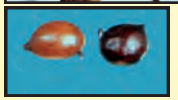
Soybean Cyst Nematode (SCN) Management



A Field Guide for SCN Management in Michigan by

Diane Brown-Rytlewski, George Bird, Fred Warner and Kelly Barnett

Soybean Cyst Nematode (SCN)

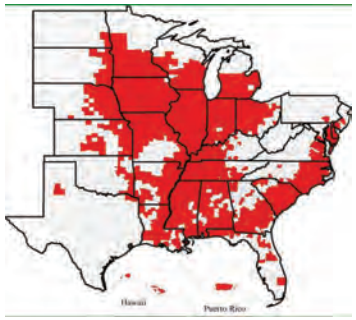
A guide to SCN Management in Michigan

Table ***page***

Photo: Greg Tylka,
Iowa State University

Why is SCN important, and where is it found?

Soybean cyst nematode is the major limiting factor in soybean production in the U.S., and can be found in 30 states. Soybean yield losses can be as high as 100%. **SCN is the number one cause of yield loss in Michigan.** The estimated yield reduction due to SCN in Michigan was nearly 4.8 million bushels[1]. SCN can also be a problem of dry beans and snap beans. SCN was found in Michigan for the first time in 1987, and is now present in all major soybean producing counties in the state (40 counties). So far, it has not been detected in Presque Isle or Oakland County, or in the Upper Peninsula of Michigan. During early infestation, stunted plant growth and yield declines may be slight making it difficult to determine economic losses. Stunting and yield losses may become severe after several soybean crops in an infested field.



US distribution of SCN, 2008 (Riggs and Tylka)

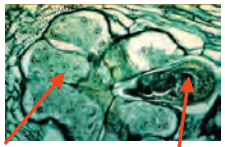
Known distribution of SCN in 2008

What SCN is, and what it looks like

Soybean cyst nematode (SCN) is a microscopic roundworm that feeds on soybean roots. Its scientific name is *Heterodera glycines*. The juvenile stage (right) penetrates soybean roots causing special feeding cells (nurse cells) to form in the vascular tissue of the root.

Head of a juvenile soybean cyst nematode

Photo: Burton Y. Endo, USDA ARS



Nurse cells Female SCN

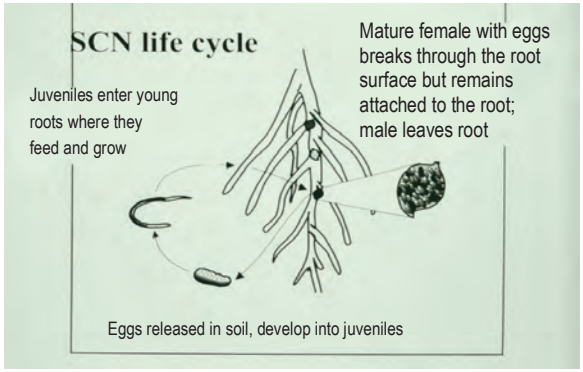
Cysts and eggs

Cyst actual size •

SCN females can be observed on soybean roots about 45 days after planting. Adult females (white) and cysts (tan to brown) shown above are ~1/32" long. Cyst broken open (right) contains about 200 eggs and juvenile nematodes. Nitrogen–fixing nodules shown on roots at right may be confused with cysts, but are always larger–up to pea size. Young nodules have a gray to white interior that turns pink after nitrogen fixation begins. Healthy soybean roots may have several hundred nodules per plant.

SCN life cycle

>The lifecycle can be completed in 24-30 days
>Females can produce 200 or more eggs
>Eggs within a cyst can survive for 10 years or more
>There can be multiple generations per year



Egg, 1/200" long

Males migrate out of roots to the soil to mate with females. Eggs produced by a female don't all hatch at the same time.

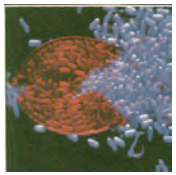


Photo: Greg Noel, Auburn University

How to know if you have SCN in your field

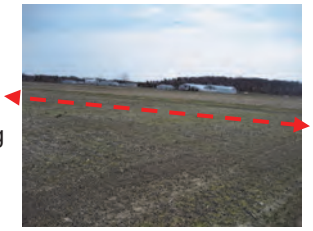
Symptoms of SCN infestation include poorly developed root systems, stunted yellow plants in patches, and decreased nodulation. Many above ground symptoms look similar to those caused by soil compaction, herbicide damage, nutrient deficiencies, or other diseases. Even with significant yield loss, there may be no obvious symptoms above ground at all. Characteristic signs of SCN on roots are females and cysts. Soybean roots infected with SCN may be discolored, stunted or smaller than normal, with fewer nodules. SCN weakens roots and makes them more susceptible to other soil-borne diseases. The roots (shown right) are heavily infested with white SCN females. The larger object by the lower pointer is a nitrogen-fixing nodule. During the growing season, dig plants from the edge of patches with poor growth and check roots for white SCN females. Cysts of SCN are brown and can not be seen in soil.

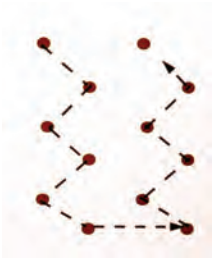
Photo: Greg Tylka, Iowa State

When should sampling be done and how do I sample for SCN ?

You can take soil samples to test for SCN any time the ground is not frozen. For the best results in diagnosing SCN problems, do not take samples until 45 days after annual root growth begins. When sampling to avoid SCN problems, collect soil samples the fall before soybeans are grown. Use a soil sampling tube or narrow bladed shovel to collect soil (and roots if present) to a 6-8 inch depth. Place the sub-samples in a clean container and mix. You will need about a quart of soil per sample. Place each sample in a plastic bag, label it with a permanent marker, and store it out of direct sunlight, at cool temperatures (ideally, 50-58°F) until it can be processed. Don't store samples in car trunks or other hot places. Nematodes will be killed if they dry out, or are stored at temperatures greater than 100°.F.

SCN sampling is done 1) to assist in avoiding SCN problems and 2) to diagnose SCN problems during or after the growing season. The area for sampling should be no larger than 80 acres. Larger fields can be subdivided. Collect samples from areas of similar cropping history and soil texture. The field at right is subdivided into two sections. One where soybeans were grown, and the other where corn was grown. You may need to collect separate samples from areas such as flood plains, ridges, or problem spots. Collect 20 to 25 subsamples per sample. For problem areas, take samples from margins where plants are still living. If collecting plants, dig, don't pull plants. From fallow fields or areas planted to a cover crop, collect samples in a zigzag pattern. From row crops, take soil samples within the rows and include roots.





For problem diagnosis, sample around the edges of problem spots, instead of directly in them.

Steps for managing SCN

If your field is diagnosed with SCN, there are important steps recommended to manage it:

1) Soil-root sampling for SCN, soil pH and nutrients
2) Rotate with non-host crops
3) Plant SCN resistant soybean varieties
4) Control weeds
5) Avoid moving infested soil, especially with machinery

Sampling for SCN

Fields infested with SCN can be found in every county south of Clare (except Oakland) according to Fred Warner, MSU Diagnostic Services nematologist. A laboratory analysis of soil/root-tissue for SCN is the best way to determine if your field is infested with this nematode. Soil from soybean sites should be tested for SCN every 3-5 years. If the site is known to be infested with SCN, and SCN resistant varieties are not resulting in high yields, it is recommended that the soil be analyzed to determine the Type of SCN present (see page 16). It is a good idea to also check pH and fertility. High population densities of SCN are often associated with a soil pH above 7.4. Soils with high pH have greater yield loss potential due to SCN.

Sampling for SCN (continued)

The Michigan Soybean Promotion Committee (MSPC) sponsors a free SCN testing program for Michigan growers (up to 20 samples/grower). Forms, sample bags and mailers are available at your local MSU extension office. Samples can be delivered or mailed to:

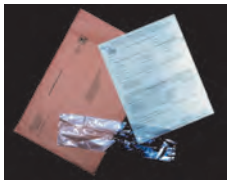
Diagnostic Services
101 Center for Integrated Plant Systems
Michigan State University
East Lansing, Michigan 48824-1311

or delivered to your local extension office.

MSU Diagnostic Services provides SCN management recommendations based on the number of eggs and second-juveniles present in the sample.
SCN Risk Level is rated on a scale from 0-3:

0) non-detectable
1) low, 1-1000 eggs,
2) medium, 1,000-10,000 eggs
3) high, >10,000 eggs.

In sites with a SCN Risk Level of 0, it is important to rotate with corn or another non-host. This reduces the risk of future SCN problems. Use of a resistant variety is recommended if a site has a Risk Level of 1 and a history of low or declining yields. With a Risk Level of 2, crop rotation, sampling and use of resistant varieties is recommended. With a SCN Risk Level of 3, a long-term comprehensive SCN management plan is needed to significantly lower SCN population densities.



Sample form for SCN soil testing sponsored by MSPC

Take the test. Beat the pest.

MSPC | Michigan SCN Consortium | Michigan State University Extension

Funded by Soybean Checkoff Dollars

The Soybean Cyst Nematode (SCN) is a major limiting factor in Michigan's soybean production. It's imperative that problem fields are identified for proper management of this important soybean pathogen. Identification of SCN requires inspection of root tissue and submission of soil samples to a Diagnostic Laboratory such as the one at MSU. Cysts are extracted from the soil to estimate the numbers of eggs and juveniles present, so risk to subsequent soybean crops can be assessed. Recommendations for management are derived from this information.

Because sampling is necessary for SCN identification, the ***Michigan Soybean Promotion Committee*** will pay the analysis costs of samples submitted to the MSU program. Please fill out the form completely (one per sample) and either deliver or mail the samples to Diagnostic Services, 101 Center for Integrated Plant Systems, Michigan State University, East Lansing, MI 48824-1311 or deliver the sample to your local MSUE office. Sample results will be returned as quickly as possible. Details for nematode sample collection and care are outlined in MSU Ag Facts Bulletins E-2199 and E-2200 and also on the back of this flyer.

GROWER INFORMATION

Name _____

Address _____

City _____ Zip _____

County _____

Phone #_____

Township _____ Sect. _____

Field I.D. _____ No. Acres _____

Present Crop _____

Yield of last soybean crop (bu/A) _____

Past Crops _____ Year _____

_____ _____

_____ _____

Number of soybean crops grown in this field in the last 20 years?_____

Have SCN resistant varieties been grown in this field? (circle one) YES ☐ NO ☐

Circle the SCN source of resistance in the last variety you planted.
PI 88788 ☐ Peking ☐ Cyst X ☐ Not Sure ☐

Please list the year(s) that SCN resistant varieties were grown._____

_____

_____

SAMPLE RESULTS

Nematodes | Soil[1] | Roots[2] | Risk[3]

MSU Sample Number _____
Date Rec'd _____

Soybean Cyst	Cysts Eggs J_{2s}	J_{2s}	
Other cysts			
Lesion			
Root-knot			
Lance			
Dagger			
Stunt			
Pin			
Spiral			

Diagnosis and Recommendations:

1. Number per 100cm³ soil
2. Number per 1.0g root tissue
3. Risk ratings: 0 = none; 1 = low; 2 = moderate; 3 = high

_____
Nematode Diagnostician

SCN Management

Rotate with non-host crops

> In Michigan, two years or more of rotation to a non-host crop is necessary to reduce the population densities of SCN.
> Do not plant dry beans, green beans or peas in the rotation on SCN-infested land.
> Alfalfa, corn, sugar beets, potato and small grains are all appropriate choices to use as non-host crops in a rotation for SCN management. Non-legume vegetables may be used as a rotation crop.

Use SCN resistant varieties

> SCN resistant varieties are used successfully by Michigan growers to prevent yield losses caused by SCN.

> There are three sources of SCN resistance available in varieties sold in Michigan. These are: PI88788, PI548402 (Peking) and PI437654.

> Over the past 10 years on one Michigan farm, use of resistant varieties increased soybean yields an average of 43%, compared to a susceptible variety.

> In this case, SCN resistant varieties significantly decreased risk of SCN for future soybean crops.

> Check with your seed dealer or search for SCN resistant soybean varieties to grow at the MSU soybean variety trial website, http://www.soybeanyielddata.msu.edu

Use SCN resistant varieties (cont'd.)

> One of the largest annual trials to evaluate SCN resistance that includes commercial soybean varieties is conducted by Iowa State University, and can be found at: http://www.isuscntrials.info/

> Don't plant the same resistant variety two years in a row.

> Rotate sources of resistance from one soybean crop to the next soybean crop, to prevent development of highly aggressive SCN populations (SCN Types, see page 16) that reproduce on SCN resistant soybeans.

> Continue rotating non host crops with SCN resistant soybeans. You can successfully use a susceptible variety when the SCN population has been reduced to zero or a non-detectable level.

NCSRP (North Central Soybean Research Program SCN Type Research-Education Program

> A NCSRP project to compare yields and SCN reproduction on three sources of SCN resistance with a susceptible variety was started in 2008. (see page 14)

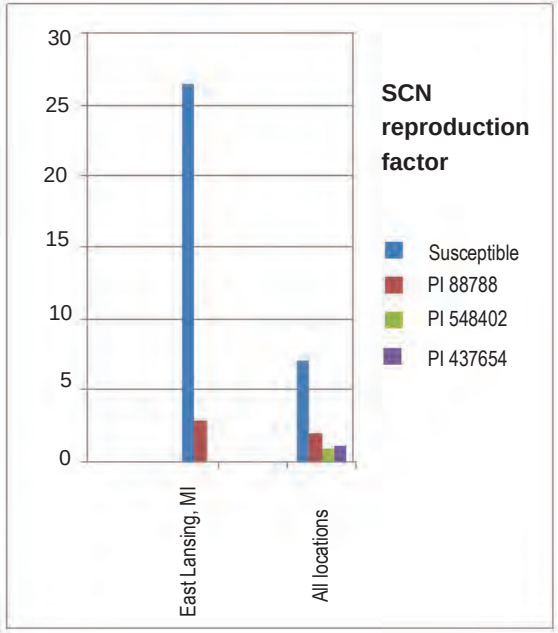
> At a Michigan site, SCN reproduction was around 12- 25 times greater on the susceptible variety than varieties with resistance.

> For the site in East Lansing, SCN was able to successfully reproduce on the variety with resistance from PI 88788. Nematodes were not able to reproduce successfully on the varieties with resistance from PI 458402 (Peking) or PI 437654.

> In this case, a variety with resistance from PI 548402 or PI 437654 would be the best choice.

SCN resistant varieties, cont'd.

This graph shows part of a 2008 NCSRP regional study comparing the performance of different sources of SCN resistance across geographic locations and SCN resistance types [2]



At the East Lansing location, SCN reproduction on the susceptible variety was higher than the average across all North Central U.S. locations. SCN reproduction was successful on PI 88788, but not on PI 548402 (Peking) or PI 437654.

SCN resistant varieties, cont'd.

Variety selection can make a difference. The table below compares soybean yields (bu/A) and final SCN field population densities (Pf/100 cm^3 soil) using six soybean varieties with different SCN resistance sources planted at two Michigan locations.

	Cass County field location 2008		Monroe County field location 2008	
Soybean Variety (SCN resistance source)	**Bean Yield (bu/A)**	**SCN (P_f/100 cm^3 soil)**	**Bean Yield (bu/A)**	**SCN (P_f/100 cm^3 soil)**
NK S-17-J5 (Susceptible)	13.1	16,392	27.9	14,594
NK S-19-L7 (PI 88788)	15.5	4,901	32.5	6,571
Stewart S2979 (PI 548402 x PI 88788)	18.5	328	34.0	1128
NK S28-G1 (Susceptible)	18.9	26,714	37.3	914
Beck 298 (PI 437654 x PI 88788)	20.2	2,158	38.5	1479
NK S29-J6 (PI 88788)	22.5	4,947	42.2	988

(All values for yield and nematode populations are statistically significant compared to the susceptible control)

SCN populations (Types): What are they and why are they important ?

> **Field populations** of SCN vary in their abilities to reproduce and damage soybeans. These are called SCN Types.
> Some SCN Types are highly aggressive. They cause severe bean yield losses and result in high at-harvest SCN population densities.
> For optimal SCN control using resistant varieties, it is important to match the appropriate soybean variety with each field population (SCN Type).
> Four systems have been developed to assist soybean growers in selection of the best SCN resistant variety for their particular situation.
> These include the:

- 2006 SCN Type System
- 2002 HG Type System
- 1988 Race System, and
- 1970 Race System

> The 2006 SCN Type System is recommended for use by Michigan growers.

Sources of SCN resistance

There are three sources of SCN resistance used by soybean breeders for development of the SCN resistant varieties commercially available in Michigan.

SCN populations (Types) cont'd.

Sources of SCN resistance commercially available in Michigan include:

PI 548402 (Peking) (SCN Type Indicator Line 1, 1966),
PI 88788 (SCN Type Indicator Line 2, 1978)
PI 437654 (SCN Type Indicator Line 4, 1992)

SCN Types-What are They?

> If a specific SCN population does not reproduce or cause damage to varieties developed from any of the three sources of resistance, it is a **SCN Type 0.**

> When an SCN population reproduces on varieties derived from PI 548402 (Peking), it is a **SCN Type 1**.

> If an SCN population reproduces on a variety derived from PI 88788, it is a **SCN Type 2**.

> When an SCN population reproduces on varieties derived from PI 437654, it is a **SCN Type 4** .

> If an SCN population reproduces on varieties derived from both PI 548402 (Peking) and PI 88788, it is a **SCN Type 1.2.**

>When an SCN population has the ability to reproduce on varieties derived from all three currently available sources of resistance, it is a **SCN Type 1.2.4.**

Types 3, 5, 6 and 7 are part of the 2002 HG Type System. They are not part of the 2006 SCN Type System.

SCN populations (Types) cont'd.

If the seed bag or brochure contains information about races, how do I convert it to the SCN Type system?
The following chart should be of assistance.

Converting SCN Races to SCN Types

SCN Type	Race
0	3
1	13
2	1
4	None available
1.2	11
1.4	None available
2.4	None available
1.2.4	None available

> With four of the potential eight Michigan SCN Types having no race determination, it should be self-evident why it is important to use the SCN Type system for assistance in selection of SCN resistant varieties.
> The most common SCN Type in Michigan is SCN Type 2.
> SCN Type 0 and SCN Type 1 are also known to exist in Michigan.

SCN populations (Types) cont'd.

> In one location, an SCN Type 1.2 has been identified, leaving varieties derived from PI 437654 as the only option for high soybean yields for this field.

Which SCN Resistant Variety to Plant?

> To obtain high soybean yields and low SCN population densities at the end of the growing season, it is essential to select an SCN resistant variety derived from a source of resistance that will not allow your specific field population (SCN Type) to feed and reproduce.

> The chart entitled "Which SCN Resistant Variety to Plant (How it Works)?" on the next page is designed to assist growers in selection of the proper variety for their specific situation.

Some current SCN-resistant varieties contain multiple sources of resistance such as PI 88788 x PI 437654 or PI 548402 x PI 88788.

Mechanisms of Resistance and Genetics: Vertical -like resistances is governed by a single dominant gene that prevents nurse cell development. This results in no or very limited SCN reproduction. Horizontal-like resistance has a number of minor genes that result in poor host nutrition for, small SCN females and low at-harvest SCN populations.

Which SCN Resistant Variety to Plant? (how it works)

Resistance source	Resistance mechanism	SCN Type 0	SCN Type 1	SCN Type 2	SCN Type 4
Susceptible (none)	S[2]	DO NOT PLANT	DO NOT PLANT	DO NOT PLANT	DO NOT PLANT
PI 548402	R(V)[3,4]	OK TO PLANT	DO NOT PLANT	OK TO PLANT	OK TO PLANT
PI 88788	R(H)[3,5]	OK TO PLANT	OK TO PLANT	DO NOT PLANT	OK TO PLANT
PI 437654	R(V+H)[3,4,5]	DO NOT PLANT	OK TO PLANT	OK TO PLANT	DO NOT PLANT

[1]Based on 2006 SCN Type System, types, **not** the 1988 Race System. [2]S = susceptible, [3]R = resistant, [4]V = vertical-like resistance, [5]H = horizontal-like resistance

SCN and interactions with other diseases

Sudden death syndrome (SDS)

Soybean fields reported with SDS symptoms have increased in Michigan in recent years. SDS is an infectious disease caused by the soil-borne fungus, *Fusarium virguliforme*. Research shows there is a relationship between SDS and the soybean cyst nematode (SCN). Although SCN is not required for the development of SDS it increases its severity.

Photo: Bruce MacKellar, MSUE, St. Joseph County

Brown stem rot (BSR)

Brown stem rot (BSR) is caused by the soil-borne fungus, *Phialophora gregata.* This disease also seems to be more severe when SCN is present. BSR tends to develop earlier in the season in soybean plants infected with soybean cyst nematode. Foliar symptoms are similar to SDS, but in soybean plants infected with BSR, stem pith turns brown, and with SDS it does not. Research to understand the interactions between SCN and both soybean sudden death and brown stem rot is underway at several universities in the North Central region.

Managing SCN– weed control

Weed control and SCN

>Weed control can be an important factor in reducing SCN populations. Research shows that some winter annual weeds are alternate hosts for SCN.
>These weeds have become more prevalent in Michigan soybean production due to the increase in conservation tillage systems and a reduced use of residual herbicides.
>Purple deadnettle is a very good host for SCN (pictured below). Henbit and field pennycress are also hosts of SCN. Shepherd's-purse and common chickweed are poor hosts.
> Winter annual weeds germinate in fall, overwinter as small seedlings and flower early in the spring. Fall or early spring herbicide applications can be used to control these weeds and may aid in reducing SCN populations.

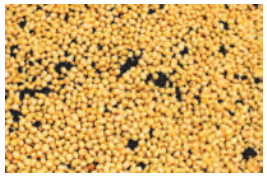
Purple dead nettle, a common winter annual host for SCN

Managing SCN– weed control cont'd.

Field pennycress (right) and henbit (below) are other winter annual weeds that are known hosts for SCN

Avoid moving infested soil and plant materials
SCN spread through its own movement is limited. Spread of SCN through infested soil on machinery, flood water, wind, soybean seeds or crop transplants has occurred in Michigan. 1. Keep soil movement to a minimum. 2. Work infested fields last. 3. Plant only soil-ped free seed. 4. Use crop transplants (tomato, strawberry etc.) that are certified SCN free. 5. Power wash equipment after use in a SCN-infested field.

Dark clusters (right) are SCN infested soil peds that are mixed in with soybean seeds



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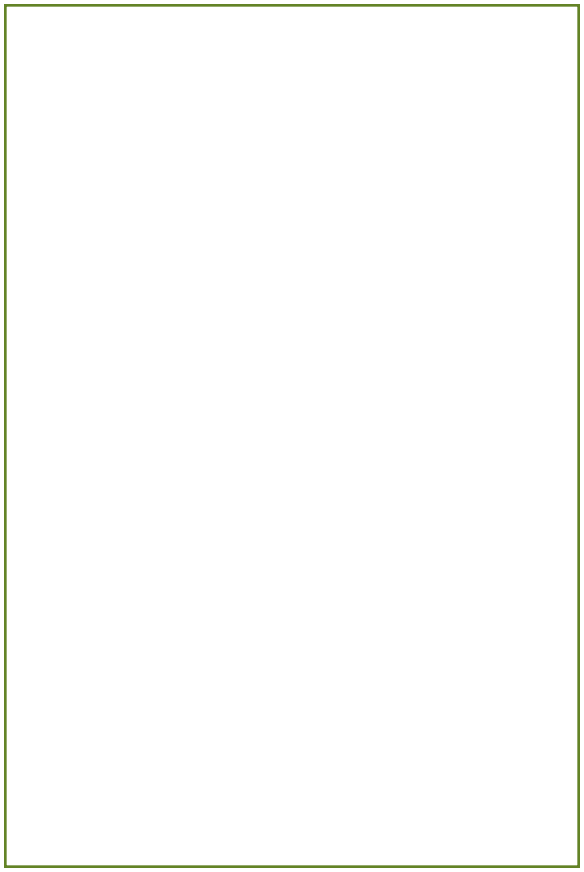

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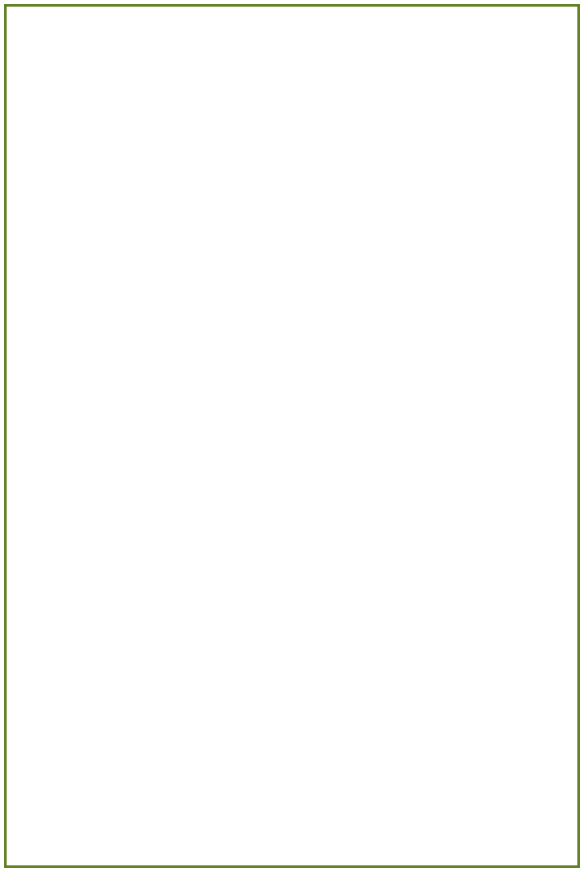

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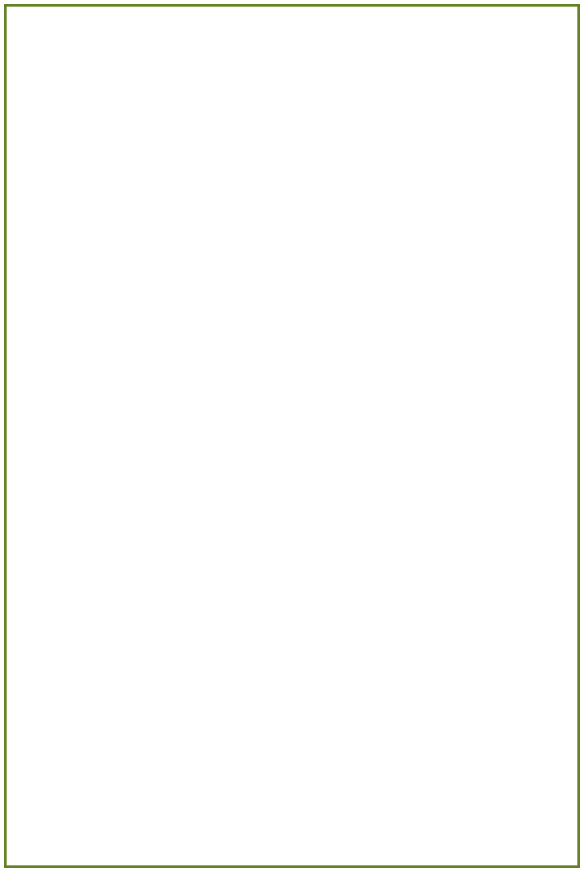

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Reviewers:

Mike Staton, Allegan County MSUE
Ned Birkey, Monroe County MSUE

Photo credits

Head of juvenile SCN, page 4, UGA177005.SCN egg, page 5, UGA 0177021 -both Agroscope FAL Reckenholz Archive, Swiss Federal Research Station for Agroecology and Agriculture, http://www.Bugwood.org
Cyst broken open, page 4; SCN females on root, SCN lifecycle diagram, page 5; sampling diagram, page 8; and soil peds, page 23. Leader's Guide for SCN Management and Training, 1997. The SCN Coalition, NCSRP.

References

[1.] Allen Wrather and Steve Koenning, 2006. Estimates of Yields Suppressed by Diseases in the United States During 2006. United Soybean Board Domestic programs, Final report 2006.

[2.] Improving Management of Soybean Cyst Nematode through Extension Demonstration and Outreach.2009. North Central Soybean Research Program. Final report on Project Progress (March 1, 2008-February 28, 2009). *Loren Giesler co-project leader (University of Nebraska), Carl Bradley co-project leader (University of Illinois), Anne Dorrance (The Ohio State University), Terry Niblack (USDA/ARS/University of Illinois), Greg Tylka (Iowa State University), Doug Jardine (Kansas State University), Dean Malvick (University of Minnesota), Laura Sweets (University of Missouri), Sam Markell (North Dakota State University), Lawrence Osborne (South Dakota State University), Paul Esker (University of Wisconsin), George Bird (Michigan State University), Albert Tenuta (Ontario Ministry of Agriculture, Food & Rural Affairs)*

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