Plant-parasitic Nematode Management Strategies

1. The soil contains many nematode species and some (but not all) species are parasites of plants and animals. Plant-parasitic nematodes share four common characteristics: Most species are microscopic; all species require microscopic identification. Adults range from about 1/60-1/4-inch long.
2. They are obligate parasites of plants. This means they must have living plant tissue to feed on in order to grow and reproduce.
3. They all possess stylets. Stylets are structures similar to hypodermic needles that nematodes use to puncture plant cells to obtain the contents.
4. They all spend at least part of their life cycle in soil. However, some remain in root or leaf tissue for extended amounts of time.

Every plant species has at least one nematode species that parasitizes it. About 95 percent of all plant-parasitic nematodes feed on roots. Some nematodes feed within leaves. Plant-parasitic nematodes must feed on living host tissue to grow and reproduce. This means that if the host dies, the nematodes will disperse to search for other plants.

Plant-parasitic nematode feeding does not necessarily result in characteristic secondary (aboveground) symptoms. For this reason, nematode problems often go undiagnosed. Typical aboveground symptoms of nematode infections include stunting, yellowing, and wilting. In some situations, nematodes can cause considerable yield losses; however, nematodes can reduce yields without plants showing any noticeable aboveground symptoms.

The best defense against nematodes is to avoid them. Eradicating them from fields is usually not a viable option. Due to their microscopic nature and abundance in soil, avoiding nematodes is nearly impossible, so nematode infestations in some fields are inevitable.

Nematodes can travel long distances on machinery, in plant material, in or on animals, in water, and on the wind. The bottom line: Anything that moves soil, may move nematodes. Many of these factors are uncontrollable. However, growers can control how they move and sanitize their machinery. If field samples indicate that pathogenic nematode species are present at damage threshold levels, take steps to reduce the population densities of these organisms (see Sampling Nematode Populations, page 59).

Here are five effective tactics for controlling nematode populations.

Biological Controls

The majority of nematodes in the soil are beneficial. They typically feed on bacteria, fungi, or small animals including other nematodes. Research results indicate that increasing beneficial nematode populations often correlates with a decrease in the numbers of plant-parasitic nematodes. Try to increase the diversity and numbers of these beneficial nematodes in fields. For information, consult bulletins or other publications focused on soil ecology and health.

In addition, many organisms are parasites or pathogens of nematodes. Most of these occur naturally in soils, but they often do not sufficiently control plant-parasitic nematodes enough to keep their population densities below damage threshold levels. Some manufacturers market products as biological nematicides. Such products may help to increase beneficial nematodes to levels that may help manage plant pathogenic nematodes See Nematicides Labeled for Use on Vegetables 2018 (page 60).

Chemical Controls

Nematicides are compounds that kill nematodes. There are two main types of synthetic nematicides: fumigants and nonfumigants.

Fumigants are typically sold as liquids that react with water in the soil to produce gases that kill a wide variety of organisms (including plants). They are wide-spectrum biocides. If you fumigate, you should do it in the fall (preferably) or spring when soil temperatures are adequate. Fumigant nematicides labeled for use in vegetable production are shown in Nematicides Labeled for Use on Vegetables 2018 (page 60).

Nonfumigant nematicides do not volatilize in soil water. They can be applied before, during, or even after planting in some situations. These compounds are often not as broad in their spectrum as fumigants. They will control nematodes, but using them will often decrease the numbers of beneficial nematodes, too. Nonfumigants may be less detrimental to beneficial nematodes since some of these compounds are systemic in the plant and thus target pathogenic nematodes.

Cultural Controls

Cultural nematode management options include choosing crop plants or cover crops that are not hosts for the problem nematode, selecting the optimal planting date, planting companion plants, and so on. We recommend rotating with a non-host. For example, grasses are non-hosts to most root-knot nematodes, so rotating with a grass (such as corn, wheat, etc.) will reduce nematode populations. Using cultural tactics requires you to properly identify which plant-parasitic nematodes are present.

Genetic Controls

Plant resistance is often the most sustainable control tactic. For example, many tomato varieties have resistance to root-knot nematodes. However, most vegetables do not have resistance against nematodes, and currently, there are no genetically modified varieties available. Some vegetable varieties may better tolerate nematode feeding, but this information is not always readily available.

Physical Controls

Physical nematode control options include using heat, steam, or water (flooding) to reduce nematode population densities. In field situations, these types of controls are often not feasible in the Midwest. However, in glasshouse or poly-house production, growers may use heat or steam to sterilize growing media.

Sampling Nematode Populations

Plant-parasitic nematodes are microscopic organisms with aggregate (often highly clumped) distributions in fields. As a result, the symptoms their feeding causes often occur in circular or elliptical patterns. If you observe plant symptoms are uniformly distributed, the cause of the problem is typically not nematodes.

All sound nematode management programs include rigorous sampling. Since nematodes are microscopic and typically do not always produce noticeable symptoms that indicate their presence, it is necessary to sample to detect nematodes and avoid problems.

A great deal of research has gone into sampling nematode populations. Here are three important points:

1. Due to their microscopic nature, the only way to diagnosis a plant-parasitic nematode problem is to collect a soil and/or plant tissue sample(s) and send it to a nematode diagnostic lab for analysis (see Selected University Laboratory Services, page 45). It is critical to properly identify the nematode's genus or species to provide specific management recommendations. Please refer to any bulletin or other publication devoted to sampling for these organisms for more detailed instructions.
2. When collecting soil samples for plant-parasitic nematodes, the more soil cores you can gather, the better the sample. Collecting roughly 20 soil cores is usually adequate. You can combine and mix these cores. A lab usually only requires you to submit a pint to a quart of soil. You should place nematode samples in plastic bags and close them to retain moisture. Keep the samples out of the sun and heat to ensure that nematodes arrive in good condition for identification at the diagnostic lab.
3. Use different methods for different sample areas. It may be a good idea to separate different areas of the field when sampling. For example, high or low areas of the field or changes in soil types may require different samples.

Nematicides Labeled for Use on Vegetables 2018[1]

Name	Type[2]	Active Ingredient	Rate	Crops	Comments
ClandoSan 618®	O	crustaceans	1-3 tons/A	all vegetables	Apply on a broadcast basis. Contains 10.4 lbs. N per 100 lbs. of product.
DiTera DF®	B	90% w/w *Myrothecium verrucia* strain AARC-0255	5.0-38.4 oz./1,000 ft2	many vegetable crops	Can be applied to the soil as a pre-plant, post-plant, or at planting.
EarthMAX®	O	4.2% humic acid	1 gal./A	all vegetables	Apply in enough water to cover an acre every 2-4 weeks. Do not use if soil temperatures are below 50°F.
Kontos®	NF	22.4% spirotetramat	No more than 5 fl. oz./A/year	eggplant, pepper, tomato, many leafy vegetables	Applied as a drench or foliar application to vegetable transplants. Not specifically labeled for nematode control.
K-PAM HL® (RUP)	F	54% potassium N-methyldithiocarbamate	62 gals./A	all vegetables	Can be applied by chemigation, soil injection, or surface incorporations when soil temperatures range from 40-80°F. DTP=14-21. Can be used with Telone II®.
Lorsban 15G®	NF	15% chlorpyrifos	4.6-9.2 oz./1,000 row ft.	brassica crops, other leafy vegetables, sweet corn	Labeled for root maggot control. May provide some control of nematodes.
MeloCon WC®	B	6% *Paecilomyces lilacinus* strain 251	2-4 lbs./A	all vegetables	Can be applied pre-plant, post-plant, or at planting when soil temperatures range from 70-90°F.
Mocap 15G® (RUP)	NF	15% ethoprop	34-60 lbs./A (broadcast), or 0.9-1.4 lbs./1,000 row ft. (banded)	cabbage, corn, cucumber, mint, potato, snap beans	In Michigan, for best results, Apply Mocap® on a broadcast basis and incorporate it into the top 2-4 inches of soil. Product may damage crop.
Mocap EC® (RUP)	NF	69.6 % ethoprop	2.4 -4.4 fl. oz./1,000 row ft. (banded)	cabbage, mint, potato	In-row or broadcast.
Movento®	NF	22.4% spirotetramat	4-10 oz./A	many vegetables	Recommended for insect control. May not be effective as a standalone product for nematode control.
NemaKILL®	O	55% botanical oils	32 oz./A	all vegetables	Apply through drip or overhead irrigation and monthly during the growing season.
Nematec®	O	0.56% plant extracts	2.5 qts./A at planting, plus 1 qt. 30 and 60 DAP	all vegetables	Can be applied as spray, drench, or through drip or sprinkler.
Nematode Control®	O	2.5% geraniol		all vegetables	Apply to the soil on a weekly basis.
Nem Guard Gold®	B	3.3% *Bacillus chitinosporus*	2 qts./A at planting	all vegetables	Apply at planting and during the growing season.
Nimitz®	NF	40% fluensulfone	3-5 pts./A (broadcast)	many crop groups	Apply a minimum of 7 days before transplanting.
Telone II® (RUP)	F	97.5% 1,3-dichloropropene	9-25 gals./A	all vegetables	Fumigate in the fall when the soil temperature at 6 inches exceeds 50°F. Inject the product at 8 inches and lightly seal after application. [[MERGE 2 DOWN]]
Telone C-17® (RUP)	F	81.2% 1,3-dicholopropene; 16.5% chloropicrin	10-30 gals./A	all vegetables	
Telone C-35® (RUP)	F	63.4% 1,3-dichloropropene; 34.7% chloropicrin	13-36 gals./A	all vegetables	
Vapam HL®	F	42% methyl dithiocarbamate	37.5-75 gal/A	all vegetables	Do not plant for 14-21 days after application. Effective at soil temperatures down to 40°F.
Velum Prime®	NF	41.4% fluopyram	6.5-6.84 fl. oz./A	many vegetables	Apply using chemigation equipment. Do not apply more than 13.7 fl. oz./A/year.
Vydate L® (RUP)	NF	24% oxamyl	do not exceed 24 pts./year	carrot, celery, cucumber, eggplant, melon, onion, peppers, potato, tomato	Can be applied pre-plant or at-planting, and/or as a foliar spray. Nematode control requires higher rates. Supply is extremely limited.

[1]Most of these products have not been field tested in Michigan for their effectiveness. It is always best to consult with a nematologist before using any of these materials. These compounds may not be labeled for use in every state in the Midwest.

[2]Nematicide type: B=biological. F=fumigant. NF=nonfumigant. O=other.