sanitation is highly beneficial. Always try to remove as much old, dead leaf material as possible as these are preferred overwintering sites. Good weed control is imperative.

Stem nematodes, *Ditylenchus sp.*, also feed on leaf tissues. *D. dipsaci* is the most commonly encountered species of stem nematodes in temperate climates. It has a very wide host range but is most associated with plants propagated as bulbs or corms. Like with foliar nematodes, woody plants are not often attacked by stem nematodes.

These nematodes overwinter as fourth-stage juveniles and adults in plant tissues or the soil. When moisture is adequate, the nematodes migrate from their overwintering sites onto the stems and leaves of young plants. Maximum activity of these nematodes coincides with the principal growing periods of most hosts, especially annual ones. Females can produce up to 500 eggs and live 10 weeks or longer. The life cycle can be completed in about 21 days in optimal conditions. These nematodes are very active early in the spring and egg laying can commence at temperatures less than 40⁰F. Cool, wet springs favor stem nematodes although symptoms of their feeding may not become evident until the summer.

Stem nematodes can persist for long periods of time. They are quite resistant to desiccation and cold temperatures. These nematodes will often form aggregates of large numbers of individuals (sometimes called “eelworm wool”) to survive during adverse conditions. Even in a dried state, these nematodes will become active very quickly in water. Therefore, populations will decline in fields in the absence of host plants due to rewetting and drying out of old plant tissue and soil.

The symptoms caused by *D. dipsaci* infections vary depending on the plant species attacked. Narcissi and tulips are very susceptible to these nematodes but the symptoms differ on these two hosts. On narcissus, the typical symptom is the presence of pale-yellowish, blister-like swellings on the leaves called spickels and concentric brown rings when the bulbs are cut open (transverse section). The spickels are best seen before flowering when the leaves are actively growing. If the nematodes are present at low population densities, it may be easier to feel the spickels than see them.

On tulips, infestations are best detected at flowering. The initial symptom is a pale or purplish lesion on one side of the stem immediately below the flower which bends in the direction of the lesion. These bulbs do not show brown rings as with narcissus, hyacinth or *Allium* when cut across. Infestations start at the base of new bulbs. Upon removal of the outer brown scale, soft grayish or brownish patches can be observed on the outer fleshy scale.

D. dipsaci also parasitizes many herbaceous perennials and one frequently attacked is creeping phlox, *Phlox subulata*. Infested shoots are typically thickened and brittle, with shortened internodes with a tendency to split. However, symptoms on creeping phlox are unique with crinkling and reduction of laminae of the upper most leaves, the uppermost which may be reduced to filaments, principally petioles and midribs. Severely infested plants often have a hollow appearance like they are being eaten “from the inside out.” *Rhizoctonia* may interact with stem nematodes on creeping phlox increasing the severity of the symptoms.

Like with other nematodes, steps should be taken to avoid stem nematodes. Avoid planting bulbs, corms or tubers that may be infested with these nematodes. Try to purchase these items from reputable nurseries. This advice is also pertinent when purchasing herbaceous perennials especially creeping phlox. If the plants look unhealthy in flats or pots at the nursery or garden center, chances are they will remain that way when planted into the home landscape.

It is best to rogue out any plants that exhibit symptoms due to stem nematodes. As with other plant-parasitic nematodes, it is necessary to have plant tissue tested to obtain positive diagnoses of their presence. It should be noted that both foliar and stem nematodes are quite difficult to diagnose in soil samples.

For other cultural tactics used to control stem nematodes such as plant spacing, watering, etc., see the information on foliar nematodes. It is also important to note that many weeds also serve as hosts to stem nematodes, so good weed control is important.

Other Nematodes

There are many other types of nematodes that will feed upon garden plants. However, the most common and important ones have been covered in this publication. Grasses grown in home lawns are hosts to over 10 different types of plant-parasitic nematodes, the most common being ring, spiral and stunt nematodes. Consult other publications for information on these nematodes.

Upon perusing trade journals, advertisements or articles on entomophagous (entomophilic) nematodes may be observed. These are a group of nematodes that can provide biological control of many soil-inhabiting insect species. Typically, it is recommended that these nematodes be applied at rates of 2-4 billion per acre quite often for control of grubs although they are often used in greenhouses to control fungus gnat and shore fly larvae. Although they are nematodes, these nematodes are not parasites of

plants and will not harm vertebrates. In certain situations, they have been demonstrated to provide good to excellent control of some species of insects.

Chemical Controls

There has been little or no mention of chemical controls in this publication for nematodes in home gardens. Most nematicides (chemicals that kill nematodes) are restricted use pesticides therefore you must have pesticide certification training to purchase and apply them. Nematicides tend to be some of the most toxic pesticides available. Effective nematicides usually possess one or both of two properties, being either highly toxic or persistent for long periods of time in the soil. The EPA tends to frown upon chemicals of this nature. In addition, most are carcinogens and are environmental and human health risks.

If any homeowners wish to dabble in the sale of nematode-free plant material, a product that may be available is Vapam (methyl isothiocyanate). It is not a restricted use product and can be applied in water (usually in a 2-1 water to Vapam ratio) as a drench using a watering can. It should provide good to excellent control of most soil-inhabiting nematodes. However, any time a site is treated with a nematicide, it is very important to use nematode-free planting stock. If the planting material is infested, nematode population densities will typically increase very rapidly due to the fact many of the competing and controlling organisms have been killed by the chemical applied. Basically, the checks and balances often present in the soil, have been nearly eliminated.

Conclusions

The goal of this publication was to increase the knowledge of home gardeners about nematodes. Home garden sites can often become infested with nematodes and the problem never properly diagnosed. Aesthetics and yields of plants can be compromised due the presence of many nematodes. Often this leads to frustration as home gardeners struggle to grow healthy plants.

Many land-grant universities employ a nematologist. If nematodes are positively identified in your garden(s) by a trained nematologist, don't hesitate to consult your state specialist. Most are more than happy to chat with people about the organisms to which they've devoted their careers. To locate your nearest nematologist, check the Society of Nematologists' web site, www.nematologists.org and click on the button on the right side of the page titled "Ask the Experts."

Other Publications

Consult web sites for additional information on plant-parasitic or other types of nematodes. Many nematologists or diagnostic labs provide information as fact sheets, extension bulletins, short articles, etc. on their web sites. For example, consult

www.pestid.msu.edu, the web site for Diagnostic Services at Michigan State University for fact sheets on nematodes.

This publication was produced by the Society of Nematologists Extension Committee, 2010.