Soybean Cyst Nematode Management Guide

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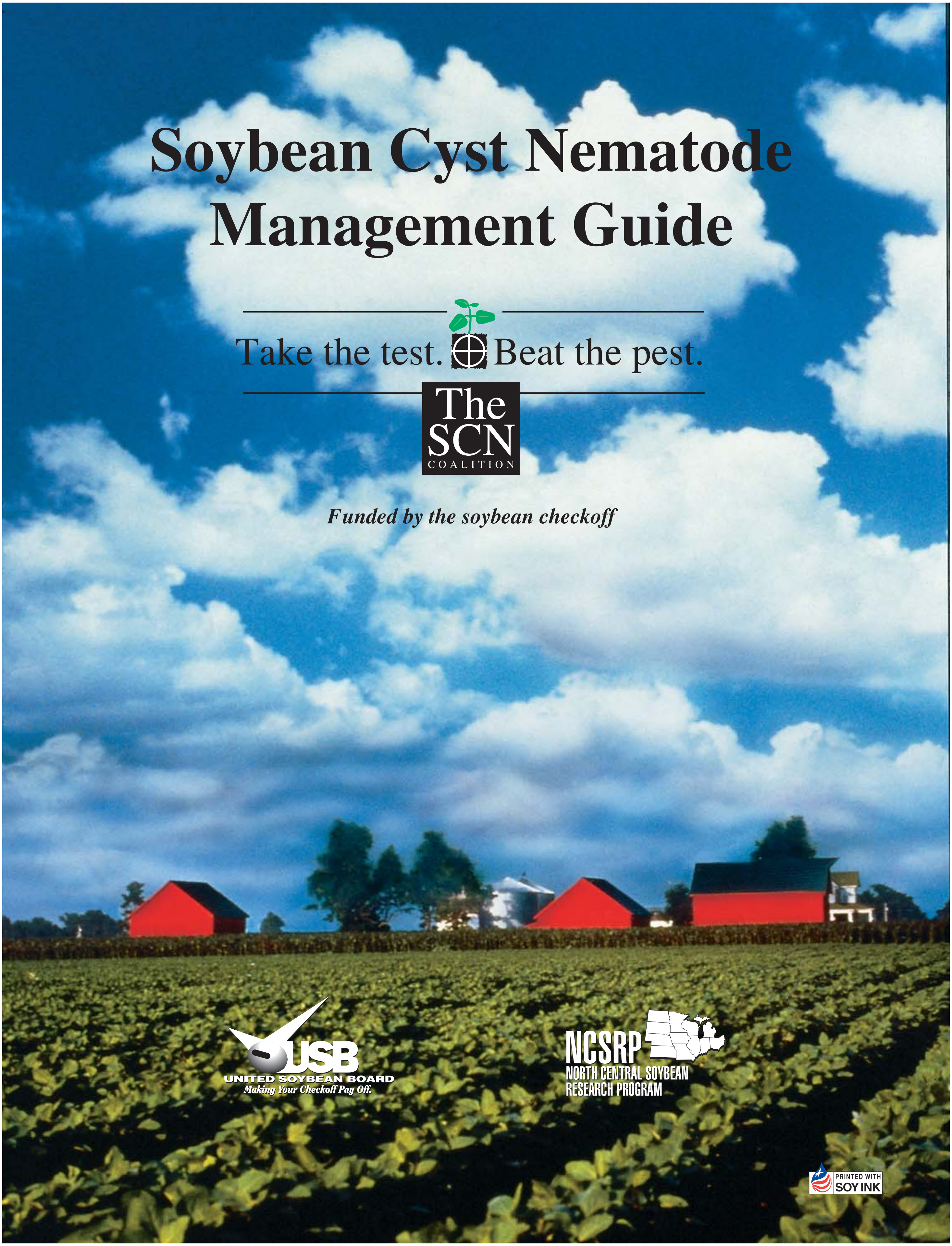

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About This Guide

The soybean cyst nematode (SCN) is the most serious soybean pest in the United States. Even though soybeans can be produced profitably in SCN-infested fields, the nematode robs soybean farmers of hundreds of millions of dollars worth of soybean yield each year. Why? Because SCN causes no specific symptoms and its effects are often not dramatic. Many farmers do not know that their fields are infested with SCN until a severe problem develops. Meanwhile, up to 30% yield losses can occur without obvious symptoms.

This publication was developed with you, the soybean farmer, in mind. Included in these pages are the answers to frequently asked questions, recommendations, and information 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 burden is on you to determine whether you have SCN infestations, and to tailor a management strategy for your farm. We hope the following sections will be useful to you:

Even if you think you don't have SCN, you should read this guide.

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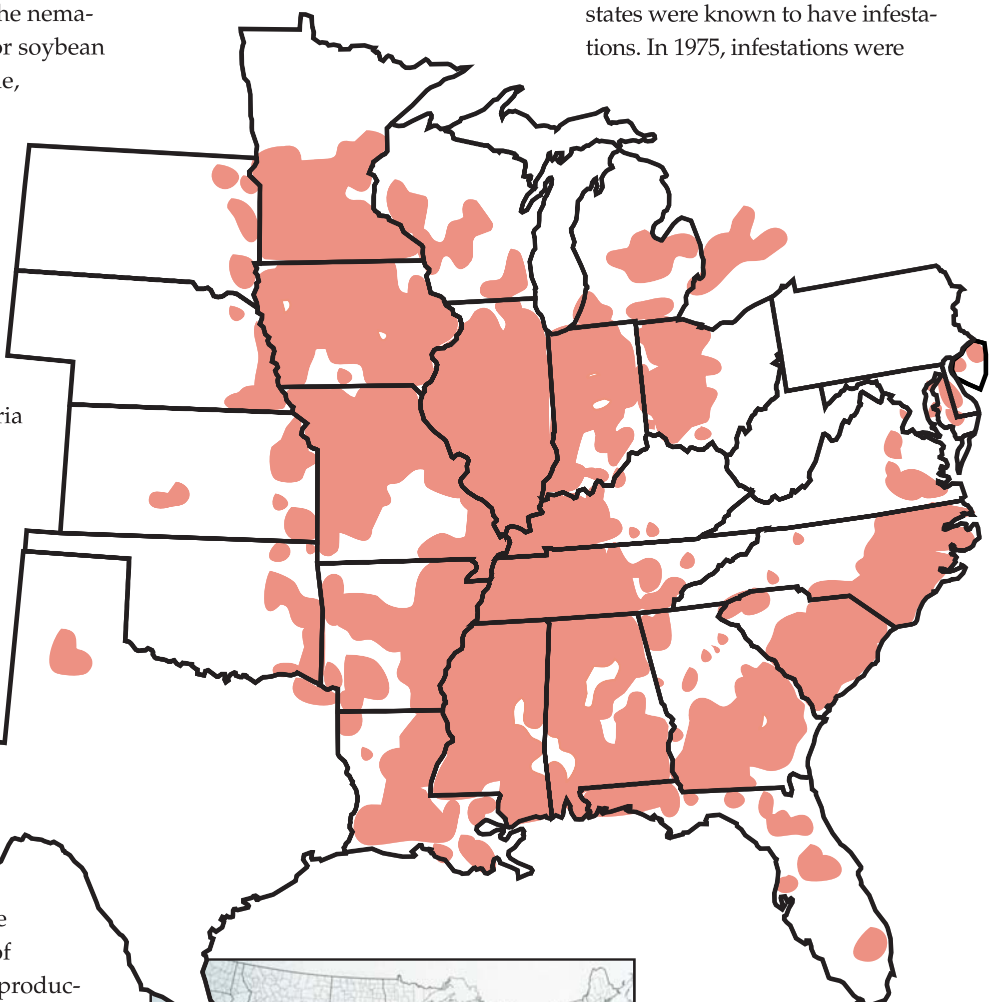
How important is SCN?

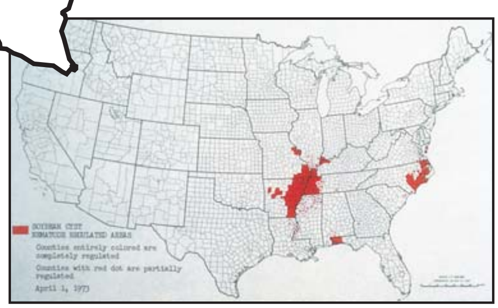
Soybean cyst nematode (SCN), also known as *Heterodera glycines*, was first found in the United States in North Carolina in 1954. Before then, SCN was known only from China, Japan, and Korea. The nematode now occurs in all major soybean production areas worldwide, including both North and South America.

The nematode may have been introduced into the U.S. several times during the late 1800's in soil imported from the Orient for the purpose of obtaining bacteria to nodulate soybean roots. During the ensuing years, bacterium-infested soil was used as inoculant, which was spread locally by growers and was sent to various state experiment stations for research purposes.

The early use of soybean in the U.S. was primarily as a forage or green manure crop. In 1919, 99,000 acres of soybeans were planted for production of seed. During the WWII era, soybean acreage for production of seed increased from 4.2 million acres in 1939 to about 9 million acres in 1942. Coinciding with the continuing increase in soybean acreage in the 1940's and 1950's was a decrease in oat acreage in northern states and a decrease in cotton acreage in the southern states.

At present, soybean is planted on nearly 70 million acres. In many production areas, rotations that had prevented the buildup of SCN populations were abandoned. In 1965, 8 states were known to have infestations. In 1975, infestations were





Above, distribution of SCN in the United States and Canada in 1998. At left, SCN distribution in 1973.

This crop shows severe SCN damage.

reported in 14 states. By 1987, 26 states and Ontario, Canada had infestations. Today, SCN occurs in 28 states, including Hawaii, where it has been found in winter soybean nurseries.

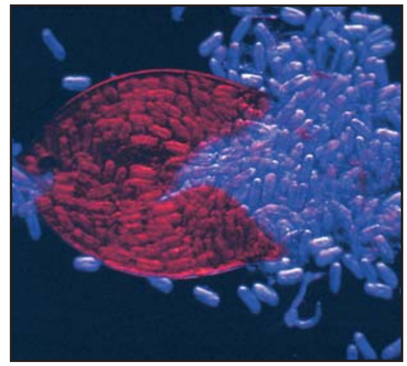
Documenting the economic impact of SCN is difficult because many producers suffer declining yield for several years without knowing that they have SCN. Planting SCN-resistant Forrest soybean in the southern U.S. on farms with known SCN infestations prevented $401 million in crop loss during 1975-1980. The cost of developing Forrest was less than $1 million. Today's SCN-resistant varieties prevent even more crop loss. If nationwide losses were conservatively estimated at 1%, SCN cost soybean producers over $136 million in 1997. However, as **Table 1** shows, losses in infested states normally exceed 1%. The value of the estimated loss of soybean yield in 1998 was $1.67 billion.

Table 1. Estimated percent losses in soybean production due to SCN in 1998.

State	Yearly Range	1998	State	Yearly Range	1998
Alabama	2.0-4.0	2.5	Mississippi	0.2-0.5	0.2
Arkansas	1.0-4.0	1.3	Missouri	3.0-7.0	4.0
Delaware	2.0-4.0	4.0	Nebraska	--	0.3
Florida	0.0-3.0	1.0	North Carolina	5.0-7.0	5.5
Georgia	0.5-3.0	3.0	North Dakota	--	0.0
Illinois	3.0-6.0	5.0	Ohio	0.1-1.0	1.0
Indiana	1.5-4.5	4.0	Oklahoma	0.5-1.5	1.5
Iowa	--	>10.0	Pennsylvania	--	0.0
Kansas	0.1-1.0	1.0	South Carolina	3.0-5.0	3.0
Kentucky	2.3-4.5	3.5	South Dakota	--	3.0
Louisiana	1.0-4.0	1.0	Tennessee	2.5-4.0	3.5
Maryland	3.0-7.0	3.0	Texas	0.0-.02	0.0
Michigan	--	12.0	Virginia	2.0-4.0	3.0
Minnesota	0.3-3.3	2.0	Wisconsin	0.5-1.0	0.5

What is Soybean Cyst Nematode?

The **infective juvenile** of SCN is invisible to the naked eye. Its length is about 1/64 inch.



This SCN **cyst** has been broken open to reveal the eggs inside. Eggs can remain viable for years even in the absence of a suitable host.

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 that hatches from the egg is the **infective** stage of SCN.

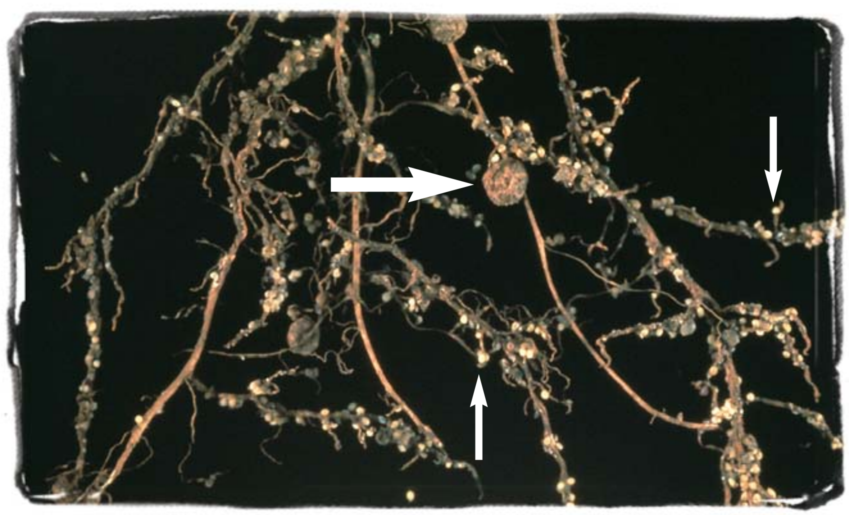
The juveniles penetrate soybean roots and cause the formation of specialized feeding cells in the root's vascular system (veins). If the juvenile becomes a male, it leaves the root and moves through the soil and probably does not contribute further to plant damage. If the juvenile becomes a female, it loses the ability to move and swells to a lemon-shape as it matures. The young adult female is referred to as a **white female**. Plant damage is primarily due to the feeding of females.

White females become yellow as they age and then brown after 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 many fewer eggs. The cyst protects the eggs from the soil environment.

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

- planting date
- soil temperature
- length of growing season
- host suitability
- geographic location

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



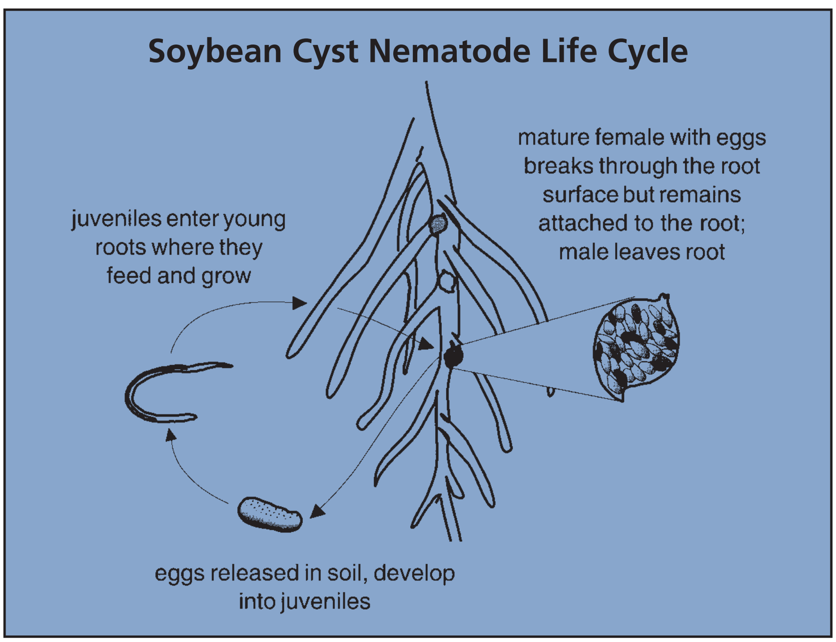
White females (small arrows) of SCN on soybean roots are visible to the naked eye, but are still very small - about the size of this circle ○. Nitrogen-fixing nodules are much larger (large arrow).

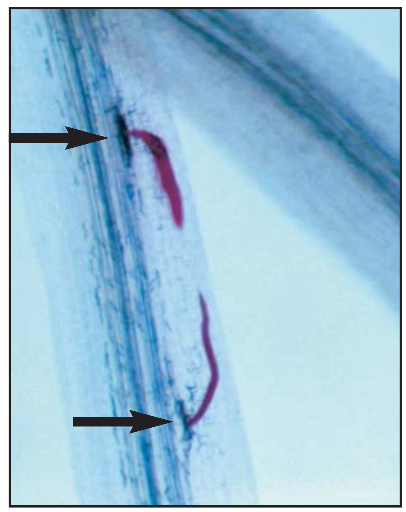
How Does SCN Cause Disease?

The effect of SCN on soybean growth and yield involves several mechanisms that 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. Plants infected with high numbers of SCN have poorly developed root systems that cannot efficiently utilize nutrients and water available in the soil. The results are stunted plants and, often, chlorotic (yellow) foliage. 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 infection may also reduce the number of nodules formed by the beneficial nitrogen-fixing bacteria that are necessary for optimum soybean growth. In addition, penetration of roots by the maturing female may create openings in the root surface that serve as entry points for other soil-borne soybean **pathogens**. This may allow infection by root-rotting fungi such as *Rhizoctonia* (cause of seedling blight), *Fusarium* (sudden death syndrome, Fusarium wilt), and *Macrophomina* (charcoal rot).

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 juveniles (stained pink) inside a soybean root. The specialized feeding cells are visible as gray masses (arrows).

Does SCN Interact with Other Diseases?

Several diseases may affect soybean at the same time. These plants are infected with SCN, and also show symptoms of potassium deficiency (yellowed leaf edges), seedling blight (reddish coloration), and charcoal rot (gray lesions on stem), which are not clearly visible in this photograph but would be evident to someone in the field.

Soybean plants growing in SCN-infested fields in southern states are often infected with other parasitic nematodes (for example, root-knot, lesion, sting, or lance) or fungi that cause diseases such as stem canker, red crown rot, charcoal rot, root rot, and wilt. In the northern soybean-producing states, other nematodes (such as lesion), or fungal diseases such as sudden death syndrome, Phytophthora root rot, charcoal rot, wilt, brown stem rot, and white mold may be present in SCN-infested fields.

In addition, SCN infections may suppress nodule formation and nitrogen fixation by the beneficial *Bradyrhizobium* bacteria.

Most studies involving SCN and one or more pathogenic organisms have shown that **yield loss is additive** - that is, the yield loss from two or more pathogens is equal to the sum of the yield loss due to each pathogen alone. For example, yield loss on a susceptible variety grown in soil infested with both SCN and root-knot nematodes was additive. Yield loss in a SCN-resistant, root-knot-susceptible variety was due to root-knot alone and vice versa. Similar results have been obtained with Phytophthora root rot. Other studies on the effects of SCN infections on insect damage by the corn earworm, soybean looper, or three-cornered leafhopper, and various weed infestation levels have shown also that yield loss is additive among these pests. There are reports that SCN-resistant varieties are more tolerant of sudden death syndrome (SDS); in addition, SDS severity is greater on SCN-susceptible varieties grown in SCN-infested fields. **Synergistic** (greater than additive) yield losses have been reported for SCN in combinations with Fusarium wilt and red crown rot.

SCN does not "break" resistance to other pathogens. Nematologists, pathologists, and breeders have combined efforts to develop soybean varieties with resistance to several pathogens. 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 cannot be included here but is available from local Cooperative Extension Service offices.

Soybean production fields are commonly inhabited by several pathogens (disease-causing agents). Plant infection by two or more pathogens may have any of the following effects:

- one pathogen may enhance infection by other pathogens,
- one pathogen may suppress infection by other pathogens,
- multiple infections may produce greater stress and yield loss in the plant compared with infections by either pathogen alone, or
- total yield loss may be the sum of loss due to each pathogen separately.

What are the Symptoms of SCN Infection?

The most commonly observed symptom associated with SCN is reduced yield. Visible symptoms of plant damage often are not seen, particularly in high yield environments.

SCN can cause yield reductions of 15 to 30% on susceptible varieties that show no visible symptoms of nematode damage.

Symptoms of SCN infection are not obvious. In this field, the resistant variety (right) yielded 39 bushels per acre, while the susceptible variety (left) yielded only 24 bushels

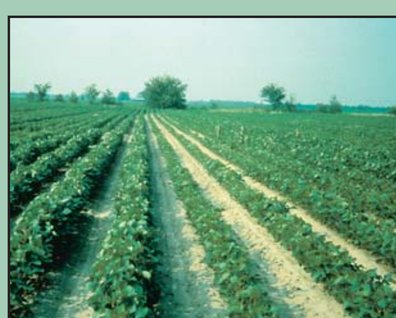
In a low-potassium field, SCN infection intensifies the potassium deficiency symptom. Adding potassium will not reduce the damage due to SCN.

Symptoms of SCN infection can be misdiagnosed as herbicide injury (unaffected rows are SCN-resistant).

Infested fields - even those with high numbers of SCN - are not always evident.

Iron deficiency chlorosis can be mistaken for SCN infection and vice versa.

Poor stands caused by high levels of SCN look similar to those caused by seedling diseases.



SCN can cause stunting without associated yellowing (unaffected rows are SCN-resistant).

Severe SCN infection can cause plant death when other stresses are present.

What Does SCN Damage Look Like?

Soybean producers frequently ask, "What does SCN damage look like in the field?" As you can see from the photos on the previous page, the answer is not simple and requires a professional diagnosis for these reasons:

1 Symptoms of SCN infections can range from no visible evidence of plant injury to plant death in certain areas of the field,

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

3 The young female SCN is white or yellow, and is the only visible sign of SCN infection. Young females may not be present at the time of sampling. Older females, which are brown cysts, are not visible on roots or 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. Research has shown, however, that yield losses of 15 to 30% on a susceptible variety are common in these fields. Soybean farmers in these situations often notice poor or static yields over several years, uneven plant height in the field, or a delay in canopy closure. This lack of apparent symptoms is more commonly associated with soybean grown in the Midwest where soils tend to be more fertile and growing conditions less stressful on soybean.

White females of SCN are most readily seen in the field when the soybean plant begins to flower. In order to see them, you must carefully dig up the feeder roots with a shovel and remove the soil gently or the females will be 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 a professional diagnostic laboratory (see page 11).

Soybean damage due to SCN is frequently misdiagnosed. Reduce your risk of loss by submitting soil samples for professional diagnosis.

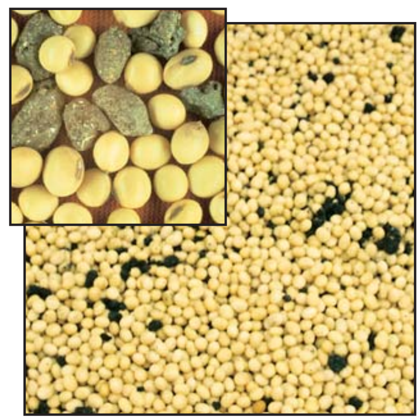
The white females of SCN may be detected around the time of flowering, if the roots are dug up carefully (not pulled!).

Why are SCN populations variable?

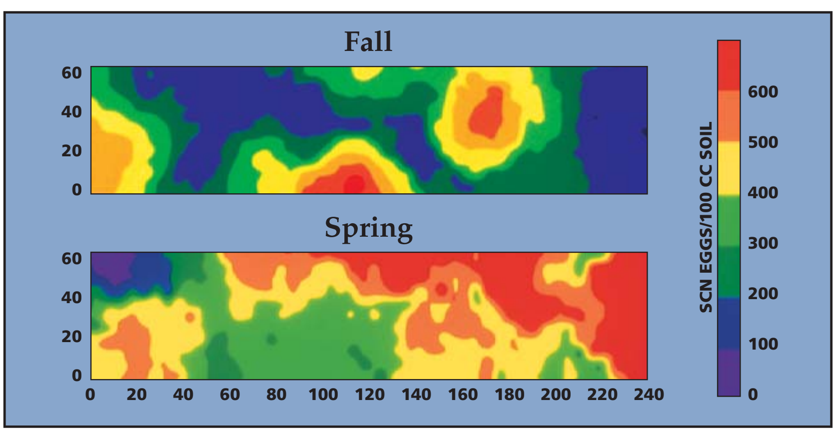
In this aerial photograph of a heavily infested field in Minnesota, areas where SCN has severely damaged plants - hot spots - can easily be seen. Note that the patches are elongated in the direction of tillage.

Variability in SCN numbers within a field at a single point in time depends on any of the same factors that affect seasonal changes (see box). The numbers are extremely variable. If two samples are taken from different places in a single field, one may have very high numbers of SCN while the other may have none. This is why **hot spots** (see aerial photo) develop in heavily infested fields. The presence of a hot spot does not mean that SCN is absent from the apparently "healthy" area.

Anything that moves soil will move SCN with it: wind, water, migratory birds, tillage and harvest equipment, and soil peds in seed stocks. Once introduced into a field, SCN may take about 10 years to build up to a damaging level, depending on how often susceptible soybean varieties are grown.



When you buy seed that has not been cleaned in modern equipment, the soil peds in the bag may contain viable cysts.



SCN distribution within a field depends on many factors (see box). It is not uniform across the field. Sampling a field in only one spot can result in misleading test results (see page 11). Area shown is 1/2 acre.

Seasonal changes in numbers of SCN in a field are dependent on

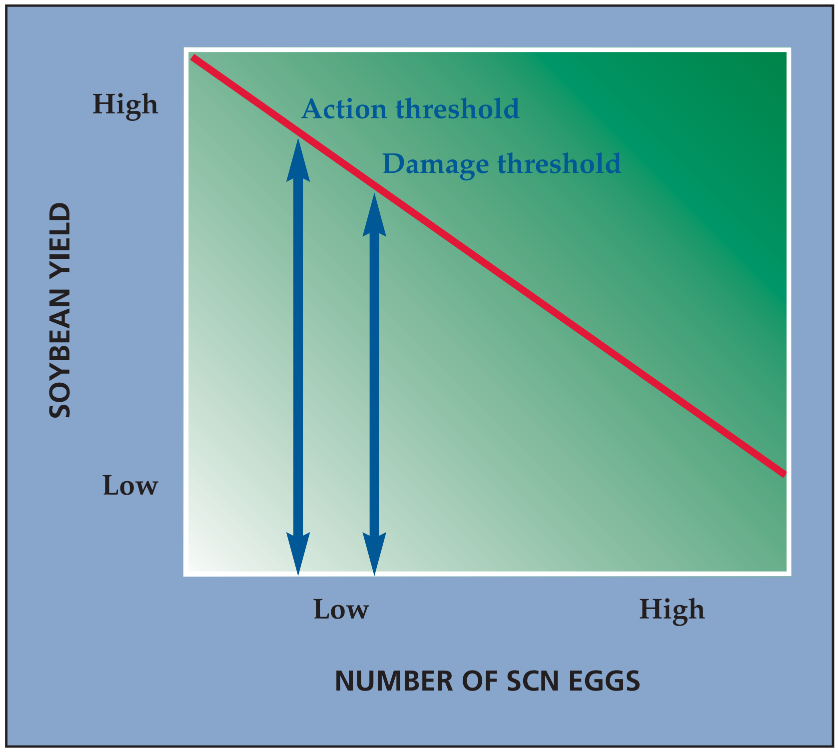
- temperature
- moisture
- row spacing
- host suitability*
- overwinter survival*
- crop
- soil type
- tillage

*see page 10

What do the numbers of SCN mean?

The only definite way to confirm the presence of SCN, determine the level of infestation in a field, or determine the race, is to submit a soil sample to a qualified laboratory for analysis. The results you obtain can be used for soybean variety selection or to select a crop rotation sequence that will reduce or keep SCN numbers below the **damage threshold**.

Damage thresholds for SCN depend on regional and local conditions, so local sources should be consulted for this information. It is important to distinguish between a damage threshold and an action threshold, the infestation level at which some action should be taken to prevent future losses. The **action threshold** for SCN is the same as the detection threshold: if there is any infestation at all, a long-term SCN management strategy should be adopted.



Host suitability refers to the relative susceptibility of the plant. SCN-susceptible soybean is a highly suitable host plant on which SCN can develop and increase to high levels. The result is decreased seed yield. In contrast, alfalfa is not a suitable host, and SCN develops and reproduces poorly. The crop suffers no yield loss. The host suitability of SCN-resistant soybean depends on the numbers of SCN present in the field, and may depend on the race of SCN (see page 14).

Overwinter survival refers to the ability of SCN to remain dormant when temperatures are low and host plants are not available. The number of infective juveniles in the soil at planting depends on the number of eggs produced in the previous season and on the eggs' overwinter survival rate. This rate is higher in northern states than it is in the South, because the lower winter soil temperatures in the north inhibit hatching. Overwinter survival rates can be as low as 10% in the Deep South and as high as 100% in the Midwest.

How do I sample for SCN?

Once a field is known to be 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 again or once every 3 years if resistant varieties are grown in a rotation.

While 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 provide you with information, and enough time for variety selection or choosing alternative crops for the next year.

Soil samples collected for soil fertility analysis can be split into

- 1 for fertility
- 1 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!

Procedure for collecting samples:

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

Large fields may be subdivided into sections and a single composite sample from each of the different sections submitted for analysis. If the 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 or fields where soybeans were drilled. 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. **The quality and condition of the sample determines the reliability of the results.**

Hot spots in an SCN-infested field.

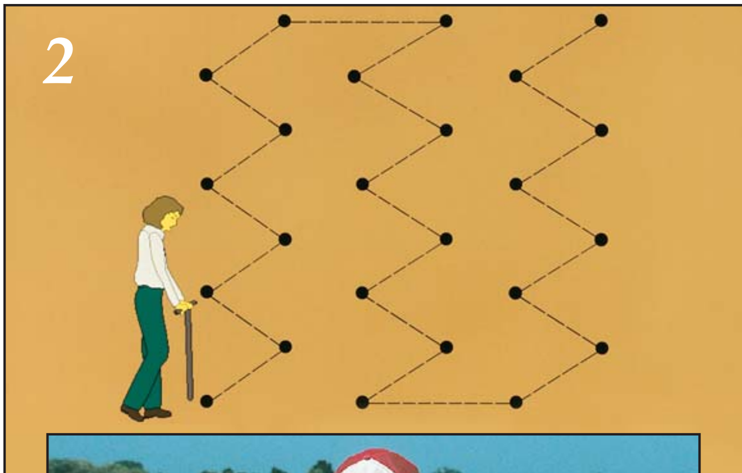
How to Deal With Hot Spots

Soil samples should be collected from the area between the damaged plants and the "healthy" plants. Do not collect the sample from the center of the affected area because these plants usually have severely stunted root systems that cannot support SCN. Thus, the sample may show that SCN numbers are low when in fact there are high numbers present in the areas where plants are apparently "healthy.”

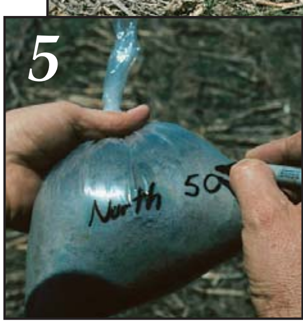
Nematode diagnostic laboratories usually have special forms to be submitted with soil samples. Even if such a form is not available when you sample, you should provide the following information:

- your name, address, and phone number
- the county in which the field is located
- the date when the field was sampled
- the number of acres represented by the sample
- crop history (2 to 4 years)
- the name or number of the field
- pesticide applications for current and previous years.

1. Use a cylindrical soil probe to collect soil samples. Collect to a depth of 6 to 8 inches.



2. 10 to 20 soil cores should be collected from a 10-acre area of a field for a realistic estimate of the numbers of SCN. Larger fields should be subdivided and each area sampled separately.



3. If the crop row is identifiable, take each soil core near the row.
4. Bulk the cores in a container and mix thoroughly.
5. Soil samples for SCN analysis should be placed in a plastic bag labeled with an indelible marker, and stored away from sunlight before submission to a laboratory.
6. Cushion soil samples with packing material before shipping them to a laboratory.

What are races of SCN?

Just as in humans and other animals, SCN is genetically diverse. SCN can feed and reproduce (with varying degrees of success) on soybean varieties with different genes for resistance. Soon after the first SCN-resistant soybean varieties were introduced in the early 1960's, field populations of SCN were found that would develop on and damage these resistant varieties. Thus, nematologists and soybean breeders use a race system to differentiate and name these SCN populations. A **race** was defined as a field population of SCN that developed (produced females) on a selected set of four soybean lines in a specific pattern (see **Table 2**). It is impossible to determine the SCN race based on a single nematode because counts of females that develop on all four soybean lines are required. Laboratories that perform race determinations for farmers or researchers often require 20,000 or more nematodes in order to conduct the race test.

Originally, four races were described. Race 3 was defined as a population of SCN that produced very few females on any of the four test lines. Race 3 is still the most common SCN race found in the United States. In comparison, Race 4 was defined as a population of SCN that produced many females on each of the four test lines. Race 4 is comparatively rare. Other races were defined by their ability to produce many females on some but not all of the four lines.

As the use of SCN-resistant varieties increased, SCN adapted. Consequently, field populations were found that did not fit the four original races. Therefore, the original system for describing SCN races was expanded to include all 16 possible combinations of the same selected set of four soybean lines as was originally used.

Table 2. Race scheme for soybean cyst nematode populations (shaded races are those most common in the U.S.).

	Percentage of females on soybean lines*			
Race	Pickett	Peking	PI 88788	PI 90763
1	-	-	+	-
2	+	+	+	-
3	-	-	-	-
4	+	+	+	+
5	+	-	+	-
6	+	-	-	-
7	-	-	+	+
8	-	-	-	+
9	+	+	-	-
10	+	-	-	+
11	-	+	+	-
12	-	+	-	+
13	-	+	-	-
14	+	+	-	+
15	+	-	+	+
16	-	+	+	+

*A "-" means that the number of females on this soybean line was less than 10% of the number that developed on the standard susceptible cultivar, Lee. A "+" means that the number of females was 10% or more than the number that developed on Lee.

What does it all mean to you?

Repeated use of the same resistant variety will result in development of an SCN race that is adapted to that variety. But many resistant varieties have the same resistant parent, or source of resistance, and so rotation of resistant varieties alone is not sufficient to avoid this problem. Nonhosts 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.

SCN races differ in their ability to develop on and damage the same soybean varieties. Here, two SCN races show different effects on the same variety. This situation can develop when the same resistant variety is planted frequently in the same field.

Do you need a race determination test?

Perhaps, if your SCN numbers are large and resistant varieties do not perform as expected, a race determination test will help you 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. Laboratories that offer SCN diagnostic services may or may not be able to provide race tests; it's best to check first.

SCN race determination is based on the ability of a population to develop well (+) or poorly (-) on four SCN-resistant soybean lines compared with a susceptible variety. Based on this system, the predominant races found in U.S. soybean fields are races 1, 2, 3, 4, 5, 6, 9, and 14. Resistant varieties are available (check your local sources of information) that will perform well in the presence of one or more of these races.

How do I minimize the impact of SCN on my

Resistant varieties are the most cost-effective tools for reducing losses due to SCN. Here, resistant and susceptible varieties are grown side-by-side.

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. Therefore, you must choose appropriate management practices so that you can continue profitable soybean production.

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

- improved soybean health and yield
- reduced SCN numbers
- preservation of yield potential of resistant varieties

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

RESISTANT VARIETIES

Unlike susceptible varieties, resistant varieties reduce the ability of SCN to develop and complete its life cycle. Reproduction is not eliminated, but continues at a reduced rate. The use of resistant varieties allows you to grow soybeans with adequate yield while managing SCN numbers so that soybean 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. Because of joint efforts of soybean breeders and nematologists, high-yielding SCN-resistant varieties are now available.

As explained earlier (see page 14), more than one race of SCN exists. Fortunately, several different sources of resistance also exist and these sources have been incorporated into various soybean varieties. Most resistant varieties contain only one source of resistance. This allows you to rotate sources of SCN resistance to help prevent the development of more damaging SCN populations. Check with your Cooperative Extension Service for more information on sources of resistance in varieties adapted to your area.

Screening soybean varieties for SCN resistance is a priority in U.S. soybean breeding programs.

y soybean crop?

Table 3. Some crop and weed hosts for soybean cyst nematode.

Crop Plants	*Weed Plants*
Alsike clover	American and Carolina vetch
Bird's-foot trefoil	Hemp sesbania
Edible beans	Common and mouse-ear chickweed
Common and hairy vetch	Common mullen
Cowpea	Henbit
Crimson clover	Hop clovers
Crownvetch	Milk and wood vetch
Lespedezas	Pokeweed
White and yellow lupine	Purslane
Pea	Spotted geranium
Sweet clover	Winged pigweed

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 non-host crops and resistant soybean varieties. Once you successfully reduce SCN numbers, you should consider including susceptible soybean varieties in your rotation. Your rotation should not include other hosts for SCN. **Table 3** shows crops and weeds that are hosts of SCN, and **Table 4** shows a list of non-host crops.

Non-host Crops

Non-host crops cannot be used as a food source by SCN and reproduction of SCN is impossible. In a field planted to a non-host, SCN numbers will not increase and should decrease. The amount of decrease varies in relation to geographical area. SCN numbers may decrease by as much as 90% in the southern U.S. but only 10 to 40% in the Midwest (some of the difference is due to poor overwinter survival in the South).

Resistant Soybean Varieties

Once your field is infested with SCN, resistant varieties must be used in a rotation if you want to grow soybean profitably over the long term, but they must be used appropriately. Even on these resistant varieties, some nematodes will grow and reproduce. Therefore, continued use of the same resistant varieties will result in a nematode population in that field that can damage plants and reduce yield. Each time in your rotation that you grow an SCN-resistant variety, you should select a different variety. It is sometimes recommended that you select a variety with a different resistance source, if that information is available.

Susceptible Soybean Varieties

One of the goals of crop rotation is the reduction of SCN numbers. If you are successful in reducing SCN to below the damage threshold, you may want to plant SCN-susceptible variety. Susceptible varieties are used in the rotation to slow the SCN population changes that may occur with continual use of resistant varieties. Some susceptible varieties are less sensitive to SCN feeding; these tolerant varieties should be considered for inclusion in your rotation.

Table 4. Some non-host (and poor host*) crop plants.

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

Rotation Design

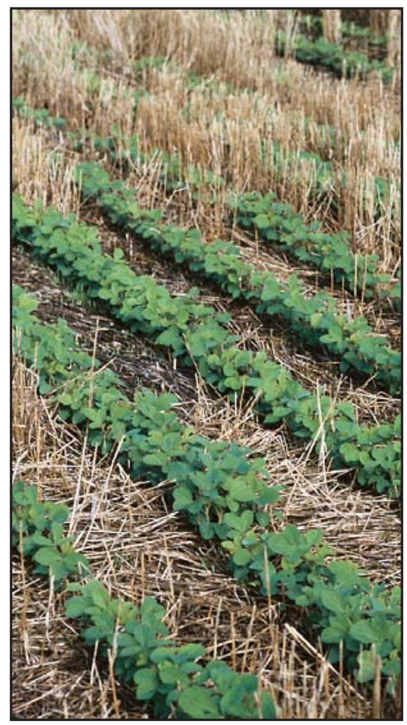
Rotation design depends on conditions specific to your farm and individual fields. Your success at reducing SCN numbers is clearly related to geographical region. Farmers in the northern corn belt will observe slow reduction in SCN regardless of rotation design. In these areas, more frequent use of non-host crops is appropriate. For example, a rotation may consist of two years corn, one year oats, and one year resistant soybean variety. Several rotation sequences may be required before an appreciable drop in SCN is observed. Farmers in the southern U.S. should observe a more rapid reduction in SCN numbers. A southern rotation may consist of alternating years of non-host and resistant soybean varieties. In any rotation, 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 exceeding the damage threshold is just as likely.

Rotation designs have been thoroughly tested in many locations in the U.S. Be sure to check with your local Cooperative Extension Service for specific recommendations useful to you.

You must be flexible in rotation design. The slower your decrease in SCN numbers, the more often you need to grow non-host crops. To determine effectiveness of your rotation, you must sample for SCN (see page 11). If SCN numbers increase on resistant varieties, your source of resistance is no longer effective and you should choose a variety with a different source of resistance (see page 14) or plant a non-host.

Whether the use of susceptible varieties is appropriate can be determined only with an SCN count. These varieties are not recommended unless you have reduced SCN below the damage threshold.

Crop rotation with nonhost crops is highly effective in reducing numbers of SCN, which will reduce the damage it can do. The plot on the left was rotated and produced much higher yields and lower SCN numbers than the plot on the right.



Soybean grown under no-till frequently develop lower SCN numbers and yield better than conventionally grown soybean. The combination of increased surface residue and reduced soil movement is critical to this effect. The effect exists only as long as no-till is maintained in the field, and disappears if tillage is renewed.

Nematicides may be an option for SCN control under certain conditions. Check local sources for current chemical labeling information. This photo illustrates the effect of nematicide treatment on soybean growth.

Factors that make chemical control an uncommon choice are:

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

OTHER CULTURAL PRACTICES

Maintaining adequate soil fertility, breaking hardpans, irrigation (if available), and weed, disease, and insect pest control 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.

Because SCN moves with soil, sanitation may help reduce the spread of SCN. No-till reduces water and wind-caused erosion and should slow SCN movement. Soil adhering to tillage and harvest equipment should be removed when they are moved from an infested to non-infested field. Always purchase seed from a trusted source because some seed sources contain soil peds that may be infested with SCN (see page 9).

NEMATICIDES

Nematicides are seldom recommended for SCN control. Check with local authorities for further information on SCN control with nematicides.

BIOLOGICAL CONTROL

Biological control of SCN is not currently an option. Although some soil-dwelling fungi, bacteria, and predaceous nematodes are natural enemies of SCN that suppress multiplication of SCN, none have been developed into commercial products.

SCN egg-destroying fungi are currently under study as possible SCN control tools of the future. These SCN eggs are stained pink. The healthy egg (left) has a juvenile SCN inside; the infected egg contains only a fungus (right).

Summary.

Find Out If You Have Soybean Cyst Nematode. You Might Have SCN And Not Know It.

- SCN may not cause obvious symptoms.
- SCN symptoms may look like those due to other causes.
- SCN is not always visible on roots of infected plants.
- SCN can cause substantial yield loss without causing symptoms.

Take a good soil sample (page 11) and submit it to a qualified lab for diagnosis. Check with your Cooperative Extension Service office for the lab nearest you.

SCN Can Survive For Years Even If You Don't Grow Soybeans. But You Can Increase Your Soybean Profits Despite SCN-infested Fields.

Combine management practices recommended for your location. Recommendations for Minnesota will differ from those for Mississippi!

ROTATE, ROTATE, ROTATE

1. Rotate with non-host crops to reduce SCN numbers.
2. Rotate with resistant soybean varieties to reduce yield loss due to SCN.
3. Rotate with tolerant or susceptible soybean varieties when SCN numbers are low to slow down the adaptation of SCN to resistant varieties.

RELIEVE STRESS

Good management of weeds, water, and 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 in response to your management practices.