Initial Steps for Detecting Plant-Parasitic Nematode Problems in Vegetables

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Plant-parasitic nematodes (PPN) are microscopic roundworms that cause serious crop losses worldwide. These soilborne pests attack and feed on plant roots, causing serious injury to the root system of the host plant. Consequently, the host plant's water and nutrient uptake is disrupted and plant growth is inhibited, resulting in loss of crop yield and quality. The economic damage caused by nematodes in agricultural crops can range from insignificant to severe and the degree of damage can depend on the crop species and variety planted, the type and density of PPN present in soil, and environmental conditions.

In 2021, more than 92,000 acres in Georgia were planted with vegetable crops, making it one of the leading producers of fresh market vegetables in the United States. According to the University of Georgia Center for Agribusiness and Economic Development, vegetable production in Georgia has increased rapidly in recent years and accounted for $1.18 billion in farm gate value in 2021. This high volume of vegetable production can be attributed to the sandy soil and the region's warm and humid climate. However, these conditions are also ideal for PPN reproduction and movement within a field. Anything that moves soil can spread these nematodes between fields; once established in a field it is extremely difficult to eradicate them. Thus, early detection through nematode sampling and proactive management based on nematode population data is critical and can ultimately lead to improved profit margin for crop growers.

Nematode Problems in Vegetables

A wide array of nematode species can attack and damage vegetable crops. Root-knot (*Meloidogyne* spp.), reniform (*Rotylenchulus reniformis*), sting (*Belonolaimus longicaudatus*), root-lesion (*Pratylenchus* spp.), lance (*Hoplolaimus columbus*), and stubby root (*Paratrichodorus* spp.) nematodes are some of the most economically important PPN. These cause significant annual yield losses in vegetable crops. Among them, root-knot nematodes are considered the most devastating group because of their worldwide distribution, rapid reproduction, and wide host range. These nematodes can attack and parasitize numerous vegetable crops, causing moderate to severe swelling or galls on the roots (Figure 1). Heavy infections of host plants are common in most vegetable-growing regions. Root-knot nematodes are especially problematic in southern Georgia, as they are well adapted to the region's sandy loam soil. Without proactive and effective management, population levels of these nematodes can rise rapidly. Because some vegetable crops are much more sensitive than others to specific species of root-knot nematodes, it is important to know which nematode species are present and their population densities.

Figure 1. Moderately and severely damaged eggplant (left) and cucumber (right) by root-knot nematodes in Georgia's Colquitt County. A healthy root system is also shown in the right picture for comparison.

Why Test Plant and Soil Samples for Nematodes?

The accurate assessments of nematode incidence, abundance, and distribution are very important for planning and developing integrated management activities in field production systems. Growers are often unaware of the damage caused by nematodes because much of the plant injury is below the soil surface. When symptoms do appear aboveground, they are not unique to PPN, as they mimic symptoms caused by other diseases and abiotic stressors (e.g., nutrient deficiencies). Thus, nematodes often reduce yield without causing symptoms that would prompt a grower to get a nematode analysis to determine why the crop is producing poorly. These problems can be mitigated by

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sampling the soil in a field for identification of the types and population densities of nematodes present. This information will help determine if nematode management is necessary to prevent crop damage.

For instance, identifying nematodes prior to seeding or transplanting allows growers to implement suitable and sustainable management procedures to minimize crop losses instead of discovering the nematode disease symptoms when it is too late to prevent damage. Sampling may also discover patterns of nematode distribution in a field, which may allow targeting the treatment only to areas that need it. This reduces treatment cost and minimizes environmental impact without reducing effectiveness.

Why Identify Which Nematodes are Present?

There are numerous different species of nematodes that can parasitize vegetable crops, and each species can cause damage to a unique range of hosts. The aggressiveness or severity of yield losses can vary between different plant species and the type of parasitizing nematode. For this reason, accurate identification of nematode species is crucial to vegetable growers in Georgia for selecting management options, especially for root-knot nematodes. For example, the use of rotational nonhost crops (as a component of integrated pest management) can only be effectively implemented based on the knowledge of nematode species present in the soil. Additionally, appropriate selection of cover crops for managing nematodes involves a precise diagnosis of the targeted nematode species. Commercial nematology labs typically identify only the genus of important nematodes. For example, they report *Meloidogyne* spp. (root-knot nematodes) but do not differentiate *M. incognita* (southern root-knot nematode) from *M. arenaria* (peanut root-knot nematode) or *M. enterolobii* (guava root-knot nematodes). Some labs are now able to use DNA-based molecular techniques for precise and reliable identification of nematode species.

Why Quantify Nematode Populations?

There is a direct relationship between the number of parasitic nematodes present in the soil and crop loss, with more nematodes leading to greater yield loss. Therefore, knowing the nematode population numbers prior to or at planting time allows growers to make management decisions that will reduce the impact of nematodes on vegetables. For instance, if the nematode population numbers are high and above the action threshold, it's economically justifiable to apply preplant or postplant fumigant to control nematode populations for improved production. On the other hand, if the nematode population numbers are low, less expensive treatment options can be a more practical choice for increased profit margin. Knowledge of nematode population numbers can also help growers decide on the length of a nonhost crop rotation period that would be effective in ensuring minimal crop losses because of nematodes. Several other control options are also reliant on nematode population numbers.

It is important to note that, without effective and proactive management in a cropping field, nematode population numbers can rise rapidly.

Sampling for Nematodes in Vegetable Fields

Plant-parasitic nematode population numbers in soil can vary significantly throughout the growing season, especially for endoparasitic nematodes, such as root-knot nematodes, that spend a major portion of their life inside the roots of a host crop rather than in soil. Nematode population distribution in a field is generally uneven and in an aggregated pattern in most infested fields. Because of this, it is critical to be methodical when sampling for PPN.

When to Sample

The best time for sampling is at the end of the cropping cycle or immediately after harvest. At-harvest or postharvest sampling is useful in predicting or preventing nematode-related yield loss in the next cropping cycle. If samples were not taken at the end of the previous cropping cycle, the next best time to sample is well before planting. Once a plant is infected with nematodes, the corrective measures available to growers may not fully rectify the problem for the current cropping season.

How to Sample

A 1-in.-diameter soil sampling probe is optimal for collecting soil samples. If a probe is not available, a hand trowel or a shovel can be used to collect soil samples. Regardless of the tool used, it is important to collect a soil core or slice around 8–12 in. deep. Sampling too deep or too shallow may result in an inaccurate nematode count. Each sample should be a composite of multiple subsamples and cores. Collect enough subsamples to represent the situation in your field. Eight to 10 subsamples per acre is generally recommended. Collect a handful of soil from each site and combine them into one composite soil sample.

Where to Sample

Depending on your situation, different sampling strategies may be appropriate.

If you are **sampling at harvest or postharvest**, collect root and soil samples from multiple spots of the problematic areas. Examples of such problematic regions include symptomatic areas with stunted plants, yellowing of leaves,

wilting, or a combination of these. It is also important to collect soil samples as close to plant roots as possible since a majority of PPN are near the root zones of the plants. One approach to root and soil sampling is to gently remove the entire plant, ensuring roots are intact, then collect a soil sample from the root zone of that plant. Examine the roots for swelling or *galls* and, if galls are present, include the roots with your soil sample. For optimal nematode count, avoid collecting samples from the center of the problematic areas, as plants may be substantially weakened or dead from early-season nematode attack. Instead collect samples near the inside edges of the problematic areas. A similar approach to at-harvest sampling can be taken for **sampling during the growing season**.

If you are **sampling well before planting** and raised-bed making, you can divide your field into smaller subsections and collect multiple subsamples in a zigzag pattern from each subsection, generating one composite sample per subsection. This sampling tactic can help in understanding nematode distribution in your field, allowing you to use targeted management tactics. If you are sampling after beds are made, collect samples from the center of your beds where planting will occur. A zigzag pattern can be implemented to collect soil samples across multiple beds.

It is critical to avoid direct sunlight exposure to the soil samples during storage and shipping, as the heat generated from sun exposure can kill the nematodes and may prevent their detection in your samples. It is critical not to allow samples to get too hot or dry. For nematode testing, soil samples can be sent to the University of Georgia Extension Nematology Laboratory. To interpret nematode testing results and the action threshold, consult UGA Cooperative Extension Circular 834 *Guide for Interpreting Nematode Assay Results*. For more information and management strategy development please consult your local county Extension agent.

Summary

Accurate detection of damaging nematode infestations can enable growers to significantly increase crop productivity and profitability. Although a single tactic—such as soil fumigation—may be adequate in some situations, successful control of nematodes can be achieved by integrating two or more management strategies. It is imperative that growers test their soils and obtain information about which nematode species are present in their fields and at what population densities. The best way to detect and identify nematode problems is through collecting soil or plant samples (or both) and having those samples analyzed in a reliable nematode diagnostic lab. If you suspect a field has a nematode problem, have the soil tested and consult with your local Extension agent or nematologist for advice on how to manage the nematode infestation.

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