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Cotton Nematodes in Missouri: Your Hidden Enemies

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In 1996, diseases, including nematodes, reduced the U.S. cotton crop by 2,505,287 bales valued at $789.2 million, according to estimates by the Disease Loss Committee of the National Cotton Council. Plant parasitic nematodes alone accounted for an estimated yield loss of 763,066 bales valued at $240.4 million.

What is a nematode?

Nematodes are wormlike animals that are mostly invisible, ranging in size from microscopic to more than 10 feet in length. There are more than 10,000 known species of nematodes. Fortunately, only a limited number cause problems to humans and domesticated plants and animals.

Cotton nematodes in Missouri

In 1989 members of the Cotton Foundation, part of the National Cotton Council, decided that too little was known about cotton nematode problems in the United States. They asked scientists from each cotton-producing state to form a committee and conduct studies, including surveys of cotton fields for nematodes. University of Missouri scientists surveyed for cotton parasitic nematodes in Dunklin, New Madrid, and Pemiscot counties, which produce about 98 percent of Missouri's cotton. They sampled 90 fields in this three-county area. Lance nematodes were found in two fields and reniform nematodes in three, but root-knot nematodes were present in many fields. The percentage of cotton fields where root-knot nematodes were found was 45 percent in Dunklin, 20 percent in New Madrid, and 26 percent in Pemiscot. Fortunately, only a few fields had enough root-knot nematodes to cut yield.

Root-knot nematodes

Root-knot nematodes were first recorded as parasites on vegetables in 1885. They are called root-knot nematodes because the galls they produce on roots look like knots in a rope. Five years later, they were observed attacking cotton in the southern United States. Root-knot nematodes, which include more than 60 species, attack nearly all crop and weed species. The most common species of root-knot nematodes are *Meloidogyne incognita*, *Meloidogyne arenaria*, *Meloidogyne hapla* and *Meloidogyne javanica*. These nematode species are generally considered to be among the 10 most important plant pathogens in the world and are responsible for hundreds of millions of dollars in crop losses annually. All four species occur in the U.S. Cotton Belt, but only some populations of the species *Meloidogyne incognita* (also known as the southern root-knot nematode) attack cotton. Recent survey data show populations of this nematode are widespread throughout the Cotton Belt. More than 75 percent of the cotton fields in some areas are infested. *Meloidogyne incognita* was the only root-knot nematode found in Missouri.

Biology of root-knot nematodes

Like all other plant parasitic nematodes, root-knot nematodes must have a plant to feed on to complete their life cycle. The simple life cycle has four juvenile stages in addition to egg-laying adult female. Egg production occurs without sexual cross-fertilization of eggs. Even though adult males may be present, they are not required for reproduction. The number of days required for this nematode to complete its life cycle depends on soil temperature. One life cycle, from egg to reproducing adult, will occur every 28 days when the soil temperature is 80 degrees F. However, little or no development occurs at soil temperatures below 50 degrees or over 100 degrees.

After the second-stage juvenile hatches from the egg, it migrates through the soil in search of a cotton root. It usually enters a root near the tip and begins feeding. Since the nematode is much smaller than the root tip, it can completely embed itself within the root. Once feeding begins, it loses its ability to move within the root. As many as 20 juveniles may invade a single root tip. Second-stage juveniles cause little physical damage to the roots during the penetration process. Most damage to the cotton plant results from chemical changes caused by nematodes feeding.

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The plant root cells near the nematode's head are not killed by the feeding, but they are transformed. The cells enlarge many times their normal size and are called "giant cells." Giant cells, which are approximately 10 times larger than normal root cells, interfere with the development of the root. The damaged root cannot transport water and nutrients from the soil to the developing leaves and bolls. In addition, some of the sugars the plant produced by photosynthesis to support normal root growth are diverted to the giant cells to sustain the developing nematode.

About three weeks after root penetration, the female becomes swollen, and pear-shaped. The male at the same time reverts to its previous worm-shape and exits the root without feeding. The adult female deposits eggs in a mass; an egg mass contains from 500 to 3,000 eggs. Eggs may hatch immediately and juveniles may reinfect the root, or may overwinter and hatch next spring. The female dies soon after laying eggs.

The number of nematodes in a field varies throughout the year. Populations usually are lowest at planting and greatest at crop maturity. Root-knot nematodes have limited ability to survive in frozen soil. Populations decline in the winter when soils freeze. As much as 99 percent of the nematodes in a field may die during the winter. However, the population can increase rapidly during the summer. It is not unusual for populations to increase more than 100 times between planting and harvest. Because population densities can fluctuate greatly and detection procedures are less than 100 percent accurate, it is important to sample fields when the population densities are expected to be the highest, August to mid-September in Missouri.

Distribution of root-knot nematode and estimates of losses

Root-knot nematodes will be a greater problem when cotton is planted year after year and the soil is sandy. Root-knot nematodes are best adapted to coarse-textured, sandy soils rather than fine-textured silty or clay-based soils. The presence of root-knot nematodes in a field does not always mean they are causing a significant yield loss. Cotton plants can usually tolerate a small amount of damage from root-knot nematodes before yield loss occurs. Many factors influence the amount of crop damage that will occur with a given population of root-knot nematodes. Factors to be considered include soil type, soil fertility levels, moisture availability, and presence of other pathogens or pests.

Beltwide cotton losses due to root-knot nematodes are as variable as the distribution of the nematode. The Cotton Disease Council's annual estimates of total yield losses caused by all nematode species from 1952 to 1990 ranged from 1.2 percent to 2.5 percent per year. However, losses may exceed 50 percent of the yield potential in severely affected fields.

Interactions with other pathogens

Cotton is susceptible to several different pathogens. Root-knot nematodes are noted for interacting with other pathogens to cause disease complexes. In most instances, disease complexes result when soil-born fungal pathogens are present in addition to root-knot nematode. The Fusarium wilt / root-knot nematode complex is an example in which the nematodes increase the incidence of the fungal disease and the severity of the disease symptoms. It usually requires 100 times more of the individual Fusarium wilt pathogen to cause the same amount of damage to cotton as when root-knot nematode is also present. The Fusarium wilt / root-knot nematode disease complex frequently results in the death of large numbers of plants in a field. When the nematode is present alone, it is quite capable of causing yield losses; however, plants are not normally killed. The absence of Fusarium wilt symptoms does not indicate an absence of nematode problems. Cotton root rots caused by several different fungi are affected similarly by the root-knot nematode. However, the pest does not interact with the Verticillium wilt pathogen.

Symptoms

Root-knot nematodes are not uniformly distributed in soil; they occur in irregular patches. These patches may be small and limited in number, or they may be large and widely distributed. Depending on the nematode population, plants in these patches may be damaged and show symptoms ranging from mild to severe stunting and a reduced rate of development (Figure 1). Leaves on infected plants may wilt at midday more readily than healthy plants.

Root-knot nematodes cause visible galls, or knots, on roots (Figure 2). Swellings of the infected root tis-

Figure 1. The cotton in the foreground has been stunted by southern root-knot nematode.

Figure 2. Southern root-knot nematode has caused the galls (see white pointers) on these cotton roots.

sues can be found on the cotton taproot and the lateral roots. The galls are easier to detect if cotton plants are carefully dug (not pulled) from the soil.

Root-knot nematode management and control

There are two strategies for managing cotton nematode problems: rotating cotton with resistant soybean cultivars, and using nematicides. An integrated approach that uses both methods usually is the most effective and profitable. Strategies that may be practical for one grower may not be feasible for another.

Crop rotation. Southern root-knot nematode populations can be reduced by rotating cotton with a resistant soybean cultivar like Hartwig. The root-knot nematodes that hatch when this soybean variety is grown in a field die due to lack of food. Maintaining a clean, fallow field will also reduce nematode populations. However, this practice is impractical because of the loss of revenue during the fallow period.

Biological control. No reliable biological control systems are currently available, although research is being conducted.

Resistant varieties. Unfortunately, no cotton cultivar currently available has a high level of tolerance or resistance to the root-knot nematode. Cotton cultivars with resistance to the Fusarium wilt / root-knot nematode complex do not show any significant resistance to the nematodes. Although some cultivars are resistant to Fusarium wilt, it is important to understand that root-knot nematodes alone can and do cause substantial yield losses to these cotton cultivars. In research at the University of Arkansas, Stoneville LA887 was the variety most tolerant of root-knot nematode. Unfortunately, this variety matures very late in Southeast Missouri and may not produce a harvestable crop.

Nematicides. Chemical nematicides are widely used to control root-knot nematodes. Numerous studies show that when nematicides are used to control nematodes, yields increase significantly. Yield increases of more than 50 percent are common in severely infested fields. The objective for using chemical nematicides is to protect the seedling roots from nematodes for four to six weeks. By protecting the roots during early development, yield losses will be reduced substantially even though nematodes may penetrate the roots during the latter part of the season. Several nematicides labeled for use on cotton include soil fumigants and contact nonfumigant products (see Table 1). All pesticides should be used only in accordance with label instructions.

Table 1. Nematicides for root-knot nematode control in cotton.

Nematicide	Rate
Soil fumigants	
Telone II	
(Do not plant for 1–2 weeks after use)	5.6–11.2 gal/acre
Vapam	
(Do not plant for 2–3 weeks after use)	7.5–100 gal/acre
In-furrow nematicides	
Temik	3.5–10 lb/acre
Nemacur	6.5–14.7 lb/acre

Sampling for nematodes

Nematode distribution in a field is generally irregular and uneven. Populations may be very high in a localized area of a field and low in the remainder of the field. Because irregular nematode distribution affects the accuracy of population density estimates, it is necessary to collect several composite samples from a single field. Good soil samples that accurately represent nematode populations are essential for prudent management decisions. Collecting several samples from each field may increase the cost of sampling, but it is more valuable because the estimate is more accurate and reliable. Nematode populations usually are low in the spring and build through the growing season to reach peak densities at harvest. Nematode populations are easier to detect when bolls begin to open than at any other time. Samples should be collected from within the row because the nematodes are concentrated there. Generally, a sample should represent about 10 acres of similar soil type and should consist of at least 20 individual soil cores in that area. Soil probes, which are steel tubes about 1 inch in diameter, are commonly used to extract soil cores.

Insert the probe 6–12 inches deep into the soil. Soil cores are collected in a bucket and thoroughly mixed. About a quart of mixed soil is then placed in a plastic bag and sealed to inhibit drying. Nematode samples require special care, because nematodes are living creatures. A nematode sample should not be handled like a soil fertility sample. For example, if a sample dries or is placed in the sun, the nematodes will die. The laboratory information on a dried sample will not accurately reflect the field situation. A nematode sample should be handled like a carton of milk. It should be kept cool, but not frozen. During sample collection, it is important to keep the soil sample in a cool location, such as an ice chest with ice. The sample should be transported in a precooled ice chest to prevent overheating. Samples should be delivered to the diagnostic laboratory as soon as possible. Overnight delivery service should be used if feasible.

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