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Crop Rotation for Management of Nematodes in Cotton and Soybean

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Introduction

Plant-parasitic nematodes can be found in the soil in every field in Arkansas feeding on the roots of crop plants or weeds. Some types of nematodes cause very little loss in yield, while a few types can be very costly to growers.

The three nematode species that are the most economically important in Arkansas row-crop agriculture are the root-knot nematode (*Meloidogyne incognita*), the reniform nematode (*Rotylenchulus reniformis*) and the soybean cyst nematode (*Heterodera glycines*). These three nematodes account for at least 90 percent of the nematode-induced crop losses that occur in the state each year.

Nematode control can be difficult and expensive. In some crops such as cotton, nematicides are available that may provide an effective level of nematode control. These chemicals are relatively expensive, toxic to man and animals and must be applied annually. There are no cotton cultivars with effective levels of resistance to nematodes, but genetic resistance to each of these three nematode species can be found in a few soybean cultivars. Unfortunately, no soybean cultivar is resistant to all three nematodes, and cultivar selection alone may not always be a practical means of nematode control. Crop rotation can play a valuable role in managing a nematode problem. Lowering nematode population densities in the soil by the production of non-host or resistant crops or cultivars can be very effective in mitigating nematode damage in a subsequent susceptible crop. Three crops are effective in rotation with cotton or soybean for nematode management: corn, grain sorghum and rice. Each crop has certain strengths and weaknesses as a rotational crop for nematode management, and it is important to be aware of the effects of each crop on plant-parasitic nematodes.

Planning a Cropping Sequence for Nematode Management

Step 1. Know the Nematode Status of Each Field

An accurate knowledge of which nematodes are present in the field and the population density (how many of the nematodes are in the field) is the first step in any nematode management strategy. Since plant-parasitic nematodes are microscopic and live in the soil, the only way to gain this knowledge is through careful and thorough soil sampling of each field and proper assay of the soil samples by a nematology laboratory.

In Arkansas, any producer can obtain a nematode assay from the University of Arkansas Nematode Diagnostic Clinic located at the Southwest Research and Extension Center in Hope. Advice and instructions for proper sampling technique, timing and handling of the sample after it is collected, fees and transport to the clinic are available through all local county extension offices in the state or from www.uaex.uada.edu/agriculture/pestmanagement/nematodes.

Step 2. Understand How Nematodes Act and How Different Crops Affect Their Life Cycle

The only generalization that can safely be made regarding nematodes is that **there are no generalizations**. Each nematode and host plant relationship is unique. For example, soybean cyst nematodes can reach extremely damaging populations on soybean (a good host) but will not reproduce at all on most other crops. Root-knot nematodes, by contrast, can reach damaging population densities on several crops including cotton, soybean and corn. Since crop rotation is, by definition, a relatively long-term nematode management strategy, it is important to understand how each crop species will affect each nematode. The following is a short synopsis of the ecology of our three major economic nematode species as they relate to various crops.

Figure 1. Root galls formed by the root-knot nematode. A. Cotton. B. Soybean.

Root-Knot Nematodes

Ecology. The root-knot nematode occurs in the field as "hot spots." Very seldom will a root-knot problem field show uniform crop damage. This spotty distribution is due to several factors that relate to the life cycle of this nematode.

Root-knot nematodes lay eggs in tiny egg masses that are attached to the root near the site of infection. These eggs (generally 500 to 1,000 per individual female) are contained in a gelatinous matrix known as an egg mass. Because the egg masses tend to concentrate the eggs, which are the life stage that overwinters, they also tend to concentrate the infective juveniles that hatch from the eggs in the spring.

Consequently, root-knot nematode density tends to be highest near where the crop was severely infected and much less dense in areas a few feet away. Since the life cycle is completed in about one month, by the end of the season, root-knot can be extremely high in these "hot spots" in the field. Root-knot nematodes also tend to be most successful in sandy soil or sandy spots within fields and may cause considerably more crop damage in these areas than in areas with more silt or clay nearby.

Crop effects. Root-knot has the broadest host range of our major nematode species. Cotton, soybean and corn are particularly susceptible to this nematode. Root-knot nematodes cause galls or knots to form on the roots of infected cotton and soybean plants that are easily seen (Figure 1). With corn, root-knot nematodes infect and reproduce well, but galls are inconspicuous and difficult to see (Figure 2). Root-knot population densities that carry over to the next crop may be extremely high following corn, but above-ground plant symptoms may not be obvious.

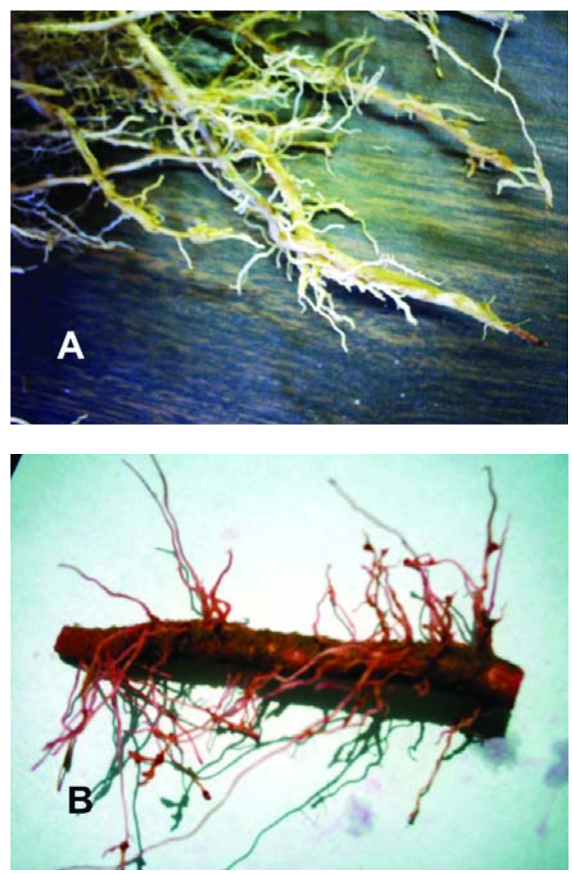

Figure 2. Corn roots infected by the root-knot nematode. Note the galls are difficult to see (A) until a biological stain is used to improve visibility (B).

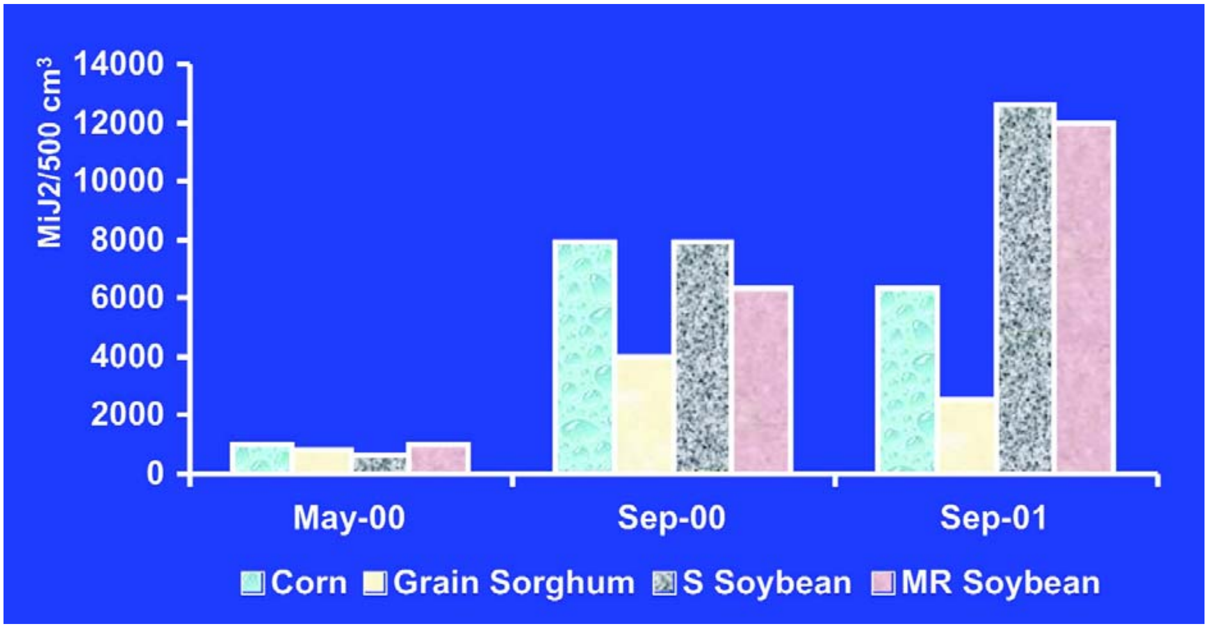

Figure 3. Root-Knot Population Densities After Corn, Grain Sorghum, Moderately Resistant Soybean and Susceptible Soybean *(Courtesy of C.M. Coker and T.L. Kirkpatrick)*

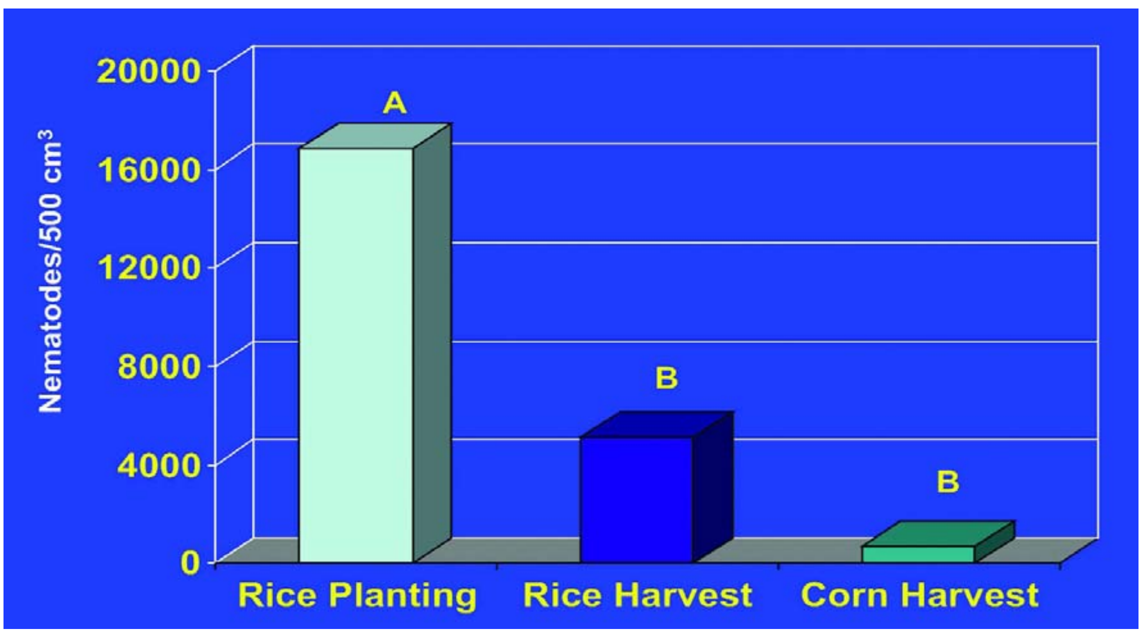

Figure 4. Population Density of *R. reniformis* in a Cotton-Rice-Corn Rotation *(Courtesy of W.D. Kirkpatrick)*

Grain sorghum is a rather poor host for this nematode. If grain sorghum is planted where root-knot is severe, some infection may occur, but reproduction is not nearly as high as with corn, cotton or soybean. Rotation sequences that include grain sorghum tend to lower nematode population densities, but corn, or even soybean cultivars that are classified as moderately resistant to *M. incognita*, will maintain or increase the problem (Figure 3).

Rice is reported to be a host for *M. incognita*, but the nematode does not survive well under flooded soil conditions. Where root-knot nematode population densities are high, a single year in rice will lower nematode populations dramatically.

Reniform Nematodes

Ecology. The reniform nematode is a relative newcomer to Arkansas. Prior to 1990, reniform nematodes were known to be present in only a few cotton fields in Monroe and Jefferson counties. However, this nematode species has expanded its range throughout the eastern half of the state, and reniform nematodes have now been identified in both cotton and soybean fields in 11 counties from the Louisiana line to the Missouri Bootheel.

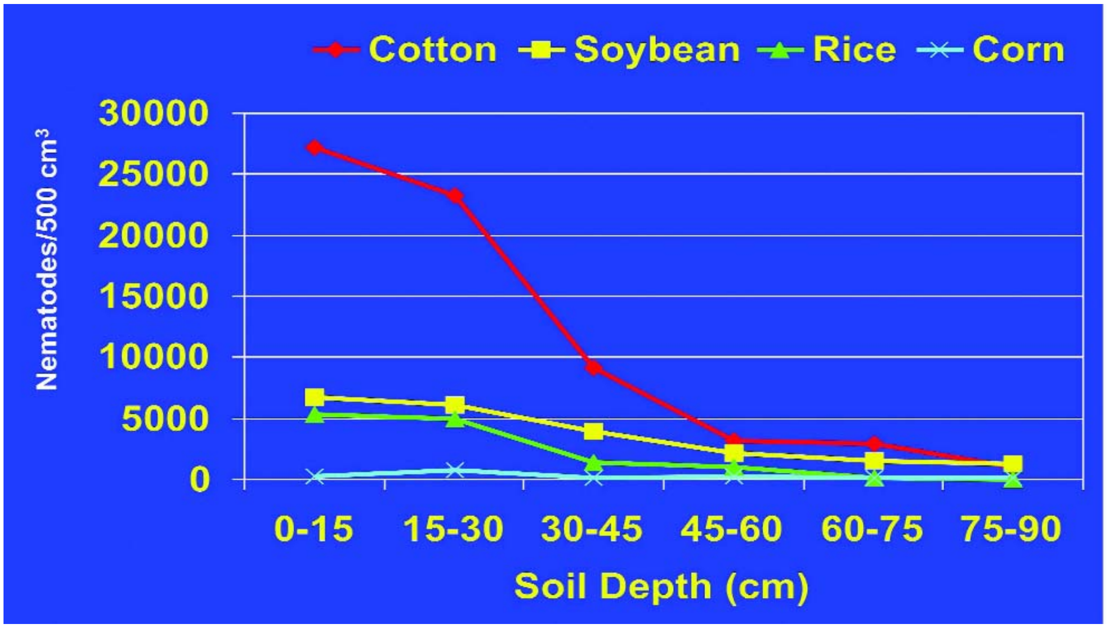

Figure 5. Vertical Density of *R. reniformis* After Cotton, Soybean, Rice and Corn *(Courtesy of W. D. Kirkpatrick)*

Reniform nematodes, in contrast with root-knot, may be distributed throughout fields rather than in hot spots, making reniform nematode problems more difficult to detect visually. Diagnosis in the field is also difficult because the reniform nematode does not produce any obvious symptoms on infected plants other than a smaller-than-normal root system. Reniform nematodes are most successful in soil types that contain considerably more silt or clay than those that favor root-knot nematodes.

The life cycle of the reniform nematode is a few days shorter than that of root-knot. Juveniles, pre-infective adults and eggs overwinter, and reniform nematode population densities in either cotton or soybean may be extremely high (several times the density of root-knot) after only a few seasons. The length of time that a field has been infested, the cropping history of the field and soil type influence the severity of the reniform problem in the field.

Crop effects. Cotton is the most suitable host in terms of nematode population densities that may be achieved, although soybean is also a good host for this nematode. Monoculture of either crop or rotation of cotton and soybean may result in extremely high reniform nematode population densities within only a few years. Rice, grain sorghum and corn (in contrast to root-knot) are all non-hosts for reniform nematodes. Cropping sequences that include one or more of these crops can significantly lower reniform nematode population densities (Figure 4). Following rotation, however, a resurgence in the nematode population may occur within only a year or two after a susceptible crop is grown. Reniform nematodes are mobile vertically in the soil profile, and it appears that a residual population of the nematodes may remain deep in the soil following a non-host crop (Figure 5).

Soybean Cyst Nematodes

Ecology. The soybean cyst nematode has a narrow host range and attacks only soybean and a few closely related legumes (green bean, hemp sesbania, lespedeza). The fact that Arkansas farmers plant about 3 million acres of soybean annually has pushed this nematode to prominence as an economic pest, and conservative estimates indicate that about 70 percent of our soybean acreage has a detectable population of this pest. Soybean cyst nematodes can be found across a range of soil types from clay to loamy sand, although crop loss is most often associated with lighter-textured soils.

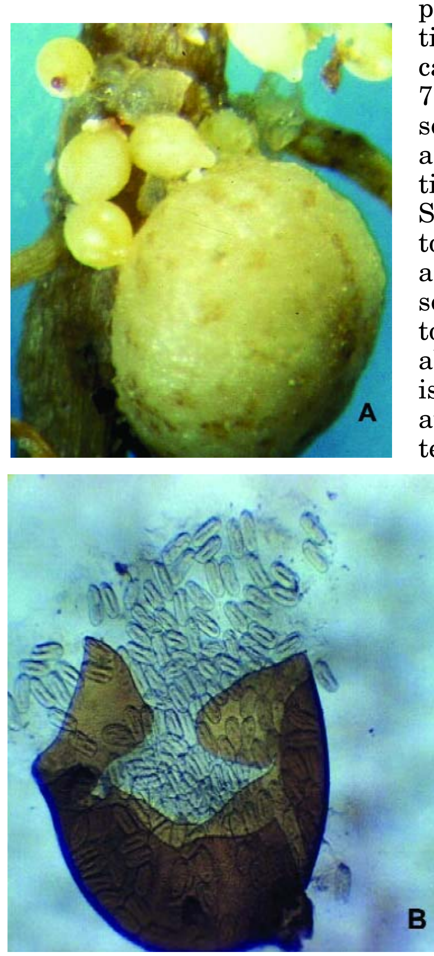

Figure 6. A. Mature soybean cyst nematode females (cysts) on a soybean root. Note the size and shape difference between the cysts and the root nodule (larger, round structure) that is a normal component of the root. B. A ruptured cyst showing the eggs it contained.

The life cycle of *H. glycines* is similar in duration to that of the root-knot nematode. Mature females produce eggs, most of which are retained inside the body. These egg-filled female bodies, also known as cysts, are visible on the roots if the roots are dug carefully and inspected (Figure 6). During adverse weather (drought or excessive moisture) in the absence of a host, or during the winter, these cysts become a protective covering for the eggs and assist in nematode survival. *Heterodera glycines* can enter a period of long-term dormancy or quiescence when no host is available. While the number of individuals in the population that may enter this resting state is low, a residual population of soybean cyst nematodes will likely remain in the field for several years, even in the absence of soybean. Because cysts tend to be concentrated near the areas where infection occurred and host roots were present, soybean cyst nematode problems in fields tend to be spotty.

Crop effects. Rotation to essentially any crop other than soybean is effective in lowering soybean cyst nematode population densities, and rice, corn, cotton and grain sorghum are good rotational choices. Recent studies and grower experience in Arkansas, however, indicate that rice in rotation with soybean may be slightly less effective in lowering nematode population densities than the other crops mentioned. Although it is not known why this is the case, it is likely that flooding inhibits microbial activity that may result in a certain degree of biological control of this nematode in non-flooded soils.

Numerous soybean cultivars are currently available with genetic resistance to the soybean cyst nematode. Unfortunately, in Arkansas the utility of these resistant cultivars is somewhat limited. A majority of the soybean cultivars currently marketed in the mid-South derive their soybean cyst nematode resistance from a single germplasm source. Recent surveys in the state indicate this particular type of resistance is not highly effective against a majority of *H. glycines* populations isolated from our production fields. Consequently, planting a "resistant" cultivar may not effectively minimize damage to the crop where nematode population densities are high.

Step 3. Consider the Nematode Risk and the Grower's "Risk Tolerance"

Successful nematode management using crop rotation requires an accurate estimate of the problem or potential for a problem (Step 1) and an understanding of the pest to be managed (Step 2). In addition, the economic feasibility and practicality of a rotational management strategy must be considered. Other management practices that will be required, particularly herbicide programs for all crops in the sequence, must be carefully evaluated for compatibility. Specialized requirements such as planting and harvesting equipment, crop drying or storage requirements, land ownership and rental agreements and price outlook for all crops in the strategy must also be weighed carefully before a rotational program will be practical and economically beneficial. Nematode management by crop rotation is a long-term, ongoing strategy directed toward maintaining the overall profitability of a farming operation. To be successful, this approach will require annual evaluation of all aspects of the strategy and ongoing monitoring of the nematode populations in each field.

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