Sampling and Diagnosis of Plant-Parasitic Nematodes
Department of Plant Pathology, University of Georgia
(Revised 7/1/2025)

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Service Fees for Nematode Identification and Quantification

	Category	Fees*
1	All field, vegetable fruit and nut crop nematode samples submitted through GA County Extension office. Please provide name of the County of origin and name of Agent as indicated on the form. Results will be emailed to the respective County Office and each client.	$20.00
2	Samples from UGA research or demonstration projects. As charge for UGA research samples will be handled by internal billing to UGA chart-strings, **Speed-type must be provided**.	$20.00
3	All in-state turfgrass nematode samples and samples **not** submitted via GA County Extension Office.	$35.00
4	State Certification (Georgia Department of Agriculture).	$35.00
5	All Out- of- State nematode samples. Must contact lab for permit and shipping label prior to shipping samples.	$80.00

***Payment (or Speed-type to be billed) must accompany all samples. Alternatively, sample processing fees can be paid by credit card. A proper link will be provided with the invoice and instructions on how to pay.**

A QUICK GUIDE TO SAMPLING FOR NEMATODES

By Ganpati Jagdale, Ph. D.

What are nematodes?

Nematodes are thread-like microscopic round worms that live in all habitats, especially soil and water. Most species are beneficial, but some are harmful parasites of plants and animals.

What are plant-parasitic nematodes?

Plant-parasitic nematodes (PPNs) are characterized by a needle-like structure in their mouth called a stylet, which, depending on the nematode species, is used to feed on plant parts such as roots, stems, leaves, and seeds.

Why are plant-parasitic nematodes important?

Plant parasitic nematodes are important because of their significant economic and ecological impacts on agriculture and ecosystems.

1. **Agricultural Damage**
   - Plant parasitic nematodes cause billions of dollars in crop losses annually worldwide. They damage roots, impair nutrient uptake, and reduce yields. For example, Root-knot nematodes (*Meloidogyne* spp.), cyst nematodes (*Heterodera* and *Globodera* spp.), and lesion nematodes (*Pratylenchus* spp.) are among the most destructive.
2. **Wide Host Range**
   - Plant-parasitic nematodes can cause significant economic damage to almost all vegetable and field crops, fruit trees, ornamentals and turfgrass by reducing both yield and quality
   - Some are highly specialized (e.g., potato cyst nematode), causing major issues for specific industries.
3. **Difficult to Detect, Identify and Control**
   - They are microscopic and live in the soil or within plant tissues, often causing damage before symptoms appear.
   - Chemical controls are limited due to environmental and health concerns, and resistant plant varieties are not always available.
4. **Interactions with Other Pathogens**
   - Nematodes often facilitate secondary infections by disease- causing bacteria or fungi. For example, root damage from nematodes can allow fungi such as *Fusarium* to invade more easily and cause disease complexes that may cause additional loss in crop quality and yield.

What does damage caused by plant-parasitic nematodes look like?

Damage caused by plant-parasitic nematodes can vary depending on the type of nematode, the plant species, and the severity of infestation. However, there are several common above-ground and below-ground symptoms that may indicate their presence:

Above-Ground Symptoms

These are indirect effects of root damage:

- **Stunted growth:** Plants may appear smaller or grow more slowly due to impaired root function due to damage by nematodes or abiotic factors.
- **Chlorosis (yellowing):** Leaves may be yellow from nutrient deficiencies or due to damage by nematodes or abiotic factors.
- **Wilting:** Even with adequate water, plants may wilt due to poor root uptake due to damage by nematodes or abiotic factors.
- **Uneven crop development:** Patches of poor growth may appear, especially in rows due to damage by nematodes or abiotic factors.
- **Reduced yield or fruit size/quality**. Due to damage by nematodes or abiotic factors.

Below-Ground Symptoms

This is where nematode damage is most direct and diagnostic:

1. Root-Knot Nematodes (e.g., *Meloidogyne* spp.):

- Galls or knots on roots (swollen areas caused by nematode feeding and hormonal changes).
- Severely galled roots may rot or become less effective at water and nutrient absorption.

2. Lesion Nematodes (e.g., *Pratylenchus* spp.):

- Dark, sunken lesions on roots.
- Roots may become necrotic and more prone to fungal infections.

3. Cyst Nematodes (e.g., *Heterodera*, *Globodera* spp.):

- Tiny white or brown cysts (dead females full of eggs) attached to roots.
- Stubby, reduced root systems.

4. Stubby Root Nematodes (e.g., *Trichodorus* spp.):

- Roots appear shortened, stubby, or swollen at the tips.
- Poor branching and overall loss of root mass.

5. Dagger and Needle Nematodes:

- Delayed germination or death of seedlings.
- Reduced root hair development.

Diagnosis Tips

- Damage often resembles nutrient deficiency, drought stress, or fungal root rot—soil and root analysis is needed for confirmation.
- Use of a nematode diagnostic lab or soil bioassays can identify species and severity.

How are plant-parasitic nematodes managed?

Managing plant-parasitic nematodes requires a combination of cultural, biological, chemical, and genetic strategies, collectively known as Integrated Nematode Management. The first and most critical step is accurate detection and identification of the nematode species to help limit their spread and reduce economic losses. Because most PPNs live in the soil and around plant roots, timely sampling of soil and plant tissue is essential for selecting effective control measures. Below are specific strategies for managing plant-parasitic nematodes.

1. **Cultural Practices**

These aim to reduce nematode populations through changes in farming practices.

- Crop rotation: Alternating with non-host or resistant crops (e.g., corn after soybean to manage soybean cyst nematode).
- Fallowing: Leaving soil bare for a season can reduce populations, though it's not always practical.
- Cover cropping: Some cover crops (e.g., marigold, mustard) have nematicidal properties.
- Sanitation: Cleaning tools and equipment to prevent nematode spread.
- Soil solarization: Using plastic tarps to heat soil and kill nematodes in warm climates.

2. **Resistant Varieties**

Planting cultivars that are resistant or tolerant to specific nematodes.

- Resistance genes can limit nematode reproduction.
- Widely used for root-knot nematodes (*Meloidogyne spp.*) and soybean cyst nematode (*Heterodera glycines*).

3. **Chemical Control**

Use of nematicides, though this is often restricted due to cost and environmental concerns.

- Fumigants: e.g., 1,3-Dichloropropene (Telone), effective but highly regulated.
- Non-fumigant nematicides: e.g., oxamyl, fluopyram—safer but may have limited efficacy.

4. **Biological Control**

Using natural enemies of nematodes or biopesticides.

- Fungi (e.g., *Paecilomyces lilacinus*, *Purpureocillium lilacinum*) and bacteria (e.g., *Bacillus firmus*, *Pasteuria penetrans*).
- Commercial products are available but often need careful application to be effective.

5. **Physical and Mechanical Methods**

- Soil steaming (used in greenhouses).
- Soil amendments (e.g., composts, organic matter) can boost microbial communities that suppress nematodes.

6. **Integrated Nematode Management (INM)**

Combining several strategies tailored to local conditions and cropping systems is often most effective and sustainable.

How and When to Sample for a Nematode Assay

Timing:

Nematode sampling timing is critical, as populations fluctuate throughout the year. Nematodes are often undetectable in winter and early spring but can reach high densities in early fall before harvest, when living roots are present. After harvest, populations may decline sharply. Sampling at the right time reduces the risk of missing damaging species and helps prevent future problems. Early fall sampling supports timely decisions for effective nematode management before the next crop is planted.

The optimum time to take samples for nematode assay from various Georgia crops is given below:

Crop	When to sample	Sampling depth in inches (cm)	Common nematodes
Cotton	Oct. and Nov.	8 inches (20)	Lance, Reniform, Root-knot
Peaches and other fruit orchards	Feb. to Apr. and Sept. to Oct.	8 inches (20)	Root-knot
Peanuts	Sept. to Oct.	8 inches (20)	Root-knot
Soybeans	Sept. to Nov.	8 inches (20)	Lance, Reniform, Root-knot, Cyst
Tobacco	July	8 inches (20)	Root-knot
Warm season turfgrass	Jun. to Aug.	6 inches (15)	Lance, Reniform, Root-knot, Sting
Cool season turfgrass	Sept. to Oct.	6 inches (15)	Lance, Reniform, Root-knot, Sting
Vegetables	Aug. to Sept.	8 inches (20)	Root-knot

Where to sample

Nematode distribution in the field is typically patchy due to factors such as crop growth, presence of weed hosts, chemical use, and environmental conditions. Because of this uneven distribution, it is essential to collect a soil sample that accurately represents the entire area.

To ensure a representative sample, collect soil from multiple spots throughout the field—not just one or two. Sampling should be done only when soil moisture is suitable for field work; avoid collecting samples from soil that is excessively dry, wet, or frozen.

Soil should be taken from the plant root zone (rhizosphere). Sampling depth varies by crop (see table above). In fallow fields, sample from the root zone depth of the intended future crop. If the field has been fallow, dry, or frozen for an extended period, collect samples from deeper than 20 inches, as nematodes tend to move deeper to escape unfavorable conditions.

If nematode infection is suspected, collect plant samples from symptomatic parts (e.g., leaves, stems, bulbs, tubers, or roots). Both soil and plant samples should be taken from areas showing symptoms and from healthy areas for comparison.

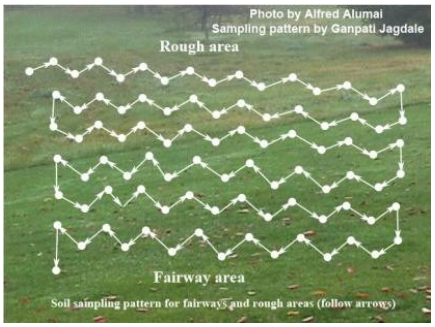
Figure 1

When sampling a problem area, collect soil from the margin of the affected zone (Figure 1), where nematode populations are often higher. Even in small problem areas, sample from multiple spots. In large fields (>5 acres), nematode hotspots can be diluted in composite samples, making detection harder. Therefore, take one composite sample

for every 4 to 5 acres. Each sample should represent a section with uniform soil type, conditions, and management. The shape of the field may influence how many acres a single sample can represent.

How to sample

- Properly collected samples from small field units can reduce production costs by allowing the grower to eliminate nematode control practices where they are unnecessary and implement them where they are needed.
- Improper sampling can result in poor recommendations and avoidable economic losses.
- Both large areas (e.g., fields, golf course fairways, and roughs) and small areas (e.g., home lawns, recreational parks, and golf course greens) should be sampled using a systematic zigzag pattern (Figures 2A, 2B and 2C).



Home lawns/ Parks/ golf rough area- Figure 2A

Golf green- Figure 2B

Soil probe- Figure 3

Row crops- Figure 2C

- Since nematodes may not survive in the upper 1–2 inches of soil due to extreme environmental conditions (heat or cold), first remove the upper soil layer, then collect samples using a 2.5 cm (1-inch) diameter soil probe (Figure 3).
- Take 20–30 soil cores in a zigzag pattern from regularly spaced locations throughout a large area (4–5-acre section) or a small area (≤1.25 acres [≤5,000 m²]).
- For individual plants such as fruit trees and ornamental shrubs, collect samples under the canopy drip line (Figure 4).
- The number of soil cores collected will depend on the size of the tree or shrub canopy. For example, collect approximately 8 soil cores for a 10-foot diameter canopy and about 12 soil cores for a 15-foot canopy.
- The collected soil cores should be thoroughly mixed to create one composite sample. From each composite sample, approximately 1

Figure 4

pint (1/2 liter) of soil should be placed into a labeled **sandwich size plastic bag** for nematode analysis.

Handling of soil samples for nematode assay

- Improper sample handling can lead to inaccurate nematode population estimates and incorrect recommendations. Nematodes must be alive for extraction.
- Avoid exposing samples to direct sunlight or heat, even briefly, as excessive heat or drying can kill them and lead to false negatives.
- During transport, keep samples in an insulated cooler to prevent heat or drying.
- In the lab, store samples in a refrigerator until they are processed for nematode extraction.

Labeling of soil samples for nematode assay

- Label plastic bags on the outside with a permanent marker, including sample name/number, location, and sampling date.
- Each sample must be accompanied by a completed **Nematode Assay Form**, which is available for download on the UGA Plant Disease and Nematode Clinics web page (https://plantpath.caes.uga.edu/extension/plant-disease-clinics.html).
- Provide all requested information, as it directly impacts the quality of recommendations.
- List current, past, and intended crops to help identify nematode issues and guide management.
- Including the crop variety; cultivar information is essential for many crops.

Shipping of soil samples for nematode assay

- Deliver samples in person or ship via express services like FedEx, UPS, or USPS).
- Send early in the week to avoid weekend delays.
- Submit samples through your local county Extension office.
- The Extension office will forward them to the Extension Nematology Laboratory.
- The sender is responsible for all shipping costs.

Mailing address:

Extension Nematology Laboratory,
2350 College Station Road,
Athens, GA 30602

When you obtain the results

- Assay results and management recommendations will be returned through your county Extension office within 4–5 days of receiving the samples.
- Keep a record of which nematodes are found in each field.

Nematode diagnosis

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