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2011 Overview of Soybean Cyst Nematode

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Introduction

The soybean cyst nematode (Heterodera glycines) is the most significant nematode pest affecting soybeans in Delmarva and in the United States. First detected in Delaware in the fall of 1979, the soybean cyst nematode (SCN) was widespread in Sussex County. Although found in Kent County just a few years later, SCN was not discovered until 1991 in New Castle County in the southwest corner near Clayton. SCN, which is not restricted by soil type, can be found anywhere soybeans have been grown for a long time.

A close view of a soybean cyst nematode.

It is a problematic disease because symptoms of infection are not always observable. It can go undetected for years until severe stunting or yield losses are experienced during harvest. Often growers can be unaware that SCN is present so it is important for soybean growers to understand how to identify and manage SCN.

Symptoms

Symptoms of SCN infections range from no visible evidence of plant injury to yellowing and stunting, leading sometimes to plant death in certain areas of a field. Symptoms commonly associated with SCN damage are similar to other crop production problems, such as manganese deficiency, spider mite infestations, herbicide injury, potassium deficiency, low spots, drought stress, and soil compaction. The only visible sign of SCN infection is the presence of white or yellow female cysts on the roots, but they might not be present at the time of sampling. Growers should look for these visible symptoms as well as other soybean production problems, including continuous soybean production, declining yields and weed control failures, all of which could indicate SCN.

Biology and Life Cycle

Like all plant parasitic nematodes, SCN is a microscopic roundworm. The second stage juvenile is the infective nematode, so-called because it molts once in the egg from the first stage to the second stage. Juveniles penetrate soybean roots and cause the formation of specialized feeding cells in the root's vascular system. These feeding sites divert materials needed for root growth to nourish the developing nematodes. These nurse cells also prevent nutrients from reaching the shoots and leaves of the plant; the resulting plant damage is primarily because of this feeding by females. Molting three more times before becoming adults, the SCN female juveniles lose their ability to move and swell to a lemon-shaped mature female. White females become yellow as they age and then brown when they die.

The brown stage is the cyst for which the nematode is named. Each cyst can contain up to 500 eggs, but under field conditions, they usually contain fewer. The cyst, which protects the eggs from the soil environment, overwinters, and egg hatch begins in the spring. If the emerging juvenile nematodes cannot find a host plant within several weeks, they die. When soybeans are planted, exudates from developing roots stimulate more hatching and attract juveniles to the root systems.

The females will generally mature in 21 to 28 days and begin to produce eggs. After 30 to 40 days, yellow and brown cysts can be seen on the roots. The number of

eggs produced during a season can be influenced by the length of the growing season, which is related to the soybean maturity group and the environment during the growing season. A long-season variety will allow for more generations and more reproduction. Hot weather limits SCN reproduction. Soil temperatures above 90 degrees F shut down reproduction, while cool to moderate conditions with ample moisture increase reproduction. In seasons with adequate rainfall, infected soybeans without symptoms can lead to population increases that, if not detected by soil sampling, can be serious the following season.

The effect of SCN on soybean growth and yield involves several mechanisms that are directly related to the number of nematodes feeding on the root system: plant nutrients are removed, nutrient and water uptake in the roots are disrupted, and root growth is retarded. Plants that are infected with high numbers of SCN have poorly developed roots that cannot efficiently utilize nutrients and water available in the soil. The result is stunted plants and, often, yellow foliage. SCN infection also can reduce the number of nodules formed by the beneficial nitrogen-fixing bacteria that are necessary for optimum soybean growth. The nematode feeding also wounds the roots so that they can be invaded by secondary fungal pathogens such as Rhizoctonia, Fusarium, and Pythium. Although Sudden Death Syndrome occurs infrequently in DE, this disease is also favored by SCN infestations.

Races of SCN

Field populations of SCN are genetically variable. In the early 1960s, researchers found that geographically distinct populations of SCN varied in their ability to reproduce on resistant soybean cultivars or plant introductions (PIs). These PIs were soybean relatives from the Orient (China, Japan, Russia) where soybeans originated. In 1969, a group of nematologists and soybean breeders proposed calling these variable populations "races" based on a host test. The race differential soybean lines were two cultivars, Peking and Pickett, and two soybean plant introductions from Asia PI 88788 and 90763. The cultivar Lee was recommended as the standard susceptible for race determination tests. The original race scheme described only four races, but this was expanded in 1988 to include 16 races based on all the possible combinations of four differentials.

In 1993 and 1994 a major effort was made to survey Delaware soybean acreage for SCN and determine the race composition of the SCN populations present at the time. The Delaware Soybean Board (DSB) funded this project, and the results demonstrated that roughly 60% of the populations that were race-tested were race 3, 30% race 1, and the remainder a mix of races 5, 7, and 9. In 2009, a second survey funded by the DSB was conducted on fewer fields than in the previous survey but it was discovered that the race composition had changed dramatically since 1996. Seven race 1 populations (47%) were identified, 5 race 5 populations (33%) and 3 race 2 populations (20%). No race 3 populations were found. The other alarming result was the high reproduction values for these populations on PI88788. The range is 44- 80% of the susceptible variety, which indicates that for these populations, PI88788 is no different than a susceptible variety.

This has important implications for soybean growers since almost all currently grown soybean varieties with SCN resistance obtain that resistance from PI88788. Within the last 5 years, there were indications that race 3 was no longer the predominant race. All populations tested here in the last five years and those sent to other institutions have tested as race 1. Since the majority of resistance in Round-Up Ready soybeans is from PI88788, which allows varying levels of reproduction of race 1 populations, these varieties may have reduced effectiveness in suppressing current SCN populations.

These results indicate that under adverse growing conditions and high initial egg numbers, stunting and yield loss would be expected if a race 3, 14 resistant varieties with PI88788 as its source of SCN resistance are grown here in Delaware. Consequently, growers may need to plant soybean cultivars derived from non-PI88788 resistance sources to successfully manage soybean cyst nematode in the future. This is a problem since there are no varieties that are Round-Up Ready. There is little interest in growing conventional soybeans with resistance from other sources, and the varieties that could be grown here are not available in sufficient quantities to satisfy the immediate need. Growers are going to have to manage SCN by judicious variety selection and rotations with non-host crops for the immediate future.

SCN Management

SCN can be managed by several strategies, including rotation with or without the use of resistant soybean varieties. Management plans should aim to reduce SCN populations and promote soybean health.

Rotation: Crop rotation is beneficial for profitable soybean production and can significantly reduce SCN populations. Alternating non-host crops with different SCN-resistant varieties is the basis of an effective, long-term SCN management program. Planting a non-host crop such as sorghum, corn, sunflower, forage grasses, or vegetables (except snapbeans) will reduce SCN populations. Small grains, although non-hosts, are not considered to be rotation crops since they are not growing when SCN is active. However, small grains can help reduce SCN populations, because the soybeans planted behind small grains usually are exposed to fewer SCN at planting and allow less time for SCN reproduction. SCN numbers in a field decline faster when the grower uses non-host crops instead of planting resistant varieties. Two or more years of using non-host crops and/or resistant varieties may be needed to reduce SCN populations to manageable levels depending on the starting populations and the growing conditions during the season.

Resistant varieties: Using resistant varieties is an essential tool and the most economical means of managing SCN. Although some of the early resistant varieties in the 1980s did not perform as well as elite susceptible varieties, newer resistant varieties that can be grown here do not suffer the same yield penalty. In non-infested fields it is common for modern SCN resistant varieties to do as well or better than susceptible varieties in university variety tests. Most, if not all, of the Roundup Ready soybean varieties that are available from all the seed companies have PI88788 in their background. PI88788 has been the major source of resistance to SCN for the last 25 years, was very effective against the common races of SCN, and its resistance was easily incorporated into new varieties. In fact, there are few modern soybean varieties without SCN resistance.

There has always been a range of effective SCN resistance in soybean varieties due to differences in breeding programs, which have used a handful of resistance genes from PI88788 as the basis for their breeding programs. This has resulted in different levels of resistance, although all are listed as resistant to race 3 or race 3 and 14. If continuous resistant soybeans are selected as the major control measure, it is important to remember that resistant varieties are still attacked by the nematode. They are resistant because they prevent or limit nematode reproduction, but the nematodes can enter the root and cause damage. Some reproduction can occur. They will still yield better than a susceptible variety. Periodic monitoring of egg numbers is important to detect any shift in SCN races. As stated earlier in the description of the races of SCN, the recent survey demonstrates that SCN populations have adapted to soybean varieties with resistance from PI88788 here in Delaware and similar studies have shown the same shifts in other parts of the U.S. as well. Despite the high reproductive potential of these current SCN populations and the yield-limiting effect they could have under optimum conditions for yield reductions (high initial SCN egg numbers and dry weather early in the growing season), we can expect to see differences in impact among the currently available soybean varieties. Selecting the best resistant variety is not easy because of a general lack of industry standards for developing and marketing SCN-resistant varieties.

Ideally, the approach to retain the usefulness of SCN-resistant varieties would be to rotate varieties with different sources of resistance eg. PI88788, PI437654, and Peking. This would slow the adaptation of SCN populations to the current sources of resistance, however, the availability of sources other than PI88788 is extremely small to non-existent. Until varieties are developed with resistance from other sources, growers are going to have to implement the next best thing, which would be growing different SCN-resistant varieties each year. Basically the recommendation is to not plant the same SCN resistant variety two or more times in a row. This approach has been shown to be useful by research conducted in Illinois and Missouri. Regardless of the situation, however, most resistant varieties will out-yield an SCN-susceptible variety if SCN populations exceed the damage threshold.

Susceptible varieties: Never plant susceptible varieties without first taking a nematode soil test. Never presume that your control program has reduced the numbers to a safe level. If SCN is not detected or is at very low levels, susceptible varieties can be grown for one season. Planting susceptible

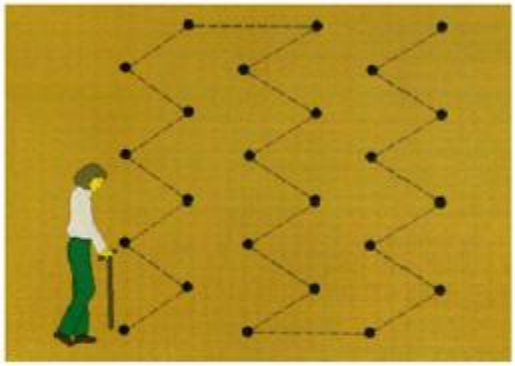
varieties in rotation with non-hosts or resistant varieties can prevent race shifts, according to some nematologists. In the sandy soils of Sussex and Kent counties, planting susceptible varieties in an SCN-infested field may be possible once every three or four years if SCN egg counts are low prior to planting.

Chemical control: Chemical control is not economically feasible nor as effective as rotation and planting resistant soybeans. For these reasons, chemicals (nematicides) are generally not recommended. It could be a "last resort" effort under special circumstances but would be very costly and results can be inconsistent.

Cultural practices and weed control. Providing a crop with the best possible growing conditions will reduce stress and limit yield loss due to SCN. Maintain optimum soil fertility to optimize plant growth and development. Control weeds and other pests to reduce overall plant stress. Certain common weeds, especially chickweed and henbit, are known hosts of SCN. These weeds are winter annuals that frequently persist in fields spanning the period from fall to late spring. When left unchecked, there is slight potential for these weeds to result in an increase in SCN populations, however, there is no evidence from field studies that either of these weeds (or any other weed for that matter) will significantly increase SCN populations. This is because low soil temperatures during most of the lifespan of the winter annual weeds are unfavorable for SCN development. Similarly, the risk that SCN populations will be increased on annual weed hosts is very low because of the short time those weeds exist in fields (such as following harvest in the fall or prior to planting in the spring). There is some evidence that wheat residue can somewhat limit SCN reproduction when soybeans are double-cropped behind wheat. Because this effect is not evident until the end of the season, damage to soybean plants will still occur if SCN levels (at planting) exceed the damage threshold. However, the so-called "residue effect" may help in the long-term management of SCN by keeping populations in a field lower than they otherwise would be (in the absence of wheat residue).

Soil Sampling

The best way to confirm an SCN infestation is to sample soil when symptoms are first seen. Or if the white or yellow females are not observed at the end of the season once the crop is harvested. The Nematode Assay Program provided by Delaware Cooperative Extension can provide this information. Sample submission forms are available online at the UD Plant Diagnostic Clinic. At the site, go to the sidebar on the left and select the form. Soil sample bags for nematode assays are available for $10.00 in-state and out-of-state from county Extension offices. Fall is the best time for nematode sampling. Sample after fall harvest but before fall tillage. Take 20 to 30 soil cores between plants in the row of the harvested crop. Soil test bags and detailed nematode sampling instructions are available from the Extension office in each county.



Soil sampling pattern for survey sample after fall harvest

In areas of the county known to have SCN infestations, do not plant susceptible varieties without first taking a nematode soil test. Fortunately, SCN can be found at any time of the year as long as the soil is not frozen, too wet, or too dry.

For fields known to be infested, monitor nematode numbers by taking nematode samples in the fall following harvest. Routine monitoring of SCN egg numbers can indicate the effectiveness of your management plan. This is very important when resistant varieties are used almost exclusively. Increases in egg numbers following a resistant variety could indicate that SCN populations are shifting. SCN can be managed, but not eradicated.

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Additional Resources

Soybean Cyst Management Guide, 5th edition (North Central Soybean Research Program, 2010). A limited number of hard copies are available in the county Extension offices.

Caution: The information and recommendations in these fact sheets were developed for Delaware conditions and may not apply in other areas.