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General Recommendations for Managing Nematodes in Field Crops

Nematodes are a highly diverse group of roundworms that have adapted to nearly every terrestrial and aquatic ecosystem. In fact, nematodes are the most numerous multicellular animal species on earth. One tablespoon of soil can contain thousands of nematodes of many different species, each contributing different ecosystem services. Many nematodes are free-living and feed on bacteria and fungi, while others may feed on organic matter and contribute to the natural cycling of nutrients. A small subset of nematodes are plant-parasitic nematodes, which can cause serious problems in production agriculture. Table 1 lists plant-parasitic nematodes and their hosts that are common in Maryland.

Plant-parasitic nematodes have highly specialized, needle-like mouthparts that they use to feed on plants. While some nematodes feed on leaves (foliar nematodes), most plant-parasitic nematodes feed on plant roots. These nematodes find susceptible hosts by following chemicals exuded by the roots. In many cases, these chemicals also trigger the nematode eggs to hatch. Once they find the roots, they begin to feed.

Managing plant-parasitic nematodes in production agriculture fields can be challenging, but following the general management guidelines in this publication can help get you started. Identifying the nematode species causing the problem is the first step towards a solution,

Table 1. *List of common plant-parasitic nematode species found in Maryland and their select hosts.*

Nematode Species	Common Hosts
Root-knot (*Meloidogyne incognita*)	Soybean, common bean, pea, tomato, corn, lima bean, carrot, lettuce, watermelon, cucumber, pumpkin, squash, pepper, potato, grape, tobacco, corn, sorghum, sudangrass, mustard and brassica crops.
Soybean cyst (*Heterodera glycines*)	Soybean, tobacco, common bean, lima bean, tomato
Ring (*Criconemella xenoplax*)	Peach, cherry, plum, grape, birdsfoot trefoil, vetch, crimson clover, soybean
Spiral (*Helicotylenchus spp.*)	Corn, soybean, onion, carrot, strawberry, wheat and other small grains, tobacco, lettuce, clover
Lance (*Hoplolaimus galeatus*)	Wheat, corn, several other grasses, vetch, clover, soybean, pine
Sting (*Belonolaimus spp.*)	Soybean, common bean, carrot, corn, sorghum, potato, strawberry, turf
Stunt (*Tylenchorhynchus spp.*)	Soybean, corn, small grains, clover, tobacco, raspberry, black berry, potato, pine
Lesion (*Pratylenchus spp.*)	Soybean, corn, potato, wheat

so be sure to take a good sample for testing. With results in hand, you can explore appropriate management practices. Consult additional resources and/or contact your local agriculture extension agent for further assistance.

Different Species of Nematodes Have Varied Feeding Habits

Some nematodes, like the sting nematode (*Belonolaimus longicaudatus*, figure 1), are ectoparasites, meaning that they feed and complete their lifecycle outside of the plant root. Others, like the root-knot nematode (*Meloidogyne incognita*, figure 2), are endoparasites, feeding and completing their lifecycle inside the root. Regardless of their feeding behavior, plant-parasitic nematodes disrupt the flow of water and nutrients into the plant and can cause severe root deformities and stunting, leading to decreased plant vigor, water stress, nutrient deficiencies, and overall poor growth and yield reduction (figures 1 & 2).

In addition, nematodes can vector (carry) plant diseases, such as viruses, that infect the host plant. Feeding injury can also cause plants to be more susceptible to root diseases, such as Fusarium root rot. Common symptoms of nematode damage include stunting, chlorosis (yellowing) of plants, wilting, root pruning, yield reduction, and in extreme cases, plant death. Symptoms are often non-descript from above the soil (foliage) and can be confused with other diseases or disorders, such as nutrient deficiencies. Digging symptomatic plants and observing symptoms such as lesions, galls, deformities, or pruned roots may indicate that nematodes are present.

If left unchecked, plant-parasitic nematode populations can increase to where the production of susceptible crops are nearly impossible. If you suspect nematodes are a problem in a field, the first step to proper management is identifying the culprit. In some cases, this can be easy. For example, if you dig up symptomatic tomato plants and notice large galls on the roots, then you know you have root-knot nematode. However, diagnosing a nematode problem is not always that simple, so you will need to send a soil sample for a nematode analysis.

In general, the best time to sample for nematodes is just before or immediately after harvest (late summer-early fall timeframe). Nematode populations fluctuate with the natural cycle of plant root growth and dieback. Populations will increase when roots are actively growing, then diminish when roots dieback. Therefore, sampling in the winter and spring is not recommended because nematode populations are too low.

Figure 1. *Sting nematode feeding damage on corn showing stunting and root pruning. Image: Department of Plant Pathology, North Carolina State University, Bugwood.org.*

Figure 2. *Root-knot nematode infection on snap bean showing root galls and deformities.*

To take a sample, use a soil probe to take soil cores 6-8 inches deep in between plants within a row. Take 20-25 samples across the field and mix all the cores together in

a clean plastic bucket. After mixing thoroughly, place one pint of the soil in a plastic bag and seal it. You can keep the sample refrigerated (do not freeze) until you are ready to ship it to a lab for testing. Ship samples early in the week so that they do not sit over the weekend in a holding facility. Do not let the sample dry out or get hot (i.e. do not leave it in your hot truck all day). Nematodes need to be alive in order to enumerate their populations in your soil. Remember, your test results will only be as good as your sample.

For Maryland, Virginia Tech is the closest lab to send samples. Mail samples (keep cool) and the appropriate form to: Tidewater AREC Nematode Diagnostic Lab, attn. Linda Byrd-Masters, 6321 Holland Rd. Suffolk, VA 23437. For forms and more information, visit their website (https://www.arec.vaes.vt.edu/arec/tidewater/arec-updates/nematodelabTAREC.html)

Once You Get Your Results, You Can Begin Weighing Your Management Options

Management strategies will vary depending on the nematode species present and your cropping system. As a general guide, the following management options are applicable for most species of plant-parasitic nematodes; however, you should refer to additional resources and/or consult with your local extension agent or crop consultant to discuss management options for your specific situation.

- **Crop rotation** to non-host crops is typically one of the first steps taken when nematodes are a problem. This can be an effective management strategy if populations are not excessive and can help keep populations manageable. Rotation out of host crops for at least 1-2 years is recommended. Crop rotation may also include planting cover crops and leaving a field fallow. Keep in mind that some cover crops can also be hosts for some nematode species. For example, forage or tillage radishes are excellent hosts for root-knot nematode. Also be aware that some nematodes have a very wide host range, so crop rotation may not always be effective, which is why it is important to identify the species of nematode causing the issue.
- **Planting resistant varieties** is a good strategy but they may not always be available. Resistant varieties are only available for root-knot and soybean cyst nematode and only available in some crops (for example, corn has no resistant varieties to root-knot). Nematodes can also overcome resistance genes due to their high fecundity (fertility), so check to make sure the resistance gene is still effective by consulting an expert (Extension or crop consultant).
- **Sanitation** should be high on the list of priorities, even if nematodes are not a problem. The goal is to avoid transferring infested soil to new fields. Properly cleaning tools and equipment before moving to a new field or a different area of the farm can prevent the spread of nematodes, diseases and weeds. Good sanitation practices also include purchasing certified clean seed.
- **Fumigation** is often the most effective way to manage nematodes, but it can be expensive and therefore, often limited to high-value crops. Soil fumigants are chemical compounds that kill most living organisms in the soil. A soil fumigant management plan is required before a soil fumigant can be legally applied.
- **Biofumigation** is an alternative to synthetic chemical fumigation. Biofumigation typically uses brassicas (mustard and rapeseed) that produce high amounts of chemical compounds called glucosinolates in their tissues. The glucosinolates are released from the cells into the soil when these tissues are chopped and crushed, then hydrolyze with water to form isothiocyanates, which is a gaseous compound (mustard gas) that is highly toxic to many organisms living in the soil, including nematodes. Some cultivars (such as Caliente 199) were bred specifically for biofumigation purposes. If done properly, this method is highly effective at knocking back populations of nematodes and other soilborne diseases. However, if done incorrectly, this method can actually increase some nematode populations.[1] Do your research or consult your local Extension Service before attempting biofumigation.
- **Soil solarization** can sterilize the top 8-12 inches of soil and kill plant-parasitic nematodes. This method should be done during the hottest part of the summer, as temperatures must exceed 130 ºF for at least 5 minutes under the plastic. This is a temporary solution and is only viable for shallow-rooted annual crops.

- **Organic matter and compost** added to growing areas may suppress plant-parasitic nematode populations because most (but not all) species prefer sandier soil. Adding organic matter can hinder nematode movement and create less than ideal conditions for their survival. Some trials in the mid-Atlantic region successfully suppressed nematode populations by adding compost and poultry litter, although results were not always consistent from year-to-year.[2]
- **Seed treatments** can offer short-term protection against some nematode species. Nematicide seed treatments are typically used more for field crops such as corn and beans and are less common for some vegetables. Seed treatments protect the root for a few weeks during germination and emergence, but will eventually wear off as the season progresses. Consult the Virginia Cooperative Extension Pest Management Guide (http://pubs.ext.vt.edu/456/456-016/456-016.html) for a list of recommended nematicide seed treatments for your crop and always follow label instructions.
- **Nematicides** are pesticides that target nematodes and are typically applied to the soil in the form of a surface spray, broadcast application, irrigation, or banded in the furrow. These include products such as Nimitz®, Vydate® and others that can protect plant roots for a limited amount of time from nematode feeding. Consult the Virginia Cooperative Extension Pest Management Guide for a list of recommended nematicides for your crop and always follow label instructions.

References

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