PP1732 (April 2022)

Figure 1. Deceptively robust and healthy-looking soybean field experiencing yield loss from SCN. (Sam Markell, NDSU)

Figure 2. Stunted and yellowed plants due to severe SCN infection. (Sam Markell, NDSU)

NDSU EXTENSION

North Dakota State University
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Soybean Cyst Nematode (SCN)

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Soybean cyst nematode (SCN) is the greatest threat to soybean production in the U.S., causing an estimated 1.0 to 1.5 billion dollars in economic loss annually. Since its first detection in Richland County (2003), the nematode has spread into many soybean producing counties of North Dakota. Early detection and proactive use of management tools are critical to minimize yield loss to SCN.

Cause

Soybean cyst nematode, (*Heterodera glycines*), is a soil-borne microscopic round-worm that injures soybeans and other plants by penetrating, feeding and reproducing on root tissue. In addition to soybeans, dry edible beans and several weed species are important hosts in North Dakota. The nematode can be spread by any means that moves soil, and once established, their population levels can increase rapidly, surviving for many years. Moreover, SCN is genetically diverse, and new HG types (similar to races or strains) are becoming dominant in the U.S. as the nematode adapts to genetic resistance.

Signs and Symptoms

The most common above-ground symptom of SCN is **no symptoms** (Figure 1). Up to a 30% yield reduction can occur without any obvious above-ground symptoms. When above-ground symptoms do appear, they are not unique to SCN (Figure 2).

Figure 3. Cream-colored and lemon-shaped SCN females (cysts) on soybean root. (Sam Markell, NDSU)

Figure 4. Cream-colored and lemon-shaped SCN cysts and nodule (R) on soybean roots. (Sam Markell, NDSU)

Figure 5. Cream-colored and lemon-shaped SCN cysts on soybean root near nodule (L). (Sam Markell, NDSU)

Symptoms often manifest as general yellowing or stunting and are mimicked by other diseases, herbicidal injury, drought stress and/or nutrient deficiency. They are often first observed in circular to oval patches of yellowed or stunted plants late in the growing season. Patches may be as small as several feet or as large as many acres. Commonly, affected areas increase in size if left unmanaged.

Below-ground SCN cysts (dead adult females) may be visible in mid-to late part of the growing season. The lemon-shaped, cream to white-colored females (cysts) are very small (1/40th inch long by 1/60th inch wide) and may be visible to the naked eye, but a hand lens and light (sunlight or flashlight) will make identification easier (Figure 3). SCN cysts are much smaller than a nodule (Figure 4) and their characteristic lemon shape can help differentiate them from soil particles (Figure 5). SCN cysts will eventually darken from yellowish white to brown as they mature (Figure 6). To look for SCN, carefully dig the plants roots and remove soil gently to avoid shaking off SCN females (Figure 7). *However, the best way to detect SCN is to soil sample (see page 4).*

Life Cycle

The life cycle of soybean cyst nematode has three main stages which include egg, juvenile and adult females (cyst) or males. When the egg hatches, a second stage juvenile (J2) emerges and migrates to root tissue. The J2 then penetrates the surface of soybean roots by using a hollow spear-like mouth structure called a stylet. After penetration, nematodes migrate towards the vascular tissue and establish a feeding cite called a syncytium. The juvenile then enlarges and molts three more times to become an adult.

Adult females become sedentary (unable to move) and begin producing eggs in their bodies. A single adult SCN female can produce hundreds of eggs inside its body. As eggs are produced, the females increase in size and take on a lemon-shaped appearance. Females secrete pheromones that attract the males, who remain mobile. Sexual reproduction occurs when mobile males mate with the sedentary females, fertilizing the eggs. As the female continues to enlarge, its body will burst out of the root tissue. At this stage, the white to cream lemon-shaped females (cysts) are visible to the naked eye.

After egg production, the SCN female dies and its body becomes a brown-colored leathery/protective shell (brown cysts) that allows the eggs to survive for many years and under harsh environmental conditions. The protective cysts that accumulate in the soil can be spread by anything that moves soil, which includes agricultural equipment, boots, flooding, dust storms, birds (feet and digestive tract) and tare soil. The robust protective nature of the cyst contributes to the longevity of survival and persistent expansion of the nematode across North America.

The environmental and soil conditions that favor soybean development also favor SCN population development. The optimal soil temperature for SCN egg hatching and root penetration is 75 F and 82 F, respectively. Optimal soil temperature for juvenile and adult development can range from 79 to 82 F. Under favorable conditions, a complete life cycle can occur in less than a month. In North Dakota, we expect that SCN can complete two to three life cycles in a growing season. Thus, SCN population numbers can build up at an alarming rate as multiple generations can occur in a single growing season. Little to no SCN population development occurs at temperatures below 59 F or above 95 F.

Yield loss

SCN contributes to yield loss directly and indirectly. As a parasite, SCN essentially steals nutrients that would have been used by the soybean. SCN also causes damage to the plant roots during its life cycle. With damaged and parasitized root tissue, the soybean may struggle to reach its yield potential in any given year. However, yield loss can be particularly high in dry years, on light soils or in other conditions where soybeans are drought stressed. Yield loss is also more likely to occur in high pH soils, which favor SCN reproduction. Additionally, SCN can facilitate the infection or increased severity of other diseases, most notably Sudden Death Syndrome and Brown Stem Rot.

Figure 6. Brown SCN cysts on soybean roots. (Sam Markell, NDSU)

Figure 7. Dig (don't pull) soybean roots when examining them for SCN. (Sam Markell, NDSU)

SCN Sampling

Sampling for SCN is critical:

- The most reliable way to identify SCN
- The only way to determine your egg number (and risk)
- The best way to determine if your management tools are working

When to sample

SCN sampling should be conducted in the spring before planting or in the fall, near, at or after harvesting. Sampling can also be done during the growing season by collecting soil samples from soybean root zones of plants; however, the SCN population numbers are generally the greatest during the fall and lowest after any tillage has been done in the field.

How to sample

A 1-inch diameter sampling probe should be used to collect soil cores of 6 to 8 inches deep (Figure 8). Collecting soil samples too deep or too shallow may result in an inaccurate nematode count because SCN distribution is generally uneven in the soil profiles. If sampling is conducted during the growing season, angle the probe towards the root zone. If a probe is not available, a shovel can be used in each sampling spot to collect about a fistful of soil from 1-inch depth to 8-inch depth.

Where to sample

Distribution of SCN is generally uneven and in an aggregated pattern in most infested fields. Therefore, depending on your situation, different sampling strategies may be appropriate.

- If you are SCN-sampling for the first time, target high-risk areas of the field, where SCN populations might first be introduced, such as field entryways, previously flooded areas, along field borders, shelter belts, fence lines, and near buildings, equipment and storage areas. You can also target low-yielding spots, low spots and areas with high pH where SCN has a greater chance of increasing quickly (Figure 8).
- If you already know SCN is present in your field, you can best understand the distribution and egg levels in your field by dividing your field into smaller subsections. Fields can be divided in a grid, or along naturally occurring geographic zones. Then collect approximately 20 soil cores following a zig-zag pattern (Figure 8).
- If you would like to evaluate the effectiveness of your management tactics, you can divide the field into different management zones and monitor the population changes in these zones. If egg levels are staying approximately the same or less from the time of planting to harvest, the management tools may be working. If a dramatic increase in the population occurs over the course of the growing season, current management tools may be insufficient.

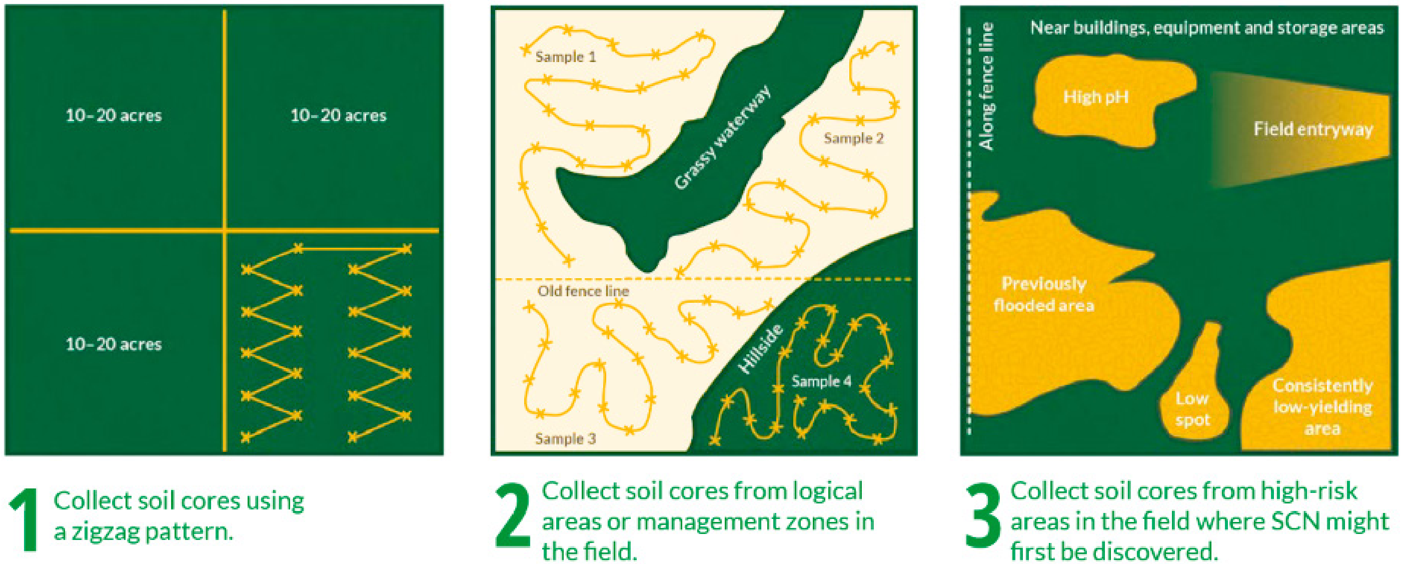

Figure 8. Three approaches to collecting SCN soil samples 1) collect soil cores using a zig-zag pattern, 2) collect soil cores from logical areas of management zones in the field and 3) collect soil cores from high-risk areas in the field where SCN might first be discovered. (www.thescncoalition.com)

What is an HG Type?

An “HG type,’” named after the genus and species name (*Heterodera glycines*), was developed to identify nematode populations that begin to adapt to genetic resistance. Importantly, the HG type alone does not tell us how much the SCN population has adapted to a resistance source, only that the process has begun. “Races” were (and in some cases still are) used to classify differences in SCN populations before the HG type was developed. HG type and races are similar, but the HG type test incorporates the seven breeding lines that are available as sources of resistance and makes room for more as they are developed. For information on converting a race name into an HG type, please visit www.thescncoalition.com.

The HG type tests characterize the ability of SCN populations to reproduce on seven different soybean breeding lines known to have resistance to SCN. These are called “indicator lines,” and each has a numeric designation (1 to 7). HG type tests are conducted under greenhouse conditions by growing each of the seven indicator lines in soil infested with a SCN sample population. A female index (FI), which is the percentage of reproduction on each line, relative to the susceptible check, is calculated on each indicator line.

If the *female index is 10% or greater*, than an indicator line is considered susceptible. Let’s consider three examples:

Example 1. A SCN population was tested, and FI values were less than 10% on all indicator lines tested. This population would be designated as HG type 0. In this example (HG type 0), SCN population has not overcome the resistance provided by any of the seven indicator lines. *Currently, a majority of the SCN populations tested from North Dakota were HG type 0.*

Example 2. An HG type test reveals that a SCN population had FI values greater than 10% on indicator lines 2, 5 and 7, while having less than 10% FI values on all other indicator lines. This population would be designated as HG type 2.5.7. This demonstrates that an increase in SCN reproduction is beginning to occur on soybean varieties that derive resistance from indicator lines number 2 (PI 88788), 5 (PI 209332) and 7 (PI 548316). *Currently, several populations in North Dakota were discovered with increased reproduction on PI 88788 (indicator line 2), the most commonly used source resistance in commercial soybean varieties.* Elevated reproduction has also been observed on indicator lines 5 and 7, but because those sources of resistance are not used in commercial soybean varieties, increased reproduction is not currently a concern.

Example 3. An HG type test reveals FI values greater than 10% on indicator lines 1 and 2 but values less than 10% on the remaining five lines. This population would be designated HG type 1.2. The implication of this HG type is that the nematode is beginning to overcome resistance on the two most important sources of resistance to SCN, PI548402 (Peking) (indicator line 1) and PI88788 (indicator line 2). *Recent surveys found several SCN populations from North Dakota reproducing on PI88788, beginning to overcome the PI88788-type resistance, but very few were able to overcome Peking-type resistance.*

For practical purposes, the most important numbers to pay attention to in an HG type are 1 and 2. When 1 is present, the nematode population is beginning to overcome the resistance in ‘Peking’. When a 2 is present, the nematode is beginning to overcome the resistance in ‘PI88788’.

Where is SCN in North Dakota?

Between 2013 and 2021, the North Dakota Soybean Council has supported a grower-based SCN-sampling program. In that time, approximately 4,700 samples have been submitted by growers and their advisors throughout the state. Results are presented as the number of eggs plus J2 found in 100cc of soil (a little less than half a cup). To date, approximately two-thirds of the samples have been negative. However, the remainder have been ‘positive’ (>50 eggs/100cc) and levels as high as 100,000 eggs/100cc or more have been observed (Figures 9 and 10). As SCN can increase rapidly in a field, active management of SCN at *any positive level* is strongly encouraged. Notably, very low levels of SCN (50 eggs/100c to 200 eggs/100cc) could be false positives, and future testing is encouraged.

How do I interpret the results?

False negatives and false positives can exist. Specifically, a zero indicates no eggs were found and means that SCN was not observed in the specific sample submitted. As SCN is very spotty in a field and soil moves over time, we encourage growers to sample again in the future.

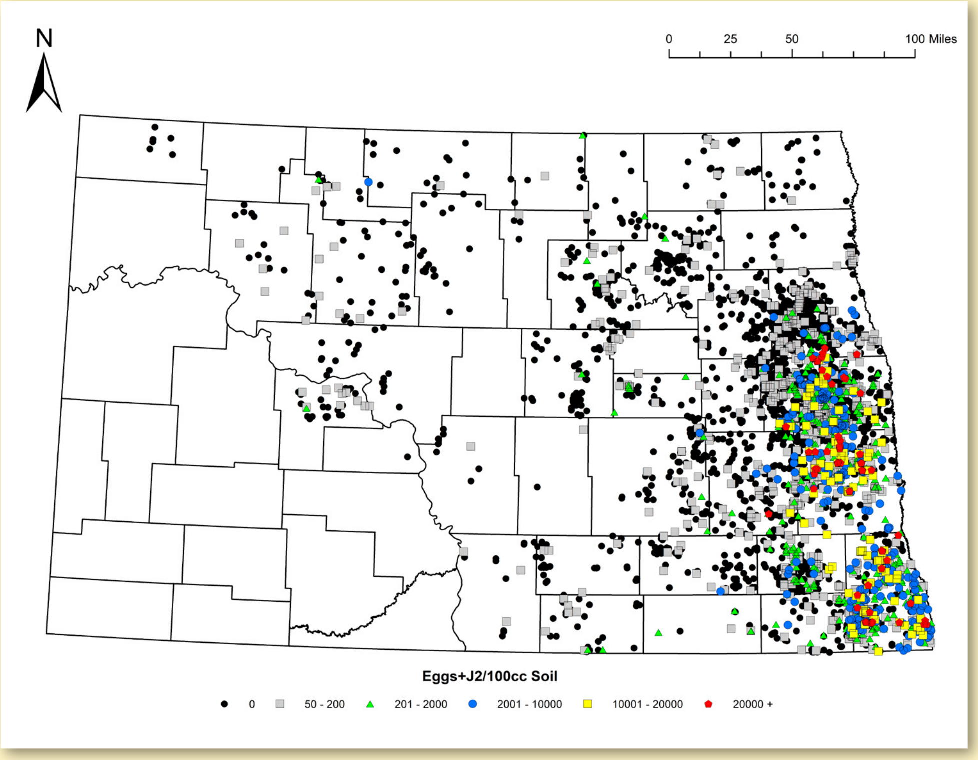

Figure 9. Cumulative distribution and egg levels of soybean cyst nematode in North Dakota received though the NDSC / NDSU sampling program 2013-2021.
(Sam Markell, NDSU)

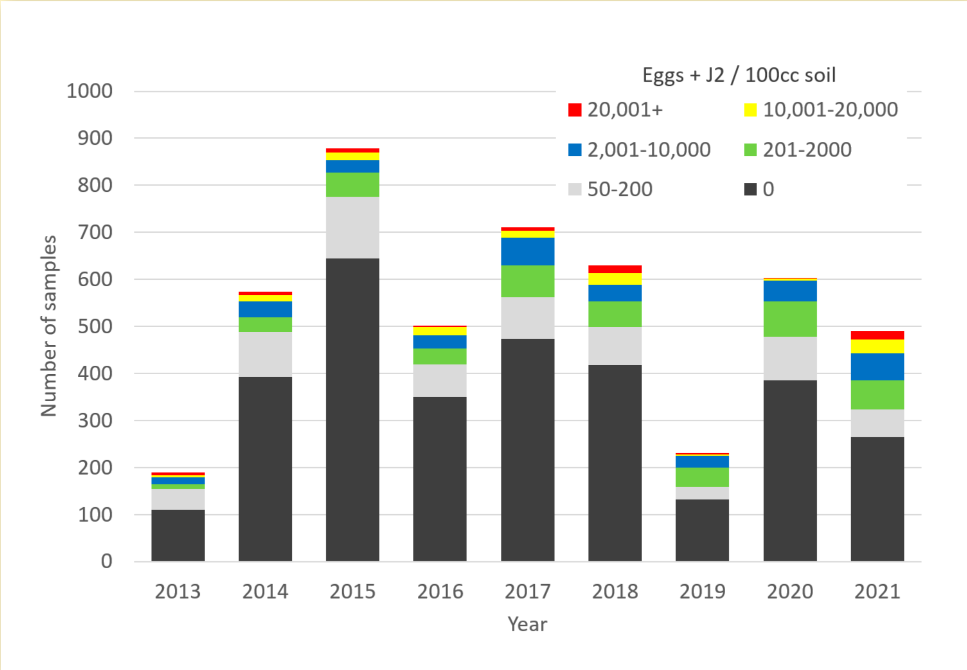

Figure 10. Egg levels (eggs + J2/100cc soil) of soil samples received by the NDSC sponsored SCN sampling program from 2013 and 2021.
(Sam Markell, NDSU)

Management

Minimizing Spread

When possible, it is important to limit spread of SCN. Remember, anything that moves soil can move SCN (and other pathogens, weed seeds and more). Limiting spread is critical if you are not in an area with SCN. It is similarly critical if you are moving (or purchasing) equipment from a long distance away, where widespread adaption of SCN to genetic resistance (such as Peking or PI 88788) is occurring (such as southern Minnesota and states in the soybean/corn belt).

SCN Scouting and Soil Sampling

Early detection of SCN infestation and proactive management can help prevent yield losses. Moreover, monitoring SCN population levels in infested fields can help evaluate the effectiveness of your management strategies (page 4).

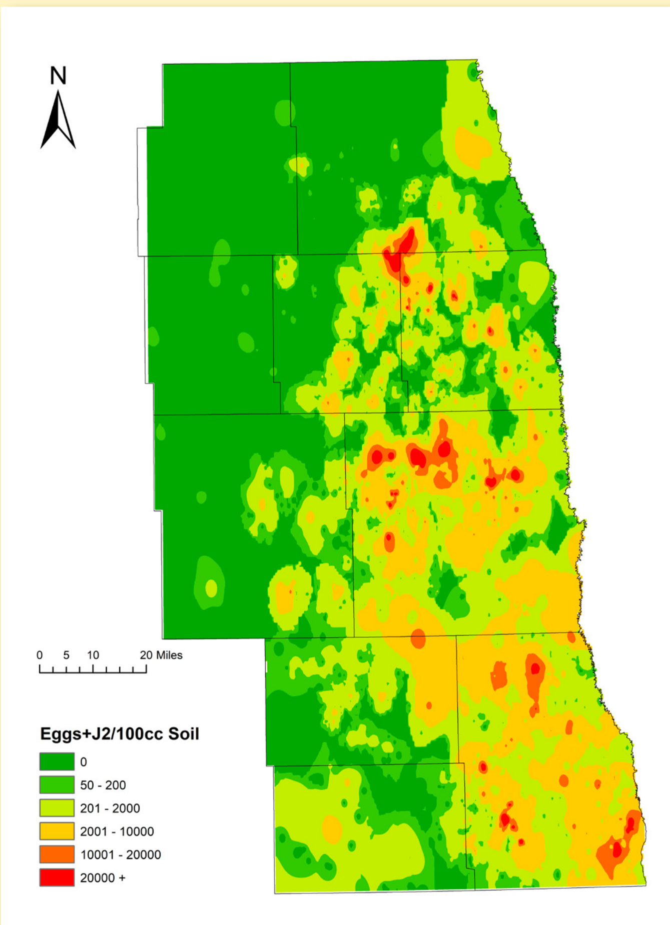

Figure 11. Cumulative distribution and egg level of soybean cyst nematode in southeast and east central North Dakota received though the NDSC / NDSU sampling program in 2013-2021. (Sam Markell, NDSU)

Host Resistance

Planting a good resistant variety will limit SCN reproduction and keep egg levels low. This reduces yield loss in the current growing season and helps prevent yield loss in future seasons. Although many soybean varieties have been developed with SCN-resistance, growers should consider several aspects when selecting a variety. First, a strong majority of the varieties in the market have PI88788-type resistance. While several nematode populations in North Dakota have begun to adapt to PI88788, the resistance is generally effective in our state. Second, because of the complexity of resistance in PI88788 (multiple genes and copy numbers of those genes in PI88788), some PI88788 varieties will be far more resistant to SCN than others. Whenever possible, obtain information about the efficacy of the resistance in the variety planted. Third, rotating varieties with different sources of resistance (i.e., PI88788 and Peking) is a very effective way keep egg levels low *and* slow the adaption of nematode populations that overcome genetic resistance. However, there is also benefit in rotating among varieties with PI88788. As resistance in PI88788 is conferred by multiple genes, rotation among PI88788 varieties may expose the nematode population to different gene combinations.

Crop Rotation

Crop rotation is the most effective tool that can be used to reduce SCN population levels. The greatest reduction in SCN population levels occur in the first year a non-host crop is planted. Further reduction (although less dramatic) in population numbers will occur with additional years of non-host crop planting. All cash crops grown in our region are excellent rotation choices except dry edible beans. Dry edible beans are good hosts for SCN, although differences exist among varieties and market classes. A soybean every-other-year rotation may be used successfully, but is most successful when sources of resistance are rotated in a six-year crop cycle (Figure 11). When SCN levels are high, there is benefit by switching out of soybeans for more than one year. Soybean on soybean rotations are risky and over time are likely to faciltate an increase in yield loss to SCN.

Weed Control

Among the 50 common weed species from North Dakota recently tested by research at NDSU against SCN, only henbit and field pennycress allowed substantial reproduction of SCN. The rest of the weed species were classified as non- or poor host of SCN. Thus, these two weeds should be intensively managed. Similarly, management of volunteer soybeans is critical in crop rotations.

Nematicide Seed Treatments

Numerous seed-treatment nematicides are currently available or are in phases of development. Like fungicide seed treatments, nematicide seed treatments should not be expected to offer season-long control. If using a nematicide seed treatment, it is strongly recommended that it be used in addition to host resistance and crop rotation.

Keep your egg levels low and limit yield loss with ***active management of SCN***

- Test your fields to know your numbers
- Rotate resistance varieties
- Rotate to non-host crops
- Consider using a nematode-protectant seed treatment

For more information visit **www.thescncoalition.com**.

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