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Nematode Management in Field Crops

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Plant parasitic nematodes can be highly damaging to crops and reduce yields. Aboveground symptoms of nematode damage in a field include patches of poor growth/yield, high incidence of soilborne diseases, and stunting, yellowing, wilting, or dying plants. Below ground signs and symptoms include stubby roots, root proliferation or abnormal branching, stunted roots, root rot, or the presence of galls (root-knot nematode) or cysts (soybean cyst nematode) on the roots. Approaches to management of nematodes depend on the types and numbers of nematodes present, so sampling fields for nematodes is a necessary first step in developing a management strategy.

TYPES OF SAMPLES: Soil can be submitted for either a *diagnostic* or a *predictive* nematode assay. Diagnostic assays are performed with the purpose of identifying the cause of poor growth in the current crop. Predictive nematode assays are performed to determine the risk of next year's crop being impacted by nematodes. The processing of the two types of samples is identical, but procedures for sampling and interpretation of results differ. Instructions for collecting samples for the two types of assays are described in Table 1.

HANDLING AND SUBMITTING SAMPLES: Place 1 pint of soil from each sample in a labelled plastic bag and seal the bag tightly. Do not expose the samples to heat or freezing temperatures. Samples may be refrigerated up to a week prior to submission. Fill out the Nematode Assay Submission Form (see VCE Publication "*Instructions for Sampling and Submitting Crop Nematode Samples*") with all the required information and mail or hand deliver samples to the Virginia Tech Tidewater AREC Nematode Diagnostic Lab.

INTERPRETATION OF NEMATODE ASSAY RESULTS: Diagnostic assays will determine if the damage or poor growth in a field is associated with high nematode populations, but they do not necessarily predict the risk of damage to subsequent crops. In order to make management decisions for a future crop, a predictive assay must be submitted. Predictive assay reports indicate the risk of damage (low, moderate, or high) to different crops based on the types and numbers of nematodes present in the sample. Risk categories are based on Virginia Cooperative Extension damage thresholds for nematodes, and thresholds are crop-specific. Threshold numbers for corn, cotton, peanut, and soybean are shown in Tables 2-5.

Table 1. Instructions for collecting nematode diagnostic and predictive assay samples.

	DIAGNOSTIC	PREDICTIVE
WHEN TO SAMPLE	Collect samples when symptoms indicating a potential nematode problem are observed (e.g. patches of stunting or yellowing in the field).	For annual crops, sample in the late summer or early fall near harvest when nematode populations are at their highest.
HOW TO SAMPLE	Collect samples from areas with symptomatic plants, but DO NOT collect from areas where plants are dead or dying because these will not support high nematode populations (nematodes need a living host). For each sample, collect at least 20 soil cores at approximately a 6 inch depth. Submit a pint of soil. A second sample from a "good" part of the field should be collected and submitted for comparison. Submission of root/plant samples along with the soil is recommended since this will aid in an accurate diagnosis.	Collect samples when the soil is moist but not water logged. If the crop planted or agronomic practices vary throughout the field, collect a separate sample from each area. If a field has multiple soil types, take a separate sample from each soil type. Collect soil cores from throughout the field with a minimum of 20 composite soil cores per 10 acres. Collect samples in a zig-zag pattern from the root zone of the most recent crop. Thoroughly mix the composite sample in a plastic bucket, and put a pint of soil in a plastic bag for submission to the nematode lab.

Table 2. Nematode damage thresholds for corn.

CROP HOST: Corn	Nematodes per 500 cc soil		
NEMATODE	**Low**	**Moderate**	**High**
Root-knot*	0-490	500+	---
Soybean cyst	N/A		
Lesion	0-190	200-490	500+
Stunt	N/A		
Spiral	N/A		
Lance	0-90	100-290	300+
Ring	0-190	200-690	700+
Stubby root	0-10	20-290	300+
Sting	0	0	10+
Dagger	N/A		

*Corn is a host for southern root-knot (*Meloidogyne incognita*) but not northern root-knot nematode (*M. hapla*). N/A = not applicable; this crop is a poor host or non-host for the indicated nematode. --- = no threshold level for this category.

Table 3. Nematode damage thresholds for cotton.

CROP HOST: Cotton	Nematodes per 500 cc soil		
NEMATODE	**Low**	**Moderate**	**High**
Root-knot*	0-190	200-490	500+
Soybean cyst	N/A		
Lesion	0-90	100-240	250+
Stunt	N/A		
Spiral	N/A		
Lance	0-190	200-490	500+
Ring	N/A		
Stubby root	0-90	100-240	250+
Sting	0	0	10+
Dagger	N/A		

*Cotton is a host for southern root-knot (*M. incognita*) but not northern root- knot nematode (*M. hapla*). N/A = not applicable; this crop is a poor host or non-host for the indicated nematode.

Table 4. Nematode damage thresholds for peanut.

CROP HOST: Peanut	Nematodes per 500 cc soil		
NEMATODE	**Low**	**Moderate**	**High**
Root-knot*	0-20	30-90	100+
Soybean cyst	N/A		
Lesion	0-20	30-90	100+
Stunt	N/A		
Spiral	0-290	300+	---
Lance	N/A		
Ring	0-30	40-190	200+
Stubby root	0-90	100-290	300+
Sting	0	10	20+
Dagger	0-90	100-280	290+

*Peanut is a host for northern root-knot (*M. hapla*) but not southern root-knot nematode (*M. incognita*). N/A = not applicable; this crop is a poor host or non- host for the indicated nematode. --- = no threshold level for this category.

Table 5. Nematode damage thresholds for soybean.

CROP HOST: Soybean	Nematodes per 500 cc soil		
NEMATODE	**Low**	**Moderate**	**High**
Root-knot*	0-40	50-160	170+
Soybean cyst - juveniles	0-10	20-50	60+
Soybean cyst - females	0	0	1+
Lesion	0-90	100-290	300+
Stunt	0-290	300-990	1000+
Spiral	0-990	1000+	---
Lance	0-290	300-490	500+
Ring	0-190	200-690	700+
Stubby root	0-80	90+	---
Sting	0	10	20+
Dagger	0-90	100-290	300+

*Soybean is a host for both northern root-knot (*M. hapla*) and southern root- knot nematode (*M. incognita*). --- = no threshold level for this category.

MANAGEMENT RECOMMENDATION ACTION CODES: Management recommendations are based on nematode thresholds and the crop that will be planted in a field. To determine the nematode management recommendations for a particular field, refer to the action codes in Tables 6-9. For example, if a predictive assay report indicates high risk for damage to soybean from cyst nematode, the action codes B, C, and E in the "high" threshold category column of Table 9 apply to the field. Management recommendations associated with each action code are the following:

A. Nematodes will not damage the crop and no action is needed.
B. Crop rotation to a non-host will reduce nematode populations.
C. Planting a nematode resistant variety will minimize damage to the crop and reduce nematode populations.
D. Nematode damage to the crop may be minimal and yield is unlikely to be impacted if growing conditions are favorable.
E. Nematodes will likely cause crop damage and a nematicide may be profitable.

Table 6. Nematode management action codes for corn based on economic thresholds.

CROP HOST: Corn	Threshold Category & Action Code		
NEMATODE	**Low**	**Moderate**	**High**
Root-knot*	A, B	B, D	---
Soybean cyst	N/A		
Lesion	A	D	E
Stunt	N/A		
Spiral	N/A		
Lance	A, B	B, D	B, E
Ring	A, B	B, D	B, E
Stubby root	A	D	E
Sting	A	D	E
Dagger	N/A		

*These action codes apply only if southern root-knot nematode (M. incognita) is present in the field. N/A = not applicable; this crop is a poor host or non-host for the indicated nematode. --- = no threshold level for this category.

Table 7. Nematode management action codes for cotton based on economic thresholds.

CROP HOST: Cotton	Threshold Category & Action Code		
NEMATODE	**Low**	**Moderate**	**High**
Root-knot*	A, B, C	B, C, D	B, C, E
Soybean cyst	N/A		
Lesion	A	D	E
Stunt	N/A		
Spiral	N/A		
Lance	A, B	B, D	B, E
Ring	N/A		
Stubby root	A	D	E
Sting	A	D	E
Dagger	N/A		

*These action codes apply only if southern root-knot nematode (*M. incognita*) is present in the field. N/A = not applicable; this crop is a poor host or non-host for the indicated nematode.

Table 8. Nematode management action codes for peanut based on economic thresholds.

CROP HOST: Peanut	Threshold Category & Action Code		
NEMATODE	**Low**	**Moderate**	**High**
Root-knot*	A, B	B, D	B, E
Soybean cyst	N/A		
Lesion	A	D	E
Stunt	N/A		
Spiral	A, B	B, D	---
Lance	N/A		
Ring	A, B	B, D	B, E
Stubby root	A	D	E
Sting	A	D	E
Dagger	A, B	B, D	E

*These action codes apply only if northern root-knot nematode (*M. hapla*) is present in the field. N/A = not applicable; this crop is a poor host or non-host for the indicated nematode. --- = no threshold level for this category.

Table 9. Nematode management action codes for soybean based on economic thresholds.

CROP HOST: Soybean	Threshold Category & Action Code		
NEMATODE	**Low**	**Moderate**	**High**
Root-knot	A, B, C	B, C	B, C, E
Soybean cyst	A, B, C	B, C	B, C, E
Lesion	A	D	E
Stunt	A, B	B, D	B, E
Spiral	A, B	B, D	---
Lance	A, B	B, D	B, E
Ring	A, B	B, D	B, E
Stubby root	A	D	---
Sting	A	D	E
Dagger	A, B	B, D	E

*These action codes apply for both northern (*M. incognita*) and southern root-knot nematode (*M. incognita*). --- = no threshold level for this category.

APPROACHES TO NEMATODE MANAGEMENT IN FIELD CROPS: Integrated approaches to nematode management that incorporate host resistance, cultural practice such as crop rotation and sanitation, and judicial use of nematicides are typically the most effective and economical. The management action codes listed above can be used to identify which approaches will be effective in a specific field based on economic thresholds. Fields should be re-sampled on a regular basis (at least every three years) to verify that management practices are reducing or maintaining crop parasitic nematode populations below economic thresholds. The extent to which a particular management practice will adequately control nematodes and minimize crop damage depends on both the field-specific nematode populations and the crop being planted. Host resistance is one of the most effective

management approaches, but nematode-resistant varieties are limited to cotton and soybean varieties with resistance to southern root-knot nematode and soybean varieties with resistance to specific races of soybean cyst nematode. Crop rotation can be effective for nematodes with a narrow host range, but several nematodes can reproduce on a wide range of crops and other plant species (Table 10). Nematicides registered for field crops are somewhat limited, but recent research in Virginia has evaluated the efficacy and profitability of seed treatment and in-furrow nematicides for control of nematodes in field crops. For more information refer to the current version of the Virginia Cooperative Extension Pest Management Guide for Field Crops or the Applied Research on Field Crop Disease Control publications (pubs.ext.vt.edu).

Table 10. Host status of corn, cotton, peanut, and soybean for economically important plant parasitic nematodes found in Virginia.

Nematode	Corn	Cotton	Peanut	Soybean
Southern root-knot	YES	YES	NO	YES
Northern root-knot	NO	NO	YES	YES
Soybean cyst	NO	NO	NO	YES
Lesion	YES	YES	YES	YES
Stunt	NO	NO	NO	YES
Spiral	NO	NO	NO	YES
Lance	YES	YES	NO	YES
Ring	YES	NO	YES	YES
Stubby root	YES	YES	YES	YES
Sting	YES	YES	YES	YES
Dagger	NO	NO	YES	YES

YES = the crop is a good host for the indicated nematode; NO = the crop is a poor or non-host for the indicated nematode.