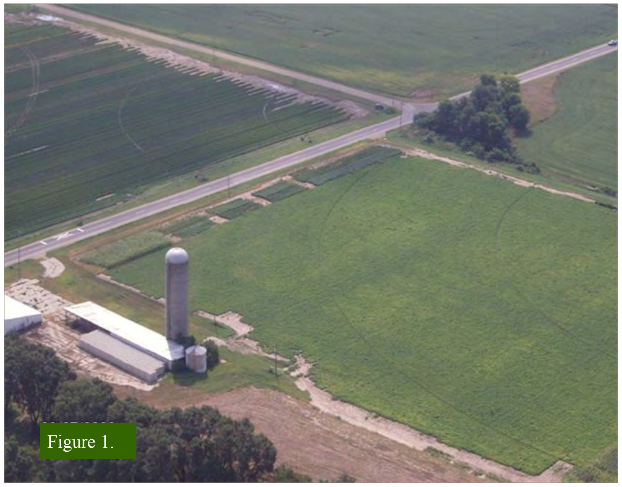
Potato Nematodes



A Farm Guide to Nematode Diagnostics and Management

Appendix B.

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Potato Nematodes was developed at Michigan State University through a USDA Specialty Crop Block Grant to the Michigan Potato Industry Commission from the Michigan Department of Agriculture .

Potato Nematodes

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Nematodes are roundworms classified in the Phylum Nematoda of the Animal Kingdom. Because they inhabit soil, freshwater and marine environments, they are considered the most numerous group of animals on our planet. Many species damage plants by using their stylet to feed on root or shoot system tissues. A significant number of these species cause infectious diseases of potato, vector potato viruses or make potato plants more susceptible to diseases caused by fungi. This Farm Guide is designed to: (1) assist growers in diagnosis of problems caused by nematodes, (2) provide an overview of the types of nematodes that impact potato production and (3) describe management options. Special reference is given to good agricultural practices designed to reduce risks associated with potato nematodes.

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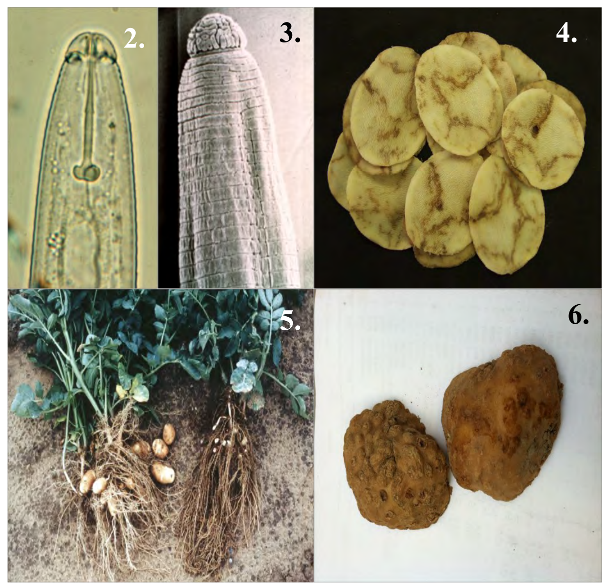
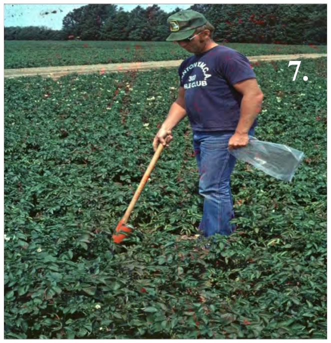
Problem Identification: Nematodes can reduce both potato yield and tuber quality. For proper diagnosis of nematode problems, it is essential to (1) recognize field symptoms, (2) know what type of nematode is present and (3) have an estimate of its population density. Field symptoms include poor stands, small plants, off-color foliage, low tuber set, small tubers, early-die or poor tuber quality.



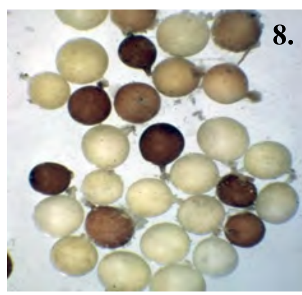
Diagnosis Confirmation: In modern potato production, it is necessary to keep complete records for every field. In addition to field maps, input records and crop yields, this should include descriptions of symptoms that could be caused by nematodes. Results from a laboratory analysis of soil and associated root tissue is necessary to properly confirm a nematode problem and select appropriate management tactics. Soil, root tissue and tuber samples should be collected from numerous sites throughout the problem area at soil depths of 2-12 inches . A subsample of a pint to a quart of soil and root tissue should be placed in a plastic bag, keep cool and submitted to a diagnostic laboratory having one or more nematologists. For a proper diagnosis, it is essential for the diagnosticians to have as much historical information about the site as possible. In return, the laboratory should provide the farm with the types of nematodes detected, population densities and an indication of the risk associated with the problem. Some may also provide management recommendations.



Nematode Types: Plant parasitic nematodes feed as sedentary endoparasites, migratory endoparasites or ectoparasites. At least 18 different species of nematodes are known to be a problem in potato production in the U.S. These can be classified into the following six categories:

- Potato Cyst Nematodes
- Root-Knot Nematodes
- Root-Lesion Nematodes
- Potato Rot Nematode
- Stubby-Root Nematodes
- Other Ectoparasitic Types

Potato Cyst Nematodes: Potato cyst nematodes are serious pathogens that reduce stands, yield and tuber quality. The Golden Nematode (NY) , Pale Cyst Nematode (ID) and a new species (OR & ID) are highly regulated species. As sedentary endoparasites, the female body hardens into a cyst that protects its eggs for a decade or so in absence of a host.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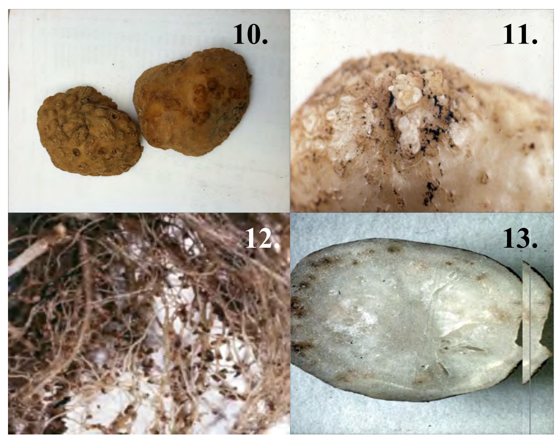
Root-Knot Nematodes: There are four species of root-knot nematodes known to be a problem in potato production in the U.S. The most important is the Columbia Root-Knot Nematode. It is only known to be present in the Pacific West, Mountain West and West South Central Regions. The Southern, Javanese and Northern Root-Knot Nematodes are more widely distributed. While present in MI potato production, the Northern Root– Knot Nematode has never been documented as a significant problem. As sedentary endoparasites, root-knot nematodes cause severe to mild galls (swellings) on roots and tubers, reducing both yield and tuber quality.



Root –Lesion Nematode: Root-lesion nematodes feed as migratory endoparasites in root tissue. They stunt plant growth and result in low yields. More than 70 species have been described. Some are aggressive and others are not. In the North Central and North Eastern Regions, the highly aggressive penetrans root-lesion nematode is the most common species. It thrives in cultivated soil. Its wide host range makes it difficult to control with cultural procedures. In MI, Potato Early-Die (PED) is caused by an interaction between the penetrans root-lesion nematode and the dahliae Verticillium fungus. PED is a serious problem in about half of MI's potato acreage. If not managed, PED causes yield losses as high as 50%. A Good Agricultural Practice (GAP) laboratory analysis is essential for determining risk to PED. MI potato growers, private consultants and company reps commonly submit soil and root tissue for PED risk analysis to Michigan State University, Diagnostic Services at www.cips.msu.edu/diagnostics. The following tables are used for interpretation of the PED risk analysis results.


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Table 1. Population densities of penetrans root-lesion nematodes and dahliae Verticillium fungi the fall before a potato crop (go to Table 2.).

Risk Rating	Root–lesion nemas per 100 cc soil	Verticillium Colonies	
		Dilution-plating/g soil	Wet-sieving/10g soil
0	0	0	0
1	1-25	2	1-15
2	26-75	4	16-35
3	76-150	6	36-60
4	151-300	8-16	61-100
5	>300	>16	>100


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Table 2. Potato Early-Die Risk Matrix

Pratylenchus penetrans Risk	*Verticillium dahliae* Risk					
	0	**1**	**2**	**3**	**4**	**5**
0	0	1	2	3	4	5
1	1	1	2	3	4	5
2	2	2	3	4	5	5
3	3	3	4	4	5	5
4	4	4	5	5	5	5
5	5	5	5	5	5	5

Potato Rot Nematode: The potato rot nematode feeds as a migratory endoparasite in tuber tissue. Infestations are scattered throughout the U.S. It is a regulatory nematode with a zero tolerance for international export. There are no noticeable symptoms on roots or above ground shoot/leaf tissues. Following tuber set, small white lesions develop beneath the tuber skin. This is followed by an internal tuber dry rot and surface cracking. It is common for symptoms not to be noticed until the potatoes are harvested or in storage.

Stubby-Root Nematodes: Stubby-root nematodes feed as ectoparasites on root tissue. This group includes nearly 100 species in five differ-genera. Some of these transmit the Tobacco Rattle Virus which causes Corky Ring-Spot (CRS). This is a serious disease of concern in CA, CO, FL, ID, MI, MN, OR, WA and WI. CRS infection can result in devaluation or total rejection of a potato crop (Fig. 4). Stubby-root nematodes are widely distributed throughout the U.S. Modern diagnostics and virus vector mechanism research are badly needed for development new CRS management practices.

Other Ectoparasites: Five other ectoparasitic nemtodes (Sting, Spiral, Lance, Stunt and Dagger) are known to be problems in U.S. potato production. Of these nematodes, the sting nematode appears to be the greatest direct ectoparasitic risk to potato production.. Sting nematodes have a very long stylet, allowing them to feed deep in root tissue near the tips. This stops root growth, resulting in stunted plants and poor tuber yield. Known sting nematode distribution is limited to the East North Central, West North Central, South Atlantic and West South Central Regions of the U.S. Species of the other four genera are widely distributed throughout the U.S., but have only been reported as problems in potato production in isolated cases.

Nematode Management: Under modern Good Agricultural Practices, nematode management should result in favorable socioeconomic and environmental consequences. The four basic strategies for nematode management are (1) avoidance/exclusion, (2) containment/ eradication, (3) control or (4) do nothing. Avoiding or excluding plant parasitic nematodes can be achieved through use of sound crop rotation programs, planting only nematode-free certified seed and maintaining high quality soil. If a nematode problem is present, it is important to prevent it from spreading. With regulatory nematodes, eradication programs have been used to stop or slow the spread of specific nematodes. Cultural, plant resistance and chemical control procedures are available and used for nematode control. Biological controls for nematodes in potato systems are under development. To do nothing is not usually acceptable.

Cultural Practices: Cultural practices such as use of nematode-free seed, crop rotation, cover crops and soil quality enhancements are important parts of a sound nematode control program. *The practices, however, must be designed for each specific nematode, site and geographical region.* **Use of nematode-free seed is imperative.** For example, potato cyst nematodes have a relatively narrow host range. Crop rotation will reduce the risk of ever having a problem. Potato, wheat and corn are all hosts of the Columbia root-knot nematode. Use these crops in a rotation in a Columbia root-knot infested site enhances the problem. On the other hand, corn and wheat are not hosts for the northern root-knot nematode. They are very suitable as rotation crops for decreasing population densities of northern root-knot nematodes. The penetrans root-lesion nematode, however, has many hosts and is very difficult to manage with rotation or cover crops.

Cover Crops: Cover crops can be used to indirectly reduce risk to nematodes through soil quality enhancement or directly as nematode starvers. *Once again, this must be nematode species and* *cover crop **variety** (cultivar) specific!* Cover crops that have been used successfully for nematode control in specific situations include cereal rye, cowpea, hairy indigo, marigold, mustards, oats, oilseed radish, pearl millet, perennial rye, rapeseed, sorghum-sudangrass, sunn hemp, Use of cover crops for nematode control is tricky and should only be undertaken with advise from a local expert or as an on-farm research project. Use of cover crops as described above is different than using them in bio-fumigation programs. Bio-fumigation is covered in the fumigation section of this Field Guide.

Compost: High quality compost is used to maintain or rebuild soil quality (ability to resist degradation and respond to management). In these situations, compost is being used as a pulsing agent to stimulate beneficial microbial activity and not as a direct source of nutrients.

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Resistant Varieties: Plant genes with resistance to nematodes exist in cultivated and wild species. They have been incorporated into commercial varieties for control of golden nematode, sugar beet cyst nematode, soybean cyst nematode and southern root-knot of tomato. Plants with resistance genes detect nematodes, send chemical signals to the cell's nucleus, which responds by producing reactions that prevent nematode invasion, reproduction or damage . With sedentary endoparasites, this usually consists of a failure to produce nurse cells or the nutrition necessary for normal nematode reproduction. As a result of the USDA breeding program, a number of Golden Nematode resistant varieties have been commercialized. There is a distinct need for future varieties with resistance to the pale cyst nematode, penetrans root-lesion nematode and corky ring-spot virus disease of potato.

Chemical Control: Fumigant and non-fumigant nematicides are available for control of nematodes. The soil fumigants, metam (Sectagon, Vapam), 1,3-D (Telone II) and chloropicrin are registered for use in potato production. Oxamyl (Vydate) and ethoprop (Mocap) are the most commonly used non-fumigant potato nematicides.

Soil Fumigants: In 2010, the U..S. Environmental Protection Agency completed Phase I of the re-registration process for metam and chloropicrin. The new labels mandate a Fumigant Management Plan (FMP) and a Post-Application Report (PAR) for every site treated. Buffer Zones (BZ) will be mandated in Phase II labels. Details about the label requirements can be found at the ***EPA Soil Fumigation Tool Box*** (http://www.epa.gov/pesticides/reregistration/soil_fumigants/).

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The soil fumigants, metam (sodium or potassium), 1,3-D and chloropicrin are toxic to plants and must be applied on a pre-plant basis at optimal soil temperature and moisture conditions. Metam is a dual purpose chemical, controlling nematodes at a low dosage (38 gal/acre) and fungi at a high dosage (75 gal/acre). 1,3-D is registered as a nematicide and

and chloropicrin is basically a fungicide. While there are a number of ways to apply soil fumigants, only shank injection technology for metam use in MI will be discussed in this Farm Guide.

In MI, metam sodium is applied in the fall at rates between 38 and 50 gal/A acre using modern shank injection technology. In some cases, it is applied at a soil depth of 12 inches. In others, it is injected at both 6 and 12 inch depths. Some operators dilute metam with water and others do not. It is applied when soil temperatures are < 60 F and at a soil moisture potential of 60-80% into seedbed tillage conditions. The final pre-application tillage is done immediately before fumigation. A physical seal immediately after fumigant injection is an essential process for good nematode control and prevention of atmospheric emissions. Both of these properties can be enhanced with an irrigation application of 0.25 to 0.33 inches of water immediately after fumigation.

Fumigant Management Plan: A FMP is required for every site. It must be signed, dated, available at the site during fumigation and retained for two years. Details for FMP are describe in the companion publication entitled, *Soil Fumigation: A Field Guide to Fumigant Management Plans*.

26.

Post-Application Report: A PAR must be completed immediately after fumigation. It must include any deviations from what is described in the FMP. It must be signed, dated, and retained for a period of two years. Details about PAR are describe in the companion publication entitled *Soil Fumigation: A Field Guide to Fumigant Management Plans.*

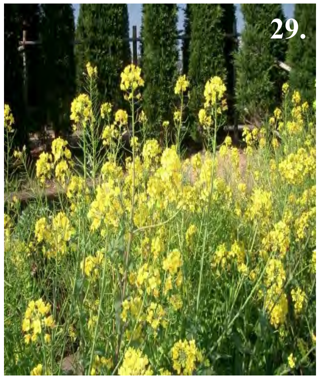
Buffer Zones: A buffer zone (BZ) is required for every application. These are areas outside the treated site that can not be entered for 48 hours after completion of the fumigation. They must be posted. This is a separate posting and different from the treated area posting. Final BZ information will be available from EPA in Phase II labels. It is expected that these will be available in the spring of 2012. It is anticipated that Phase II labels will allow for BZ reduction credits based on various Good Agricultural Practices and site characteristics . In no case will a BZ of less than 25 feet be allowed. BZ reduction credits can not be used to reduce the size of a BZ more than 80%. Descriptions of probable BZ sizes and GPA for BZ area reductions are included in *Soil Fumigation: A Field Guide to Fumigant Management Plans.*

Non-Fumigant Nematicides: Oxamyl (Vydate) and ethoprop (Mocap) are the most commonly used non-fumigant potato nematicides. Oxamyl is a organo-carbamate and ethoprop a organo-phosphate. Both are restricted use pesticides. Both have nematicidal and insectical properties. Oxamyl is a unique systemic. When applied as a foliar spray it is translocated downward in the phloem as a sugar-conjugant. In MI, oxamyl is used in PED management. It is used by itself or in addition to soil fumigation. It is used at-planting, as foliar sprays or both.

28.

Biofumigation:
Biofumigation is the process of incorporating tissue from certain plant families, most commonly Brassicas (yellow mustard, rapeseed, oilseed radish), into soil. The process must cut the plant tissue to release glucosinolates, which are then transformed into isothiocyanate in

soil. The results from biofumigation in MI has been mixed. It has, however, been successfully used and has potential to be effective in combination with other GAP for PED management.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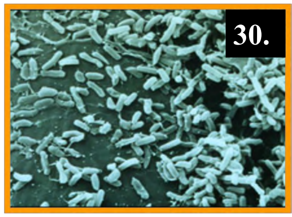
Biological Control: Use of living organisms for control of nematodes in potato production has excellent potential, but is still in a research phase. A bacterium (*Bacillus firmus*) is currently marketed as a seed-treatment for management of nematodes in corn and soybean systems and under development for sugar beets.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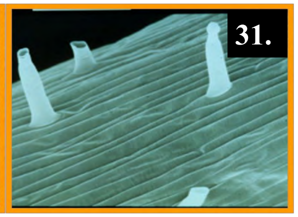
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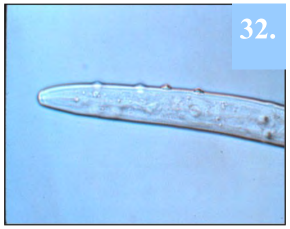

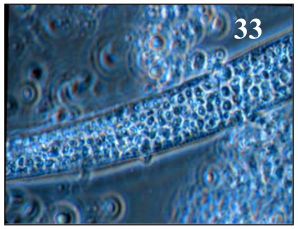

In potato systems, it may be possible to reduce nematode population densities with nematicide-treated rotation crop seed.

Good Agricultural Practices: Three types of Good Agricultural Practices (GAP) are associated with MI potato production.

1. GAP used for overall individual potato enterprise (farm) certification,
2. GAP to be used for soil fumigation BZ size reduction credits, and
3. GAP recommended for soil quality enhancement and maintenance.
    a. Sound crop rotations,
    b. Use of cover-crops and compost,
    c. Soil organic matter monitoring.
    d. Soil and root tissue analysis for nematodes and *Verticillium* fungi.

Figures: 1. Nematode problem field (light green infested areas, dark green non-infested areas). **2.** Nematode stylet. **3.** Nematode head. **4.** Corky ring-spot infected tubers. **5.** Root-lesion nematode induced tuber yield reduction. **6.** Columbia root-knot nematode infected tubers. **7.** Soil and root-tissue sampling for nematode analysis. **8.** Potato cyst nematodes. 9. Potato cyst nematode induced stand reduction. **10.** Columbia root-knot nematode infected tubers. **11.** Northern root-knot nematode infected potato tuber. **12.** Root-knot nematode females on potato roots. **13.** Root-knot nematode infected tuber. **14.** Root-lesion nematode infected root tissue. **15.** Potato early-die symptoms. **16.** Root-lesion nematode. **17.** G. W. Bird inspecting a very large compost pile. **18.** EPA Fumigation Tool Box. **19.** Soil fumigation process. **20.** Physical sealer a behind soil fumigation rig. **21.** Fumigator injection shanks for 12-inch depth application. **22.** Fumigator injection shanks for 6 and 12-inch application depths. **23.** Fumigation process view in front of tractor. **24.** Fumigation process view behind tractor. **25.** Post-application water seal process. **26.** Fumigation site posting sign. **27.** Fumigation buffer zone posting sign. **28.** Oxamyl foliar application. **29.** Bio-fumigation plant. **30.** Root surfaced covered with a biological control bacterium. **31.** Sterile root surface. **32.** Nematode being infected by bacteria. **33.** Nematode cuticle after all of the nematode's matter and energy has been transformed and transported into bacteria.

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