

APPENDIX B

Nematodes and Michigan Vegetable Production

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Nematodes are believed to be the most common animals on our planet. They inhabit most soil, fresh water and marine environments. At least 12 types of nematodes are known to parasitize or cause infectious diseases of Michigan vegetable crops. Hundreds of other species are involved in making nutrients available for plant growth. The objectives of this article are to: 1) provide an overview of the nematode problems associated with vegetable production in Michigan, 2) discuss the management options for plant-parasitic nematodes, 3) describe how nematodes are involved in nitrogen mineralization and 4) provide some recommendations on how to enhance the role of nematodes in making nutrients available for plant growth.

The 12 types of plant parasitic nematodes that feed on vegetable crops in Michigan cause diverse symptoms, attack a wide variety of crops and have different behaviors.

ROOT-KNOT NEMATODES

Only one species, the Northern Root-Knot Nematode is known to over-winter under Michigan conditions. Other species can be brought into the state on transplants produced in the south.

Crop Symptoms -Root galls, yellowing, wilting, stunted top growth, stunted root growth, low crop yield and poor crop quality.

Crops Attacked -Beets, Broccoli, Brussels Sprouts, Cabbage, Carrots, Cauliflower, Celery, Cucumber, Eggplant, Garlic, Leeks, Lettuce, Melons, Onions, Parsnips, Peppers, Potatoes, Pumpkins, Squash, Tomatoes.

Nematode Behavior -Second-stage juveniles invade root tissue a short distance behind the root tip. They migrate towards the root tip, stop, turn and then migrate to where the vascular cylinder is being formed. Here, the plant forms nurse cells for use by the nematodes for their growth and development. The plant also forms root galls for protection of the hundreds of eggs in each egg mass. Extensive amounts of plant matter and energy are used in this process, resulting in unsatisfactory crop growth and development. A close relative, the False Root-Knot Nematode, has been found associated with sugar beets in Michigan and has the potential to feed on beets and potato.

This species, however, has not been detected in Michigan during the last 25 years.

CYST NEMATODES

Michigan is the home to nine different species of cyst nematodes. Three of them, Carrot Cyst Nematode, Soybean Cyst Nematode and Sugar Beet Cyst Nematode can be serious problems in Michigan vegetable production.

Crop Symptoms -Yellowing, stunted top growth, stunted root growth, poor nodulation, pinhead size white females on root tissue, poor crop yield and poor crop quality.

Crops Attacked -Carrot Cyst Nematode (carrots), Soybean Cyst Nematode (Snap Beans, Peas) and Sugar Beet Cyst Nematode (Beets, Broccoli, Brussels Sprouts, Cabbage).

Nematode Behavior -Second-stage juveniles invade root tissue about one half of an inch behind the root tip. They burrow to where the vascular cylinder is being formed and induce the plant to form nurse cells for nematode feeding. The female swells and breaks through the root tissue. When she has filled her body with eggs, she dies and drops from the root. Her body hardens to become a protective cyst that can survive in soil in the absence of a host for up to 12 years. Extensive amounts of plant matter and energy are used in this process, resulting in poor crop growth and development.

ROOT-LESION NEMATODES

The Penetrans Root-Lesion Nematode is the most common plant parasitic nematode in Michigan and feeds on the root systems of many crops. A second nematode, the False Root-Lesion Nematode causes damage to mint grown in muck soil.

Crop Symptoms -Yellowing, stunted top growth, stunted root growth, root lesions, poor crop yield and poor crop quality.

Crops Attacked -Beets, Broccoli, Brussels Sprouts, Cabbage, Carrots, Cauliflower, Celery, Corn, Cucumber, Eggplant, Garlic, Leeks, Lettuce, Melons, Mint, Onions, Parsnips, Peppers, Potatoes, Pumpkins, Squash, and Tomatoes.

Nematode Behavior -All stages of root-lesion nematodes are mobile and penetrate root tissue as endoparasites. After root penetration, the nematodes migrate throughout the root cortex, where females deposit their eggs. This migration, combined with chemical exudates, results in reduced uptake and transport of water and nutrients throughout the plant. Root-lesion nematodes are known to interact with soil-borne fungi to cause disease complexes. The best known of these is the Potato Early-Die Disease Complex.

NEEDLE NEMATODES

There are two types of Needle Nematodes in Michigan, the Common Needle Nematode and the Corn Needle Nematode. They can exist in both muck and mineral soil.

Crop Symptoms -Greatly stunted top growth, barren areas, swollen root-tips, reduced crop yield and poor crop quality.

Crops Attacked -Celery, Corn, Garlic, Onions.

Nematode Behavior -Needle nematodes are large ectoparasites and only the nematodes' stylets penetrate root tissue. The Corn Needle Nematode feeds early in the growing season and then migrates deep into the soil. Its distribution is limited to very coarse textured sandy soils. The Corn Needle Nematode has a narrow host range and can easily be managed through crop rotation. Needle nematodes have the ability to vector viruses.

BULB AND STEM NEMATODES

Bulb and Stem Nematodes feed on shoot and not root tissue. There are two very different species associated with Michigan vegetable production systems. One attacks onion and celery, and the other feeds in potato tubers. Both are rarely detected in vegetable fields in Michigan.

Crop Symptoms -Yellowing, stunted top growth, a highly characteristic odor, bloated leaves and bulbs or tuber rot, reduced yields and unsatisfactory crop quality.

Crops Attacked -Onions, Garlic and Potato.

Nematode Behavior -The Bulb and Stem Nematode is a migratory endoparasite of shoot tissue. Fourth-stage juveniles penetrate onion tissue at the junction of the root and shoot system. They migrate through leaf and bulb tissue resulting in greatly deformed growth.

PIN NEMATODES

There are two types of Pin Nematodes associated with Michigan vegetable production, one limited to muck vegetable production and the other associated with mineral soil production systems. **Crop Symptoms** -Stunted top growth, no feeder roots (witches-broom), reduced yield.

Crops Attacked -Carrots, Celery and Corn.

Nematode Behavior -Pin Nematodes are small ectoparasites that feed only from the outside of root tissue.

These nematodes have a long stylet that can be inserted into the central vascular system of roots.

STUBBY-ROOT NEMATODES

Although several species of Stubby-Root Nematodes are known to exist in Michigan, they have not been detected as often recently as in the past. **Crop Symptoms** - Yellowing, stunted tops, stubby roots and poor yields. **Crops Attacked** -Corn and Onions. **Nematode Behavior** - Stubby-Root Nematodes are small ectoparasites. They feed close to the root-tip and prevent cell division and root elongation.

MANAGEMENT OF PLANT PARASITIC NEMATODES IN MICHIGAN VEGETABLE PRODUCTION

The first part of any pest management program is proper identification of the problem. While the cause of some nematode problems can be confirmed under field conditions, a laboratory analysis is usually needed. Michigan growers are encouraged to submit soil and plant tissue samples to MSU Diagnostic Services for confirmation of the cause of an existing problem or information for use in problem avoidance. MSU has two Nematode Diagnosticians responsible for nematode analyses. Additional details about this service can be obtained by contacting www.cips.msu.edu/diagnostics or the County Office of MSU Extension.

As with all pest issues, problem avoidance is always the first-line defense and best strategy. This can be achieved by growing or purchasing high-quality nematode-free transplants or propagation material. Most of the other tactics related to problem avoidance or exclusion are based on common sense. For example, a field with a documented nematode infestation should not be worked immediately before moving equipment to a high quality nematode-free site. With proper planning, it is often possible to isolate or contain a nematode problem to a single field without infesting the rest of the farm. When this fails, control or nematode population reduction is usually required. In many cases this is expensive and results in a significant reduction in potential profits.

Once a Michigan vegetable production site is infested, crop rotation is the first control tactic that should be considered. For example, corn and wheat are not hosts for the Northern Root-Knot Nematode and can be used to reduce population densities of this species below its damage threshold. Crop rotation with agronomic crops is the main reason that current Michigan mineral soil carrot producers have very few nematode problems. In general, muck soil carrot growers have not had this option and have had to contend with serious nematode problems. Although the only known host in Michigan for the Carrot

Cyst Nematode is carrots, this species can survive for up to a decade in the absence of a host, making the use of crop rotation impractical. Corn Needle Nematode problems can be resolved with a year or two of a non-host crop. Cover, trap and green manure crops that produce decomposition chemicals with nematicidal properties have been used in Michigan vegetable production. Cover crops, however, are variety specific in relation to their suitability for use in nematode management systems. For example, Adagio or Colonel oil seed radish are excellent trap crops for control of the sugar beet cyst nematode, but are good hosts of the Northern Root-Knot and Root-Lesion nematodes. Because of this complexity, it is often necessary to interact with a consultant or MSU Diagnostic Services for assistance in designing of the best possible nematode management program.

Nematode population reduction can also be achieved through the use of nematicides. There are basically two types, fumigant and non-fumigant nematicides. Telone II and metham are the most commonly used soil fumigants in Michigan vegetable production. Telone II must be injected into the soil; whereas, metham (Vapam and others) can be injected or applied as a chemigant in irrigation water. Methyl bromide, Telone C-17, Telone C-35 and chloropicrin can also be used under special circumstances. The non-fumigant options are organophosphates or organocarbamates. Vydate, Nemacur, Mocap, Counter and Furadan are the most commonly used non-fumigant nematicides. These materials are all very different in relation to the best methods of application and suitability for specific nematode species. Information about the use of nematicides is present in this MSU Extension Bulletin (E-312).

ROLE OF NEMATODES IN NITROGEN MINERALIZATION

Plants take-up inorganic forms of nitrogen from soil for use in their growth and development. While we often think that the fertilizers applied serves this role, the situation is often more indirect and complex. Fertilizers often feed microbes and subsequently the microbes feed the plants. Bacterial and fungal feeding nematodes play im-

portant roles in this process. For example, plant root-exudates or decomposing organic matter serve as food for bacteria. The bacteria serve as food for bacterial feeding nematodes which receive excess organic nitrogen from this process. The excess nitrogen is transformed into an inorganic form and excreted from the nematode into the area immediately adjacent to the root surface when it is taken-up by the plant for use in the growth and development process. It is important to maintain high population densities of bacterial and fungal feeding nematodes. Most of these species have relatively short life cycles (72 hours); whereas, life cycles of plant-parasitic nematode range from 30 days to two years, with the exception of the cysts which may remain viable in the absence of a host for up to 12 years.

NEMATODES AND SOIL QUALITY

Soil quality can be defined as the ability of a soil to resist degradation and respond to management. Soils with nematode problems are not high quality soils. Anything that can be done to increase quality soil organic matter (SOM) will decrease risk to plant parasitic nematodes and enhance soil quality. What is quality organic matter? Quality SOM is composed of active soil carbon and active soil nitrogen. The term active refers to the ability of the SOM to mineralize soil carbon and soil nitrogen, respectively. Much of this is done by microbes and soil fauna such as bacterial and fungal feeding nematodes. The best way to create an appropriate environment for these organisms and their essential functions is to maintain a diversity of plants and organic amendments in the system. Mixtures of grass and legume cover crops supplemented with manure or compost can be used to create a biologically active soil that is highly productive and devoid of problems caused by plant parasitic nematodes. Do not hesitate to contact me at birdg@msu.edu or (517) 353-3890 if you have any questions about nematodes and their relationship to soil quality. The MSU Nematode Diagnosticians, Fred Warner (517-432-1333) and Angela Tenney (517-353-8563) are available to provide information about management of plant-parasitic nematodes.