DIVISION OF AGRICULTURE
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Nematode Management

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Although many different nematodes can be associated with soybeans in Arkansas, only a few are sufficiently damaging to the crop to be of economic concern. Unfortunately these economic species are widespread throughout the soybean production regions of the state. Yield suppression as high as 50% may occur with these nematodes at high population densities under the right conditions.

Three nematode species – the southern root-knot nematode (RKN), *Meloidogyne incognita*, the soybean cyst nematode (SCN), *Heterodera glycines*, and the reniform nematode (RN), *Rotylenchulus reniformis* – are responsible for the majority of soybean yield losses due to nematodes. In addition, the lesion nematode (LN), *Pratylenchus* spp., occasionally may suppress soybean yield. Historically in Arkansas, SCN was the most widespread, but in recent years RKN has surpassed it as our most common nematode. RKN is also the most damaging species and can actually kill infected plants in sandy soil types if populations are high enough (Figure 10-1).

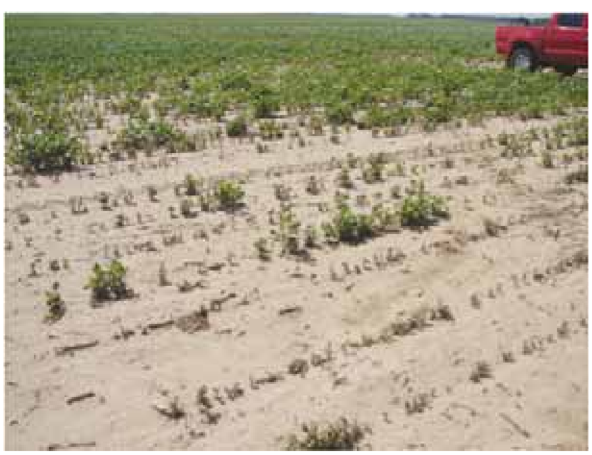

Figure 10-1. Severe root-knot nematode damage in soybeans.

Root-Knot Nematodes

As the name implies, RKN damages plants by inducing knot-like swellings (called galls) to form on roots of infected plants (Figure 10-2). These galls can lower the ability of the root system to absorb and translocate water and nutrients, and they also provide entry points for secondary fungal pathogens that may further damage the roots.

Figure 10-2. Root galling caused by the root-knot nematode.

Life Cycle – RKN overwinters in the soil as eggs in egg masses attached to roots of the previous crop, although in mild winters, particularly in southern Arkansas, immature nematodes (juveniles) may be present in the soil throughout the winter. When soil temperature is favorable (77º-86ºF), eggs hatch and juveniles migrate to soybean roots. RKN enter roots and migrate to the vascular tissue where they establish a permanent feeding site, become stationary and develop through three molts to adults. The feeding activity of the adult female induces gall formation. Within 20-30 days, depending on soil temperature, several hundred eggs are deposited into an egg mass on the surface of the root.

Symptoms – Root galls are diagnostic for RKN. It is the only nematode that causes root galling. RKN is not uniformly distributed in fields, and the presence of "hot spots" with stunted, yellow plants is an indication that RKN may be involved (Figure 10-3). Because infection interferes with normal root function, nutritional deficiency symptoms are commonly associated with nematode-infected plants. During late season, severe root-knot damage may actually include plant death, due in part to the activity of secondary fungal pathogens. The severity of yield suppression caused by RKN is dependent on several factors that include the population density of the nematode and the severity of other stress factors in the field.

Figure 10-3. Symptoms of RKN in a field. Note the presence of hot spots.

Soybean Cyst Nematodes

In contrast to RKN, SCN does not cause gall formation on soybean roots. SCN can, however, be relatively easily diagnosed with a hand lens because they are visible on the exterior of the root as small white or yellow lemon-shaped females (Figure 10-4). As the females age, they turn darker in color and die – becoming the cysts for which the nematode is named (Figure 10-5).

Figure 10-4. White soybean cyst females attached to soybean roots.

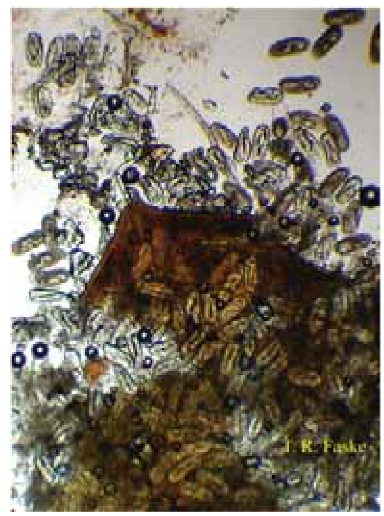

Figure 10-5. Ruptured soybean cyst containing eggs and second-stage juveniles.

Life Cycle – The nematode overwinters primarily as eggs that are encased in the cysts. Both the cysts and the eggs themselves are very resistant to damage from the environment, and some eggs within cysts may remain viable 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 infect the roots and establish a feeding site where they remain through the remaining three molts. In contrast to RKN that reproduces by parthenogenesis so mating of males and females is not necessary, adult SCN males leave the root and mate with adult females who are attached to the roots by their head and neck. Within a few days after mating, females begin to lay eggs that are either retained inside the body or deposited into an egg mass attached to the posterior of the female. The generation time for SCN is around 25 days at favorable soil temperatures (75º- 82ºF).

Symptoms – Plant symptoms of SCN infection can range from essentially undetectable to readily apparent depending on the severity of the problem. SCN can occur in the field as a number of biotypes, called "races" or "HG types," that differ in their ability to parasitize different soybean cultivars and breeding lines. Some of these biotypes cause more dramatic symptoms than others on certain cultivars. In general, however, symptoms of severe SCN infection are similar to those with RKN, although it is rare for SCN to result in plant death. Stunted, chlorotic plants, particularly when they occur in patches or localized areas in fields, are an indication that SCN may be involved.

Reniform Nematodes

Detection of RN in the field is more difficult than with either RKN or SCN because they do not produce cysts or cause root galling.

Life Cycle – RN overwinter as eggs in egg masses attached to root pieces or as juveniles or immature adults free in the soil. In the spring, males and infective females partially enter roots and establish a feeding site. As the females mature, they become reniform- or kidney-shaped and can sometimes be seen with a hand lens protruding from the root surface (Figure 10-6). The life cycle of RN is slightly shorter than for RKN or SCN and is completed in 17-23 days at favorable temperatures (81°-86°F).

Figure 10-6. Mature female reniform nematodes protruding from the surface of a soybean root.

Symptoms – As with SCN, symptoms of RN damage are general stunting and chlorosis of infected plants. RN are less widely distributed in Arkansas than RKN or SCN and are much more common in southeastern Arkansas than in production areas in the northeastern part of the state. RN have not been detected in Southwest Arkansas or in the Arkansas River Valley. RN is generally more uniformly distributed within fields than either RKN or SCN, so patches or "hot spots" of stunted plants are not usually obvious. Root systems of infected plants may be smaller than normal with fewer feeder roots, and foliage may exhibit nutrient deficiency symptoms or a general chlorosis. However, the only accurate method for determining RN presence is through a soil assay for nematodes conducted by a nematology laboratory.

Lesion Nematodes

On occasion, lesion nematodes may be found at high levels in soybeans. This nematode has only infrequently been associated with yield loss in soybeans, but severe root infection can suppress plant growth and yield. LN are migratory endoparasites that penetrate into the roots and feed in the cortex, without any external signs other than the formation of discolored lesions that occasionally form on feeder roots. A soil assay by a nematology laboratory is required for detection of LN.

Nematode Management

The foundation of any nematode control program is the identification of the types of nematodes that are present and an estimation of their relative population density. The most effective means of determining these things is with a soil sample that is assayed by a nematology laboratory. Careful and thorough sampling of each field and proper handling of the sample after collection are vital to developing an effective nematode control program.

The Arkansas Nematode Diagnostic Laboratory

The Arkansas Nematode Diagnostic Laboratory located at the Southwest Research and Extension

Center near Hope, Arkansas, offers soil nematode assay for a small fee to any Arkansas producer. Details of this service and a list of fees may be obtained by emailing rbateman@uada.edu or by contacting your local county Extension agent.

There are two types of nematode samples: predictive samples, which are collected in the late summer or early fall to help determine a strategy for the next year, and diagnostic samples that are collected during the growing season to help diagnose a nematode problem in the current crop.

Predictive Samples

Collecting soil for a predictive nematode assay is done in much the same way as for a soil test for fertilizer recommendations. Sample each field thoroughly. Large fields should be divided into smaller blocks so that no more than 50 acres is represented by a single sample. Where obviously different soil types exist in a field, sample each soil type separately. A sample is defined as a composite of several subsamples (soil cores) collected across the field with a soil sampling tube. Cores should be taken in the bed or in the root zone for flat-planted crops to a depth of 6 to 8 inches using a soil core sampler (sampling tube). Include at least 20 individual cores to represent each field that is sampled. The total volume of soil per sample should be approximately one pint.

A second type of predictive assay that is available is a SCN race determination. This test is a biological assay that actually evaluates the ability of the SCN detected in the soil to reproduce on an array of soybean cultivars (called differentials) – which is how races are determined. With this test, SCN are isolated from the soil sample and increased in a greenhouse by growing them for 45-60 days on a susceptible soybean cultivar. The SCN is then inoculated onto the soybean differentials and allowed to grow for about 30 days to ensure that a single generation of the nematode has been completed. The race is then determined based on the ability of the nematodes to reproduce on the differentials.

Diagnostic Samples

Diagnostic samples are used to determine if nematodes are present in a particular field or are causing a specific problem. These samples are mainly used to identify possible causal agents and quantify the types of nematodes that are associated with the issue. Diagnostic samples can be taken at any time during the growing season, but are most useful if they are taken soon after a problem is seen. In addition to soil samples, plants in the affected area should also be dug up (carefully, as if preparing to transplant) with a shovel and root systems inspected for the presence of galls, cysts or lesions. It is generally a good practice to collect soil and plants from the affected area and also soil and plants from adjacent areas that are not showing symptoms for comparison. Either a core sampler or a cone sampler (Figure 10-7) can be used to collect soil for diagnostic samples, and soil should be collected within the root zone. If neither a core or cone sampler is available, a shovel can be used to collect a composite sample. Soil that is shaken from the root system can be used for the soil assay, and the roots can be inspected for signs or symptoms of nematodes. The total volume of soil per sample should be approximately one pint, and root samples should be placed in a separate bag.

Figure 10-7. Cone-sampler (left) and core sampler (right) for collection of soil samples.

Proper Handling of Samples

Nematodes are living organisms and must remain alive until the assay is performed. This means that special care is needed in handling, storing and shipping soil samples for an accurate nematode assay. Immediately upon collection, place each composite sample into a plastic bag and seal the bag to retain moisture. Label the outside of the bag with the field number or name and the farm name. Protect soil in the bag from direct sunlight and from excessive heat or cold as this could contribute to an inaccurate count of nematodes in the soil sample. Placing the samples into insulated coolers (without ice) is the best way to protect nematodes samples until they can be shipped to the nematology laboratory. Samples in sealed plastic bags may be stored for several days in insulated coolers at cool (60°F) room temperature, but should be shipped soon after sampling. If samples are diagnostic, plant samples should, however, be either stored in an ice chest with ice or in a refrigerator until they are shipped. DO NOT STORE SOIL FOR NEMATODE ASSAY ON ICE.

Thresholds

Although many factors influence the severity of the damage that can be caused by nematodes, thresholds have been established for RKN, SCN and RN that can be useful guidelines for determining the risk associated with nematodes in a particular field or site. Thresholds are the population densities at which there is a high probability of yield loss due to the nematode. Although thresholds provide a general guide to identifying problem fields, keep in mind that the presence of these nematodes at any level in a field indicates a potential problem. As indicated earlier, samples collected during late summer or early fall are the most useful in predicting nematode risk for the following year. Samples collected in the winter or early spring may not accurately detect RKN or SCN because at that time the population is surviving mainly as eggs that are not recovered efficiently with most laboratory soil assay procedures. It appears that because RN survives well as juveniles or immature adults, samples during the winter or spring are useful in predicting crop risk. Thresholds that are used in Arkansas in reporting results from soil assays are given in Table 10.1.

Table 10-1. Soil population density thresholds for soybeans.

Nematode	No. Nematodes/100 cm^3 of Soil	
	June - November	December - May
RKN	60	NA*
SCN	500	NA
RN	1,000	500

*Not appropriate – soil samples collected during this time period may not be accurate.

Resistant Cultivars

Planting nematode-resistant cultivars is an effective and economical method for managing nematode problems. Resistance in the cultivar must match the nematode that is present in the site, and there are RKN-, SCN- and RN-resistant cultivars available. Very few cultivars, however, are resistant to all three species. In addition, as indicated earlier, SCN can occur as numerous races, so resistance to one biotype may not provide resistance against others. Information on the nematode-resistant cultivars that are available and adapted to Arkansas is available through all county Extension offices, in the current *Soybean Update* and in SOYVA. As a service to growers, many new cultivars are screened for nematode resistance each year through the annual Soybean Cultivar Disease Screening Program that is supported through the Arkansas Soybean Promotion Board. This information is used to develop the annual *Soybean Update*, which is available at http://www.arkansasvarietytesting.com/. Although few RKN-resistant MG IV cultivars are available, there are numerous MG V cultivars with good resistance to RKN. Planting a resistant cultivar generally results in yield improvement of 10%-25% depending on the severity of the problem, although where RKN is extremely severe, yield improvement can be much greater (Figure 10-8). An additional advantage of growing a resistant cultivar is that generally nematode population densities decline in the site. Some cultivars are advertised as moderately resistant or moderately susceptible to RKN, and these may result

Figure 10-8. RKN-resistant cultivar (foreground) and susceptible cultivar.

in a significant yield improvement if the nematode pressure is not excessive. However, most of these cultivars also allow the nematode to reproduce at nearly normal rates, so nematode populations remain high and may pose a risk for the next crop that is grown in the field. Numerous SCN-resistant cultivars are available across all soybean maturity groups, but these cultivars are not resistant to all SCN. Unfortunately, a majority of the available SCN-resistant cultivars are effective against races of historical importance in Arkansas (races 3, 9 and 14), none of which are common in the state today. A few RN-resistant cultivars exist, but the majority of soybean cultivars are susceptible to this nematode. No cultivars with LN resistance are known to exist.

Crop Rotation

Crop rotation has become a much more attractive tactic in an overall nematode management strategy in recent years due to the increasing diversity of Arkansas crop production systems. Growing crops that are not hosts for a particular nematode can be a very effective way to lower nematode population densities, and the inclusion of a non-host in the cropping sequence at the appropriate times can maintain nematode populations below economic levels for sustained periods of time. As with selection of the right resistant cultivar, it is vital that the cropping sequence be matched to the nematode species that are to be managed. For example, if SCN is the issue, then any of our more popular crops including rice, corn, cotton, grain sorghum or peanuts can be effective in lowering nematode density because none are hosts for SCN. However, if RKN is severe, then growing rice, peanuts or grain sorghum can effectively lower the nematode population, but growing cotton, corn or soybeans in the field will likely enhance the severity of the problem. Always obtain an accurate identification of the nematode(s) that are of economic concern in each field before planning a rotation sequence. Suggested crops for management of RKN, SCN and RN are listed in Table 10.2. Rice and cotton are effective in lowering LN populations.

Table 10-2. Suggested rotation crops for nematode management.

Nematode	Suggested Crops	Crops Not Recommended
RKN	grain sorghum peanut rice	corn cotton vegetable crops (watermelon, tomato, sweet potato, etc.)
SCN	grain sorghum corn cotton peanut rice	green beans
RN	grain sorghum corn peanut rice	cotton vegetables
LN	rice cotton	corn grain sorghum peanut

Nematicides

Few nematicides are available for use in soybeans, and generally nematodes can be managed much more economically through the use of resistant cultivars and crop rotation.

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