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Soybean Cyst Nematode

The soybean cyst nematode (SCN), *Heterodera glycines*, is a small, plant-parasitic roundworm that attacks the roots of soybeans. Most nematodes can only be observed with magnification, but the adult female parasites and cysts of SCN are about '/32 of an inch long and visible to the unaided eye.

In most cases, the presence of SCN is not obvious at the time of initial soil infestation. The nematode population density must increase in the soil until it is sufficient to cause above-ground symptoms on plants or a decrease in yield. Population densities may take several years to reach significant numbers. Thus, current SCN damage to soybeans is the result of infestations that have been growing for extended periods of time.

Most likely, SCN came from Japan where it was first reported more than 75 years ago. The first reports of SCN in the United States came from North Carolina in 1954. Since then, it has been found in 25 additional states in the Southeast and Midwest, including Illinois, Michigan, Minnesota, Missouri, Nebraska, and Wisconsin.

Life Cycle

The SCN life cycle has three major stages: egg, juvenile, and adult. The life cycle can be completed in 24 to 30 days under optimum conditions. When temperature and moisture levels become adequate in the spring, worm-shaped juveniles hatch from eggs in the soil. The only time in which a nematode is able to infect soybean roots is during its juvenile life stage. After penetrating the soybean roots, juveniles move through the root until they contact vascular tissue, where they stop and begin to feed. The nematode injects secretions that modify certain root cells and transform them into specialized feeding sites. As the female nematodes feed, they begin to swell, increasing in size. Eventually, these females become so large that they break through the root tissue and are exposed on the surface of the root.

Male nematodes, which are not swollen as adults, migrate out of the root into the soil and fertilize the lemon-shaped adult females. The males then die, while the females remain attached to the root system and continue to feed. The swollen females begin producing eggs, initially in a mass or egg sac outside the body, then later within the body cavity. Eventually the entire body cavity of the adult female is filled with eggs, and the female nematode dies. It is the egg-filled body of the dead female that is referred to as the cyst. These cysts eventually dislodge and become free in the soil.

The walls of the cyst become very tough, providing excellent protection for the 200 to 400 eggs contained within. SCN eggs survive within the cyst until proper hatching conditions occur. Although many of the eggs may hatch within the first year, many also will survive within the cysts for several years.

How SCN Spreads

SCN can move through the soil only a few inches per year on its own power. However, SCN can be spread substantial distances in a variety of ways. Anything that can move infested soil (even small amounts) is capable of spreading SCN, including farm machinery, vehicles and tools, wind, water, animals, and farm workers. Seed sized particles of soil, called soil “peds,” often contaminate harvested seed. Consequently, SCN

can be spread when seed from infested fields is planted in un-infested fields. There is even evidence that SCN can also be spread by birds. Only some of these causes can be prevented.

Above-ground Symptoms

Above-ground symptoms of SCN damage are not unique to SCN. They are often mistaken for damage due to compaction, iron chlorosis, and other nutrient deficiencies such as: drought stress; herbicide injury; and/or other plant diseases. SCN injury has often remained undetected for several years because these nondescript symptoms were attributed to other causes.

The first obvious symptom of SCN injury to soybeans is the appearance, in the field of circular- or oval-shaped areas, of stunted, yellowed, less vigorous plants. These infested areas will vary in size, often showing a sharp dividing line at the edges between stunted and apparently healthy plants. Plants growing in heavily infested soils may remain stunted throughout the season. Rows of soybeans grown on SCN-infested land frequently are slow to close or fill in with foliage.

In areas with high pH soils, the yellowing of soybeans due to SCN often is confused with iron chlorosis. However, there are differences between the symptoms of the two problems. The symptoms of iron chlorosis usually appear in early June, whereas yellowing due to SCN will more likely occur in July and August. The yellowing caused by iron chlorosis typically affects the areas between the veins of the upper leaves. Yellowing due to SCN usually starts at the edges of the leaves, and can affect leaves on the entire plant. Iron chlorosis and SCN may occur in the same field and even on the same plant.

An area of SCN damage will often appear elongated in the direction of tillage operations. Most severe damage is often in the center of the area, with damage decreasing towards the margins. Such areas frequently develop near a field gate, entrance, wherever equipment enters a field, or near fences where wind-blown soil may accumulate.

The above-ground symptoms of SCN damage do not always occur consistently. Symptoms range from nonexistent to severe depending on the age and vigor of the soybean plants, SCN numbers, soil fertility, moisture levels, and other environmental conditions. Injury is usually more severe in light, sandy soils, but can also occur in heavier soils. SCN damage is not always confined to smaller areas within a field. Some fields are infested with SCN throughout; in such fields, areas of stunted plants are not obvious because the size of plants throughout the field is much the same.

One cannot rely upon above-ground symptoms for identification of SCN infestations. If soybean yields in any field have decreased for no apparent reason, or if SCN has been confirmed on nearby land, a more thorough examination of below-ground symptoms and a soil analysis of the plants is needed.

Below-ground Symptoms

Much like above-ground symptoms, most below-ground symptoms of SCN damage are not unique. Roots infected with SCN are normally dwarfed or stunted. SCN can decrease the number of nitrogen-fixing nodules on the roots. SCN infections also tend to make the roots more susceptible to attacks by other soil-borne plant pathogens. Often it is difficult to recognize if roots are stunted and have fewer nodules unless they are compared to uninfected soybean plants.

The only unique symptom of SCN infection is the presence of adult female nematodes and cysts on the soybean roots. These structures, which appear as tiny, lemon-shaped objects on the roots, are initially white. As they mature, the colors change first to tan, and then to brown. They can be seen with the unaided eye, although observation with a magnifying glass is easier. The cysts are about the size of a pinhead and are much smaller than nitrogen nodules. Roots must be carefully removed from the soil for examination or the cysts may be dislodged. **Observation of adult females and cysts on the roots of soybean plants is the only accurate way to diagnose SCN infestation in the field.**

Soil Sampling for SCN

Individuals may send soil samples to private laboratories or Michigan State University's Plant Disease Clinic in order to determine SCN egg densities. Soil samples are usually taken in the fall, after harvest, so that analysis for SCN eggs will provide timely information for use in planning the next season. However, samples

may be taken anytime during the season, particularly to confirm if SCN is present in a field. Fields currently in other crops can be sampled as well. The time of the year, current crop rotation, and other available information all factor into the interpretation of the results. To take representative soil samples:

1. Limit the number of acres represented in a single sample to between 1 0 and 20 acres, at the very most.
2. Collect 10 to 20 soil cores with a soil sampling tube from 1 to 20 locations.
3. Soil should be taken from a depth of 6 to 8 inches from within the root zone of the plants (if plants are present).
4. Combine the soil in a bucket and mix well.
5. Place about 1 pint of soil into a plastic bag or paper soil test bag.
6. Avoid storing the samples in the sun, and ship the samples as soon as possible to the laboratory.

Interpretation of Lab Results

Eggs per cc	Cysts per 100 cc	Pop. Level	Recommended Management Practice
0	0	N / D	Susceptible varieties may be grown. Resample in 2 - 3 yrs.
1	1	Trace	Susceptible varieties may be grown. Resample in 1 yr.
2 - 9	2	Low	Only SCN resistant varieties should be grown. Resample in 1 yr.
10 - 24	3 – 7	Moderate	Rotate to a non-host crop next year followed by a SCN resistant variety the following year, then resample.
25 +	8 +	High	Rotate to non-host crops for 2 - 3 yrs., then resample.

Management Practices

Once present in the soil, SCN can never be eliminated. However, the nematode can be managed, which will minimize its reproduction and maximize crop yields. Plants that have adequate moisture and fertility are better able to withstand SCN infection. Consequently, it is more critical, in terms of maximizing yield, to maintain proper fertility and soil pH levels in SCN-infested land than in uninfested land. It is also important to control other plant diseases, as well as insect and weed pests. Weakened plants are more susceptible to the yield-suppressing effect of the nematode.

Common sense sanitation practices can be very effective in delaying the spread of SCN to uninfested land. If only certain fields on a farm are infested with SCN, plowing, planting, and cultivating of these fields should be done **after** uninfested fields have been worked. After working in infested fields, equipment should be thoroughly cleaned with high pressure water or steam.

Seeds grown on infested land should not be used for planting uninfested fields unless the seed has been properly cleaned. SCN may be spread in soil peds associated with the seed.

Resistant soybean varieties are the most effective tool available for management of SCN. SCN densities usually decrease when resistant soybeans are grown because most SCN juveniles are unable to feed and develop on the roots of the resistant varieties. However, in any naturally infested field, a few SCN juveniles (usually less than 1 percent) will be able to reproduce on the resistant varieties currently available. The number of SCN juveniles that can reproduce on resistant soybean varieties increases when resistant varieties are grown repeatedly. Eventually, if SCN-resistant soybeans are grown year after year, the SCN population will be able to reproduce as well on a resistant variety as a susceptible variety. Fortunately, the number of SCN juveniles that can reproduce on resistant varieties declines when susceptible soybean varieties are grown because these nematodes do not compete well for food with the other SCN juveniles in the soil that cannot feed on the resistant varieties.

In the past, there were few SCN-resistant soybean varieties available, but numerous public and private varieties have been released in recent years. These varieties contain SCN resistance genes from the soybean breeding lines "PI88788" or "Peking." Growers are recommended to alternate use of varieties with these two different sources of SCN resistance. Furthermore, a susceptible soybean variety should be grown once after both types of resistant varieties have been used to counter the effects of growing the SCN-resistant soybean varieties. Table 1 outlines a recommended six-year corn-soybean rotation using both types of resistant soybean varieties and susceptible varieties for management of SCN. Growers should consult county extension personnel or seed company representatives for information on suitable resistant soybean varieties or to further discuss effective crop rotation.

SCN is an obligate parasite and is unable to develop and reproduce in the absence of living host roots. Consequently, numbers of SCN will decline during any year that non-host crops are grown. Corn, oat, and alfalfa are non-hosts for SCN, and nematode numbers decline similarly when infested soils are planted with these three crops. Table 2 lists several SCN host and non-host crops. Most weeds commonly found in Michigan are not hosts for SCN.

There are several nematicides that are labeled for use against SCN, though they generally do not give season-long control. When applied at planting, the effect of the nematicides may last long enough to provide an economic yield benefit. By the end of the growing season, however, SCN numbers may be as high or higher than at planting. No nematicide will kill all SCN in the soil.

The performance of the nematicide will depend on soil conditions, temperatures, and rainfall. A yield benefit is not guaranteed, and nematicides are expensive. Growers are advised to consider economics, as well as environmental and personal health concerns, when considering use of nematicides for management of SCN.

Examples of Host & Non-Host Plants of Soybean Cyst Nematode.

Host Crops	
Beans, Adzuki	Clover, Crimson
Beans, Bush	Clover, Scarlet
Beans, Dry	Clover, Sweet
Beans, Green	Cowpeas
Beans, Lima	Lespedeza
Beans, Mung	Lupine, White
Beans, Red	Lupine, Yellow
Birdsfoot Trefoil	Garden Peas
Clover, Alsike	Vetch, Common
	Vetch, Crown

Non-Host Crops	
Alfalfa	Cotton
Barley	Forage Grasses
Canola	Oats
Clover, Red	Forage Grasses
Clover, Red	Rye
Clover, Ladino	Sorghum
Corn	Tobacco
	Wheat

Host Weeds			
Common Mullien	Field Pennycress	Hemp Sesbania	Henbit
Pokeweed	Purple Deadnettle	Purslane	Shepherd's Purse
Spotted Geranium	Vetch, Milk	Vetch, Wood	Wild Mustard

Sources: **"**Soybean Cyst Nematode**"** Greg Tylka, extension plant nematologist, Iowa State University, 1994.
"Soybean Cyst Nematode", Tenney, Warner, & Smith, Michigan State University, 2004.
"Soybean Cyst Nematode: Diagnosis & Management", Wrather & Mitchum, University of Missouri, 2006.
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