Chapter 10

Nematode Control

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Nematodes are microscopic worms that live in the soil and feed on or in the roots of plants. Although many different nematodes are associated with soybeans in Arkansas, only a few are considered economically important. Unfortunately, these types are widespread throughout the soybean production area of the state, and they may be responsible for major yield suppression every year. Crop yield reductions range from none in those fields where producers are fortunate enough to not have a nematode problem to greater than 50 percent in fields with high populations of nematodes.

Three nematode species – the soybean cyst nematode (SCN), the root-knot nematode (RKN) and the reniform nematode (RN) – are responsible for the majority of Arkansas crop losses in soybeans. Of the three, SCN is by far the most widespread and economically important. SCN is present in approximately 70 percent of the total Arkansas acreage of soybeans. The root-knot nematode is less widely distributed than SCN in the state, but it can be responsible for very severe yield reductions where it occurs. RKN is generally found at damaging levels in sandy soils where soybeans are grown.

Figure 10.1. View of a nematode-infested soybean field.

The reniform nematode (RN) is an emerging problem in Arkansas. Currently, this nematode species has been found in Ashley, Crawford, Jefferson, Lonoke and Monroe counties. During the past five years, the number of fields where RN has been detected has increased dramatically, and reports of "new" fields will likely increase during the next few years. RN generally occurs at extremely high levels within a field because it has a high reproductive potential and a relatively short life cycle. Soil types with silt or clay content in the 20 to 40 percent range appear to be the most favorable for RN.

In addition to SCN, RKN and RN, two other nematode species can occasionally cause economic yield losses in soybeans in Arkansas. The sting nematode can cause devastating losses in certain situations. Fortunately, the sting nematode occurs infrequently in Arkansas and is restricted to soils that have greater than 90 percent sand and where the sand is at least 2 to 3 feet deep. Sting nematode has been found primarily in a few locations in the Arkansas River Valley where deep sandy soils are conducive for its survival.

The lesion nematode may also be found on occasion at high levels in soybeans. This nematode does not appear to be restricted by soil type and may cause significant yield reductions at high levels. The lesion nematode has only been infrequently associated with soybean yield losses in the state. Several other nematodes may be extracted from the soil around the roots of soybeans. These include spiral nematodes, lance nematodes, scutellum nematodes, stunt nematodes and stubby-root nematodes. At this time, these nematodes are not considered an economic concern in soybeans, although research on their impact on soybean yield is limited.

Soybean Cyst Nematodes

Life Cycle

Other than soybeans and a few related legumes such as green beans, lespedeza and a few bean species not grown in Arkansas, soybean is the only cultivated host for soybean cyst nematode (SCN). But, certain weeds are known hosts, and some of these may be found in Arkansas soybean fields. Hemp sesbania (sometimes called coffeebean) is a good host for SCN. This weed is relatively widespread in the state. Another weed that is a good host for SCN is henbit, a common winter annual. Other weed hosts for SCN include old field toadflax, penstemon and jointvetch. These weed hosts may maintain the nematode population when non-host or resistant soybean cultivars are planted and result in the ineffectiveness of rotation in control of the nematode. SCN populations may increase on hemp sesbania, even in flooded rice fields.

Figure 10.2. Cysts formed by female soybean cyst nematodes on plant roots.

The nematode overwinters primarily as eggs encased in the body of the adult female nematode called a cyst. Both the eggs and the cysts of SCN are very resistant to damage, and some eggs within cysts may remain viable in the soil for at least eight years in the absence of a host. In the spring, eggs hatch and the immature (juvenile) nematodes emerge from cysts to infect soybean roots. The juveniles enter the root and establish a feeding site, where they mature through several molts. Once the adult stage has been reached, males leave the roots to mate with the adult females which are attached to the root. Within a few days after mating, the female begins to lay eggs. Eggs are either retained inside the body of the female or are deposited in a protective egg mass attached to the posterior portion of the female. Generally, about 100 to 200 eggs are deposited by each female. The generation time for SCN is around 25 days depending on temperature and other factors. Several generations of the nematode are possible within a single season.

Although soybean is one of the few hosts for SCN, there are 16 possible races of the nematode, any one of which could exist in a particular soybean field. These races cannot be distinguished from each other even with a microscope, so they are identified on the basis of their ability to reproduce on a set of soybean cultivars or breeding lines known as differentials. These differentials have been used extensively in soybean breeding programs as sources of resistance for SCN. Each individual race has the ability to reproduce on a specific kind of resistance. From a practical standpoint, this means that the race of SCN in each field must be identified through a bioassay using the soybean differentials. This is called a race analysis, and it must be conducted before the proper resistant cultivar of soybean can be chosen for that field.

Symptoms

Except on rare occasions where populations are extremely high, SCN does not generally kill the host soybean plant. The severity of symptoms and accompanying yield loss are dependent both on the population level of the nematode and the environment. Plants may be stunted and yellow, exhibiting poor growth or nutrient deficiency symptoms, or the plants may exhibit poor response to either soil fertility or irrigation. Generally spots or areas within a field show severe symptoms, giving a ragged or non-uniform appearance to the field. Significant yield losses can occur, however, in the absence of visible symptoms.

Although the SCN juveniles are too small to be seen with the naked eye, the cysts can be seen on roots with the unaided eye or with a hand lens. During the growing season, beginning about a month after planting, cream-colored or light yellow females may be seen attached to soybean roots if the roots are carefully dug up and the soil gently shaken from the root system. Wetting the roots by dipping in water after removal of the soil may aid in detecting the females. The mature females, or cysts, are brown and are more difficult to see. In addition to their color, cysts are lemon-shaped and are much smaller than the nodules which are a normal part of a healthy soybean root.

Root-Knot Nematodes

Life Cycle

Root-knot nematode (RKN) gets its name from the galls or knots that form on plant roots in response to its feeding. These galls are visible to the naked eye, but they could be mistaken for the nodules that normally form on soybean roots. The nodules are easily broken from the root while galls caused by RKN are a part of the root itself and cannot be broken off without breaking the root as well.

RKN overwinters as eggs in egg masses attached to soybean roots and root pieces in the soil. Eggs hatch in the spring when soil temperature and moisture are adequate, and the juveniles enter soybean roots. Root-knot juveniles establish a permanent feeding site deep inside the root tissue. The nematode feeds in specialized cells that are formed in the transport system of the roots that is responsible for movement of water and nutrients to the top of the plant. These cells disrupt the flow of nutrients and water, and they result in damage to the plant. Development to an adult generally takes about three weeks, and during this time a gall is formed on the root around the feeding site. Once the nematode matures to an adult, eggs are deposited in a jelly-like egg mass that usually protrudes from the surface of the root. A single adult may lay 500 to 1,000 eggs during her lifetime. Freshly hatched juveniles from these egg masses may enter new soybean roots to begin a new cycle. In Arkansas, at least three generations may occur on soybeans during the growing season.

Symptoms

The RKN is the only nematode species on soybean that produces galls on the roots of infected plants. These galls are easily seen with the unaided eye, particularly after midseason. Aboveground symptoms are similar to those seen with SCN. Stunted, chlorotic plants that grow and develop slowly and do not respond well to management inputs may be an indication of a root-knot problem. As with SCN, this nematode also generally is more severe in spots in a field. Sandy spots within fields or fields with sandy soils generally exhibit the most severe symptoms when RKN is present. In addition to direct damage to the plant due to the development of galls, the galled tissue is often more susceptible to root-rotting organisms. In severe cases where secondary rotting occurs, portions of the root system may become totally non-functional. The severity of yield suppression caused by RKN is dependent on several factors including the population level of nematodes present and the degree and severity of other stress factors in the field during the season.

Figure 10.3. Galls produced on soybean roots by root-knot nematodes.

Reniform Nematodes

Life Cycle

Detection of a reniform nematode (RN) problem is more difficult than with either SCN or RKN because they do not produce cysts or cause galls to form on infected roots. RN overwinter as eggs in egg masses attached to root pieces or as juveniles or immature adults free in the soil. Juveniles hatch in the spring and mature to the adult stage in the soil. The immature adult females partially enter roots and establish a feeding site. The time from root penetration to maturity is similar to SCN and RKN, approximately 25 to 30 days. Similar to RKN, eggs are deposited in an egg mass. Egg masses are very difficult to distinguish on roots even with a hand lens, although an indication of an RN-infected root is the presence of abundant soil particles that remain adhered to the root when the root system is dug up. The only accurate method for determining RN presence is through a soil assay conducted by a nematology laboratory. RN has the potential to increase to extremely high population levels on soybeans during a single season, and it is not unusual to find 50,000 or more RN per pint of soil around soybean roots. Currently, little is known about overwinter mortality or survival of RN in Arkansas, but in fields where this nematode has

been detected, population levels several times greater than either SCN or RKN are common.

Symptoms

RN appears to have the potential for much more uniform infestation of entire fields than either SCN or RKN. Determining that a problem exists based on areas of poor plant growth within a field is often difficult. Yield may be suppressed field-wide or over large areas, but no obvious "hot spots" may be visible. Infected plants may be stunted slightly or appear slightly off color. As with the other nematode pests, response to management inputs may be disappointing. Soils with 20 to 40 percent silt or clay content appear to be optimum for RN, and environmental stress, particularly water stress, appears to amplify RN losses. In severe infestations, yield suppression may be as high as 30 to 40 percent.

Nematode Control

The foundation of any nematode control program is the identification of the nematodes to be controlled and an estimate of the number present. This can be done accurately only through collection of soil samples for assay by a nematology laboratory. Careful and thorough sampling of each field and proper handling of the sample after collection are vital to an effective nematode control program.

Sampling and Detection

For a fee, any Arkansas soybean producer can get a nematode assay from the Arkansas Nematode Diagnostic Laboratory at the Southwest Research and Extension Center in Hope. Two types of assays are available through this service: (1) A general nematode assay to determine the types of nematodes present in the field and the number of each type and (2) an SCN race analysis to determine the race of SCN present in the field. The general assay costs $10 per sample and requires about one to two weeks to complete. SCN race analyses cost $17 per sample. Because they are bioassay tests that must be conducted in a greenhouse, SCN race analyses require about four to six weeks to complete. Samples, along with payment, should be submitted to the laboratory through your local county Extension office.

Actual collection of soil for a nematode assay is done in much the same way as for a soil test for fertilizer recommendations. Sample each field thoroughly to give an accurate representation, and divide large fields into blocks so that each sample represents no more than 50 acres. **The similarity between nematode samples and samples for fertilizer recommendations ends at this point.**

Nematodes are living organisms and must remain alive until the assay is performed. This means that special care must be taken in handling and shipping of the samples after they are collected. Immediately upon collection, place each nematode sample in a plastic bag, label the **outside** of the bag with the field number or name and seal it to keep the soil from drying out. Once in the plastic bag, protect the sample from direct sunlight and from excessive heat or freezing temperatures. Placing the samples in a cooler or ice chest (without ice) is the best way to protect nematode samples for transport to the county Extension office for shipping. If samples cannot be delivered to the county office within 24 hours of collection, they may be stored for a few days **in the ice chest without ice** in an air-conditioned building or basement. However, prolonged storage of samples prior to assay may lead to erroneous results due to nematode mortality during storage.

General Assays

Collect samples when soil is moist, but not flooded. Sample with a soil sampling tube in the root zone to a depth of 6 to 8 inches. Collect at least 25 to 30 soil cores from each field and combine. After thoroughly mixing the combined sample, remove **one pint** for shipping to the laboratory for a general assay. The most accurate results will be from samples collected from midseason through early fall. Samples collected after November may not accurately represent the nematode population in the field and lead to erroneous results. The **worst** time to collect samples is during the winter and early spring (December-March).

Race Analysis

This assay is only appropriate for SCN. Collect samples in the same way as for a general assay, except more soil is needed. A race analysis requires about 2 quarts of soil. Both a general assay and a race analysis can be obtained with this volume of soil; and in situations where SCN has already been verified by the county agent by a visual inspection of roots, both tests may be requested at one time. Shipping 2 quarts of soil and requesting a race test without knowing whether or not SCN is present can be a waste of time and shipping expense if SCN is not found in the sample. Collect samples for SCN race analysis **only** from midseason through September. Although SCN may be present at high

levels in soil collected during the fall, winter or early spring, the eggs may not hatch in sufficient quantities to give an accurate race test.

Thresholds

Damage thresholds have been established for SCN, RKN and RN. Thresholds are the population levels at which there is a high probability of yield loss due to the nematode. Although thresholds provide a general guide to identifying problem fields, the presence of SCN, RKN or RN at any level in a field indicates a potential for problems. Populations of these nematodes may increase from low levels to damaging levels within a year or if susceptible crops are grown. As indicated, the most representative samples will be those collected from midseason through early fall. Winter and spring samples may not be indicative of the magnitude of a problem with SCN and RKN. RN appears to be detectable at any time of year. Thresholds used in reporting results of nematode assays for soybeans are listed in Table 10.1.

Table 10.1. Soil Population Density Thresholds for Soybeans

Nematode	No./Pint of Soil	
	June-October	November-May
SCN (eggs)	500	N/A
RKN	300	N/A
RN	1,000	500

Resistant Cultivars

Where available, the use of resistant cultivars is an effective and economical method for managing nematode problems. Selection of resistant cultivars to manage RKN is relatively straightforward. Several well-adapted cultivars are available with high levels of RKN resistance. Growing a resistant cultivar for one to three years usually lowers RKN populations significantly, although in some instances a population that is capable of parasitizing the resistant cultivar may be selected if resistant cultivars are used continuously for several years. Because of the potential for differences in race from field to field, selection of SCN-resistant cultivars is more complicated. In Arkansas, races 2, 5, 6 and 9 are the most common with races 1, 3, 4 and 14 also frequently found. The race that is present in any field can only be determined through an SCN race analysis. Several cultivars are resistant to certain of these races. Unfortunately, few well-adapted, highly productive cultivars have been developed with resistance to some of these races. The cultivar 'Hartwig' appears resistant to all races, but yield potential of this cultivar is not as high as many other cultivars in the absence of SCN. In situations where high-yielding cultivars with resistance to a particular race exist, the effectiveness of the resistance may be lost through continuous production of the resistant cultivar in the same field. SCN races have been shown to shift or adapt to resistant cultivars over time if they are continuously exposed to the resistant cultivar. Consequently, continued monoculture of a resistant cultivar may result in the loss of effectiveness of the resistance in the field within as few as three years. Apparently only a few soybean cultivars are poor hosts for RN. Because this nematode has only recently become a major problem in Arkansas, screening of many of our available cultivars has not been done.

Crop Rotation

Although probably the least attractive nematode control method for many Arkansas producers, crop rotation is the most cost-effective nematode control strategy. Non-host crops are very effective in lowering nematode population levels, and inclusion of a non-host in the cropping sequence at the right times can maintain nematode populations below economic levels for sustained soybean production. If crop rotation is used, however, it is vital that both the right rotation crop and the right timing of the rotation crop be employed. Decisions on the selection of rotation crops and how often to use them must be based both on an accurate identification of the nematode problem and the economics of the rotation program. Be careful in your selection of rotation crops because many commonly grown crops and cultivars are susceptible to various nematode species. Suggested crops for management of SCN, RKN and RN are listed in Table 10.2. Annual nematode assays allow decisions on the timing of rotation to be made most efficiently based on nematode population levels in the field.

Nematicides

Two chemical nematicides, Temik 15 G and Vydate L, are labeled for use on soybeans in Arkansas. Substantial research indicates that nematicide use is generally not economical in most production fields. Nematicides, however, may be profitable in some situations such as in seed production where potential returns from the crop are greater.

Table 10.2. Suggested Rotation Crops and Timing of Rotation for Management of Soybean Nematodes

Nematode	Suggested	Frequency or Sequence	Not Recommended
SCN	Grain sorghum Corn Cotton Peanut Rice*	Non-host ↓ Resistant soybean ↓ Susceptible soybean ↓ Repeat	Lespedeza Green bean
RKN	Grain sorghum** Peanut Rice	Based on population	Corn Cotton Vegetables
RN	Grain sorghum Corn Rice Peanut	Based on population	Cotton Vegetables

* Rice may not lower SCN populations as well as other non-hosts.
** Do not plant grain sorghum on RKN-infested soil more than one year without changing to another crop.