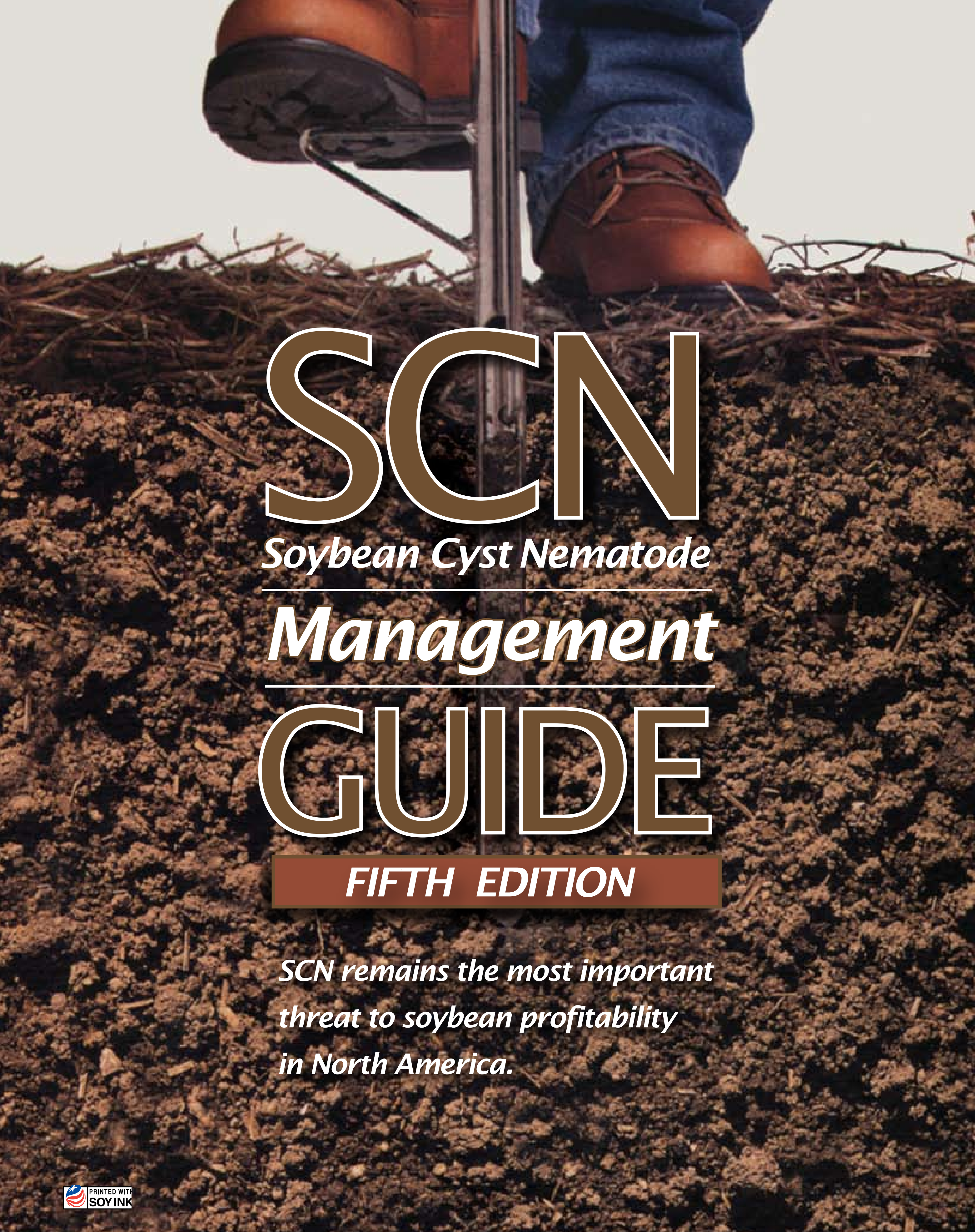

SCN

Soybean Cyst Nematode

Management

GUIDE

FIFTH EDITION

SCN remains the most important threat to soybean profitability in North America.

SCN
Soybean Cyst Nematode
Management
GUIDE

FIFTH EDITION

PLANT HEALTH INITIATIVE
AN NCSRP PROGRAM

Your guide to managing SCN-infested fields for increased yield and an increased bottom line!

This publication was developed with you, the soybean grower, in mind. Included in these pages are the answers to frequently asked questions, along with recommendations based on decades of research on soybean management in SCN-infested fields. This research has shown that soybeans can be produced profitably in spite of SCN. The first move is yours; to determine whether you have SCN infestations, then tailor a management strategy for your farm.

We hope the following sections will be useful to you.

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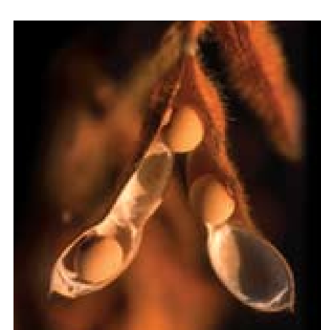


If you think you don't have SCN, you should read this guide. You could have it and not know it. If you know you have SCN, there may be more you can do to improve soybean profits.

DO YOU KNOW?

- *Soybean cyst nematode (SCN) is the leading cause of soybean yield loss in North America.*
- *SCN symptoms are NOT unique or diagnostic; they may look like those due to many other causes.*
- *SCN is not always visible on roots of infected plants.*
- *SCN can cause substantial yield loss without causing symptoms.*

1. How important is SCN and where does it come from?

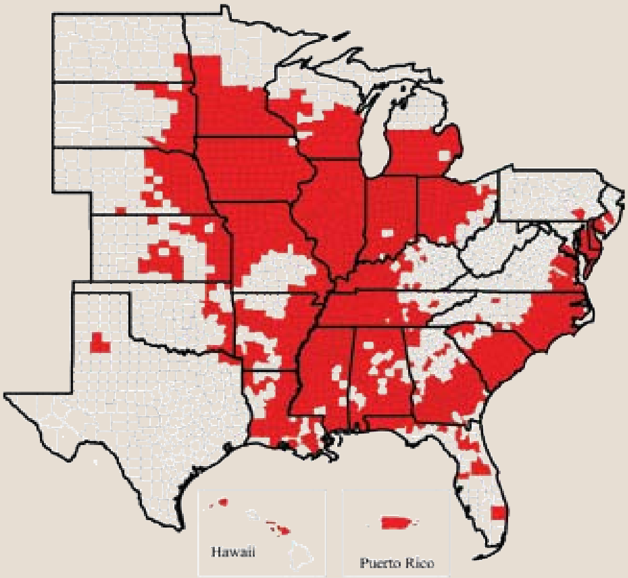
Soybean cyst nematode (SCN), or *Heterodera glycines*, is the most destructive pathogen of soybean in North America. Soybean producers in the United States lost more than 300 million bushels to the soybean cyst nematode from 2003 to 2005. More yield is lost to SCN than any other soybean pathogen.

At present, soybeans are planted on more than 70 million acres in North America. SCN is widely distributed in all major soybean production areas of the United States (see map, right).

SCN was first found in the Western Hemisphere in North Carolina in 1954. Before then, SCN was known in China, Japan and Korea. The nematode now occurs in all major soybean production areas worldwide, including both North and South America.

The nematode may have been introduced into the United States several times during the late 1800s in soil imported from Asia for the purpose of obtaining bacteria to nodulate soybean roots. SCN can be spread by anything that moves soil: wind, water, animals (especially birds) and machinery.

Documenting the economic impact of SCN is difficult because many producers suffer declining yields for several years without knowing that they have SCN. Planting the SCN-resistant variety Forrest in the southern United States on farms with known SCN infestations prevented $401 million in crop loss during 1975-1980, while the cost of developing Forrest was less than $1 million. SCN is much more widespread today, and SCN-resistant varieties prevent even more crop loss.



Map
Distribution of known soybean cyst nematode infestations in the United States in 2008. *(Riggs and Tylka)*

No Symptoms
SCN-resistant and -susceptible varieties growing side-by-side in a heavily infested soybean field. There is no way to tell which is which by looking at the plants. In this field, the resistant variety yielded over 30 percent more than the susceptible.

2. What is SCN?

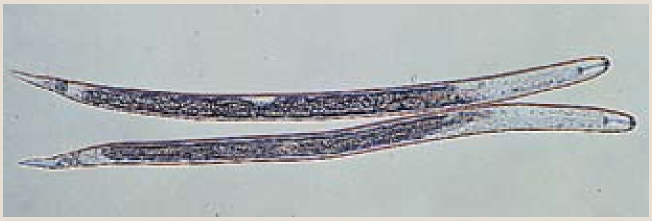
SCN, like all plant-parasitic nematodes, is a microscopic roundworm – a very simple animal, related to the animal-parasitic roundworms that infect livestock and pets. The juvenile nematode [top right] is the infective stage of SCN – the stage that actually enters the soybean root. It hatches from an egg [right].

The juveniles penetrate soybean roots and cause the formation of specialized feeding cells in the vascular system (veins) of the roots. If the juveniles become males, they leave the root after feeding for a few days, move through the soil, and do not contribute further to plant damage. If the juveniles become females, they lose the ability to move and swell into lemon-shaped objects as they mature. Females become too large to remain completely embedded within the root. Their heads remain embedded while the rest of their bodies break out of the root [young female, right]. The young adult female is referred to as a white female. Plant damage is primarily due to the feeding of females and the indirect effects of such feeding.

White females become yellow as they age and then turn brown after they die [right]. The brown stage is the cyst for which the nematode is named. Each cyst can contain up to 500 eggs [lower right], but under field conditions they usually contain many fewer eggs. The cyst protects the eggs from the harsh soil environment, helping them to persist for years in a dormant state.

SCN can theoretically complete up to six generations during the growing season, depending mainly on:

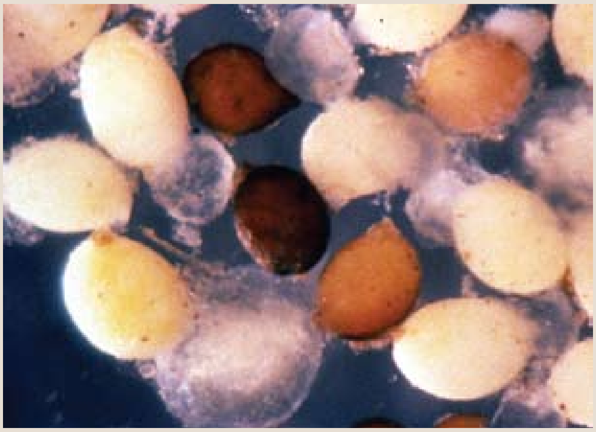
- Host suitability
- Geographic location
- Length of growing season
- Planting date
- Presence of weed hosts
- Soil temperature



Juveniles
Juvenile (infective stage) SCN after hatching. The nematodes are about 1/64-inch long, invisible to the unaided eye.

SCN Egg
The juvenile worm can be seen folded up inside. *(M. Mota, Universidade de Evora, Portugal)*

Young Female
A maturing SCN female, too large to be contained within the root. *(T. Jackson, University of Nebraska)*



SCN Cysts
SCN cysts of different ages: white females are young, yellow to brown females are older and dying or dead.

Broken Cyst
A dark brown cyst, broken open to reveal the eggs and juvenile nematodes within.
(E. Sikora, Auburn University)

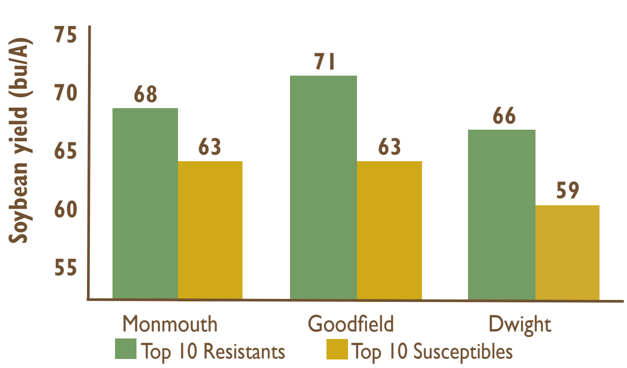
3. How does SCN affect soybean?

SCN cannot reproduce without a host plant. Conditions that favor soybean plant growth are favorable for SCN development.

The effect of SCN on soybean growth and yield involves several mechanisms, all of which are directly related to the numbers 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. SCN infection may also reduce the number of nodules formed by the beneficial nitrogen-fixing bacteria that are necessary for optimum soybean growth [below].

Plants infected with high numbers of SCN have poorly developed root systems that cannot utilize nutrients and water efficiently. The result may be stunted plants with chlorotic (yellow) foliage. More frequently, however, no obvious symptoms are produced. This is especially true for production fields from Kentucky northwards. In fact, scientists throughout this region have observed many research trials in which resistant and susceptible soybean varieties show no consistent differences in plant growth; in other words, they could not be distinguished visually [center right]. On the other hand, the yields of resistant varieties were consistently higher than those of the susceptible varieties, as in the example [lower left]. With or without visible symptoms, seed yields are low because fewer pods develop on infected plants. SCN infections by themselves do not reduce seed size, number of seed per pod or seed quality.

SCN-infected roots on right are stunted, discolored, and have fewer nitrogen-fixing nodules than noninfected roots on left.



Yield Trial Results
The bars in this graph show "Top 10" comparisons: yields of the 10 highest-yielding SCN-resistant varieties compared with the 10 highest-yielding susceptible varieties in three central Illinois locations in 2006 variety trials. All three locations were infested with moderate SCN population levels.

Variety Trial
A soybean variety trial planted with SCN-resistant and susceptible varieties, in a field infested with 10,000 SCN eggs/100 cc soil, high enough to reduce yields by 50 percent or more. There is no visual evidence of the stunning yield loss suffered by the susceptible varieties. *(T. Jackson, University of Nebraska)*

4. Does SCN interact with other diseases?

It is common for other soybean pathogens* to be present in SCN-infested fields and for interactions among the pathogens to occur.

Infection by SCN juveniles and the eruption from roots by the maturing females create openings in the root surface that can serve as entry points for other soil-borne soybean pathogens such as *Pythium, Rhizoctonia, Phytophthora, Fusarium* (the cause of sudden death syndrome, Fusarium wilt, Fusarium root rot) and *Macrophomina* (the charcoal rot pathogen).

Multiple Interactions
A row of soybean plants affected by SCN, charcoal rot and potassium deficiency, all at the same time.

SDS Symptoms
Severe sudden death syndrome (SDS) symptoms in a field heavily infested with SCN. *(T. Jackson, University of Nebraska)*

SCN and SDS

SCN is involved in the development and spread of sudden death syndrome (SDS). The fungus that causes SDS (*Fusarium virguliforme*) lives in the soil with SCN and is fully capable of causing disease on its own, but research has shown that SCN hastens the development of SDS symptoms and increases their severity, leading to greater yield loss.

***A soybean pathogen is a disease-causing agent: a fungus, bacterium, nematode or virus. Soybean pathogens often require specific environmental conditions in order to cause disease. Infection by one pathogen may affect the plant's response to other stresses, including other pathogens.**

SCN and brown stem rot

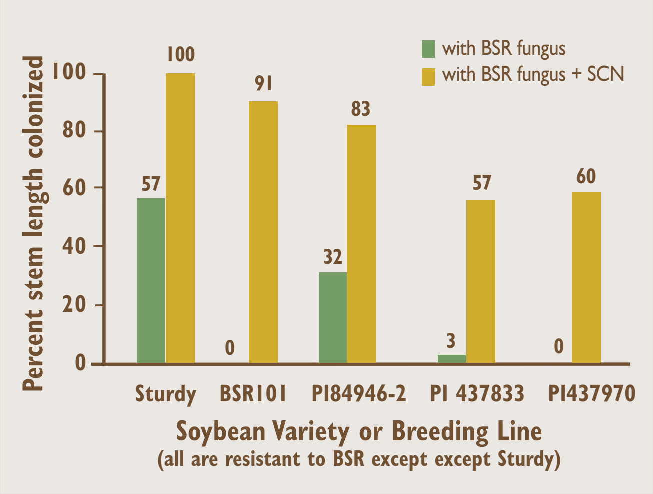
Brown stem rot (BSR) of soybeans is a stem and root disease [right] caused by the fungus *Phialophora gregata*, which lives in the soil. Soybean plants infected with SCN are infected earlier in the season with the BSR fungus, and the BSR disease is more severe in SCN-infected plants than in plants not infected with the nematode. Even soybean varieties that are resistant to BSR disease become infected and develop the BSR disease when the plants are also infected with SCN. It is not known exactly how SCN makes BSR more severe.

BSR Symptom
Internal stem rotting symptom of brown stem rot (BSR) disease. *(Tylka)*

Nematologists, plant pathologists and soybean breeders have combined efforts to address the problems posed by these soybean disease interactions. Soybean varieties have been developed with resistance to more than one pathogen. Important examples in northern varieties are those with resistance to both SCN and Phytophthora root rot, while several southern varieties are resistant to both SCN and root-knot nematodes. Information on specific resistance should be available from local sources.

Treat SCN first

What do you do if you have both SCN and another soybean disease in your field? Most people would recommend that you take care of the SCN problem first. Why? Because SCN is always present and reducing soybean yields, regardless of the environment, while fungal diseases such as SDS and BSR don't develop and reduce soybean yields every year.



BSR Graph
Infection of five soybean varieties by the fungus that causes brown stem rot (BSR) disease. Green bars are infection of the varieties with the BSR fungus alone and gold bars are infection of the varieties by the BSR fungus when also infected with SCN.

Symptomatic soybean plants growing in an SCN-infested field in Illinois. *(G.R. Noel, USDA-ARS)*

5. What does SCN damage look like?

The answer to this frequently asked question is not simple. Visible damage and SCN infestations do not always go together, and SCN cannot always be seen on roots. Professional diagnosis is the way to go, for these reasons:

- Symptoms of SCN infections are highly variable. They can range from none (no visible evidence of plant injury) to plant death in certain areas of the field. In aerial photographs of fields heavily infested with SCN, "hot spots" may be visible [upper right].

- The symptoms commonly associated with SCN damage are similar to other crop production problems such as potassium and nitrogen deficiencies, iron deficiency chlorosis, herbicide injury, soil compaction, drought stress and other soybean diseases [right].

- The young female SCN is white or yellow and is the only visible sign of SCN infection on roots [right]. Young females may not be present at the time of fall soil sampling. Older females, which are brown cysts, are not visible in soil.

In high-yield production fields (greater than 40 bushels/acre) or during years when soil moisture from rainfall or irrigation is plentiful, visible symptoms of SCN damage are rarely seen. Soybean farmers in these situations often notice poor or no-longer-increasing soybean yields over several years, uneven plant height in the field, a delay in canopy closure or early senescence.

SCN Symptoms
Aerial photograph of soybean injury in a heavily infested field in Minnesota. *(S. Chen, University of Minnesota)*

Early Season Symptoms
Severe SCN symptoms in an infested field in Canada. *(A. Tenuta, OMAFRA Canada)*

White female SCN are visible on soybean roots. *(A. Tenuta, OMAFRA Canada)*

No SCN Symptoms
Visible symptoms of plant damage such as yellowing and stunting are not always seen, particularly in high-yield environments. Though not outwardly apparent, this field is infested and experiencing yield loss.

SCN infestations can be confirmed through observation of white females on soybean roots. White females are most readily seen in the field at about the time soybean plants are beginning to flower. In order to see them, the root system must be dug up very carefully with a shovel. Gently remove the soil, because the females are easily dislodged. Although observation of white females will confirm an SCN infestation, it cannot tell you much about the level of infestation. Also, if you dig up roots and don't find white females, that does not mean that SCN is absent. The only way to get a reliable diagnosis is through analysis of a properly collected soil sample by a professional diagnostic laboratory (see Section 6).

Soybean damage due to SCN is frequently misdiagnosed. You can reduce your risk of yield loss by getting a professional diagnosis and knowing your SCN numbers.

The most commonly observed symptom associated with SCN is reduced yield. It's important to remember that visible symptoms of plant damage such as yellowing and stunting are not always seen, particularly in high-yield environments. SCN can cause yield reductions of 15 to 30 percent or more on susceptible varieties that show no visible symptoms of nematode damage. For this reason, we strongly encourage soil testing to identify fields where SCN may be impacting yield, and to monitor fields where SCN is a known problem.

6. How do I sample soil for SCN?

Once you determine that a field is infested with SCN, soil samples do not need to be collected each year. Soil samples from these fields should be collected before SCN-susceptible varieties are grown, or once every three years of soybean if resistant varieties are grown in a rotation.

Although soil samples for SCN may be collected at any time, the ideal time to sample is as close to soybean harvest as possible. SCN numbers tend to be highest when the plants are almost mature to shortly after harvest.

Sampling near harvest allows sufficient time for the nematode laboratory to process the sample and provides you with information and enough time for selecting a variety or choosing alternative crops for the next year.

Soil samples collected for soil fertility analysis can be split into:

- One for fertility
- One for SCN analysis

However, remember to place the nematode sample in a plastic bag, not in a paper soil test bag, and keep the sample out of direct sunlight!

Large fields may be subdivided into sections and a single composite sample from the different sections submitted for analysis. If the soybean crop row is identifiable, place the soil probe within 2 inches of the row when collecting the soil core. Placement of the soil probe is not important for samples collected from cultivated fields, fields where soybeans were drilled or fields in which nonhost crops had been grown.

The importance of getting a representative soil sample of the area under consideration (whole field, section of field, area where plants show symptoms of crop injury) cannot be overemphasized.

How to deal with hot spots

Soil samples should be collected from the area between the most severely damaged plants and the "healthy" plants. Do not collect the sample from the center of the hot spot because these plants usually have severely stunted root systems that cannot support SCN. A sample collected from dead or severely stunted plants may show that SCN numbers are low when in fact there are high numbers present in the areas where plants appear "healthy."

How to sample fields that have never been checked for SCN

The first time a field is checked for SCN, sample areas where SCN is likely to establish first. This includes near a field entrance, along fence lines, areas that have been flooded, areas where weed control isn't quite as good, areas of high soil pH (greater than 7) or areas where the yield was low the last time soybeans were grown.

Nematode diagnostic laboratories usually have special forms to be submitted with soil samples. Even if such a form is not available when you sample, you should provide the following information:

- Your name, address and phone number
- The location of the field
- The date when the field was sampled
- The number of acres represented by the sample
- Crop history (previous two to four years)
- The name or number of the field
- Pesticide applications for current and previous years

Results

Laboratories may report SCN sample results as the number of cysts, eggs or juveniles per 100, 250 or 500 cm^3 of soil. Cyst and egg counts generally correlate well and both are indicators of the relative amount of SCN present in the soil, but juveniles typically are short-lived and their numbers are not as informative as numbers of cysts or eggs because they are subject to different hatching behaviors at different times of the year and under different soil conditions. When comparing SCN soil sample results from different laboratories or comparing results to published thresholds or research results, be sure the same volumes of soil and the same SCN life stages are being compared. A result of 200 cysts per 100 cm^3 soil is a much higher SCN population density than 1,000 eggs per 250 cm^3 of soil because each cyst may contain 200 or more eggs and 250 cm^3 is 2½ times more soil than 100 cm^3.

Procedure for collecting soil samples

1. Use a cylindrical soil probe to collect soil samples.
2. Collect soil cores to a depth of 6 to 8 inches.
3. Collect 10 to 20 soil cores in a zig-zag or "W" pattern across the entire area to be sampled.
4. Collect soil cores from areas of similar soil texture and cropping history. If different soil textures occur in the same field, sample them separately.
5. Bulk the cores in a container (bucket) and mix.
6. Place approximately one pint of mixed soil in a plastic bag and label the outside of the bag with a permanent marker.
7. Store the sample away from sunlight in a cool area until it is shipped to the laboratory.

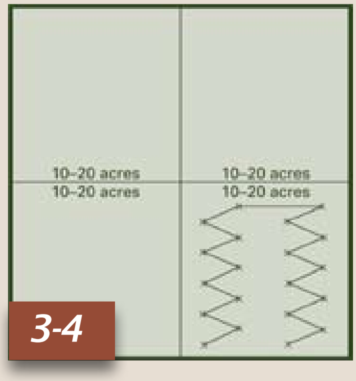
Note: If you are sampling on a 2.4 or 2.5-acre grid, you can collect two extra cores from every eight or nine grid cells for SCN analysis.

Important

The quality and condition of the sample determines the reliability of the results.


1-2

Soil Probe
A 1-inch diameter cylindrical soil probe is ideal for soil sampling for SCN. *(UIUC-ACES-ITCS: Riecks)*



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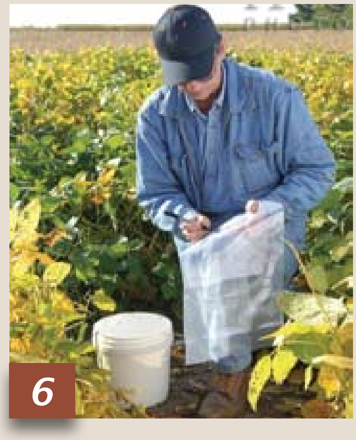
Fall Sampling
The ideal time to sample for SCN is in the fall, shortly before or after soybean harvest. *(UIUC-ACES-ITCS: Riecks)*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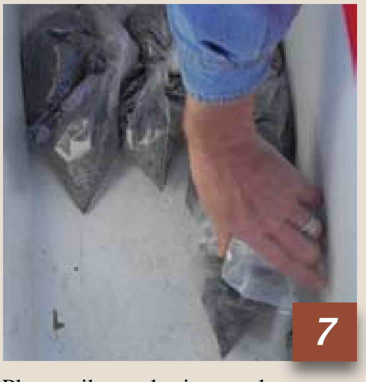
Mixing Cores
Mix soil cores in a bucket, and place about 1 quart of the mixed soil in a plastic bag labeled with a permanent marker. *(UIUC-ACES-ITCS: Riecks)*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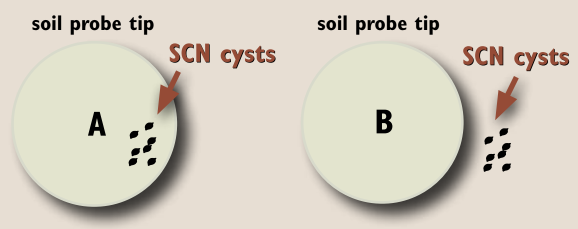
Place soil samples in a cooler to protect them from overheating and evaporation. *(UIUC-ACES-ITCS: Riecks)*

Don't allow soil samples to sit out in the sun before being transported to a lab. *(UIUC-ACES-ITCS: Riecks)*

7. Why are SCN numbers variable?

SCN cysts are very small and are usually clustered in the soil, making SCN soil sample results notoriously variable. With a typical 1-inch-diameter soil probe, random placement of the probe into the soil can have a tremendous effect on how many egg-filled SCN cysts are recovered [below].



Variability Diagram
In the diagram, soil probe A (seen in cross-section) captures a cluster of seven SCN cysts (not drawn to scale) that may contain 1,500 eggs. The placement of soil probe B is only 1/2-inch different than the placement of soil probe A and it misses the seven SCN cysts, resulting in up to 1,500 fewer eggs being present in the soil core. *(Tylka)*

In addition, variability in SCN numbers within a field at a single point in time depends on the same factors that affect seasonal changes, including:

- Crop
- Host suitability
- Moisture
- Overwinter survival
- Presence of weed hosts such as winter annuals
- Soil type
- Temperature
- Tillage

Another factor known to affect SCN numbers is soil pH. In SCN-infested fields, nematode numbers may be much higher in areas with pH levels greater than 7.0, compared with areas of pH 5.9 to 6.5. Soil with pH of more than 7.0 was consistently associated with high initial SCN egg density. Soil pH may also govern the degree to which SCN populations increase in a field after its introduction.

Finally, nematode numbers are variable because anything that moves soil will move SCN with it, including wind, water, migratory birds, tillage and harvest equipment and animals. Once introduced into a field, SCN may take up to 10 years to build up to a damaging level, depending on how often susceptible soybean is grown.

8. What are HG Types?

Until recently, SCN-resistant varieties suppressed 90 percent or more of the development of most SCN populations, resulting in a significant increase in soybean yields in SCN-infested fields. However, soon after resistant varieties were first released, scientists discovered that some SCN populations were capable of reproducing at high levels on resistant soybean varieties. A race test was developed in 1970 to assess and describe the abilities of SCN populations to reproduce on resistant soybean varieties. Today we know more about the interaction between SCN virulence and soybean resistance, and we identify SCN populations as HG Types.

Laboratories that offer SCN diagnostic services may or may not be able to provide HG Type tests; it's best to check first.

"HG" stands for the scientific name for SCN, *Heterodera glycines*. An HG Type is a description or profile of an SCN population based on the nematodes' ability to develop on resistant soybean lines. The HG Type test is similar to a race test, but is more informative and easier to understand. The number or numbers in the HG Type designation correspond directly to sources of resistance used in available SCN-resistant soybean varieties (Table 1).

Table 1. The seven soybean plant introductions used in HG type tests.

HG type index number	HG type indicator line
1	PI 548402 (Peking)
2	PI 88788
3	PI 90763
4	PI 437654
5	PI 209332
6	PI 89772
7	PI 548316 (Cloud)

**These lines are called plant introductions (PI) because they are the original soybean lines from China or Russia that are the ancestors of every SCN-resistant variety we have today. They are listed in order of discovery of their resistance.*

How the HG Type is determined:

1. SCN eggs from a field sample are used to infest seedlings of seven different resistant soybean lines (see Table 1) plus a standard susceptible variety.
2. The seedlings are grown in a greenhouse for 30 days.
3. The SCN females are removed from the roots and counted.
4. The Female Index* is calculated for each resistant soybean line.
5. If the Female Index is 10 or more on a soybean line, this indicates that SCN populations will increase if it is planted. The number for this line gets added to the HG Type of the SCN population.

Example 1:

Let's say we test the SCN population from your field, and we get a Female Index greater than 10 on PI numbers 2, 5 and 7 (Table 1). This means the HG Type is 2.5.7.

Example 2:

Let's say the results from a different field show a Female Index greater than 10 on PI numbers 1, 3 and 6. The HG Type of this population is 1.3.6.

Example 3:

The results of the test show that your nematodes cannot attack any of the seven lines listed in Table 1. This means you have an HG Type 0.

** A female index (FI) is simply a percentage: the number of females produced on each resistant line is divided by the number produced on a standard susceptible soybean, and the result is multiplied by 100. A low FI (<10) means that the SCN population was not able to reproduce well on the resistant line, and a high FI means that the SCN population was able to reproduce well.*

What does it all mean to you?

Repeated use of the same resistant variety will result in development of an SCN population that is adapted to that variety. Use of the same resistant variety more than once in the same field is NOT recommended. But many resistant varieties have the same resistant parent, or "source of resistance," and so rotation of resistant varieties alone may not be sufficient to avoid this problem. Nonhosts (see Table 3) must be included in the rotation to decrease the numbers of SCN and slow down its adaptation to resistant varieties. The common sense approach is the best: don't grow the same variety every time you grow soybeans and include nonhosts in the rotation plan.

Do you need an HG Type test?

You may want to have an HG Type test if you have both high SCN numbers and poor yields of SCN-resistant varieties. An HG Type test can help you find the cause and decide what to do. But proper sampling and attention to the numbers of SCN in your lab reports, along with an analysis of field history, will tell you most of what you need to know about the success of your SCN management strategy. If your SCN numbers are rising when you plant a resistant variety – it is time to first switch to a nonhost and then to use soybean varieties derived from a different source of resistance after that.

Nonhosts must be included in the rotation to decrease the numbers of SCN and slow down its adaptation to resistant varieties.

9. How do I manage my soybean crop to minimize losses due to SCN?

The number of SCN in a field can be greatly reduced through proper management, but it is impossible to eliminate SCN from your field once it has become established. With currently available management options, it is much easier to keep low numbers low than it is to try and drive high SCN numbers down.

The goals of soybean management in the presence of SCN are to:

- Improve soybean health and yield
- Keep SCN numbers low
- Preserve the yield potential of resistant varieties

Because no single management practice will meet all three goals, you must use an integrated approach that combines several components. Chief among these practices are the use of resistant varieties and a properly designed crop rotation.

Resistant Soybean Varieties

Unlike susceptible varieties, resistant soybean varieties reduce the ability of SCN to develop and complete its life cycle. Resistant varieties vary in their levels of resistance. Resistance is not complete: SCN reproduction continues at a reduced rate. In general, the SCN reproduction on a resistant soybean variety will be less than 10 percent of what occurs on a susceptible variety. The use of resistant varieties allows you to grow soybeans profitably now, while managing SCN numbers so that soybeans can be grown profitably in the future.

In the recent past, farmers may have been reluctant to use resistant varieties because there was a yield gap between resistant and susceptible varieties in fields that were not infested with SCN. Because of the joint efforts of soybean breeders and nematologists, high-yielding SCN-resistant varieties are now available.

Several different sources of SCN resistance exist (see Table 1) and have been used to develop resistant soybean varieties. Most individual resistant varieties carry resistance from only one source. This may allow you to rotate sources of SCN resistance to help prevent the development of more damaging HG Types. Check with your land grant university and the seed companies with which you work for more information on sources of resistance in varieties adapted to your area.

Unfortunately, SCN-resistant varieties that yield comparably do not necessarily control the nematode equally. SCN-resistant varieties can vary considerably in how well they control nematode population densities, even top varieties. Greater SCN reproduction will result in a higher SCN population in the soil the next time soybeans are grown in that field.

Consequently, growers must consider how SCN-resistant soybean varieties affect SCN populations in addition to how well the varieties yield to maintain the long-term productivity of the field for soybean production. Selecting SCN-resistant varieties based solely on yield data is short-sighted and risky because some relatively high-yielding soybean varieties allow substantial amounts of SCN reproduction. Keep this point in mind when evaluating soybean variety trial data.

Crop Rotation

Crop rotation produces many benefits and should be part of your management program whether you have SCN or not. If you have SCN, your rotation should include nonhost crops and resistant soybean varieties. If you can successfully reduce SCN numbers, you may consider growing a susceptible soybean variety in the rotation for a single year, with the understanding that the number of SCN will increase. Be certain that SCN population densities are low before considering growing an SCN-susceptible soybean variety in the rotation. You should also avoid growing an SCN-susceptible soybean variety in an SCN-infested field, no matter what the SCN numbers are, if a drought is expected.

A good SCN management plan should not include other hosts for SCN (Table 2). Although soybean is the major host crop for SCN, the nematode has a wide host range. SCN levels have been increasing in edible bean production areas of the United States and Canada, and their inclusion in a rotation will increase SCN populations.

Table 2. Hosts for soybean cyst nematode.

Crop Plants	Weed Plants
Alsike clover	American and Carolina vetch
Bird's-foot trefoil	Common and mouse-ear chickweed
Common and hairy vetch	Common mullein
Cowpea	Field pennycress
Crimson clover	Hemp sesbania
Crownvetch	Henbit
Edible beans	Hop clovers
Lespedezas	Milk and wood vetch
Pea	Pokeweed
Sweet clover	Purple deadnettle
White and yellow lupine	Purslane
	Shepherd's purse
	Wild mustard

Nonhost crops

Nonhost crops (Table 3) cannot be used as a food source by SCN. In a field planted to a nonhost, SCN numbers will not increase and should decrease. When nonhosts are grown, juveniles will hatch from some of the eggs and will starve or be destroyed by natural

Table 3. Poor hosts and nonhosts for SCN management rotations.

Alfalfa	Melons	Sugarcane
Barley	Miscanthus	Sweet potato
Canola	Oats	Sweet sorghum
Corn	Peanuts	Switchgrass
Cotton	Red clover	Tobacco
Forage grasses	Rice	Tomato
Grain sorghum	Sugar beet	Wheat

enemies. The amount of decrease varies in relation to geographical area. SCN numbers may decrease by as much as 90 percent in the southern United States but only 10 to 40 percent in the north (some of the difference is due to poor winter survival in the South due to higher soil temperatures, which allows hatching).

Rotation design

Rotation design depends on conditions specific to your farm and individual fields as well as commodity prices and input costs. Success at reducing SCN numbers is clearly related to geographical region. Farmers in the northern Soybean Belt will observe slow reduction in SCN regardless of rotation design. In these areas, more frequent use of nonhost crops is appropriate. Several rotation sequences may be required before an appreciable drop in SCN is observed. Farmers in the southern United States usually observe a more rapid reduction in SCN numbers. A southern rotation may consist of alternating years of nonhosts and resistant soybean varieties. Double-cropped soybean after wheat should be considered a full year of soybean. SCN buildup in double-crop soybean may be less than in full season soybean, but a significant increase is just as likely to occur. Rotation designs have been thoroughly tested in many locations in the United States. Be sure to check with your local sources for specific recommendations useful to you.

The slower SCN numbers decrease, the more often you need to grow nonhost crops. To determine the effectiveness of your rotation, you must sample for SCN (see Section 6). If SCN numbers increase on resistant varieties, your source of resistance may no longer be effective and you should choose a variety with a different source of resistance or plant a nonhost.

Controlling winter annual weeds

Purple deadnettle, henbit and field pennycress are moderate to good hosts for SCN (Table 2). If these winter annual weeds are growing in SCN-infested fields and soil temperatures are greater than 50°F, SCN reproduction and increases in population densities can occur. (SCN cannot develop in roots below 50°F.)

The SCN life cycle takes 21 to 24 days to complete at ideal temperatures (76°F) and can take five or more weeks at colder temperatures. There may be periods of time in the spring or fall when soil temperatures are warm enough for SCN reproduction to occur on winter annual weeds.

Other Cultural Practices

Maintaining adequate soil fertility, breaking hardpans, irrigating (if possible), and controlling weeds, diseases and insects improve soybean plant health. These practices help plants compensate for damage by SCN, but do not decrease SCN numbers. These practices should be part of your rotation management, but cannot substitute for a properly designed rotation.

Nematicides

A few nematicides are available and labeled for use in managing SCN (labeling varies by state), but these compounds are seldom recommended. However, new seed treatments are being developed for SCN management, and these are being tested throughout the northern Soybean Belt for their efficacy. Check with local sources for further information on nematicide and seed treatment labeling and recommendations.

Factors that make nematicides an uncommon choice are:

- Resistant varieties are more cost effective
- Nematicides increase cost of production
- Nematicides frequently result in high SCN numbers at season's end
- Nematicides may adversely affect the environment

Biological Control

Natural enemies of SCN are found in most soils, and may even suppress SCN populations. Certain fungi, bacteria, and predaceous nematodes are known to destroy SCN, but they have been very difficult to develop into commercial products. Nonetheless, progress is being made in this area. Check with local sources for more information on SCN control biological agents as research progresses.

10. Recommendations for Managing SCN

Rotate, Rotate, Rotate, Rotate:

1. Rotate with nonhost crops to reduce SCN numbers.
2. Rotate with resistant soybean varieties to reduce yield loss due to SCN.
3. Rotate the resistant varieties you use: don't use the same one twice in a row.
4. Rotate with tolerant or susceptible soybean varieties only if SCN numbers are low.

Relieve Stress

Good management of weeds, water and soil fertility will avoid compounding damage due to SCN.

Other Practices

No-till, late planting or other practices may be beneficial. Check local recommendations.

Monitor SCN populations through periodic sampling and note how the numbers change. It is much easier to keep numbers low than it is to drive high number down.

SCN cannot be eliminated from an infested field, but soybean production can remain profitable with proper SCN management.

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Editors: Terry L. Niblack, University of Illinois, and Gregory L. Tylka, Iowa State University

Contributors to previous editions: G. S. Smith, J. G. Shannon, L. E. Sweets, W.J. Wiebold, and J. A. Wrather, University of Missouri-Columbia; D. I. Edwards, University of Illinois; P. A. Donald and G. R. Noel, USDA-ARS; J. H. Orf, University of Minnesota; and R. D. Riggs, University of Arkansas.

This edition produced in cooperation with:
Bond, Jason, Southern Illinois University.
Bird, George, and Fred Warner, Michigan State University.
Chen, Senyu, and Dean Malvick, University of Minnesota.
Dorrance, Anne, and Kent Harrison, The Ohio State University.
Esker, Paul, and Ann MacGuidwin, University of Wisconsin.
Faghihi, Jamal, and Virginia Ferris, Purdue University.
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Osborne, Lawrence E., and Thomas Chase, South Dakota State University.
Sweets, Laura E., University of Missouri.
Tenuta, Albert, Ontario Ministry of Agriculture, Food, and Rural Affairs.
Welacky, Tom, Agriculture and Agri-Foods Canada, Ontario.

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