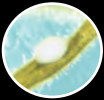
IOWA STATE UNIVERSITY
Extension and Outreach

Soybean Cyst Nematode

FIELD GUIDE

2nd Edition



A reference for identifying, scouting for and managing soybean cyst nematode

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This publication is the result of a cooperative effort between the Iowa Soybean Association and the College of Agriculture and Life Sciences and Extension and Outreach at Iowa State University.

Note: Information in this guide may be specific to Iowa. Those from outside Iowa should check with their state extension service for local information.

Biology

Soybean cyst nematode (SCN) is the most destructive pest of soybeans in the world. Understanding nematode biology is key to recognizing early infestation and managing its negative economic impact.

Life Cycle

The SCN life cycle has three major stages: egg, juvenile and adult. Juvenile worms hatch from eggs and penetrate soybean roots. After entering the soybean root, juveniles move through the root until they reach the vascular tissue, where they begin to feed. The juveniles inject secretions that modify root cells and convert them into feeding sites. As the juvenile nematodes feed, they swell. Female nematodes eventually become so large that they break through the root tissue and are exposed on the surface of the root. Male nematodes change back to worms as adults, migrate out of the root into the soil and mate with the lemon-shaped adult females.

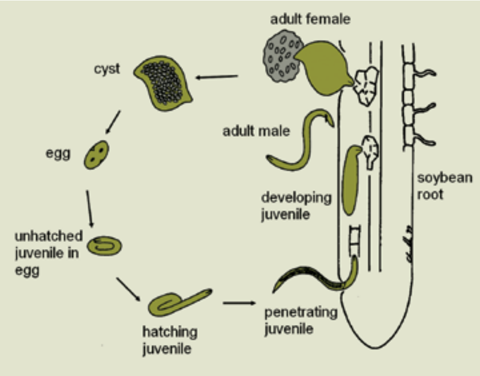


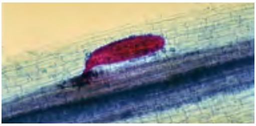
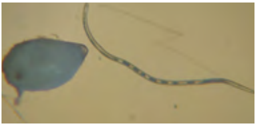
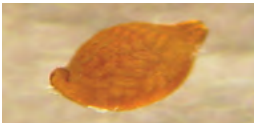
Diagram of the SCN life cycle.
Note: All stages are not drawn to same scale.

After male nematodes mate with and fertilize adult females, SCN females produce 50 to 100 eggs outside of the body, and then the female body fills internally with 200 or more eggs each. When the adult SCN female dies, the body wall toughens into a protective cyst around the eggs. Not all eggs produced by a female will hatch at the same time, and eggs within a cyst can survive for 10 or more years.

During a single growing season, there are several SCN generations. In the summer, when soils are warm, the SCN life cycle can be completed in 24 to 30 days.

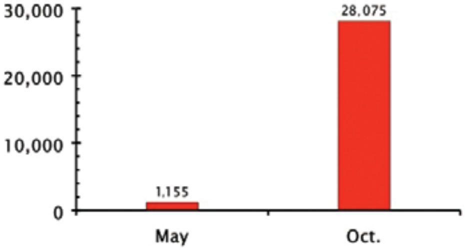
SCN damages plants and reduces soybean yield by:

- Taking food from the soybean plant
- Stunting or dwarfing roots
- Disrupting root vascular tissue function
- Reducing effectiveness and number of nitrogen-fixing nodules
- Causing wound for other pathogens to enter roots

Stages in the SCN Life Cycle	
SCN eggs (each 1/200-inch long)	
SCN juvenile entering the soybean root (juvenile 1/50-inch long)	
SCN juvenile (stained purple) developing inside soybean root	
SCN female (left) and worm-shaped male (female 1/32-inch long, male 1/16-inch long)	
Adult SCN female with egg mass on soybean root	
Egg-filled SCN cyst	

Population dynamics

SCN egg population densities can increase rapidly when susceptible soybeans are grown because of the relatively short generation time and the high reproductive capacity of SCN. In Iowa, it is almost certain that three SCN generations occur per growing season and the possibility exists for five or more generations to develop in very warm years.

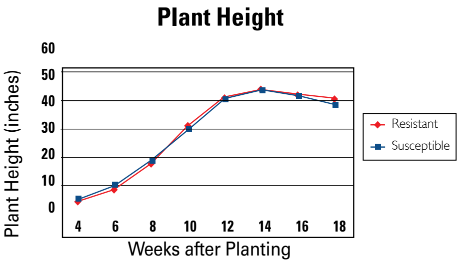


Increase in SCN eggs per 100 cm³ soil on a susceptible soybean variety in one growing season in central Iowa.

The only unique sign of SCN infection is the presence of adult females and cysts on the soybean roots.

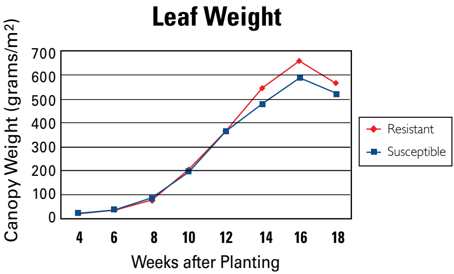
No obvious above-ground symptoms

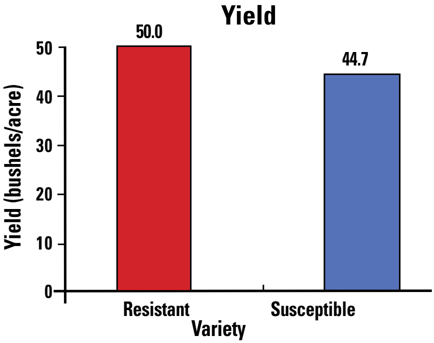
In many instances, SCN infection does not cause any above-ground symptoms, even when causing significant yield loss. The data in the following graphs are from an Iowa field experiment in which a resistant and a susceptible soybean variety were grown in an SCN-infested field. Plants were removed and measured every two weeks throughout the growing season.



The heights of the two varieties were the same during the growing season (above) and leaf weights were nearly identical until the last month of the season (top graph next page).

Despite no difference in heights and no difference in leaf weights until the last month of the growing season, the resistant soybean variety yielded more than five bushels per acre or 10 percent more than the susceptible soybean variety (bottom graph).





Below ground

Roots infected with SCN are generally dwarfed or stunted and can have a decreased number of nitrogen-fixing nodules. SCN infections also may make the roots more susceptible to attack by other soil-borne plant pathogens. Roots infected with SCN and other soil borne pathogens are generally discolored.

SCN-infected roots (right) are stunted, discolored and have fewer nitrogen-fixing nodules than uninfected roots (left).

Above ground

SCN can cause several above-ground symptoms, such as stunting, yellowing and early maturation of the crop. However, above-ground symptoms of SCN are not unique. They often are mistaken for symptoms of damage from soil compaction, iron deficiency chlorosis and other nutrient deficiencies, drought stress, herbicide injury or other plant diseases. SCN injury often remains undetected for several years because the nondescript symptoms are attributed to other causes.

Uneven plant height caused by SCN

Mid-season yellowing caused by SCN

Severe stunting and yellowing of leaf margins caused by SCN

Severe stunting and overall foliar yellowing caused by SCN

Early senescence of soybeans due to SCN infection

Effects of Drought

The severity of symptoms and yield loss caused by SCN is affected greatly by availability of moisture during the growing season. Above-ground symptoms of SCN damage can be quite severe in dry years, but mild or nonexistent in years with adequate or excess rainfall. SCN stunts the soybean roots, which is much more harmful to the soybean plant in drought years than in years of adequate or excess soil moisture as stunted roots explore less soil for water and minerals than normal-sized roots.

There are indications that SCN reproduction may be greater in dry soil conditions than in wet soils. Hatched SCN juveniles enter soybean roots and set up permanent feeding sites, called syncytia, inside root tissue. The SCN juveniles possibly establish feeding sites deeper into the root vascular tissue under dry soil conditions than wet conditions. And the nematode feeding sites may be considerably more disruptive to root function if they are located in the vascular tissue rather than in the outer cortex region of the roots. Also, SCN juveniles feeding in the vascular tissue may have better nutrition than those feeding in the root cortex, possibly leading to greater SCN reproduction.

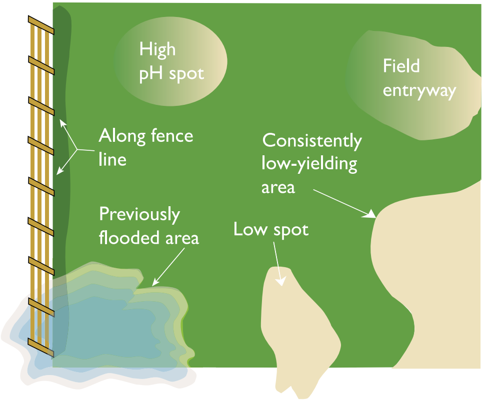
Yield loss from SCN is considerably worse in drought years. SCN reproduction may be much greater under these severe conditions as well.

Scouting

Scouting for SCN by checking soybean roots or collecting soil samples is the first step in managing SCN.

There are areas where SCN is more likely to be first discovered in a field. These are:

- Near a field entrance
- Areas that have been flooded in the last decade (had soil introduced)
- Alkaline areas (soil pH greater than 7)
- Areas where weed control isn't good
- Areas where yields seem low when soybeans are grown
- Along fence lines where wind-blown soil accumulates
- Areas of high waterfowl activity



Checking these "high risk" areas may be an efficient way to focus initial scouting efforts.

Looking for SCN Females

The first SCN females usually will appear on roots four to six weeks after planting. Females may take longer to appear on roots if spring weather is cool and/or wet.

The adult SCN females will appear as small, round objects on the younger roots. SCN females are creamy white, but turn yellow to tan to brown over the course of several days.

Digging roots to look for SCN females is very simple. Just dig – don't pull. Pulling plants from the soil will strip the SCN females from the young roots.

Once a clump of plants with roots and soil has been removed through digging, carefully shake or crumble off much of the adhering soil and look closely on fine roots for adult SCN females. As the season progresses, dig deeper and farther from the soybean row to get to young, healthy roots.

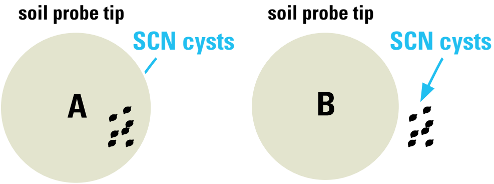
Adult SCN females on root

Adult SCN females are about the size of a period at the end of a sentence, and are much smaller and lighter colored than nitrogen-fixing nodules. Nitrogen-fixing nodules are the same color as the roots and will grow to be much larger than SCN females.

Exactly when and how to collect a soil sample for SCN analysis depends on your specific purpose. Soil samples can be collected to determine if SCN is present in a field or to determine if SCN is causing stunting and/or yellowing of a soybean crop. You can also use soil sample results to determine if your SCN management plan has kept the SCN population in check.

SCN cysts are very small and are usually clustered in the soil, making 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, as illustrated below.



In the diagram above, soil probe A 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 ½ inch different from 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.

Soil must be collected from many different places within the sampling area. Limit the area represented in a single soil sample, ideally, to no more than 20 acres.

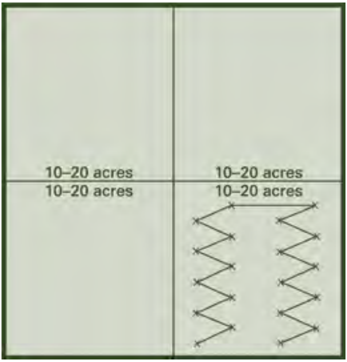
- Use a soil probe or soil tube to collect cores.
- Avoid collecting soil cores when the soil is frozen or very wet.
- Mix multiple soil cores very well before placing mixed soil into a bag.
- Keep soil samples at room temperature or cooler until shipped.
- Send samples to a private soil testing laboratory for analysis or send to:

  Plant and Insect Diagnostic Clinic
  327 Bessey Hall, Iowa State University
  Ames, IA 50011

Laboratories may report SCN sample results as the number of cysts, eggs or juveniles (refer to pages 26-27) per 100, 250 or 500 cm^3 of soil. When comparing SCN soil sample results from different laboratories, be sure the same volumes of soil and the same SCN life stages are compared. A result of 500 cysts per 100 cm^3 is a much greater SCN population density than 1,000 eggs per 250 cm^3 soil (each cyst may contain as many as 200 more eggs; 250 cm^3 is 2½ times more soil than 100 cm^3).

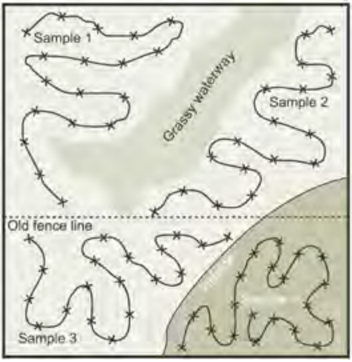
Determining if SCN is present in a field:

- Collect soil samples anytime (except when the soil is frozen or very wet).
- The more soil collected and the smaller the area sampled, the more accurate the results.
- Soil cores should be collected from the upper eight inches of soil.
- If corn or another nonhost crop was last grown in the field, it doesn't matter if soil cores are collected from underneath the previous crop rows or not.
- It is better to collect soil cores after a previous corn crop's rows have been destroyed by tillage.
- If soybeans were last grown in the field, collect soil cores from under the old crop rows if possible.



- If sampling conventionally (not grid sampling), collect 15 to 20 soil cores in a zig-zag pattern from no larger than a 20-acre parcel of land.
- If grid sampling, collect one or two soil cores from every grid cell sample and combine cores from the number of cells that represent approximately 20 acres.

The parcels of land represented by the soil cores need not be square or rectangular areas. Divide fields for sampling according to obvious agronomic features.



Determining if SCN is responsible for stunting and/or yellowing:

- Angle the soil probe underneath the row of soybeans into the root zone.
- Soil cores should be collected from the upper eight inches of soil underneath the row.
- Collect 15 to 20 soil cores from underneath stunted and/or yellow plants.

Collecting a soil core from under a soybean row

Multiple soil cores representing an area must be mixed thoroughly.

Assessing SCN population densities to monitor management:

- Collect soil samples in the spring before soybeans are planted, or in the fall after the previous crop has been harvested.
- Take note of specific sampling details to refer back to when samples are again collected (areas sampled, numbers of cores, sampling time, before or after a soybean crop, etc.).
- The more soil collected and the smaller the area sampled, the more accurate results you can expect.
- Soil cores should be collected from the upper eight inches of soil.
- If corn or some other nonhost crop was last grown in the field, it doesn't matter if soil cores are collected in the previous crop's row.

Sampling a harvested soybean field for SCN

Soil cores should be eight inches deep.

- It is better to collect soil cores after the previous corn or other nonhost crop's rows have been destroyed by tillage.
- If soybeans were last grown in the field, collect soil cores from under the old crop rows.
- If sampling conventionally (not grid sampling), collect 15 to 20 soil cores in a zig-zag pattern from no larger than 20 acres.
- If grid sampling, collect one or two soil cores from every grid cell sample and combine cores from the number of cells that represent approximately 20 acres.

Multiple soil cores representing an area must be mixed thoroughly before filling a bag to send to a processing laboratory.

Cysts vs. eggs

It is important to know what life stage of SCN is reported when a soil sample is analyzed. The Iowa State University Plant and Insect Diagnostic Clinic and most other soil test labs in Iowa count and report the number of SCN eggs. But some labs report numbers of SCN cysts or juveniles in the soil (page 27).

Cyst and egg counts generally correlate well, and cyst counts can be loosely converted to egg counts by multiplying the cyst count by 125, which is the average number of eggs per cyst in naturally infested field soil. Juveniles typically are short lived, and their numbers are not as informative as numbers of cysts or eggs.

Low vs. medium vs. high egg counts

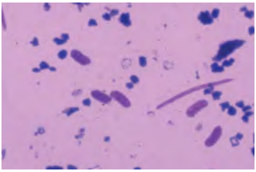
Egg counts can vary greatly depending on the extraction procedure used by the laboratory. There are no industry standards for procedures to extract SCN from soil samples. Comparing numbers from samples processed by different laboratories is not recommended.

Also, the numbers of eggs considered to be low, medium or high depend on whether soybeans will be grown as the next crop.

Life Stages of SCN Counted from Soil Samples

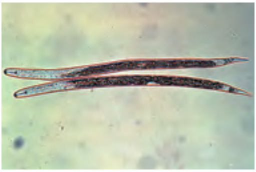
Stained SCN eggs

SCN egg counts are an important indicator of the level of infestation. Almost all SCN field research is based on SCN egg counts.



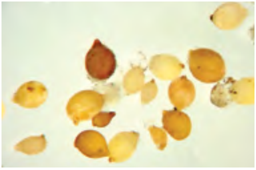
SCN juveniles

SCN juvenile counts fluctuate greatly and are not as informative as cyst or egg counts.



SCN cysts

Cysts are dead females full of eggs. Cyst counts correlate well with egg counts.



For soil samples processed by the Iowa State University Plant and Insect Diagnostic Clinic:

If soybeans are the next crop to be grown

Low	=	1 – 2,000 eggs per 100 cm^3 soil
Medium	=	2,001 – 12,000 eggs per 100 cm^3 soil
High	=	> 12,000 eggs per 100 cm^3 soil

If soybeans are NOT the next crop to be grown

Low	=	1 – 4,000 eggs per 100 cm^3 soil
Medium	=	4,001 – 16,000 eggs per 100 cm^3 soil
High	=	> 16,000 eggs per 100 cm^3 soil

Warning: Fields may be infested with SCN even if soil sample results are zero.

Up to 25 percent of soil samples with egg counts of zero are infested with SCN. The reasons for the false and misleading zero egg counts are:

- Laboratory extraction procedures used to process samples do not recover 100 percent of the cysts and eggs present in the soil.
- SCN cysts are very aggregated or clustered throughout a field, and soil cores may not have been collected from the spots in the field where cysts were present.

If soil sample results are zero, follow-up soil sampling is recommended to check for SCN infestations in future years.

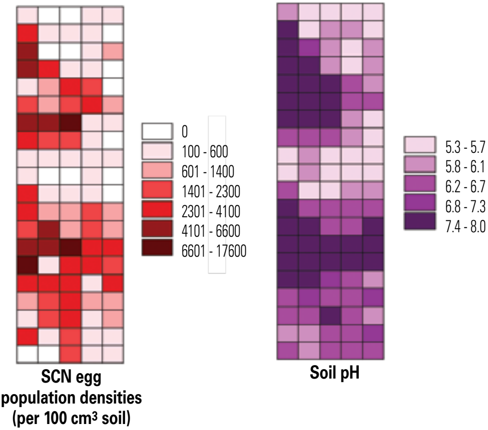
SCN and Soil Factors

It is possible that many soil factors may affect SCN reproduction and soybean yield loss, but only two soil factors are commonly associated with SCN damage and population densities – soil texture and soil pH.

SCN is capable of infesting soils of all textures, but symptoms and yield loss generally are greater in sandy soils than medium- and fine-textured soils. SCN-infected roots are stunted and lack fine roots and, thus, can explore much less soil for water and nutrients than healthy roots. Also, coarse-textured soils do not hold water and some nutrients as well as medium- or fine-textured soils, and SCN seems to cause greater damage to plants stressed by other factors, such as lack of water and/or minerals. It is possible that SCN reproduces better in dry soils, such as during a drought (page14).

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

In the mid 1990s, it was discovered that there is a consistent relationship between SCN population densities and soil pH. Greater SCN population densities are consistently found in areas of fields with higher pH. The relationship occurs over a wide range of soil pH – from pH 5.5 to 8.0. It is not clear if SCN population densities would decline if soil pH was lowered.



SCN egg population densities (per 100 cm³ soil, left) and soil pH (right) in 100 half-acre cells in a soybean field in Dallas County, Iowa. Note the consistent occurrence of higher SCN population densities in cells with higher soil pH.

MANAGEMENT

Soybeans can be produced profitably in SCN-infested fields with a tailored management program.

SCN cannot be eliminated from an infested field if soybeans are ever grown again. Once SCN is discovered, a management program should be implemented immediately to minimize SCN reproduction and maximize crop yields. The goal of an SCN management plan is to maintain profitable soybean yields while keeping SCN population densities at low to medium levels.

It is much easier to keep low SCN population densities low than it is to drive high populations down.

SCN management can involve:

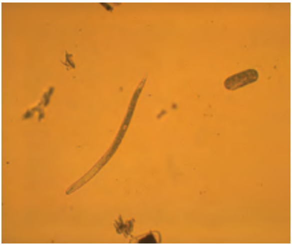
- Growing nonhost crops
- Controlling winter annual weeds
- Applying nematicides to the soil
- Using nematode-protectant seed treatments
- Growing SCN-resistant soybean varieties

Nonhost Crops

There are many crops on which SCN is unable to feed. These are called nonhost crops. Without a host crop, SCN cannot complete its life cycle and population densities will decline. Thus, growing nonhost crops is one way to manage SCN population densities.

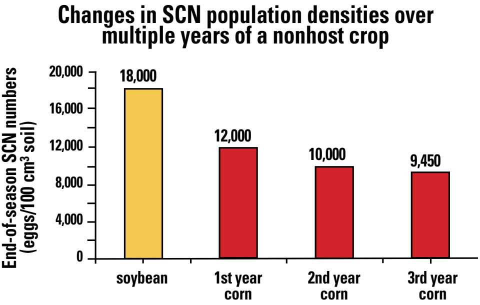
Corn, oats, rye, wheat, sorghum and alfalfa are nonhost for SCN. Nematode numbers decline similarly when infested soils in Iowa are planted with corn, oats or alfalfa.

The greatest decrease in SCN population densities will occur during the first year a nonhost crop is grown following soybeans. SCN densities will decline only slightly more if a second nonhost crop is grown.



SCN juvenile (left) hatched from an egg (right). The juvenile will starve if it does not feed upon a living host root.

The graph below illustrates how SCN population densities decline in three successive corn crops (red bars) following a soybean crop (gold bar) in Iowa.

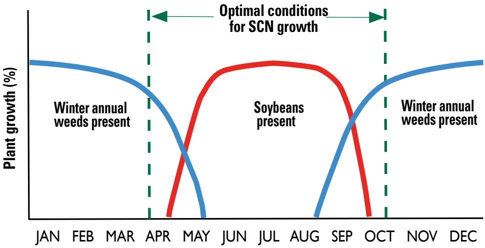


Winter annual weeds

Common weeds that occur in Iowa corn and soybean fields during the growing season are not hosts for SCN. However, the winter annual weeds henbit, field pennycress and purple deadnettle are moderate to good hosts for SCN. 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 about 24 days to complete at ideal temperatures (76ºF) and can take five or more weeks at colder temperatures. There may be periods in the spring or fall when soil temperatures are warm enough for SCN reproduction to occur on winter annual weeds.

Timeline of winter annual weed and soybean growth and SCN activity



Reprinted with permission from Winter Annual Weeds and Soybean Cyst Nematode Management, 2007, Purdue University

Field pennycress (left) and henbit (right)

Soil-Applied Nematicides

There is at least one soil-applied nematicide labeled for use against SCN, but this management option is not commonly used.

Nematicides generally do not give season-long control. When applied to the soil at planting, the effect of the nematicide may last long enough to provide an economic yield benefit. However, by the end of the growing season, SCN numbers may be as high as, or higher than, they were at planting.

Use of nematicides increases the cost of production. Field-wide applications are often considered uneconomical, although an increase in yield of a few bushels per acre could offset the cost of the nematicide.

Unpredictable yield responses and inconsistent decreases in SCN population densities are the main reason why soil-applied nematicides are not more commonly used.

In the future, site-specific application of soil-applied nematicides to manage SCN may make this option more economical.

Seed Treatments

Protectant seed treatments are a new category of management products for SCN. Currently, products are available with active ingredients or modes of action that include a bacterium (Votivo® from Bayer CropScience), a bacterial fermentation compound (Avicta® from Syngenta Corporation) and a protein that stimulates natural plant defenses (N-Hibit® from Plant Health Care Inc.).

The products are on the seed when soybeans are planted, then move onto the developing root surface. Seed-applied products are described as providing early season protection of soybean roots, but protection from these products will diminish over time during the growing season and nematode reproduction will resume later in the season.

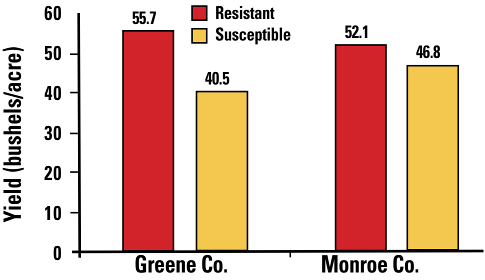
Using nematode-protectant seed treatments increases the cost of production, and their value depends on the severity of yield loss caused by SCN, the effectiveness of the product used and the value of the soybean crop. Consider these factors when deciding whether to use these nematode management products.

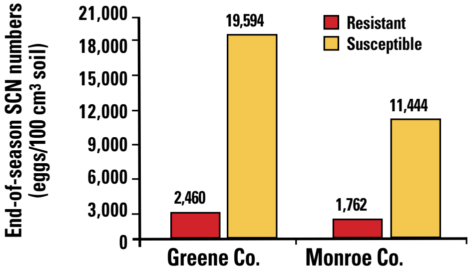
Treated soybean seed

SCN-Resistant Varieties

SCN-resistant soybean varieties pay dividends twice – first, by producing good soybean yields on SCN-infested fields and, second, by preventing increases in SCN population densities.

Below are averages from SCN-resistant (red bars) and SCN-susceptible (gold bars) soybean varieties at two locations in Iowa that illustrate the dual benefits of resistance.

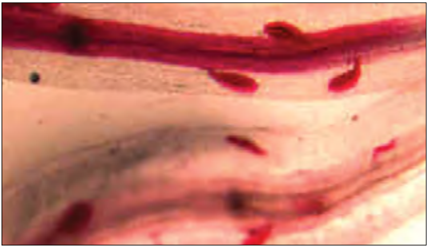




How does SCN resistance work? SCN juveniles penetrate the roots of SCN-resistant varieties, but are not able to feed in the roots. Subsequently, the SCN juveniles starve inside roots of resistant varieties.

Resistant

Susceptible



SCN juveniles after eight days in resistant (top panel) and susceptible soybean roots

Photos by Ben Matthews

Note in the photos on the previous page how much larger the developing SCN juveniles are in the susceptible roots (bottom panel) than in the resistant roots after eight days.

Different soybean breeding lines (called sources of resistance) have been used to develop SCN-resistant varieties. Some breeding lines are called "plant introductions" (abbreviated "PI") and are assigned identifying numbers.

Sources of SCN resistance available to Iowa growers include PI 88788, Peking and PI 437654, which is also referred to as Hartwig resistance or the branded CystX® resistance. Each source of resistance has several genes that provide SCN resistance to the plant. Not all of the resistance genes from a source need to be in a soybean variety for the variety to be resistant to SCN. Soybean varieties with the same source of resistance will not necessarily have the same level of resistance to SCN.

Resistance to SCN in soybean varieties is not 100 percent effective; a few SCN females will develop on roots of resistant varieties. Exactly how many SCN females develop on a resistant soybean variety depends on the resistance genes in the variety and also the genetic makeup of the SCN population in the field.

The HG type test ("HG" represents ***Heterodera glycines***, the scientific name for SCN) is designed to give practical information about how well an SCN population in a field can reproduce on the various sources of SCN resistance (refer to section labeled HG Type Test, page 55, for more information).

SCN-resistant soybean varieties pay dividends twice – good yields and control of SCN population densities.

But not all SCN-resistant soybean varieties provide the same level of nematode control, not even varieties with the same source of resistance.

Rotate resistance

Recent survey results show that SCN populations (HG types, formerly called races) with greater than 10 percent reproduction on the commonly used PI 88788 source of SCN resistance are widespread in Iowa and other states. Some SCN populations have been found with reproduction exceeding 50 percent on PI 88788.

To delay SCN populations developing the ability to reproduce on SCN-resistant soybean varieties, producers should grow varieties with different sources of resistance in different years. This is similar to using herbicides with different modes of action in different years to control weeds and avoid the development of herbicide-resistant weeds.

If it is not possible to obtain seed of an SCN-resistant variety with a source of SCN resistance different from what had previously been used, rotate among different SCN-resistant varieties with the common source of SCN resistance, PI 88788.

The Iowa Soybean Association provides soybean checkoff funds to Iowa State University to annually evaluate SCN-resistant soybean varieties throughout the state. The yields and SCN control provided by hundreds of SCN-resistant soybean varieties are shown in reports available online at www.isuscntrials.info.

Selecting an SCN-resistant variety

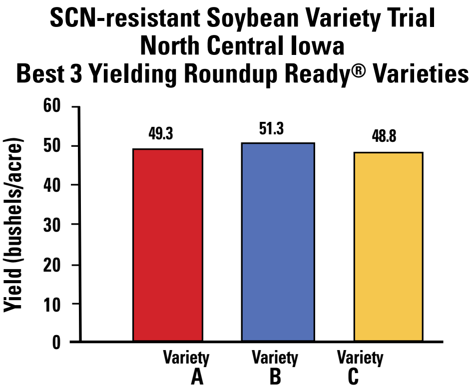
Choose a variety that yields well in various SCN-infested fields. Yield data from non-infested fields are not useful for predicting yields of soybean varieties in SCN-infested fields.

If possible, choose a soybean variety with a source of SCN resistance other than what has been grown previously. Remember to choose SCN-resistant varieties with other needed defensive traits, such as tolerance to iron deficiency chlorosis or resistance to sudden death syndrome or Phytophthora root rot.

Don’t let SCN numbers creep up

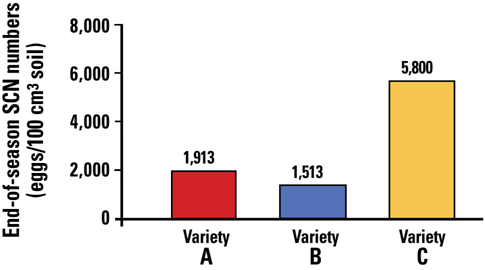
Even the highest-yielding SCN-resistant soybean varieties can vary significantly in the amount of nematode control they provide.

In the graph below, the yields of the top three SCN-resistant soybean varieties in a variety trial conducted in an SCN-infested field were not significantly different.



At harvest, there were significant differences in SCN egg population densities in the soil among the three resistant varieties (below).

SCN-resistant Soybean Variety Trial
North Central Iowa
Best 3 Yielding Roundup Ready® Varieties



Soybean varieties labeled as resistant to SCN vary greatly in yield and in control of SCN. Both are determined by the genetics of the soybean variety and also the genetics of the SCN population in the field. The results of an HG type test indicate how well a population will be controlled by the various sources of resistance used to develop soybean varieties. There is no comprehensive testing of all SCN-resistant soybean varieties to give an indication of those with the most effective resistance.

Buildup of SCN reproduction on PI 88788

There are hundreds of SCN-resistant soybean varieties for Iowa. Almost all contain resistance genes from the PI 88788 source of resistance. Repeated, widespread use of varieties with PI 88788 SCN resistance has selected for SCN populations with increased or elevated reproduction on PI 88788 resistance. More than half of Iowa's SCN populations now have greater than 10 percent reproduction on PI 88788, and some have 40 to 50 percent reproduction on PI 88788 (relative to 100 percent reproduction on a susceptible variety).

Despite increased SCN reproduction on the PI 88788 resistance, ISU research shows that varieties with PI 88788 SCN resistance often yield well (60 bushels per acre or more) and yield better than varieties with Peking SCN resistance in fields with SCN populations with elevated (>10 percent) reproduction on PI 88788 and low (<2 percent) reproduction on Peking. Major factors affecting yields in such situations are SCN egg population density and moisture availability throughout the growing season in addition to the overall genetic background of the varieties. Also, there have not been tremendous increases in SCN numbers on resistant varieties in fields with SCN populations that have elevated reproduction on PI 88788 resistance.

The yields and SCN control provided by hundreds of SCN-resistant soybean varieties, most with PI 88788 SCN resistance, at variety trials conducted throughout Iowa are available online at www.isuscntrials.info.

Adult SCN females on roots of an SCN-resistant soybean variety

Increased SCN reproduction (even up to 50 percent) on resistant varieties with PI 88788 resistance does not necessarily result in low yields or large increases in SCN population densities. Nonetheless, grow soybeans with Peking and other non-PI 88788 sources of SCN resistance, if possible, to maximize soybean yields in SCN-infested fields long term.

Integrated SCN Management

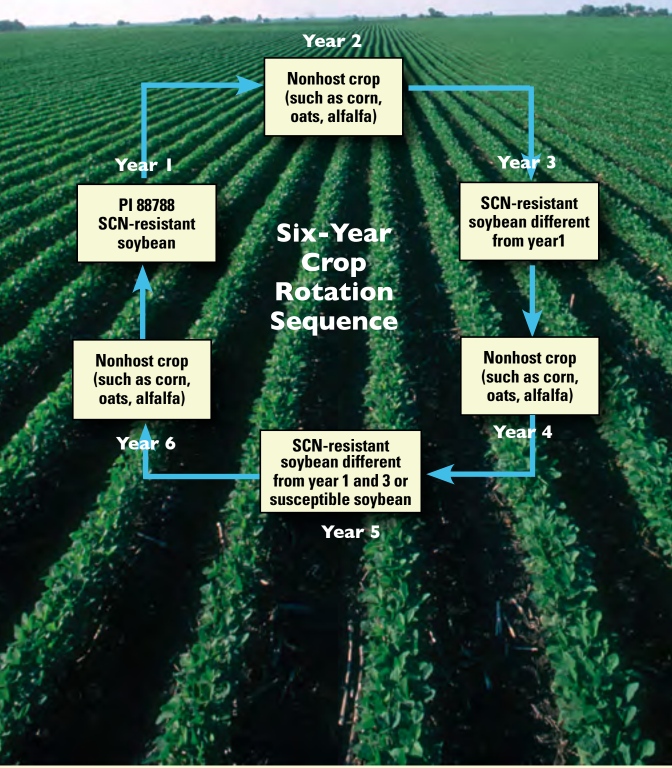
The most effective SCN management program integrates as many different management strategies as possible to maintain high soybean yields while preventing increases in SCN population densities. It is much easier to keep low SCN population densities low than to try to drive high numbers back down.

Such a management program usually includes scouting for early detection and growing nonhost crops in rotation with SCN-resistant soybean varieties.

On the next page is a six-year crop rotation sequence recommended by Iowa State University for fields with low or medium SCN population densities. The rotation begins with year one in the upper left of the diagram.

If SCN population densities are high, the rotation sequence on the next page is not recommended. Instead, grow several years of corn or some other nonhost crop and collect soil samples every fall to assess the decline in SCN egg population densities. When numbers have decreased to medium levels (page 28), the crop rotation sequence on the next page can be started.

Crop rotation plan for fields with low or medium SCN population densities.

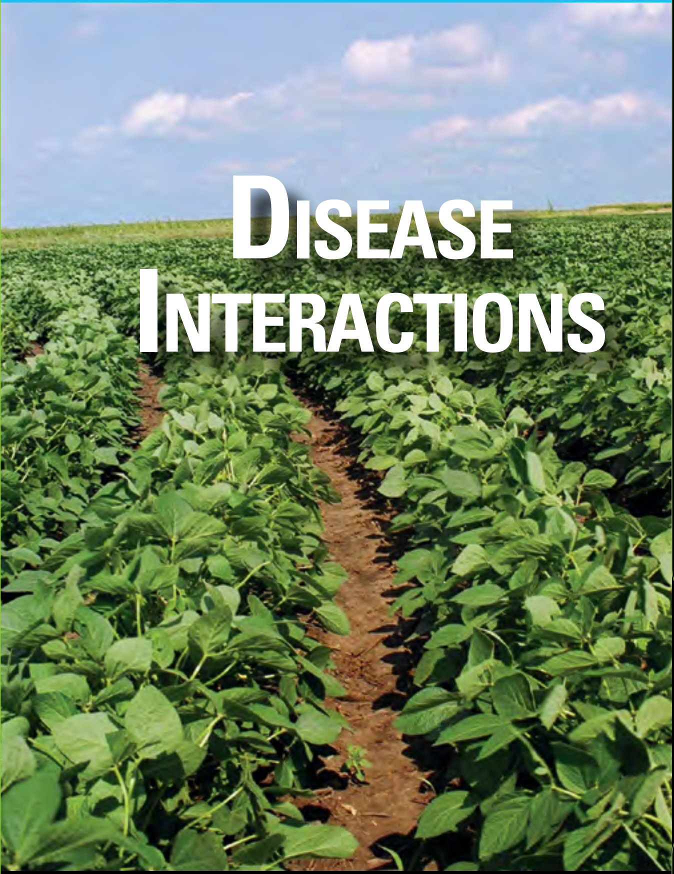


Growing soybean varieties with different sources of resistance will best discourage the buildup of SCN populations with increased reproduction on resistant soybean varieties. But if varieties with different sources of SCN resistance are not available, grow different SCN-resistant varieties derived from the common source of SCN resistance, PI 88788.

An integrated management program also includes control of winter annual weeds that can serve as hosts for SCN. Nematicides and seed treatments may also be used during years that soybeans are grown in SCN-infested fields.

Integrated SCN management should always include soil sampling to monitor SCN population densities and growing nonhost crops and SCN-resistant soybean varieties in a crop rotation sequence.

DISEASE INTERACTIONS



Infection of soybean plants by SCN can increase diseases caused by other pathogens living in the soil.

In addition to causing yield loss directly, SCN also interacts with other pathogens, making other diseases worse.

Sudden death syndrome leaf symptoms

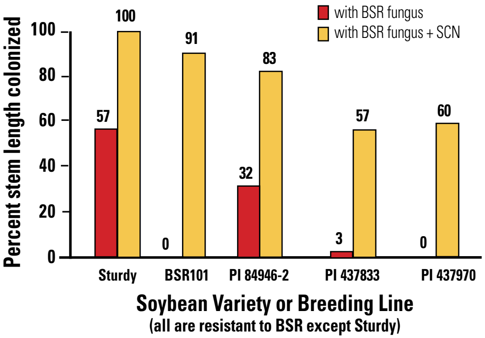
Sudden Death Syndrome

Sudden death syndrome (SDS) is a root-rotting soybean disease caused by the soil-inhabiting fungus *Fusarium virguliforme*. Soybeans infected with SCN develop symptoms of SDS earlier in the season than plants not infected with the nematode. Also, symptoms of SDS are more severe in plants that are infected with SCN. Time of symptom development and disease severity are the two major factors that determine how much soybean yield loss is caused by SDS.

Brown stem rot

Brown stem rot (BSR) of soybeans is a stem and root disease 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 plants not infected with the nematode. Even soybean varieties that have been bred to be resistant to BSR become infected and develop BSR when the plants are also infected with SCN.

Brown stem rot stem symptoms



Infection of five soybean varieties by the fungus that causes brown stem rot disease. Red 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.

It is not known exactly how SCN makes SDS and BSR more severe.

THE HG TYPE TEST

A greenhouse test, called the HG type test, can be conducted to determine how well an SCN population can reproduce on SCN resistance sources.

The HG type test is a simplified replacement for the SCN race system. To determine the HG type of an SCN population, a greenhouse test must be performed on the nematode population from soil collected from an infested field.

Results of the HG type test indicate how well an SCN population can reproduce on the different sources of SCN resistance, such as PI 88788, used in soybean varieties.

Who needs an HG type test?

Soybean growers who have experienced subpar yields from SCN-resistant soybean varieties in SCN-infested fields should consider having an HG type test performed. Also, if numerous SCN females are observed on roots of resistant soybeans during the growing season (page 46), an HG type test might be warranted, and it might be worthwhile to conduct an HG type test on SCN populations from SCN-infested fields in which resistant soybean varieties were grown numerous times in the past.

An HG type test might be needed if performance of SCN-resistant varieties decreases noticeably.

Collecting a sample from HG type testing

As a general rule, collect at least two gallons of soil from an SCN-infested field for an HG type test. The soil must be from all areas of the field in order for the test results to be meaningful. Soil should be collected to a depth of eight inches from 40 or more spots in a field.

Getting an HG type test performed

The Iowa State University Plant and Insect Diagnostic Clinic conducts HG type tests. Mail or deliver a two-gallon soil sample in a sealed plastic bag or bucket to:

Plant and Insect Diagnostic Clinic
327 Bessey Hall, Iowa State University
Ames, IA 50011

It will take at least six to eight weeks for results, depending on time of the year in which the test was requested. Call the Iowa State University Plant and Insect Diagnostic Clinic at 515-294-0581 for current fees.

It's not just about HG type

Results of HG type tests of SCN populations from throughout Iowa reveal that many populations can reproduce at levels greater than 10 percent on PI 88788, the source of resistance used in almost all commercial SCN-resistant varieties.

However, many SCN-resistant varieties with PI 88788 resistance can yield very well in fields infested with SCN populations that have greater than 10 percent reproduction on PI 88788. See pages 45-46 for more information about the buildup of SCN reproduction on resistant soybean varieties.

Conducting the HG type test

To determine the HG type of an SCN population, SCN eggs are extracted from a two-gallon soil sample collected from a field. The nematode population is then grown on soybean lines called HG type indicator lines under controlled greenhouse conditions. The HG type indicator lines are the soybean breeding lines that are the sources of SCN resistance in soybean varieties (page 60).

After 30 days (enough time for SCN females to develop), the numbers of SCN females on roots of several replicate plants of the various HG type indicator lines are counted, averaged and then compared to the number of females that form on a standard susceptible soybean variety.

Soybean plants of HG type indicator lines growing in a temperature-controlled water bath in the greenhouse

Adult SCN females recovered from roots in an HG type test

The HG type indicator lines on which there was 10 percent or more of the number of the females that developed on the susceptible variety are noted, and index numbers of the indicator lines with 10 percent or greater SCN reproduction comprise the HG type designation.

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)

An SCN population of HG type 1.3 indicates that the nematode population had 10 percent or more reproduction on Peking (indicator line #1) and PI 90763 (indicator line #3). So, if possible, SCN-resistant soybean varieties with resistance from Peking or PI 90763 should not be grown in a field infested with an HG type 1.3 SCN population.

The HG type is 0 if there is not 10 percent or more SCN reproduction on roots of any of the HG type indicator lines.

Acknowledgements

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Written and edited by: Gregory L. Tylka
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Iowa State University – Gregory D. Gebhart, Kristine Schaefer, Adam J. Sisson, Gregory L. Tylka
Purdue University – Earl Creech
USDA – Ben Matthews

Soybean Cyst Nematode FIELD GUIDE

A reference for identifying, scouting for and managing soybean cyst nematode

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