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# The Soybean Cyst Nematode



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**Extensive SCN damage in soybean field.**

## SIGNIFICANCE

The soybean cyst nematode (SCN), *Heterodera glycines*, is the cause of one of the most important diseases affecting soybeans in the United States. This problem was first recognized in 1954 in North Carolina. Infestations were found in southeast Missouri and western Tennessee two years later, and in southern Illinois in 1959. In 1978 a Faribault County field near Frost, was the first Minnesota site identified as having an SCN infestation. This nematode has been found in 26 states. A damage estimate from 1987 placed annual crop SCN loss in 16 southern states at more than $84 million.

Significant losses due to SCN have occurred in south central Minnesota. In 1989, a warm and dry year, about 20 percent of the soybean acreage on selected south central Minnesota farms was estimated to have suffered yield reductions of at least 10 bushels/acre due to the SCN. In warm, dry years losses as high as 20 bushels/acre can be expected where the nematode is abundant.

## CHARACTERISTICS

The SCN is a microscopic roundworm (about 1/50 of an inch or 0.5 millimeter [mm] long) that grows in and on the soybean root to a visible size. The nematode's life cycle begins as an egg that hatches to produce a second-stage larva which moves short distances in the water in soil pores to the roots of plants. Plant parasitic nematodes can detect chemicals released by roots. Soybean cyst nematodes are attracted to the root tip which it penetrates behind the root cap to establish a feeding site in the root's developing vascular tissue. Root penetration and rupture of the egg shell at hatching are accomplished with the aid of a protrusible hollow stylet or mouthspear (**figure 1**).

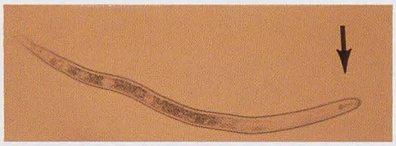

**Figure 1. SCN larvae with arrow pointing to stylet.**

The feeding site is composed of several multinucleate enlarged plant cells called syncytia. These probably develop in response to nematode secretions placed in cells through the hollow stylet. The nematode quickly becomes sedentary, enlarges to become sausage-shaped, and molts 3 times before becoming an adult. The female adult enlarges, breaks through the root cortex and epidermis to become visible on the root surface as a lemon-shaped white female (1/25 of an inch or 1 mm in diameter). Males undergo a metamorphosis during the last molt to become slender, microscopic, motile roundworms.

The female produces about 135 eggs. Some eggs are deposited outside her body in a gelatinous matrix called an egg mass (**figure 2**). These egg mass eggs quickly hatch and start the life cycle over. Three to four generations per year can be expected to occur in Minnesota. The first generation of white females is usually visible on soybean roots by mid-June. Additional white females may

**Figure 2. White female with egg mass and eggs.**

be found until September, but their numbers decrease sharply in late summer as roots suitable for nematode infection and growth become scarce. Most eggs are retained in the female's body. These eggs are protected by her body which, after death, becomes a brown-colored cyst, highly durable and protective (**figure 3**). Some eggs in the cyst can be expected to remain viable for five years or more.

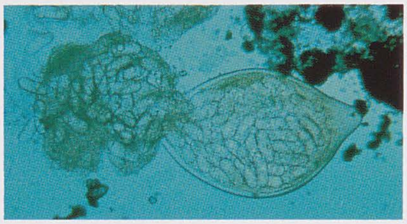

**Figure 3. Intact cyst and eggs.**

Larvae that hatch from eggs in the cyst emerge through natural openings in the cyst wall to search for roots to infect.

## SYMPTOMS

Soybean cyst nematodes alter soybean roots with chemicals and produce damage as the enlarging body of the female ruptures the root cortex and epidermis. The chemically and mechanically damaged root is very susceptible to other root rot pathogens. SCN infected roots are usually dark and necrotic (**figure 4**). These roots often do not have active nitrogen fixing nodules and are less effective than healthy roots in absorbing water and nutrients. Root system damage can cause stunted, chlorotic and unproductive plants (**figure 5**). Warm and dry growing seasons tend to increase the severity of above ground plant symptoms. Yet plants grown in fertile soils, with adequate moisture and limited heat stress, may appear nearly healthy. The detrimental effects of a warm environment are partially due to SCN being more active and completing the life cycle in as few as 20-22 days at a soil temperature of 80° F. Obviously, factors like compaction, high pH and resulting iron deficiency, root rot, and excessive soil moisture can also cause stunting, poor growth, and chlorosis.

**Figure 4. Soybean cyst females on necrotic root.**

The above ground symptoms caused by SCN are not unique, but the distinctive presence of a white female soybean cyst nematode on the root is diagnostic (**figure 2**). If white females are especially numerous and soil conditions allow the soil to readily separate from the root, then the white to yellowish, lemon-shaped nematodes on the root surface are visible. As the nematode ages it becomes more difficult to see because the body wall turns dark in color and the cysts are easily rubbed off roots pulled from soil. Thus, an accurate field diagnosis may be especially difficult late in the growing season or in lightly infested locations. In such situations, roots must be carefully removed from soil with a shovel or trowel, gently washed with

**Figure 5. Field symptoms, note color and stunting.**

water, and then inspected with a hand lens or dissecting microscope to detect the nematodes' presence. Soil samples collected at any time from suspect fields can be laboratory processed for cysts and eggs or larvae.

## DETECTION AND RACE DETERMINATION

The first Minnesota SCN infestation was detected in 1978 by extraction of large numbers of larvae from soil collected near the entrance of a problem field. An additional 13 infestations in Faribault County were found that fall using similar sampling and processing techniques. An aerial survey in 1979 and sample processing resulted in discovery of 8 infestations in 6 new counties plus additional infested townships in Faribault County (**figure 6**). Two sites were found in Blue Earth County in 1980. In 1981-1984 an additional 12 townships in counties known to have SCN were confirmed as infested. In 1985, a warm and somewhat dry year, SCN was reported in 4 more counties and in an additional 25 townships.

All but 3 townships in Faribault County and 13 of 20 Freeborn County townships were known to be infested in 1985. Additional counties, reported in 1987 and 1989, bring the number of infested counties to 18. Farmers and consultants should consider the distribution map as a guide to SCN location and not as the boundaries of its distribution. SCN distribution in Minnesota is not limited to the known and reported sites.

In 1989, during four months, August to November, more than 10 new sites were reported in Jackson County. Laboratory tests are a good method to determine if SCN is present in fields but a speedier method is to examine soybean roots for white females.

Although the first infestation of the nematode in Minnesota was identified as Race 5, all other populations identified as to race through 1987 were Race 3. An extensive survey of soil on one Faribault County farm in 1988 revealed that Race 3 was the most common and that three others were present: Races 5, 6, and 14. SCN races are currently determined by growing 4 differential cultivars and a susceptible variety like Lee or Hodgson in SCN infested soil. After 30 days of growth, the roots are removed and the number of white females that developed on each differential's root system is determined. If the average number of white females counted is equal to or greater than 10 percent of the average number that develop on the susceptible plant's root system it is scored a plus ( + ). If nematode development is less than 10 percent a minus ( − ) is recorded. (**table 1**).

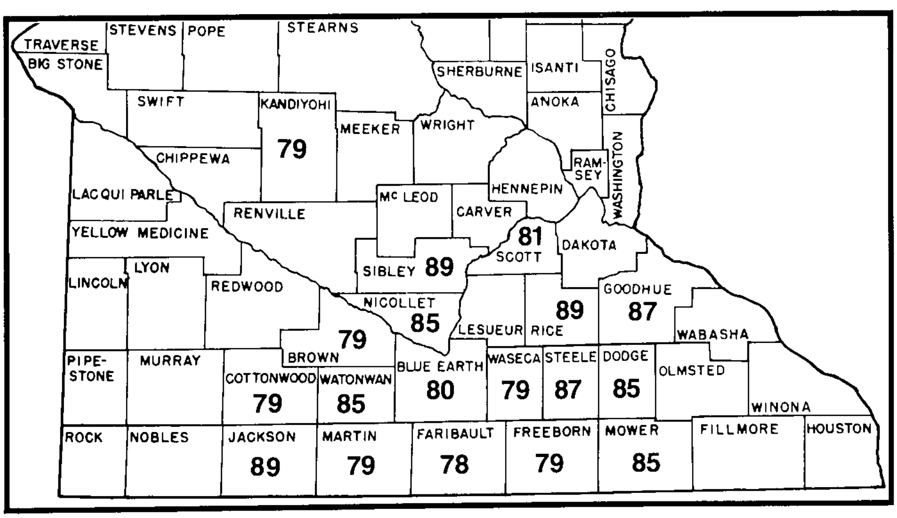


**Figure 6. Minnesota map showing counties reported to have SCN.**

## POPULATION DEVELOPMENT

Although many situations, such as the first Minnesota infestation, apparently occur as the result of cysts being deposited from equipment into soil near the entry point of the field, infestations also have developed at a considerable distance beyond the entry point. Cysts and eggs can certainly be blown by wind or carried by animals and birds to these central field locations. An additional method of spread is soil in with seed. These soil ''peds'' may contain cysts with eggs; the use of such contaminated seed should be avoided.

Although many persons accept the idea that SCN was introduced into North Carolina as a contaminant in a tulip bulb shipment from Japan and has spread from this original infestation, another explanation does exist. Research has shown that SCN from northern Indiana is different from SCN in southern Indiana and that both are very different from samples from the Far East. So it is possible that SCN is native to Minnesota, that it developed and survived for years at low population levels on native and later on certain introduced plant species. In 1989, the really serious SCN sites were often fields that had been old pastures, sloughs, or other

## Table 1. Classification of Races of *Heterodera glycines* by means of host differentials*

| | Reactions of differential cultivars[a] | | | |
|---|---|---|---|---|
| **Race** | **Pickett** | **Peking** | **PI 88788** | **PI 90763** |
| 1 | − | − | + | − |
| 2 | + | + | + | − |
| 3 | − | − | − | − |
| 4 | + | + | + | + |
| 5 | + | − | + | − |
| 6 | + | − | − | − |
| 7 | − | + | − | − |
| 8 | − | − | − | + |
| 9 | + | + | − | − |
| 10 | + | − | − | + |
| 11 | − | + | + | − |
| 12 | − | + | − | + |
| 13 | − | − | + | + |
| 14 | + | + | − | + |
| 15 | + | − | + | + |
| 16 | − | + | + | + |

**Figure 7. Race differential chart from Riggs and Schmidt*.**

[a] + = Number of females and cysts recovered is greater than or equal to10% of the number on the cultivar Lee; − = number of females and cysts recovered is less than 10% of the number on Lee.

*Race Table from E.D. Riggs and D.P. Schmitt, Compendium of Soybean Disease, Third Edition. Edited by J.B. Sinclair and P.A. Backman, pp. 65-67, APS Press.

environments where such host plants could have sustained a native cyst population. Well over 1,100 plant species are reported to be SCN hosts. **Table 2** lists some of the possible midwest hosts. Repeated planting of susceptible soybeans has allowed either the native or introduced populations to buildup to damaging levels.

In 1978, when SCN was new to Minnesota, it was estimated that only four or five crops of soybeans in a corn/soybean rotation would allow the population to increase to damaging levels. That may have been an underestimate since in 1989 the fields with the most damaging SCN problem were those that had been in a corn/soybean rotation for 15 to 20 years or at some time had been planted to soybeans following soybeans. Significant SCN losses in 1989 occurred where moisture was limiting and soil temperatures were warm.

## CONTROL

The development of the SCN problem in Minnesota is similar to what has occurred in other states. Therefore it is reasonable to expect that it will become a major factor in all areas of Minnesota where soybeans are grown frequently. The best control method is prevention and that certainly must be considered since it is easier than management after the disease is present. Efforts to keep the many apparently uninfested acres free of the nematode should be the starting point. If a field is proven by sampling to be free of the cyst nematode, sanitation efforts are of value. Equipment used in infested fields should be cleaned of soil before entering non-infested sites. Only seed free of soil ''peds'' should be used in clean fields. Sites near clean fields that are known to have SCN should be put into minimum

## Table 2. Host plants for the soybean cyst nematode

**Crops and flowers**

SOYBEAN, cultivated or wild
BEANS, GREEN (SNAP), BUSH, KIDNEY or LIMA
LESPEDEZA species
VETCH, COMMON, HAIRY or WINTER
LUPINES, WHITE
Clovers, crimson, scarlet or alsike
Sweetclover
Birdsfoot-trefoil
Crownvetch
Pea, garden
Cowpea or black-eyed pea
Locust, black
Bells of Ireland
Borage
Canarybird flower
Caraway
Chinese lantern plant
Coralbells
Cup-flower
Delphinium
Foxglove
Geranium
Geum
Horehound, common
Poppy
Sage
Snapdragon
Sweet basil
Sweet pea
Verbena

**Weeds**

HENBIT
HOP CLOVERS
CHICKWEED, COMMON
CHICKWEED, MOUSE-EAR
MULLEIN, COMMON
Purslane
Bittercress
Rocky Mountain Beeplant
Toadflax
Pigweed, winged
Vetch
Burclover or Toothed medic
Dalea
Milkvetch, Canadian
Beggars weed or Tick-trefoil
Corn cockle
Hog-peanut
Wildbean

**CAPITAL LETTERS INDICATE HIGHLY SUSCEPTIBLE HOSTS**

tillage management. This cuts down on direct movement of the nematode by equipment and wind erosion. Even if cyst distribution does occur in nature, the prevention of human assisted spread is of value.

## MANAGEMENT

Management strategies for control of SCN in infested fields include: rotation, resistance, cultural practices, and chemicals. The goal of SCN management is to lower nematode populations below economic thresholds. Short rotations with corn have clearly demonstrated the reproductive potential and survivability of SCN. The nematode apparently will only become a problem where a corn/soybean rotation is practiced or where continuous soybeans are grown. Losses due to SCN have not been reported in fields that have soybeans only once in three or four years.

Crop rotation thus can be an effective and economical way to control SCN. An effective rotation program requires the use of non-host crops: corn, sugarbeets, sorghum, alfalfa, and small grains with effective weed control. Fields known to have a moderate SCN population probably can be planted to susceptible soybeans every four years with limited yield loss. Heavily infested fields will have to have at least three and probably as many as five years of non-host crops before susceptible soybeans can be successfully grown. These fields should be monitored by soil testing to determine the population level of cysts and eggs or larvae before planting a susceptible crop. Weed control in non-host years is very important as some weeds will maintain the SCN population.

The SCN, with 3 to 4 generations per year in Minnesota, does not build up as fast as it does in the South. It is also possible that nematode populations do not decline as rapidly here as in the South where warm soils allow random hatching of eggs and premature use of food reserves. Warm soils support predator and parasite activity that can kill eggs and unhatched larvae in cysts all year long.

Resistant varieties are another means of SCN management. Yet growers must be selective. Resistant varieties usually have a lower yield potential than susceptible varieties growing in the absence of damaging SCN populations. Do not plant resistant varieties unless SCN is present. The real value of a resistant soybean is the ability to produce a soybean crop and either reduce or at least not increase the population of the nematode. Although it is likely that most fields in Minnesota are infested with Race 3, other races are present and even more than one race may be present in a field.

Once a suitable resistant variety is identified by on-farm trials or race testing in a laboratory, the resistance should be used no more often than once in four years. Repeated use of Race 3 resistance will select for races that are able to reproduce on Race 3 resistant varieties. The possibility of "losing" resistance by growing resistant soybeans repeatedly is very real and must be avoided. The rotation suggested for a field with a low SCN population is: year 1, a non-host; year 2, a resistant soybean; year 3, a non-host; and year 4, a susceptible soybean if SCN population is below the economic threshold. However, in heavily infested fields, two years of non-hosts and a single year of resistant soybeans as just outlined *probably* will not be adequate to lower the SCN population to a safe level under Minnesota conditions.

The use of cultural practices that help the soybean plant get a good, strong start helps reduce the negative effects of SCN. Adequate-to-high levels of fertility and seasons of average heat and moisture allow expression of the yield potential of resistant and susceptible varieties. High soil fertility levels may reduce the nematodes' negative yield effects but do not eliminate SCN development. In fact, the nematode will thrive under good growing conditions while causing little, if any, visible damage. Good growing conditions, desirable for the growth of the current season's crop, will have undesirable long term effects as the population of the nematode will increase.

Biological control does occur and in some southern locations SCN pathogenicity has decreased. Although the causes and management of biological control are not well understood, in some locations it is sufficiently effective to control SCN. This control option may or may not develop in Minnesota.

Nematicides, usually applied as granules at planting in a band, can protect seedlings and young soybean plant roots from infection, but a yield increase is not automatic. The effectiveness of such treatments is limited by the following factors: too much or too little rainfall, less than ideal placement, and the protective egg and cyst structures that prevent adequate exposure of the larvae to the chemical. Soil fumigants are also labeled for control of SCN but costs are high. As a result, chemical control of SCN is generally not recommended, but may be considered when nematode populations are at damaging levels, when resistant lines are not available, and where soil type and placement allow for safe and potentially effective use.

**THRESHOLDS**

It's been said that even "one cyst in a field is too many." The smallest population reported to cause a detectible yield reduction was estimated to be 50 eggs per 100 grams of dry soil. An at-planting infestation of 300 SCN eggs per 100 grams of dry soil reduced yields by 10%. The yield loss and egg or larvae count relationship is highly dependent on growing conditions, such as water availability, nutrient levels, soil type, and soil temperature in the root zone. The relationship can increase or decrease as plant growth and nematode development are either favored or reduced.

Very few economic thresholds for SCN have been established and values just presented are for one soil type and three growing seasons. The injury thresholds are difficult to establish because cysts do vary in size and thus the number of eggs contained; eggs may be viable or not and larvae counted in soil samples may not be in position to infect roots. Numbers of SCN eggs, larvae or cysts found in a sample can vary significantly depending on how the sample was taken and with soil textures. Damage, expressed as yield loss will also vary depending on soil type, texture, SCN isolate, soybean variety, and growing conditions. Higher numbers of SCN are required to damage soybeans in heavy soils, while low numbers of SCN can cause damage on sandy soils. Yield loss in dry years will be greater than in seasons of adequate moisture.

Although it is risky to assign a threshold level for the SCN in Minnesota soils and growing conditions, an at-planting population of 100-200 viable eggs per 100 grams of dry soil or 10-30 larvae per 116 $cm^3$ are probably adequate to damage soybean roots and reduce yields. This number is only a guide to be used when soil test results are considered and control strategies are developed. Soil test results can be used to determine if a field should be planted to susceptible or resistant soybeans or if it should be planted to non-host crops. Fields with egg counts in the range of 200 to 1,000 may still produce a reasonable crop yield in some soils and years, but the increase in SCN population will severely damage future soybean crops. Soils with egg counts above 1,000 should not be planted to susceptible soybeans for 2 or 3 years. Rotations without susceptible soybeans for 3 or 4 years will be required if egg counts are above 10,000. Retesting of soils, before planting susceptible soybeans, is advised when high numbers of SCN are found.





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